Amended in November 2013

ADAPTATION FUND

REQUEST FOR PROJECT/PROGRAMME FUNDING FROM THE ADAPTATION FUND

The annexed form should be completed and transmitted to the Adaptation Fund Board Secretariat by email or fax.

Please type in the responses using the template provided. The instructions attached to the form provide guidance to filling out the template.

Please note that a project/programme must be fully prepared (i.e., fully appraised for feasibility) when the request is submitted. The final project/programme document resulting from the appraisal process should be attached to this request for funding.

Complete documentation should be sent to:

The Adaptation Fund Board Secretariat
1818 H Street NW
MSN P4-400
Washington, D.C., 20433
U.S.A
Fax: +1 (202) 522-3240/5
Email: afbsec@adaptation-fund.org

Amended in November 2013

PROJECT/PROGRAMME PROPOSAL TO THE ADAPTATION FUND

PART I: PROJECT/PROGRAMME INFORMATION

Note: The IDB and the Government of Suriname presented a Concept Note proposal to the Adaptation Fund in January 2017 to apply for grant funds for adaptation measures in downtown Paramaribo. Following the Adaptation Fund's endorsement of the Concept Note in March 2017, this Full Application builds upon the original proposal and provides more detail and context for the Proposed Project. All new edits and additions in Part I are shown in red text, and Parts II and III are new.

Project/Programme Category: Regular

Country/ies: Suriname

Title of Project/Programme: **Urban Investments for the Resilience of Paramaribo**: Building adaptive capacity of Paramaribo communities to climate change-related floods and sea level rise through strategic urban planning and sustainable infrastructure investments.

Type of Implementing Entity: Multilateral Implementing Agency

Implementing Entity: Inter-American Development Bank

Executing Entity/ies: Ministry of Public Works, Government of Suriname

Amount of Financing Requested: $9,850,000* (in U.S Dollars Equivalent)

**Note that this amount has increased by US$48,381 compared to approved Concept Note proposal. This slight increase in price arises from more detail being developed for the Project since the original Concept Note submission, as detailed in Part II.*

Project / Programme Background and Context:

Provide brief information on the problem the proposed project/programme is aiming to solve. Outline the economic social, development and environmental context in which the project would operate.

INTRODUCTION

CONTEXT AND VULNERABILITY AT A NATIONAL LEVEL

1. Suriname, one of the smallest countries in South America, is located on the north-eastern coast of South America and shares borders with French Guyana (east), Brazil (south), Guyana (west) and Atlantic Ocean (north). The country has a large variety of biological species and owns natural resources that represent a total forest area of 50 million hectares. Suriname also has substantial reserves of petroleum, bauxite, gold, granite and other minerals. Approximately 400 million tons of bauxite deposits are in Suriname and together with gold and production of crude oil represent the major economic sectors in the country (MLTDE, 2008). Mineral and energy sectors (gold, oil and alumina) account for approximately 30% of the GDP.

2. Suriname is a small, open, commodity-based economy that is vulnerable to external shocks. On the back of high international commodity prices, Suriname grew at a high average yearly rate (3.8% or a total real per capita income growth of 65%) over the past decade, and therefore was one of the Caribbean's best performing economies given its rich endowment in natural resources (World Bank 2016). Growth is driven by exports from the extractive sector (gold, oil, and bauxite), which generate 90% of foreign exchange earnings and 45% of government revenues. Suriname (in common with other small economies) relies on imports to satisfy most domestic demand for goods (imports account for more than 80% of consumption), while total trade has averaged around 145% of GDP over the past five years. The transmission mechanism of the wealth generated in the extractive sector to the rest of the economy relies highly on public spending on goods and services, infrastructure and, importantly, wages and salaries of employees in the public sector and in public enterprises. The domestic private sector, limited by the small size of the economy, is geared towards satisfying domestic demand mainly with imports. As a consequence, the private sector expands or contracts responding to changes in public spending that drive aggregate demand (IDB, 2016).

3. The recent historical growth in Suriname's per capita income has not translated into a significant improvement in social indicators. Suriname has a literacy rate of 94.7% and life expectancy of 71 years. The country ranks 103rd out of 186 countries in the 2015 Human Development Index (HDI), with slight improvements over the previous years. The country's HDI rank is mostly due to improvements made in income levels over the past decade, however, both the education and health indicators fall below comparable countries categorized with a high HDI. Only 45.9% of the population has a secondary education compared to 66.6% for comparable countries while there are only 9.1 physicians per 1,000 people in Suriname compared to 20 in other high HDI countries. Data on poverty and inequality are scarce but offer indications that Suriname is somewhat in line with regional averages. Conventional income-based poverty and inequality indicators are outdated, while a recent household survey of the General Bureau of Statistics did not produce any new estimates due to low response rates. Although robust growth in income per capita over most of the past decade may have reduced absolute poverty, its impact on inequality in recent years is more uncertain. A 2013 United Nations inequality-adjusted human development indicator (HDI) estimated that the loss in human development due to inequality in 2006 was broadly in line with the regional average (IMF 2014). The 2015 Human Development Report published by the United Nations Development Program indicated that about 7.4% of the population lived in multidimensional poverty at end-2010, which is below the regional average of 12%. The unemployment rate in Suriname is estimated at 8.9 % in 2015 (IMF 2016). Female unemployment is higher than male (about 4 percentage points), and youth unemployment is significantly higher (above 20% in 2013).

4. According to UNFCCC (2015) and the Environment Statistics (2016), the total population of Suriname is estimated on 558,773 habitants but it is expected that the population reach 2.5-3 million at the end of this century. The Surinamese population is presently multi-ethnical and multi-religious including ethnic groups such as Hindustani (from India), Creoles (African descent), Javanese (from Indonesia), Maroons (descendants of runaway slaves), Amerindians (the original inhabitants), Chinese, Lebanese and descendants of European settlers. The largest part of the Surinamese population is found within the Paramaribo and Wanica districts (74.4% of households). In 2004, the population density across Suriname was estimated at 3.0 people per square kilometre, making Suriname a very lowly populated country. However, the most densely populated districts are Paramaribo and Wanica with population densities of 1,335 and 194 people per square kilometre respectively, as shown in *Figure 1* (SNC, 2013). In addition, more than 90% of the diverse economic activities in production, manufacturing, horticulture, agriculture, financial and banking services, community, society and public services occur within the Paramaribo and Wanica Districts (MLTDE, 2008).

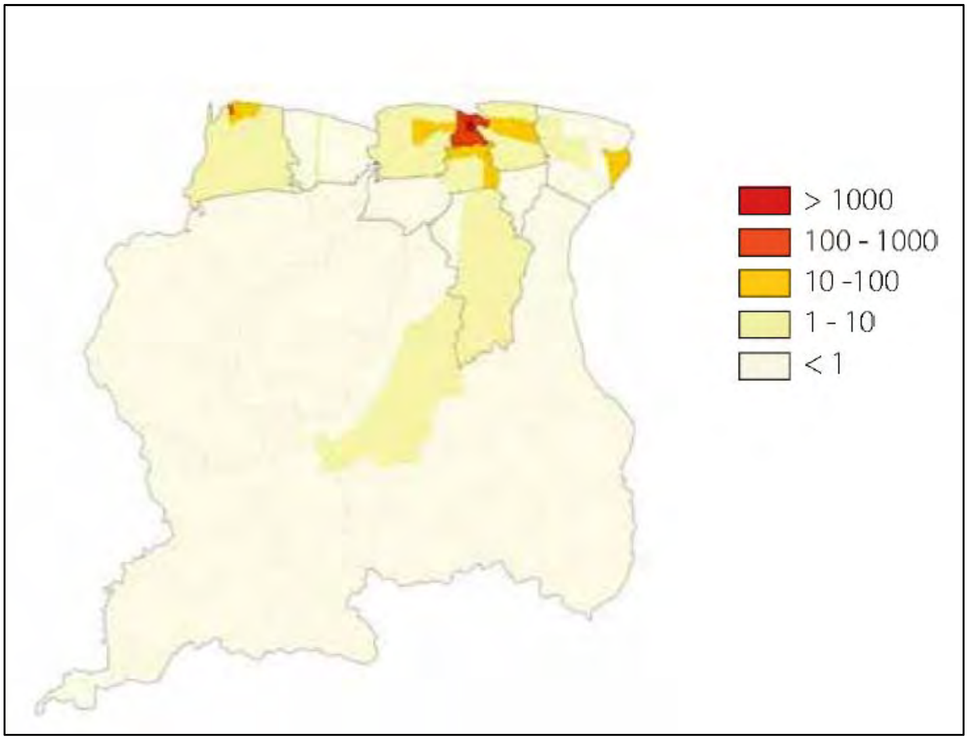

Figure 1: Population Distribution and Density per District on 2004 (Source: Figure 1.12 of SNC, 2013).

CLIMATE CHANGE VULNERABILITY CONTEXT AT A NATIONAL LEVEL

5. Suriname is a highly vulnerable country to the effects of climate change. Firstly, the country is exposed to several natural and climate change-influenced hazards. Secondly, the low-lying lands most vulnerable to these hazards also coincide with the areas of highest population density and economic activity. And thirdly, the low-income status further increases the population's vulnerability to climate change.

6. Suriname is susceptible to natural and climate change-related disasters, as detailed in its Second National Communication to the UNFCCC (SNC, 2013). These include flooding (both

coastal and inland), drought, heat exposure, strong winds and grou ndwater salinization. Scientific analysis projects that temperatures will i ncrease, sea level will rise, and the proportion of total rainfall that falls in heavy events will increase (though average rainfall will decrease). *Table 1* presents the future climate change projections for Suriname based on the A2 IPCC (Intergovernmental Panel on Climate Change) scenarios. It is projected that climate change impacts would affect over 40% of Suriname's GDP (UNFCCC, 2015). Some of the main socio-economic sectors bein g impacted by climat e change include agriculture, livelihoods, water availability, health and biodiversity.

Table 1: Climate Change Projections for Suriname based on A2 IPCC Scenarios

Parameters	Value	Year	Source
Air Temperature overall annual mean	+2.6 °C (annual); +2.6 °C (December, January and February); +2.7 °C (March, April and May); +2.6 °C (June, July and August); +2.7 °C (September, October and November)	2050s	The Caribsave Climate Change Risk Atlas (CCCRA, 2012)
Precipitation	-6% (annual); -3% (December, January and February); -8% (March, April and May); -8% (June, July and August); -8% (September, October and November)	2050s	The Caribsave Climate Change Risk Atlas (CCCRA, 2012)
Wind Speed	+0.30 m/s (annual); +0.30 m/s (December, January and February); +0.20 m/s (March, April and May); +0.30 m/s (June, July and August);+0.30 m/s (September, October and November)	2050s	The Caribsave Climate Change Risk Atlas (CCCRA, 2012)
Weather extremes, including intensity	+8% (annual); +10% (December, January and February); +9% (March, April and May); +7% (June, July and August); +21% (September, October and November)	2050s	The Caribsave Climate Change Risk Atlas (CCCRA, 2012)
Sea Level Rise (SLR)	+0.5 meter	2050s	Estimated based on info from CCCRA, Sea Level Rise in the Caribbean and The Second National Communication.

7. Flooding and sea level rise (SLR) presents a significant threat to S uriname given this extensive low-lying coastal zone and the concentration of socioeconomic activities within this area. Suriname's vulnerability is exacerbated by the fact that its main low lying coastal areas also coincide with the main population center s and area s economic activity. Suriname possesses a significant deltaic region related to four main rivers: Suriname River, Saramacca River, Coppename River, and Nickerie River. This includes sizeable north coastal plains (low-lying coast) where over 80% of the population live and where the major economic a ctivities and infrastructure are concentrated (SNC, 2013; UNFCCC, 2015). *Figure 2* shows the low-lying flat areas at the north part of Suriname that are prone to floods (approximately 2,000 km^2).

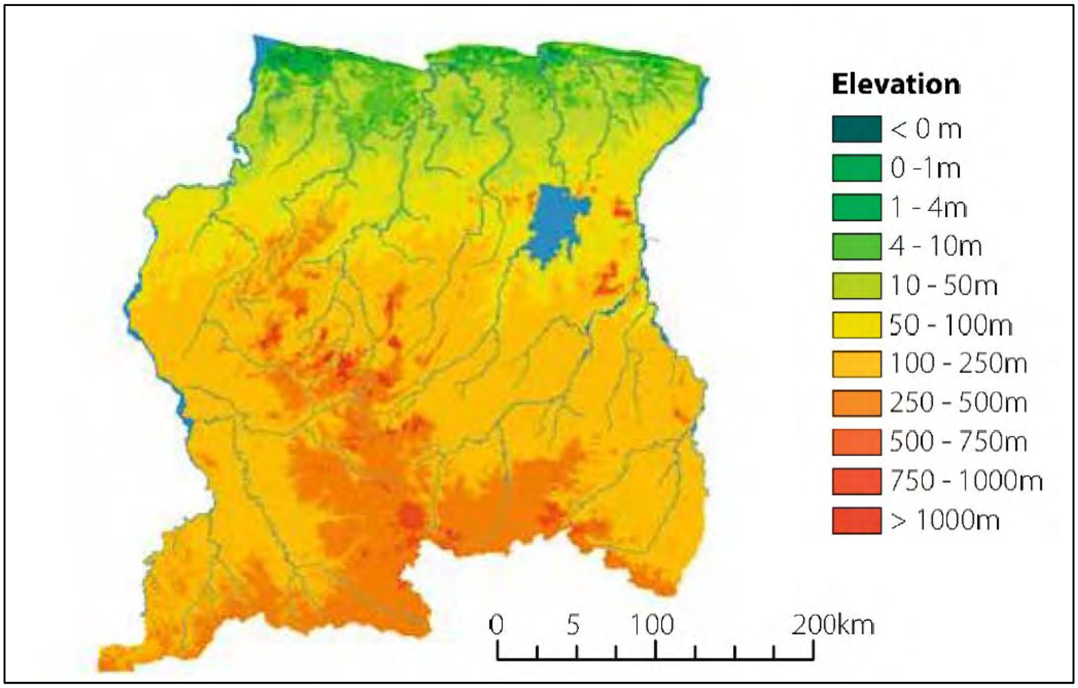

Figure 2: Topography of Suriname (Source: Figure 1.3 of SNC, 2013).

8. Even though Suriname is located outside of the hurricane area, hurricane effects are often experienced in the form of heavy rainfall. Meteorological conditions in Suriname are also influenced by climate systems including Sibibusies's (Sibi = sweep, Busie = forest), Inter Tropical Convergence Zone (ITCZ) and the El Niño phenomenon (Environment Statistics, 2016). Flooding occurs through a number of mechanisms including when sea level rises during spring tide, during tropical storms by impacting low-lying coastal and riverine development and/or by rainfall-induced accumulation of water due to outdated and insufficient drainage systems. Consequently, Suriname experiences frequent flooding, particularly in the northern coastal plain and riverine areas which are generally of low elevation and flat. *Table 2* shows a summary of the historical floods in Suriname between 2004 and 2015 based on information obtained from the Environment Statistics (2016).

Table 2: Historical Flooding Events in Suriname (Source: Adapted from Environment Statistics 2016 and NCCR Situation Analysis)

Date	Natural Disaster	Affected Areas	Population
9/7/2004	Floods associated with rainfall from Hurricane Ivan	Not specified	Unknown
6/5/2006	Flood due to excessive rainfall	Gran Rio and Pikin Rio rivers, Paramacaans on the Marowijne River, upper Marowijne, Tapanhony and Lawa, (Mofina) Suriname and Sipaliwini River	25,000 people
June 2006	Floods due to heavy rainfall	Villages along the upper Marowijne river and the upper Suriname River	20,000 people
2006/2007	Flood	Coropina triangle, Vier Kinderen, La Prosperite and Republiek	500 people
29/4/2007	Floods due to continuous rainfall	Paramaribo	

Date	Natural Disaster	Affected Areas	Population
28/5/2007	Flood due to excessive rainfall	Sipaliwini, Northern Marowijne, Tapanahony River, Lawa and Curuni	5,000 people
6/8/2008	Flood due excessive rainfall	Southern part of the interior: Djumu, Asidonhopo, Semoisi, Awaradam	Unknown
1/10/2009	Flood due to excessive rainfall	Paramaribo	Unknown
2/4/2009	Flood due to excessive rainfall	Paramaribo	Unknown
10/3/2009	Flood due to excessive rainfall	Paramaribo	Unknown
5/3/2009	Flood due to excessive rainfall	Paramaribo	Unknown
14/7/2010	Coastal flooding as a result of dam fail	Saramacca: La poule, Peperhol, north part of Wayambo	Unknown
24/4/2010	Flood due to excessive rainfall	Paramaribo	Unknown
16/4/2010	Flood due to excessive rainfall	Paramaribo: Margarethalaan	unknown
22/4/2010	Flood due to excessive rainfall	Paramaribo: Poelepantje	Unknown
17/5/2013	Flood due to excessive rainfall	Saramacca: Misgusnst	Unknown
16/5/2013	Flood due to excessive rainfall	Commewijne: Frederikdorp	Unknown
16/5/2013	Flood due to excessive rainfall	Para, Paramaribo, Marowijne (Cottica)	Unknown
20/6/2013	Tail of a heavy tropical storm/flooding (heavy rainfall)	Paramaribo, Wanica, Saramacca, Marowijne (Galibi). Roof were torn away (30 houses), trees uprooted and damaged power poles, advertising signs and Street lighting	300 people affected
27/12/2013	Flood due to excessive rainfall	Paramaribo, Wanica, Saramacca	Unknown
6/7/2014	Storm	National: Paramaribo, Coronie, Commewijne, Saramacca en Nickerie	150+
7/6/2014	Storm	Nickerie: Nieuw Nickerie	100 houses
2/5/2015	Flood	Marowijne: Alale Kondre	Unknown
18/5/2015	Persistent rainfall	Wanica: Hanna's Lust	
21/6/2015	Storm	Paramaribo: Zorg en Hoop	1 injured and 35 homes affected
28/6/2015	Storm	Paramaribo	1 (death)
27/7/2015	Flood	Saramacca	unknown
16/1/2016	Hailstorm	Paramaribo and surroundings	

9. The flooding risk of local communities living in costal and/or riverine areas of Suriname is amplified when considering the vulnerability of the areas that flood. For example, as discussed above, about two thirds of the Surinamese population live and work in the Paramaribo/Wanica area, which is prone to significant flooding. A 1999 study entitled "Country Study Climate Change Suriname" (and also known as the Netherlands Climate Assistance Programme

Phase 1, NCAP-1[1]) identified risk zones for inundation from the sea and rivers, as shown below in *Figure 3*, showing the current vulnerabilities of the northern coastal areas to flooding.

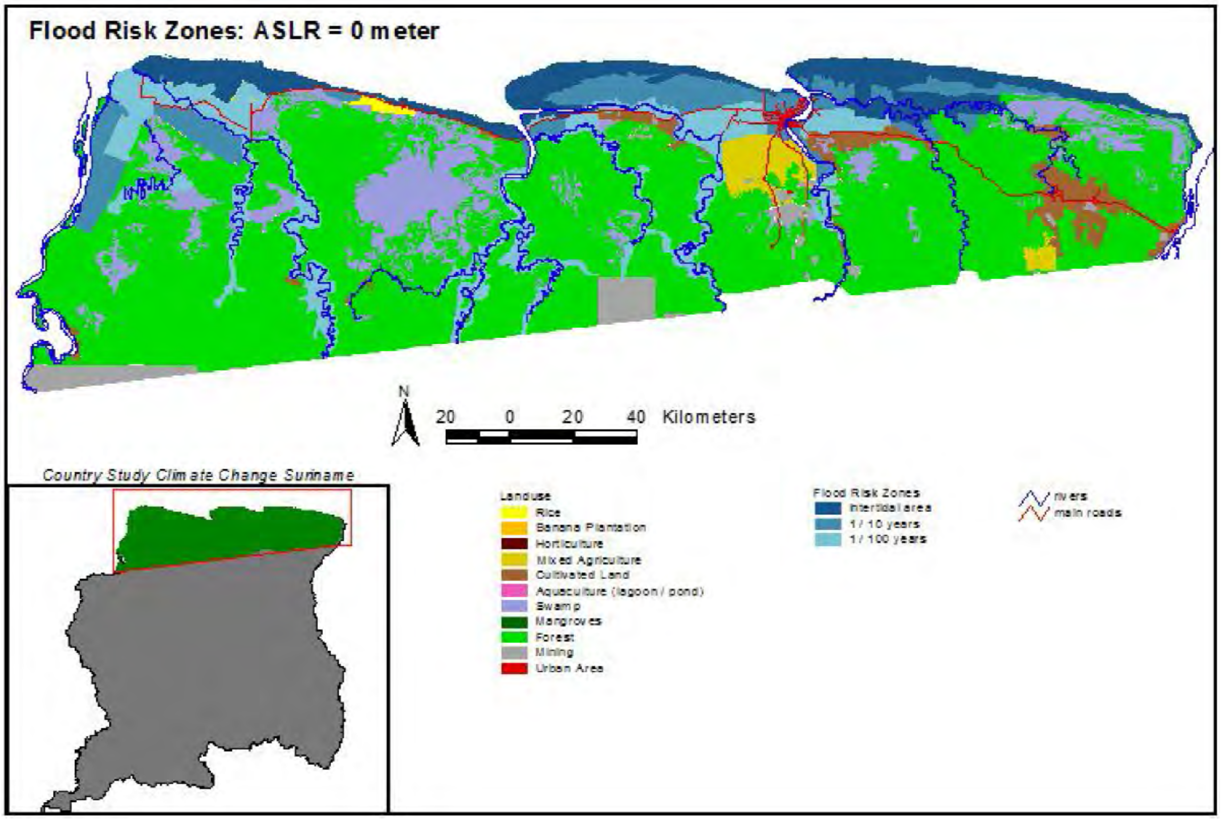

Figure 3: Flood Risk Zones for the Suriname coastal plain (Source: Figure 6-4 of Country Study Climate Change Suriname).

10. In a comparative analysis of the impacts of SLR on land, population, GDP, urban and agricultural extent, and wetlands in 84 developing countries, Suriname was ranked highest in Latin America and the Caribbean in terms of population and GDP impact, and was second only to Guyana and the Bahamas in terms of urban and agricultural extent (World Bank 2007 cited on IDB and IIC, 2016). At the global level, Suriname ranks among the top most affected countries overall. Suriname's entire economic zone is located within its coastal areas. Estimates of impacts of 1 meter SLR and storm surge in CARICOM member states, including Suriname, show that nearly 1,300 km^2 of land will be lost, over 110,000 people will be displaced, at least 149 multimillion dollar tourism resorts (including beaches) will be damaged or lost together with over 550 km of roads lost (Simpson et al, 2010). Other expected impacts include loss and damages to the agriculture, forestry and fisheries sectors as a result of increase ambient temperatures. Adaptation efforts so far remain insufficient and the continued impacts of climate change could further intensify the country's vulnerabilities, negatively affecting key sectors such as agriculture, water, energy, health and tourism.

11. The low-income segments of the population are disproportionately affected by climate risks. This is mainly due to poorer quality housing in environmentally sensitive areas and generally lower coping mechanisms in the case of hazard events. Lower income households often work

[1] https://www.weadapt.org/knowledge-base/national-adaptation-planning/methodology-of-suriname-ncap-project

in agriculture or informal activities that depend on the climate and are more exposed to communicable diseases that could become more prevalent as climate changes. Expected temperature increases, coupled with changes in rainfall patterns, will have significant impacts on human health through potential increases in the incidence of parasitic and infectious diseases (including a possible increase of vector diseases such as malaria in the interior and dengue in the coastal zone) (Government of Suriname 2013 cited on IDB and IIC, 2016). Of note in relation to these vulnerabilities is the expected disparity in impact among certain groups in society, such as women in the country's interior and farming communities (UNDP 2009 cited on IDB and IIC, 2016). Similarly, critical social infrastructure is also highly vulnerable to the effects of climate change.

12. Recognizing the vulnerabilities faced by Suriname to natural hazards and the additional effects of climate change, the United Nations Development Programme (UNDP) will develop a National Adaptation Plan (NAP) in 2017 based on UNDP's Suriname National Climate Change Policy Strategy and Action Plan (NCCPSAP). While this is under development, it can be confirmed that the proposals and interventions contained in this application are aligned and consistent with the NAP / NCCPSAP and also with IDB-funded climate change vulnerability assessment for Paramaribo city.

URBAN VULNERABILITY: A FOCUS ON PARAMARIBO

NATIONAL IMPORTANCE OF PARAMARIBO

13. Paramaribo is the capital city of Suriname and is located on the banks of the Suriname River along the northern coast of the country. Paramaribo and the surrounding urban areas is the main population center of Suriname, and where more than 70% of the country's population resides. Furthermore, Paramaribo is the main commercial and economic center, and also the location for the majority offices and activities of the GoS, which as reported earlier, is a key driver of the country's economy (IDB and IIC, 2016).

14. Paramaribo is the business and financial center of Suriname. Even though it does not produce significant goods itself, almost all revenues from the country's main export products (minerals, oil, agriculture and forestry) are channelled through the city, where the majority of banks, insurance corporations and other financial and commercial companies are headquartered. It is estimated that approximately 75 percent of Suriname's GDP is centered in Paramaribo (IDB and IIC, 2016).

15. Tourism is also an increasingly important sector for Paramaribo, both as a destination in its own right, and also as a gateway to the inner country areas. Paramaribo is a former Dutch colonial town dating from the 17th and 18th centuries. The Historic Inner City of Paramaribo is a UNESCO World Heritage Site and its certification is based on the following criteria:

- Paramaribo is an exceptional example of the gradual fusion of European architecture and construction techniques with indigenous South American materials and crafts to create a new architectural idiom; and
- Paramaribo is a unique example of the contact between the European culture of the Netherlands and the indigenous cultures and environment of South America in the years of intensive colonization of this region in the 16th and 17th centuries.

16. Paramaribo is therefore critical to the economic and development success of Suriname.

VULNERABILITY OF PARAMARIBO

17. Paramaribo sits in the lower elevation norther area of the country and is highly vulnerable to flooding and sea level rise, consistent with what has been described above. Table 2 shows the frequency with which flooding has affected Paramaribo, and this represents the principal hazard and risk facing Paramaribo.

18. A follow-up to the NCAP-1 study, the study “Promotion of Sustainable Livelihood within the Coastal Zone of Suriname, with Emphasis on Greater Paramaribo and in the Immediate Region”, known as the Netherlands Climate Assistant Programme Phase 2 (NCAP-2) (Naipal and Tas, 2016), demonstrated that a significant part of the Paramaribo area is highly vulnerable. For example, it cites that along the riverbank of the Suriname River and also in the southern part of the Paramaribo /Wanica area, the ground level is low, varying between 1.50 to 1.80m NSP, whereas the 1 in 10-year high water in the Suriname River is 1.93m at the north of Paramaribo and 2.00m near the center and south of the city.

19. Paramaribo does have some existing defences and protection measures in place, however these are not always sufficient for current levels of flooding and are insufficient when considering future implications of projected climate change (see *Figure 4*). For example, along the Suriname River from the north to the south, local protection measures in the form of earthen dams exist which aim to prevent flooding of the river at high tide. However, at locations the elevation of the top of the available structures and infrastructure is lower than the current high-water levels and as a consequence, flooding occurs (NCAP-2).

Figure 4: Examples of existing Flood Defences along the left bank of the Suriname River (Source: IDB, 2016).

20. Another key contributing factor to the flooding experienced in Paramaribo is the fact that the drainage system is undersized and poorly maintained. The current system is largely based on the original drainage design from colonial times to support the former plantation network and is therefore inappropriate for the city as itis today. Thirty-five open and closed drainage canals and channels form the current drainage system of Paramaribo. The canals can be characterized as a mixed system because in addition to rainwater, they also receive discharges of domestic waste water (partially treated by septic tanks). Interviews with local experts and government officials, and site visits as part of the IDB’s Emerging and Sustainable Cities Program, revealed that flooding within Paramaribo’s drainage system occurs due to a combination of poor maintenance of the existing canal network (including waste deposition),

lack of maintenance of outlet structures (sluices and pumping stations), unregulated development in areas intended to support drainage such as retention areas, and additional growth of the urban area meaning drainage infrastructure may be under-sized (MOGP, 2001).

21. Flooding and drainage issues in Paramaribo are therefore a noted priority for the GoS[2], as highlighted in Suriname's National Development Plan 2012-2016. The GoS has undertaken several initiatives to address climate change adaptation challenges, including the formulation of: The Climate Action Plan for the Coastal Zone of Suriname; the Integrated Coastal Zone Management Plan (ICZM), which provides several recommendations on several adaptation solutions for the North Paramaribo-Wanica coastline; National Contingency Plan; and the Second National Communication to the UNFCCC (2013). Furthermore, Suriname has participated in Phases I and II of the Netherlands Climate Assistance Program and the European Union Global Climate Change Alliance Program (2011-2015). The latter has led to the formulation of the National Climate Change Policy, Strategy and Action Plan of 2015 and the strengthening of the Meteorological Services, as well as training in climate modelling and vulnerability and risk assessments.

22. More specifically for Paramaribo, the GoS has been conducting several studies to identify appropriate adaptation measures for the city. In 2009 the GoS conducted a river protection study, which proposes the construction of a river dike to the north of Paramaribo to protect the city's historical center against flooding due to increasingly high water levels in relation to global sea-level rise. In fact, the ICZM Plan backs this proposal and further recommends the construction of dikes along the left bank of the Suriname River from Leonsberg to the Saramacca canal. Based on these recommendations and earlier studies as mentioned above, the GoS partially (incomplete due to lack of funding) built the dike and river protection (flood wall) on different parts of the Suriname River bank in 2011.

23. In addition, the Inter-American Development Bank (IDB) has developed a partnership with the GoS with respect to supporting the sustainable development of Paramaribo. This includes the application of the IDB's Emerging and Sustainable Cities (ESC) assessment methodology to Paramaribo (the ESC Study). The ESC Study is a systematic approach to assessing the current baseline situation in a city with respect to a host of key topics, sectors and sustainability indicators, and to use this information through analysis and extensive engagement with city stakeholders to develop key urban sustainability priorities for a city. Climate vulnerability and risk is a critical lens of the ESC Study through which a city's sustainability challenges and opportunities are considered. In the case of Paramaribo, the IDB has commissioned a hazard and risk analysis for the greater Paramaribo area (see *Figure 5*) with the aim of identifying areas of vulnerability and highest risk to natural hazards, and also proposing adaptation recommendations to build resilience (ESC Risk Study). This is on-going work and will be completed by February 2016; however key findings to date have been integrated into this project proposal.

[2] While administratively Paramaribo forms its own district in Suriname, it does not have its own municipal or city government. The GoS maintains governance and management over the city.

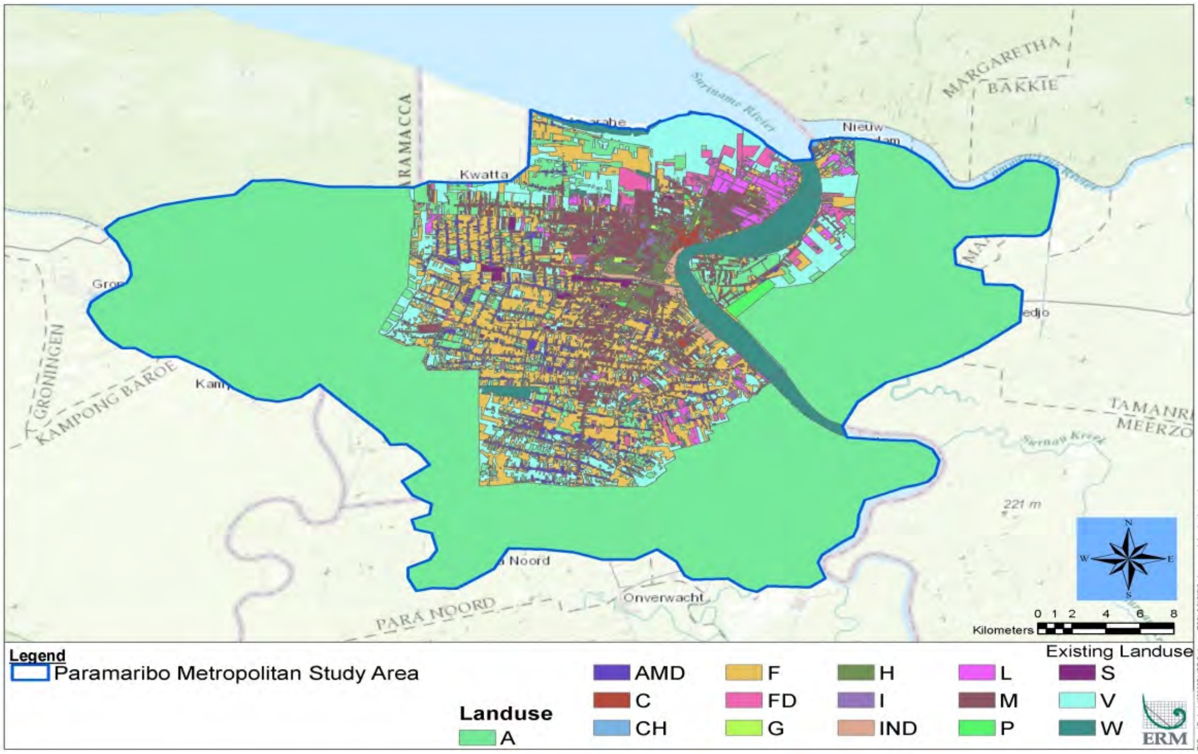

Figure 5: Paramaribo Metropolitan Study Area for the IDB's ESCI (Source: IDB, 2016).

24. In addition, the IDB is also funding a loan for the Revitalization of the Historic Centre of Paramaribo (IDB Urban Rehabilitation Program), which has been conceived to tackle the most urgent problems affecting the historical downtown and promote a sustainable urban revitalization process. This area embraces Paramaribo's UNESCO world heritage site (see *Figure 6*). The IDB also commissioned focused hazard and risk studies in this area (Downtown Risk Study).

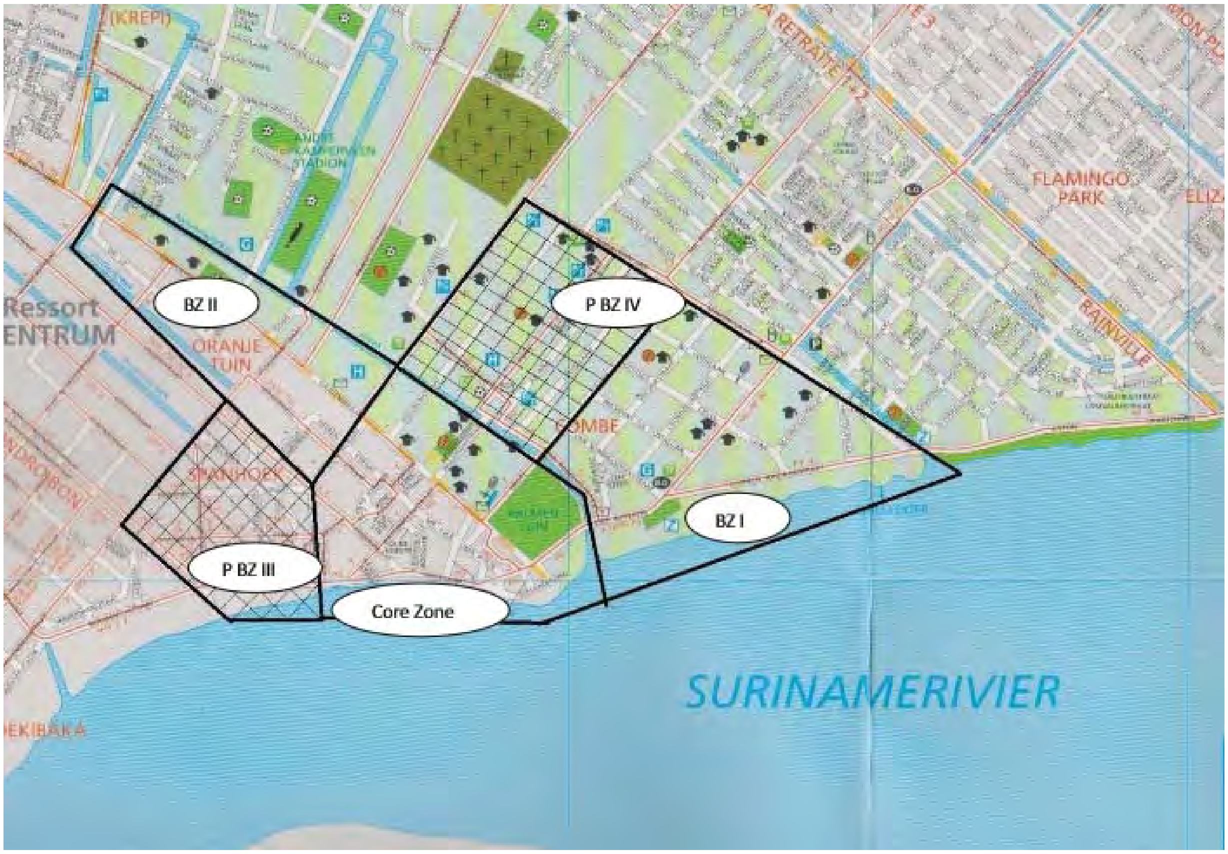

Figure 6: Program Area (Core Zone of Paramaribo World Heritage Site)

25. The ESC and Risk studies included a focus on flooding (which was prioritized as a hazard through engagement with the city stakeholders) and used the climate change projections presented in *Table 1*. The studies modelled inland and coastal flooding hazards both for the current situation and also for the future (out to the year 2050) when considering climate change projections for a series of different return periods. These results were then used to generate hazard maps for the city, such as the one shown in *Figure 7* which presents the 1 in 100-year costal hazard map for the Paramaribo Study Area with climate change projections integrated for 2050.

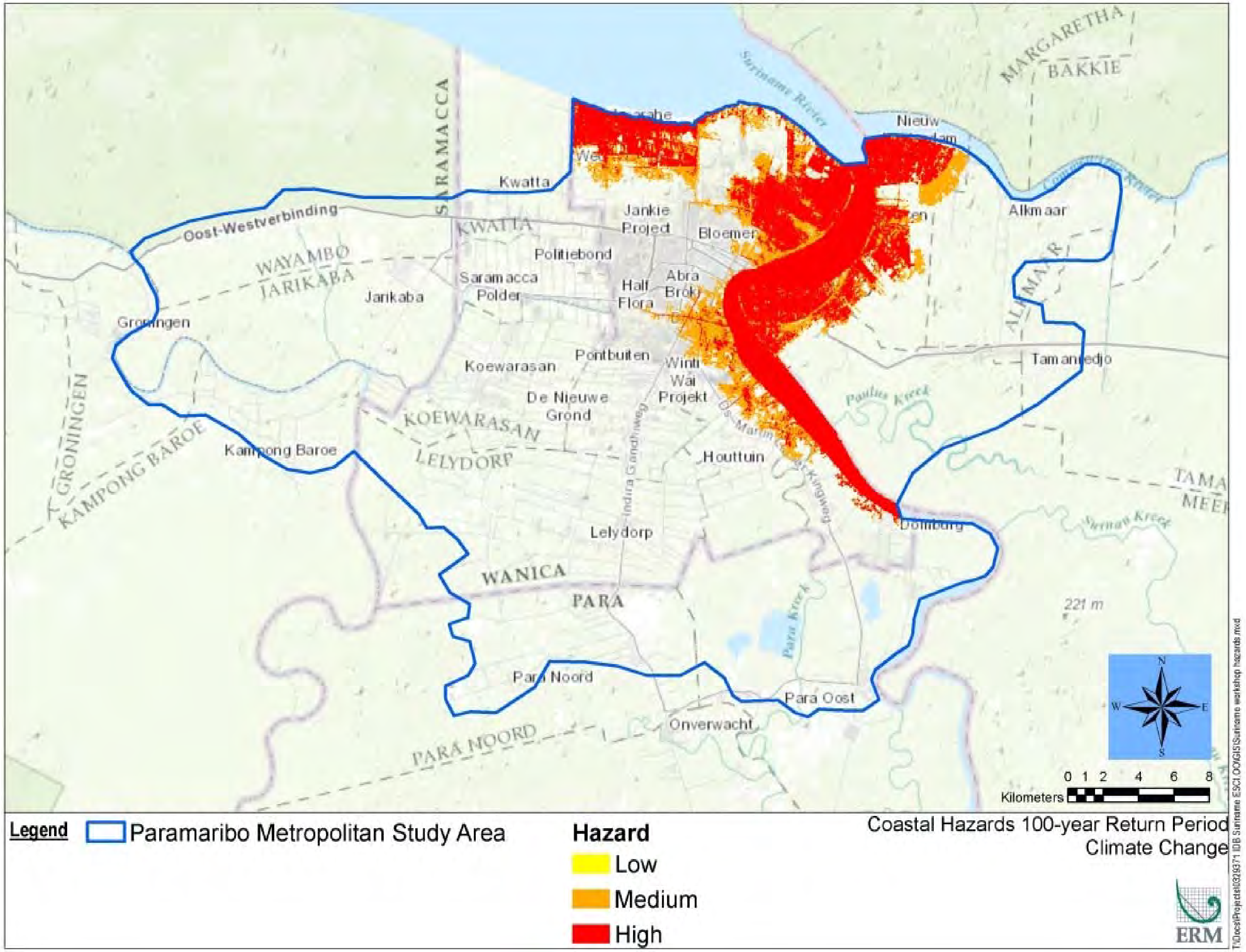

Figure 7: 100-year coastal hazard map for Paramaribo with climate change projections for 2050 horizon (Source: IDB 2016)

26. As can be seen in *Figure 7*, the modelling shows areas of high vulnerability for Paramaribo along the Suriname River and for the emerging urban areas along the northern coast. Risk maps have also been generated by linking the coastal and inland flooding hazard findings to population areas and economic land-value. For example, *Figures 8* and *9* show the economic and population-based risk maps created for the ESC Study area, which is the larger Paramaribo Metropolitan area. These risk maps serve as basis to identify areas of Paramaribo where climate adaptation measures are needed to increase climate resilience into the future.

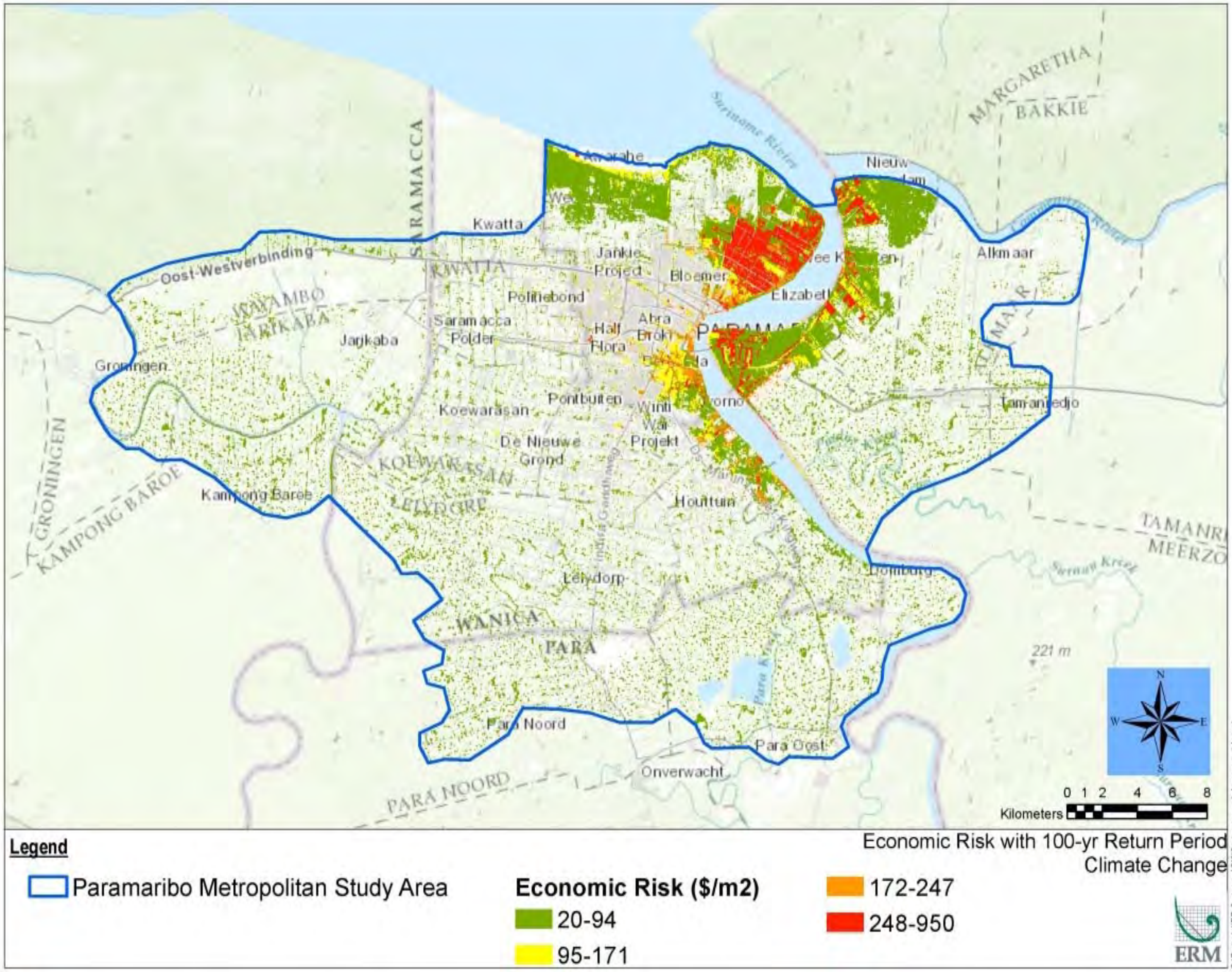

Figure 8: Paramaribo Metropolitan Economic-based risk map with Climate Change for 100-year return period (Source: IDB, 2016)[3]

[3] Economic-based risk refers to the level of potential asset loss due to hazards and vulnerability. The color codes refer to the economic risk of the area, where high (red) and low (green) damage costs are identified as results of natural events including climate change for a return period of 100 years.

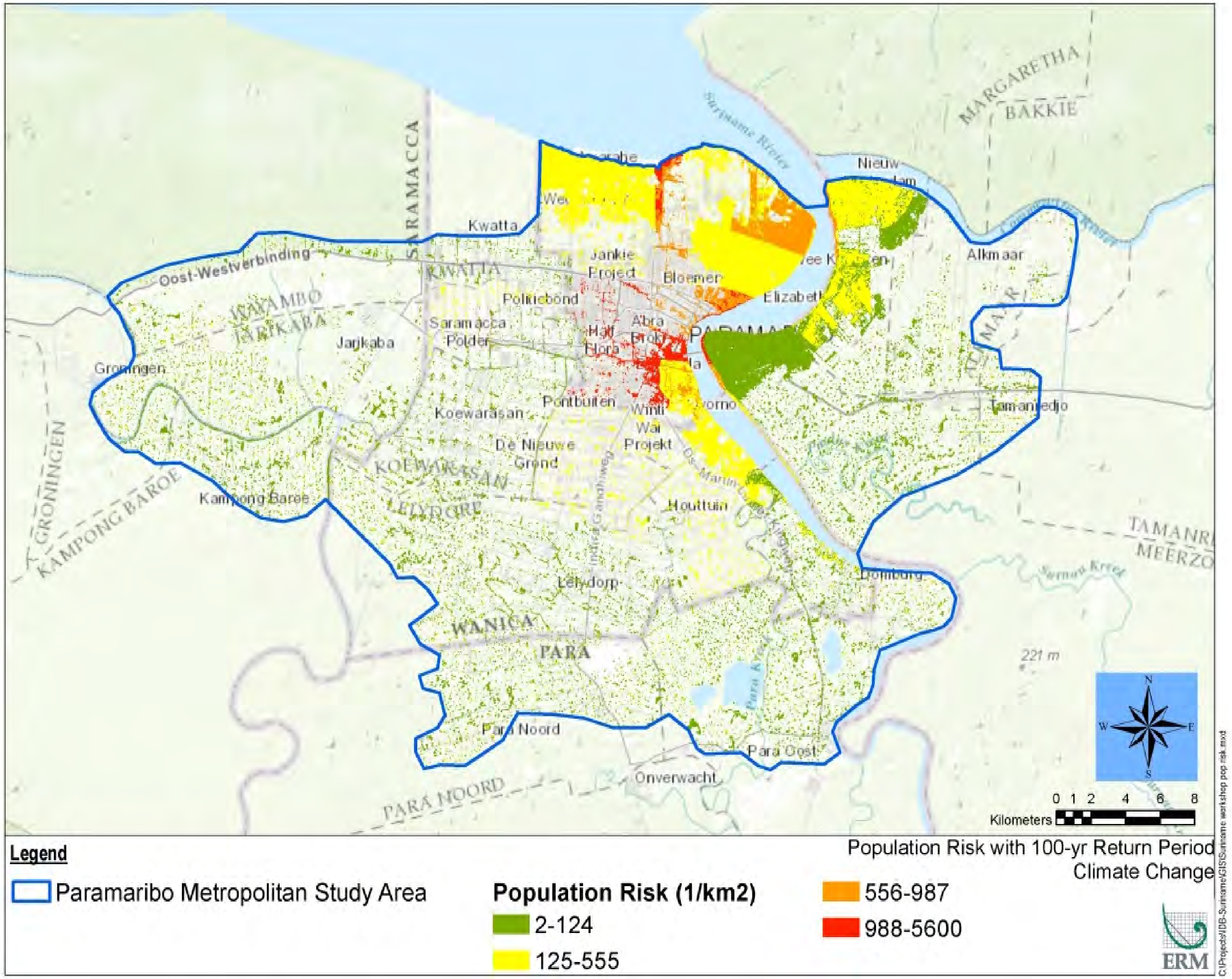

Figure 9: Paramaribo Metropolitan Population-based risk map with Climate Change for 100-year return period (Source: IDB, 2016)

27. Based on the information presented in *Figures 7* to *9*, Paramaribo and its broader metropolitan area has six priority areas which have higher vulnerability and risks to flooding and sea level rise including:

- Along the east bank of the Suriname River at (i) New Amsterdam and (ii) Meerzorg;
- Along the west bank of the Suriname River at (iii) Noord and (iv) Downtown (the Historic Center of Paramaribo);
- Along the northern coast following the (v) canal that serves Munder; and
- West of the Downtown area (vi) adjacent to Tammenga.

28. Stakeholder discussions and workshops with GoS agencies and also non-governmental agencies have also been undertaken as part of the risk studies to understand current capacity, management plans and resources for managing and responding to natural hazards and disasters. This analysis also overlaps with the ESC Study city indicator process. While this process is ongoing, some current insights and conclusions include:

- The GoS does not have existing risk maps for natural hazards;
- The GoS has an emergency contingency plan, however this does not appear to be widely disseminated and is also limited in its extent due to budget and resource constraints;
- There is only a basic infrastructure in place for an early warning system; and
- Disaster risk management has not currently been carried through to any broader city development planning;

29. The above studies were performed at the metropolitan level. These economic and population based-risk maps reinforce the urgent need for the implementation of a group of adaptation measures that go from the development of capacity building activities at different government levels and local communities, to the deployment of key infrastructure to protect the coast along the waterfront of this area.

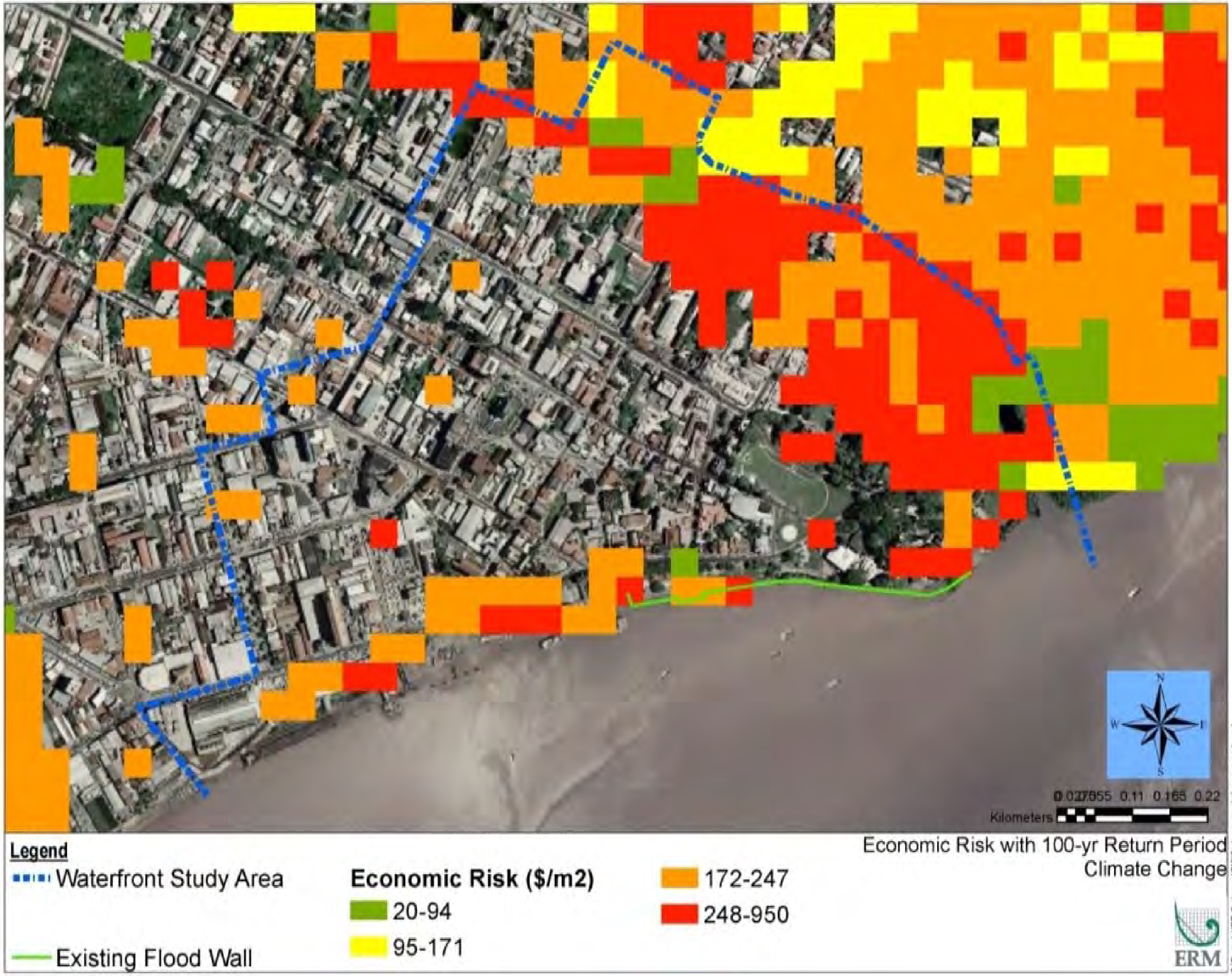

Figure 10: Waterfront Economic-based risk map with Climate Change for 100-year return period (Source: IDB, 2016)

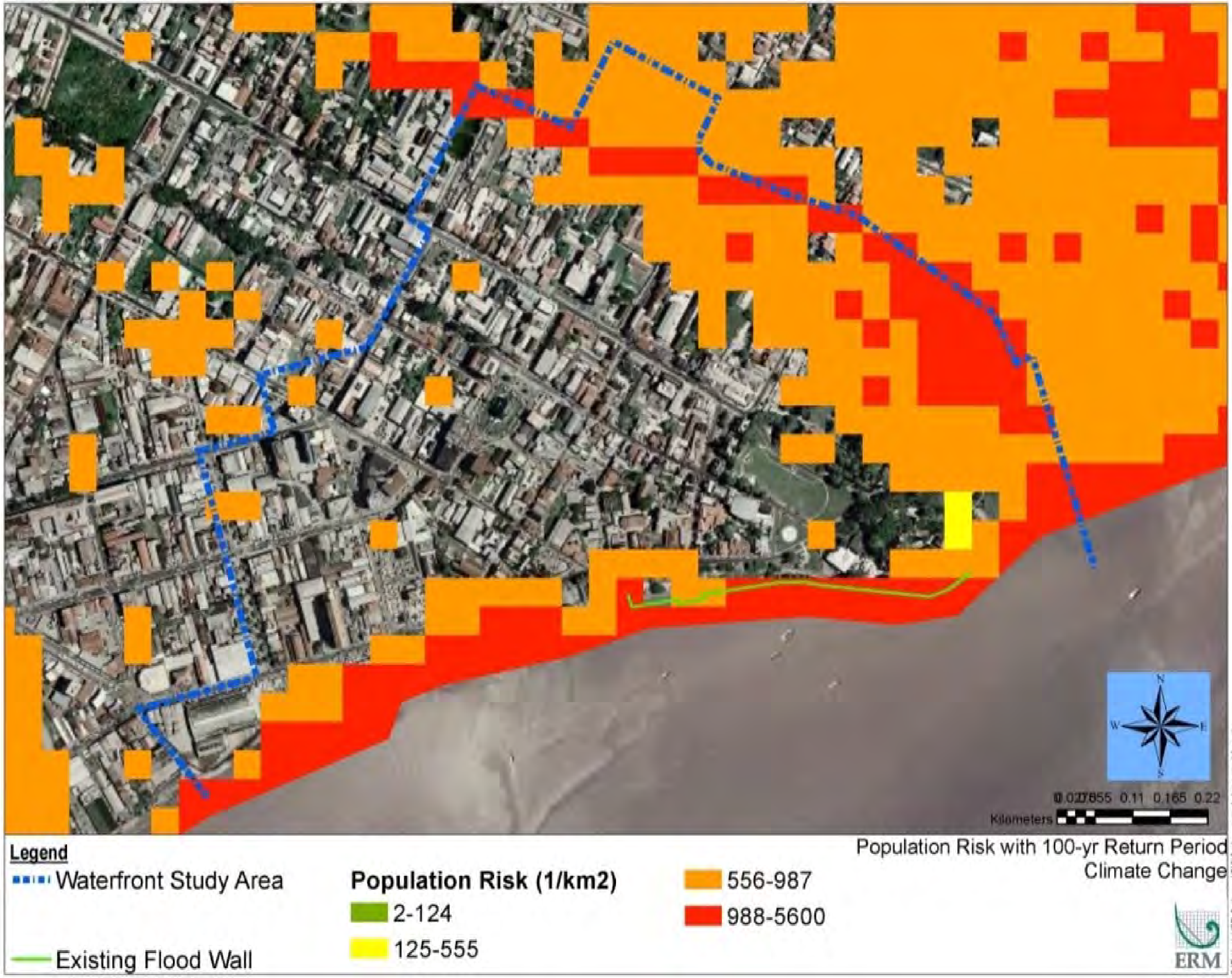

Figure 11: Waterfront Population-based risk map with Climate Change for 100-year return period (Source: IDB, 2016)

30. In summary, Paramaribo is highly vulnerable to climate change and natural hazards (floods) and given the prominent and integral role Paramaribo plays at the national level, Paramaribo's vulnerability has national consequences in terms of economic and social impacts. The challenges Paramaribo faces include:

- Vulnerability (both in terms of population and economic exposure) to flood hazards which will be further compounded by projected sea level rise;
- This vulnerability is largely in areas of the city that are important population centers and economic hubs; in order to put in place a sustainable growth plan for the city, it is necessary to better know the river and how it would interact under new hydrological conditions posed by a changing climate- that is, additional knowledge of gradual changes to local hydrology need to be monitored, filed and analyzed.
- There are several challenges that threaten Paramaribo's capacity to effectively cope with observed and anticipated effects of climate change on the frequency and magnitude of floods and sea level rise, namely limited resources; limited institutional capacity; the low-income status of much of the population limits their own ability to build resilience; and absence of a coordinated understanding and resulting action plan to build adaptive capacity.

31. The adaptation and resilience requirements identified through existing GoS and IDB studies suggests that over $60 million of investment is needed to support a city-wide fully implemented adaptation strategy. It is recognized that this level of capital expenditure is not feasible given the current economic situation in Suriname. This Proposed Project therefore seeks to incrementally respond to Paramaribo's challenges and complement current efforts lead by the GoS to protect the city by initiating a first phase of adaptation measures to demonstrate the benefits to be accrued through adapting to climate change and create an enabling environment to facilitate a long term participative and dynamic adaptation process. The Proposed Project takes advantage of the existing studies and analysis performed by the IDB and GoS to date to implement a focused adaptation solution (specific to the Downtown area), as well as create an overarching city framework to build capacity and structure in support of further adaptation and resilience building.

Proposed Project Objectives:

PROGRAMME OBJECTIVE

32. The general objective of the Proposed Project is to contribute towards increasing the adaptive capacity of communities living in the Paramaribo city and adjacent metropolitan vulnerable areas to cope with observed and anticipated impacts of climate change on floods and sea level rise. The specific objectives of this proposed Project are to generate:
    i. ***City Adaptation Framework and Plan***: Establish a framework for managing knowledge and disseminating lessons learned that could be used in future resilience programs for the city of Paramaribo and that could be part of a city-level Adaptation Plan;
    ii. ***Downtown Adaptation Measures***: Implement a group of strategic and cost-effective adaptation hard measures in the historic downtown area of Paramaribo that illustrate the benefits of building climate resilience as part of a long-term planning strategy for the city and its metropolitan area;

iii. ***Capacity Building***: Build capacity across local communities and GoS stakeholders responsible for decision making in Paramaribo to ensure strong implementation and enforcement of the Adaptation Plan; and
iv. ***Monitoring and Evaluation***: Ensure there is a robust plan and implementation structure to allow the Proposed Project to be implemented, monitored, evaluated and lessons learned disseminated.

The above components represent the 'Project' or 'proposed Project' as presented through this application.

PROPOSED PROJECT STRATEGY

33. To deliver on the identified objectives, the GoS and IDB are proposing under this Proposed Project four main components (noting the components are not necessarily sequential), as described below.

(i) City Adaptation Framework and Plan

34. This component is seen as an enabling step to ensure that decision makers and stakeholders have a robust framework to en sure investments on climate resilience are implemented in a structured manner and promote long-term adaptation in the city. The absence of such a plan will mean an on-going piece-meal approach to resilience planning, which will not be of benefit to the city or its residents. This framework and plan will be aligned to the National Adaptation Plan being prepared by the UNDP.

35. The studies carried out by the GoS and IDB for the city of Paramaribo to date, including recent ESC and Historic Downtown Study, provide solid foundations for a city-broad Adaptation Plan. Therefore, the focus of this component will be to build consensus and agreement on the objectives, priorities, actions and responsibilities that need to be built into the Paramaribo Adaptation Framework and Plan. Key steps will include:

- Workshops with local communities and other Paramaribo stakeholders including government officials to outline and discuss the requirements of the Adaptation Plan for the city and its metropolitan area;
- Broader community engagement activities to build awareness and understanding of the Plan and to ask for feedback and additional input to feel in existing information gaps;
- Establish a coordination and cooperation framework for the Plan to define main actors and ensure responsibilities for its implementation and tracking of performance are fully understood and established;
- Build key priorities, focus areas and definition of goals for the Plan; and
- Ensure alignment of the plan with existing planning documents and other relevant information and pre-agreed actions with local communities and city developers.
- Design, organize and deliver workshops on the Adaptation Plan for the general public, focusing on gender-equality and local vulnerable communities within the metropolitan area.

(ii) Downtown Adaptation Measures

36. The work of IDB and the GoS undertaken in 2016 identified the key areas in Paramaribo where hard adaptation measures are needed. One of the identified priority areas is the Historic Downtown Area (HDA), which is vulnerable to floods and which will be further exacerbated by

climate change anticipated impacts. This area is also the focus of GoS and IDB investments to try and reinvigorate the area both to protect its historic character and to act to stimulate economic growth through increased vibrancy and use of the area.

37. In the IDB and GoS' Concept Note application to the Adaptation Fund, a series of potential adaptation measures were presented comprising physical measures; complementary green infrastructure measures; drainage maintenance and upgrades; and management and maintenance measures. In addition, results were presented of preliminary risk studies financed by IDB assessing the vulnerability of the downtown area. The IDB and GoS have subsequently worked on a series of detailed studies for the Downtown area to assess a range of adaptation measures and through environmental, social, economic and technical analyses, have identified a specific set of adaptation measures that form the basis of this Full Application. Part II has been updated to present this additional work and analysis.

(iii) CAPACITY BUILDING AND KNOWLEDGE MANAGEMENT:

38. Based upon the final structure of the Paramaribo Adaptation Plan, the requirements within the GoS and other key stakeholders for capacity building will also need to be identified and actioned. It is expected that this will fall into the following two areas:

- Training and capacity building for the key individuals and departments tasked with specific actions and responsibilities within the Adaptation Plan – under this programme, it is expected that initial training needs will be delivered, and a broader training plan will be provided to the GoS for ongoing delivery; and
- Institutional strengthening needs will be identified and shared with the GoS with respect to ensuring climate change and adaptation is mainstreamed into relevant policies, development planning and regulations – under this programme, the institutional strengthening will be identified and then the implementation will be a separate responsibility of the GoS;

Main activities include:

1. Prepare, organize and deliver capacity building and technical training workshops on the Paramaribo Adaptation Plan for different government bureaus, including the Ministry of Public Works and the National Environmental Coordination Unit.

2. Formulate a long-term training plan, along with key training materials, to facilitate continuous capacity building for technical staff of the GoS on the Adaptation Plan.

3. Conduct an institutional evaluation to enhance the GoS capacity to mainstream climate change and adaptation practices into relevant policies and regulations.

39. In addition, a Knowledge Management Plan will also be developed in order to ensure that:

- Information, data and lessons learned are captured;
- This information is appropriately managed and stored so that it is readily accessible and understandable;
- This information is shared among stakeholders and appropriate training sessions are delivered; and

- A review and evaluation step are included to ensure this data management process is working effectively and also evolving as the data and information sets develop.

(iv) Monitoring and Evaluation

40. Monitoring and evaluation is critical to the successful implementation of a project. A monitoring and evaluation plan will be developed as per the following:

- ***Monitoring*** - The purpose of monitoring activities will be to follow up as the Proposed Project progresses to ensure that it is meeting the original expectations and achieving the expected results. A Results Matrix (RM) will be developed which will enable the identification of issues and problems during execution that can be corrected in due time. The monitoring program will be based on the RM, and on the associated project plans.
- ***Indicators*** - Monitoring activities will be guided by a series of selected Key Performance Indicators (KPIs) that will be defined in the RM. Each defined indicator will include a unit of measure, frequency of measurement and a means of verification.
- ***Progress Reporting*** – The required frequency of periodic monitoring reports will be defined.
- ***Coordination and Monitoring*** - The requirements for relevant administration and management requirements for the Proposed Project's monitoring activities, which will include: (i) to develop, maintain and update the data regarding monitoring indicators; (ii) coordinate the collection and processing of information on project actions and prepare progress reports; (iii) identify problems, delays and external factors affecting the project and proposing, where appropriate, remedial measures; and (iv) support monitoring meetings and program evaluation.
- ***Monitoring Plan*** – The frequency of monitoring will be defined.
- ***Evaluation*** – The evaluation of the Proposed Program will be done once the Proposed Program has been completed in order to determine if its objectives have been achieved based on a specified and agreed criteria.

Project / Programme Components and Financing:

Fill in the table presenting the relationships among project components, activities, expected concrete outputs, and the corresponding budgets. If necessary, please refer to the attached instructions for a detailed description of each term.

For the case of a programme, individual components are likely to refer to specific sub-sets of stakeholders, regions and/or sectors that can be addressed through a set of well defined interventions / projects.

The following Table 3 presents an overview of the Project's components, outcomes, main outputs and their costs.

Table 3: Proposed Project's components, outcomes, main outputs and costs.

Project Components	Expected Concrete Outputs	Expected Outcomes	Amount (US$)
(i) **City-level Adaptation Framework and Plan**: Develop a city-broad plan to build climate resilience in the city in line with a long-term adaptation process. Said plan will guide policy makers and city planners in prioritizing investments and programs to achieve climate resilience. Also design and implement a Dissemination Strategy of the Adaptation Plan for the general public.	City-wide Adaptation Plan developed and endorsed by city major and local vulnerable communities. No less than 3 dissemination workshops on the scope and purpose of the Adaptation Plan for the general public, with a focus on gender-equality and local vulnerable communities in the metropolitan area.	Strengthened awareness and ownership of adaptation and climate risk process by Paramaribo citizens including the metropolitan area. Increased public awareness on the negative effects of climate change. Public ownership of adaptation and climate risk reduction plans and processes within the metropolitan area.	$550,000
(ii) **Downtown Adaptation Measures**: Implement adaptation measures in the historic downtown area of Paramaribo that illustrate the benefits of building climate resilience as part of a long-term planning strategy for the city and its metropolitan area	Enhanced flood protection measures along the Suriname River next to the Historic Downtown area, comprising: (a) replacement of historic flood wall with the construction of a 250-meter sheet-piled wall on the south side of Waterkant Street to prevent flooding and erosion along the left bank of Suriname River; (b) Rehabilitation of the Sommelsdijck Canal pump station and sluice gates; (c) enhancement and expansion of an existing area of mangroves immediately downstream of the Sommelsdijck Canal pump station; and (d) the development of a surface water Drainage Management Plan (DMP) (see Part II for further details and	Reduced flood risk exposure of community, leisure, tourist and business areas on the waterfront adjacent to the historic downtown area. A consequential outcome is that implementation will act as the enabler for the broader regeneration program proposed by the GoS and IDB.	$7,572,000

	justification for the adaptation measures).		
(iii) **Capacity Building**: Build capacity across the GoS stakeholders responsible for decision making in Paramaribo to ensure strong implementation and enforcement of the Adaptation Plan; development and implementation of Knowledge Management Plan and carry out training to technical and managerial staff on adaptation planning and management.	Training plans and materials for key stakeholders in Paramaribo in adaptation planning and management. No less than 3 technical workshops to technical and managerial staff on the implementation of the Adaptation Plan. Special emphasis will be made to ensure a gender balance participation in the workshops. Institutional evaluation to identify specific actions to enhance the GoS capacity to mainstream climate change and adaptation into policies, regulations and development planning.	Strengthened GoS institutional capacity to reduce risks associated with climate-induced socioeconomic and environmental losses caused by flooding and sea level rise. Increased participation of women in decision making processes related to the implementation of adaptation measures in Paramaribo	$380,000
(iv) **Program Administration**: Develop a robust plan and implementation structure to allow the Proposed Project to be implemented, monitored and evaluated.	Monitoring and Evaluation plan developed	Ensuring stated outcomes are achieved and delivered. Practical knowledge about adaptation processes in cities is increased.	$580,000
(v) **Project Cycle Management Fee**: Ensuring appropriately qualified project management capabilities are applied.	On-time and on-budget delivery of the Project	Ensuring stated outcomes are achieved and delivered.	$768,000
Amount of Financing Requested			**$9,850,000**

Projected Calendar:

Indicate the dates of the following milestones for the proposed project/programme

Milestones	Expected Dates
Submission of Concept to AF	01/09/2017 (Complete)
Approval of the Concept by the AF Board (Estimate)	03/2017 (Complete)
Submission to AF of a Full Programme Proposal	08/2018

Milestones	Expected Dates
Approval of the Full Programme Proposal by the AFB (Estimate)	10/2018
Start of Project/Programme Implementation	07/2019
Mid-term Review (if planned)	07/2021
Project/Programme Closing	07/2023
Terminal Evaluation	07/2023

PART II: PROJECT / PROGRAMME JUSTIFICATION

Describe the project / programme components, particularly focusing on the concrete adaptation activities of the project, and how these activities contribute to climate resilience. For the case of a programme, show how the combination of individual projects will contribute to the overall increase in resilience.

41. The Proposed Project that forms the basis of this Full Application comprises the following main components:

- City Adaptation Framework and Plan;
- Downtown Adaptation Measures;
- Capacity Building; and
- Monitoring and Evaluation.

The predominant component (in terms of cost and scale) are the adaptation measures themselves.

City-Wide Adaptation Plan

42. The purpose of the city-wide adaptation plan is to develop a city-broad plan to build climate resilience in the city in line with a long-term adaptation process. Said plan will guide policy makers and city planners in prioritizing investments and programs to achieve climate resilience and compiling lessons learned in order to identify strategies and programs that can be applied to future resilience programs for the city of Paramaribo. The Adaptation Plan provides a continuous, iterative, standardized process to implement future city-wide adaptation measures. The plan will build on existing information and studies held by the GoS, the IDB and also other interested stakeholders such as the World Bank. It will anticipate climate impacts to, and vulnerabilities for, the city of Paramaribo, and project how climate change is expected to lead to impacts ranging from sea level rise to extreme weather events.

43. The plan will identify potential key infrastructure and other city services that could be impacted by climate change and encourage the integration of identified climate risks and vulnerabilities within relevant Governmental policies and actions.

44. The process of developing the plan will involve meaningful stakeholder engagement and interaction to both ensure collective participation, local endorsement and the opportunity to disseminate adaptation knowledge for the general public.

45. The plan will be structured to systematically consider adaptation and resilience factors including the following:

- Define the city's vulnerabilities and risks and the associated framework for adaptation;
- Define relevant factors in considering adaptation including latest knowledge/research on climate change; short-, medium- and long-term risk management considering uncertainty; and consideration of local and regional characteristics;
- Define and comment on existing measures and actions related to climate change and extreme weather events;
- Define the necessary ongoing monitoring of climate change and its impacts;
- Project future climate change and its impacts
- Assess impacts, vulnerability, resilience, and risk and determine the need for adaptation measures;
- Scope and prioritise the agreed adaptation measures;
- Ensure that climate change adaptation is wholly integrated with disaster risk reduction;
- Define the roles and expectation of the GoS, stakeholders and other relevant actors;
- Define a Climate Leadership Team for the city;
- Ensure full engagement and consultation with vulnerable groups;
- Define linkages to sectoral policies and regulations, such as building codes and planning zones, to reflect climate change risks;
- Develop relevant performance indicators for climate change adaptation;
- Identify, prioritise and cost proposed adaptations and the associated interlinkages.
- Define steps to track and assess progress and effects of adaptation actions and measures;
- Communication approach including sharing with the public;
- Process for review, adapting to change and responses to feedback.

46. A Dissemination Strategy of the Adaptation Plan and knowledge generated by its development will be designed and implemented. No less than three dissemination workshops will be undertaken on the scope and purpose of the Adaptation Plan for the general public, with a focus on gender-equality and local vulnerable communities in the metropolitan area. Objectives of the Dissemination Strategy include:

- Increased public awareness on the negative effects of climate change;
- Public ownership of adaptation and climate risk reduction plans and processes within the metropolitan area;

- Increased participation of women in decision making processes related to the implementation of adaptation measures in Paramaribo; and
- Improved policies and regulations that promote and enforce resilient measures.

Assessing the Flooding Hazard and Risk in the Downtown Area

47. Since the submission of the original Concept Note application, the IDB and GoS have worked on a series of environmental, social, economic and technical studies to identify specific adaptation measures for the downtown area. The details of these studies and the findings are summarised in the following paragraphs and relevant supporting information is cross-referenced.

48. Building off the city-level analysis that the IDB prepared as part of the ESC work (as presented in the original Concept Note), the IDB and GoS supported a detailed site-specific risk analysis related to flooding in the historic center of Paramaribo. Physical hazards due to flooding from extreme climate events were calculated and these were then used to estimate vulnerability based on asset, population density, and land use information. Maximum water levels and precipitation for 10-, 25-, 50-, and 100-year return periods were used to inform this analysis, as well as future climate change projections. The physical hazards from flooding were evaluated using high resolution numerical modelling of the study area and estimating risk using analytical approaches along with a geospatial data analysis (GIS) system. In addition to the base line flood assessment, a flood modelling study was conducted by applying infrastructure improvement alternatives to evaluate the effectiveness adaptation alternatives. This work is summarised below, and the full **Site-Specific Risk Analysis report (dated July 2018) is contained in Annex A**.

49. The analysis was performed using HEC-RAS and FLO-2D models, which are approved by the U.S. Federal Emergency Management Agency for delineating flood hazards, regulating floodplain zoning and designing flood mitigation in riverine as well as urban systems. These models were used to estimate the likely occurrence of flooding hazards within the Study Area for 10-, 25-, 50-, and 100- year return periods using site-specific data collected from various Surinamese institutions, published reports and site visits. A probabilistic inland flood hazard analysis was performed using historic precipitation data to obtain Intensity Duration Frequency (IDF) distribution during wet season using a nearest neighbour weather generator tool. Similarly, probabilistic coastal flood hazard analysis was performed using Highest Water Levels (HWLs) obtained for various return periods in the Suriname River near the Study Area. Similar inland and coastal flooding analysis was also conducted for future years (2020, 2050 and 2080) using climate change projections for precipitation (derived new IDFs for climate change years) and sea level rise obtained from Regional Climate Models driven by HadAM3 and ECHAM4. A series of both inland and coastal flooding hazard maps of the Study Area and the Canal were created for the subsequent socio-economic risk analyses that resulted in the development of economic and population risk maps that quantified damages in terms of financial loss and population affected in the Study Area.

50. Analysis of flood modelling results show that in the Study Area, most of the flooding occurs due to HWLs in the Suriname River caused by storm surges occurring at spring high tide conditions. The baseline simulations clearly show that flooding in the Study Area begins at the low ground elevation level of the Waterkant Street and Paramaribo Central Market, spreads inland and then expands east and west of the Water Taxi area towards the existing flood wall (see Figures 12-15 below). The ground elevation near the Fort Zeelandia and the

Van Sommeldijckse Canal area well above the 100-yr baseline HHWL resulting in no flooding. Inland flooding in the Study Area is caused by precipitation and water logging shows up in various regions, spread out sporadically with more inundation occurring along the Van Sommeldijckse Canal (see Figures 16-18 below). The inland flooding happens due to overflow from the drainage system at the Canal and various manholes in the street and non-operating condition of sluice gates and pumps at Knuffelsgracht Street and near Central Market.

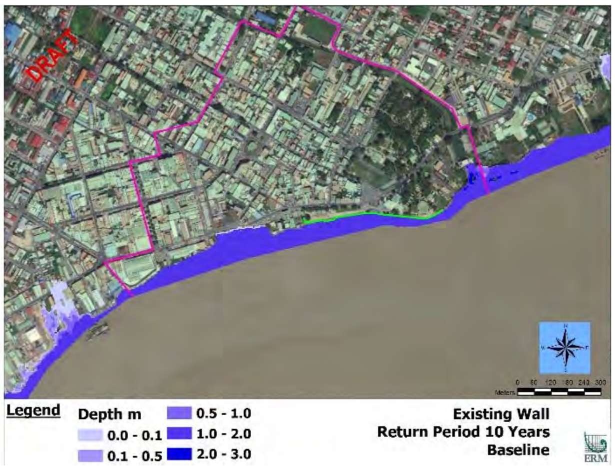

Figure 12: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 10-year return period

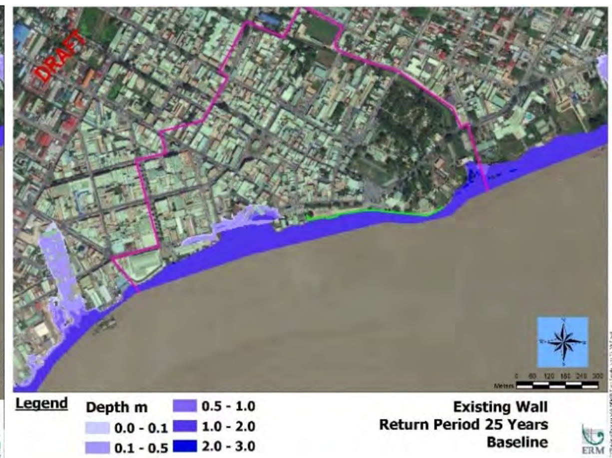

Figure 13: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 25-year return period

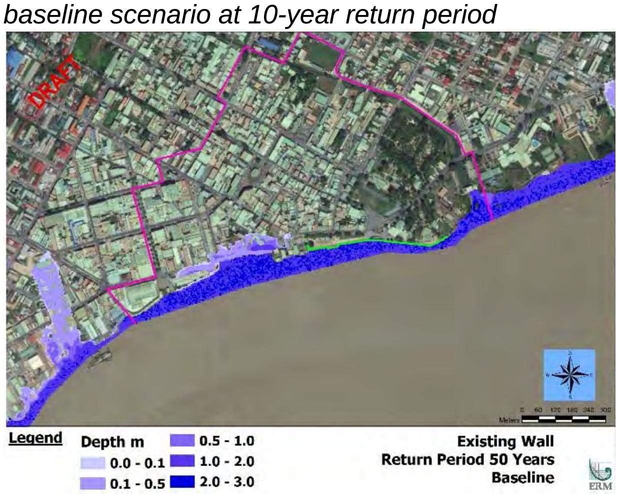

Figure 14: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 50-year return period

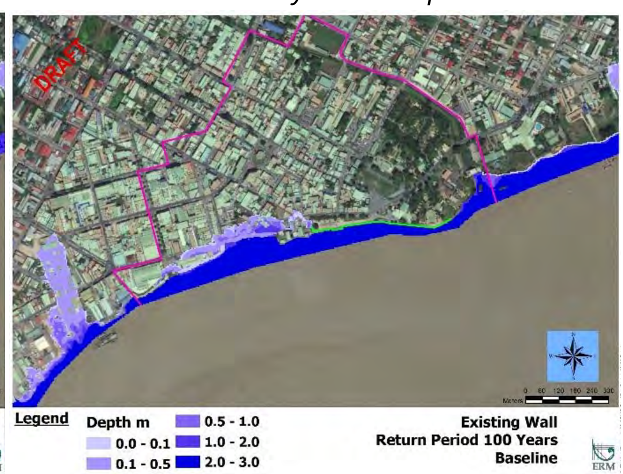

Figure 15: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 100-year return period

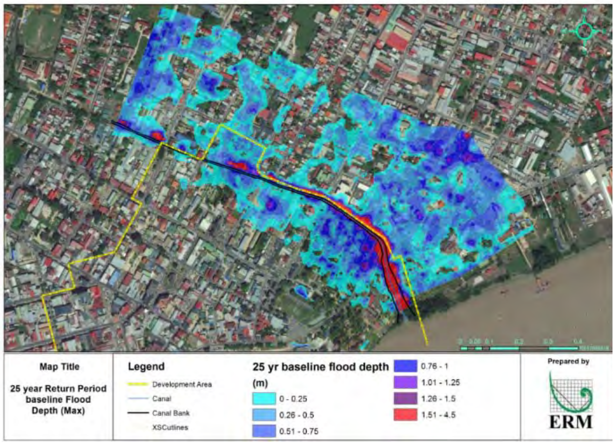

Figure 16: Inland flooding map, including canal water overflow for the baseline scenario at 25-year return period

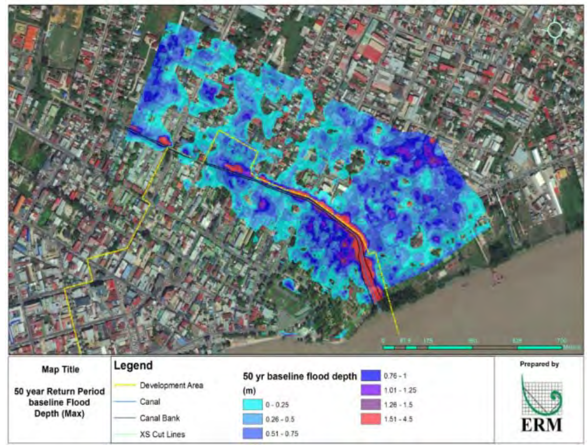

Figure 17: Inland flooding map, including canal water overflow for the baseline scenario at 50-year return period

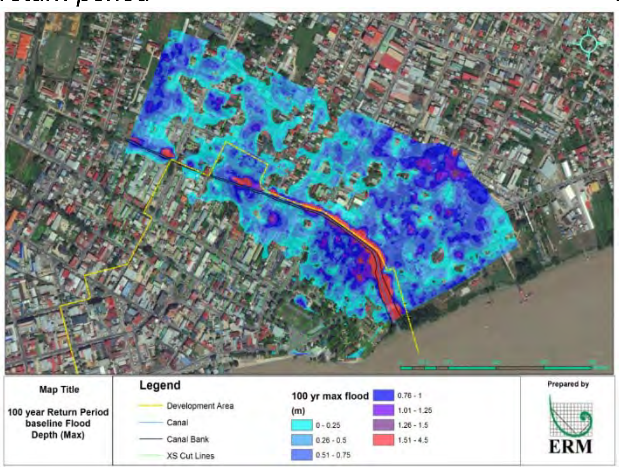

Figure 18: Inland flooding map, including canal water overflow for the baseline scenario at 100-year return period

51. With climate change, coastal flooding occurs more frequently causing more damage and disruption due to sea level rise. As sea level rises, coastal flooding events shift from being minor to more extensive, resulting in more damages. Sea level rise occurrence is a slow, multi-decadal process that alone results in gradual coastal erosion, subsidence and saline intrusion. However, using extreme value theory to combine sea-level projections with wave, tide and storm surge, the intensity and frequency of coastal flooding increases to a catastrophic level (due to gradual destabilization of the coastal region by sea level rise being impacted by extreme flood waves). Even regions with limited water-level variability will be subjected to unusual flood events. This can be clearly seen in the hazard maps of the Study Area developed for climate change scenarios at various return periods (Figures 19-25 below).

52. Areas inundated with 0.0 m to 0.5 m of water correspond to low hazard; areas inundated with 0.5 m to 1.0 m of water correspond to medium hazard and areas inundated with greater than 1.0 m of water tend to correspond to high hazard levels. The general flooding coastal flooding pattern remains the same near the Water Taxi area for future years due to climate change. However, the flooding spreads to a larger region on the east and west of the Water Taxi area resulting in more inundation along the rear of the existing flood wall. In addition, more flooding

happens in the Fort Zealandia area and on either side of the Van Sommeldijckse Canal for future years due to climate change. This happens because of the limited storage and drainage capacity of the Canal, and small-sloped flood plain regions on either side of it. There is not much change in the inland flooding for future years because of small percent increase in precipitation due to climate change.

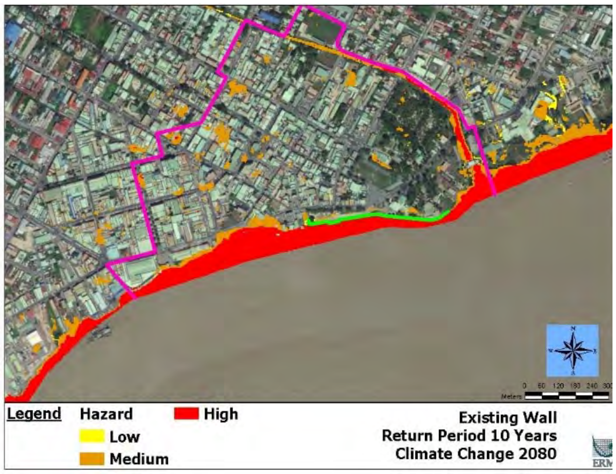

Figure 19: Coastal and inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-year return period

Figure 20: Coastal and inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 25-year return period

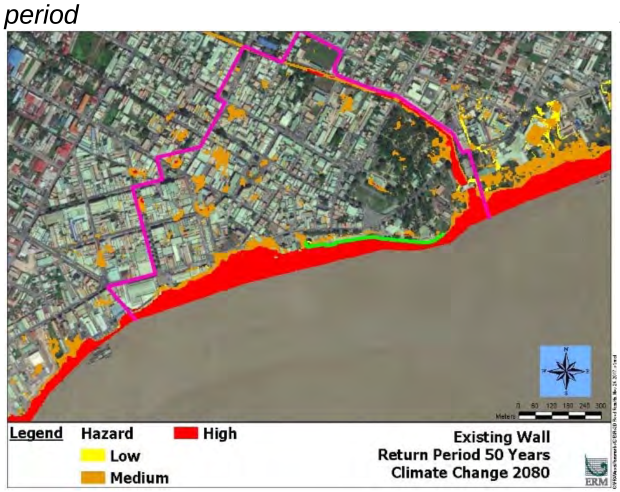

Figure 21: Coastal and inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 50-year return period

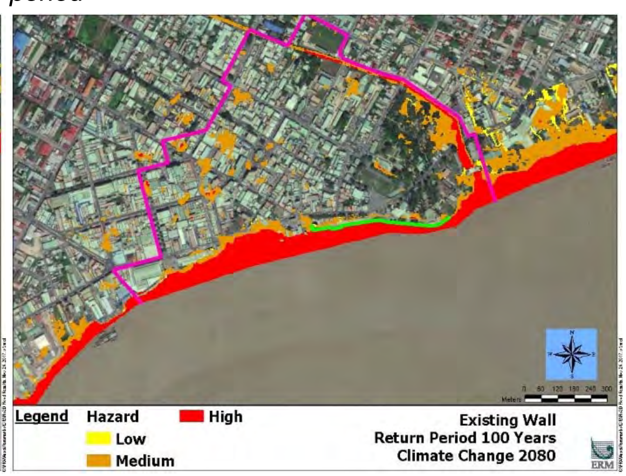

Figure 22: Coastal and inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 100-year return period

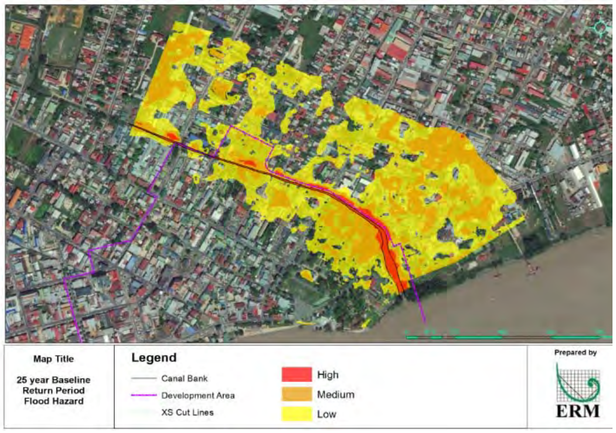

Figure 23: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 25-year return period

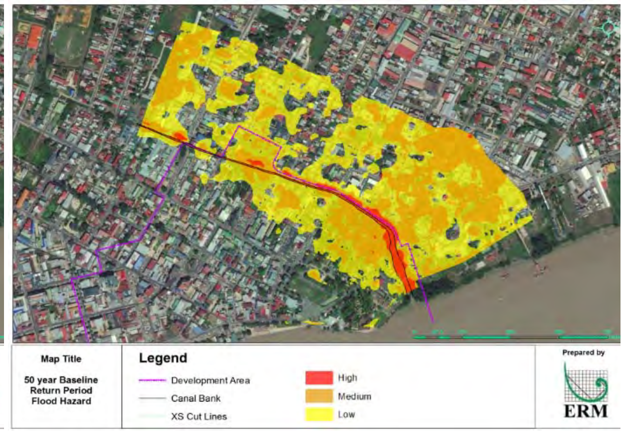

Figure 24: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 50-year return period

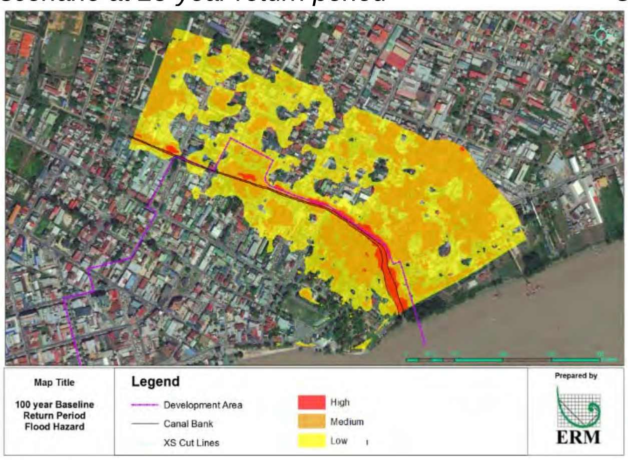

Figure 25: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 100-year return period

53. Based on this analysis, it can be concluded that two important topographical features of the riverbank control the coastal flooding dynamics in the Study Area:

i. the inland elevation; and
ii. the inland slope.

The first one restricts the onset of flooding and the second one restricts the spread of flooding. For inland flood dynamics, slope initiates the flooding (run off) and low infiltration and inefficient natural and constructed storm water drainage system spreads the flooding resulting in human and property risks. The study results show most of the flooding in the Study Area is caused by the combined influence of storm surge, tides and sea level rise, using extreme value theory. In addition, the impact from an increase in sea level rise, overlaid even on a typical storm surge is much larger than the corresponding increase in extreme precipitation resulting in less inland flooding as compared to coastal flooding.

Identification of Potential Adaptation Measures (Alternatives Analysis)

54. With the cause and extent of flooding better defined, a series of potential adaptation measures were identified and assessed. This work is summarised below, and the full **Alternatives Selection report (dated February 2018) is contained in Annex B**. Proposed adaptation measures were selected based on a systematic evaluation of alternatives undertaken in two stages.

55. The first stage consisted of identifying a broader universe of technical solutions within the framework of floodwall, green infrastructure , and drainage system improvements that may function separately or as integrated solutions. Table 4 presents a wide range of potential technologies/alternatives that were initially identified using a variety of sources, including previous experience, local knowledge, and team brainstorming/consultation. Local past experiences on similar projects was considered in determining what might work/ not work and was incorporated in the Table 4 below. These technologies were then evaluated based on site-specific conditions, implementability, cost, and effectiveness. Technologies that were deemed inappropriate based on comparison with these criteria were eliminated from further consideration. Rather than involving the universe of alternatives, the purpose of this initial screening of technologies was to streamline the process and to limit the number of alternatives that underwent more detailed evaluation.

Table 4: Initial Technology/Alternative Screening

Technology/ Alternatives	Process	Retained	Eliminated	Remarks
Regulation and Policies	Government Policy, Zoning and Land Use Options	X		Can be used for future development
Business Relocation	Relocate business/market along the shoreline and design the vacated area for recreational use		X	Livelihood and social impact, public resistance, costly
New Flood Protection Wall	Flood protection wall (sheet piles with brick or concrete cap)	X		Effective, supported by flood model
New Tidal Basin with Flow Controls	Create new tidal basins with flow controls (tidal gates, pumps)		X	Limited space within city center for new infrastructure, costly
Rehabilitate existing old retaining wall	Retrofit existing old retaining wall (sheet piles)	X		Effective, supported by flood model
Rehabilitation - Existing Flood Control Mechanicals	Rehabilitate/retrofit existing tidal gates, sluice gates, and other flood controls	X		Effective, supported by flood model
Rehabilitation - Drainage System	Rehabilitate/retrofit existing stormwater infrastructure (improve efficiency of the existing network)	X		Effective, current status -poorly maintained

Technology/ Alternatives	Process	Retained	Eliminated	Remarks
Shoreline Erosion Protection/ Stabilization	a) Riprap/gabions/articulated concrete blocks along shoreline	X		Effective for erosion protection
	b) Timber groins to promote sediment accumulation and vegetative growth in select areas		X	Space constraints consider using in combination with mangrove establishment
	c) Create buffer with enhanced mangrove	X		Proven technology in study area
Dredging	Dredging to increase capacity of Suriname River		X	Likely little impact on flood elevation and velocity, costly
Stormwater Retention and Release	a) Install underground stormwater retention system (retention vaults, pipes) and release water at lower rate	X		Secondary benefit to flood mitigation, including source of water for fire protection
	b) Construct aboveground stormwater retention and release system (swale, ponds) in open spaces	X		
	Pervious pavement: Use alternative to impervious materials (permeable pavements, vegetation,)	X		Consider implementing in select areas of city center to reduce runoff
Rainwater Harvesting/Reuse	Retrofit building with storage tanks and reuse water for toilets, etc.,		X	Difficult to implement on a large enough scale to have an impact
New Wastewater Treatment Plant	Separate storm and sewer and install WWTP for sewer		X	Although beneficial, limited impact on flood protection, costly

56. The technology screening descr ibed above re sulted in selecting 14 t argeted site-specific alternatives that represent viable op tions while preserving the concept to mitigate climate change issues considering both inland and coastal flooding. These 14 targeted site-specific alternatives are summarized in Table 5 and shown on Figure 26. A stakeholder engagement was conducted on 8 November 2017 in Paramaribo to present the project and solicit feedback on these identified alt ernatives. The meeting included presentation of the identified alternatives as well as a descriptionof the criteria used to evaluate the alternatives and identify those that are preferred.

Table 5: Site-Specific Alternative Description

Technology/ Alternatives	Site-Specific Alternatives	Description
Regulations and Policies	Alternative 1: Government policy, zoning, and land use options	Incorporates government interventions via poilicies, zoning, and land use limitation with a goal of allowing more open space and green in the city center, enforce built-up area restrictions, enhance water management, update master plan, and implement environmental policies (waste collection).

Technology/ Alternatives	**Site-Specific Alternatives**	**Description**
New Flood Protection Wall	Alternative 2: New flood protection wall from Knuffelsgracht Street to SMS Pier	Includes a new flood protection wall, approximately 250 meters (m) long, for a section from Knuffelsgracht Street to SMS Pier along south side of Waterkant Street. The flood wall consists of metal sheets pushed into the ground several feet below the ground surface. The sheet pile will be reinforced along the embankment side with riprap/stone. The sheet pile will be finished with concrete/brick cap on top with a two- to four-meter wide walkway. Roadside drainage along the wall will be impoved and trees/plants will be planted. Existing historic landing for small boats and a steel jetty that are within the limits of the proposed flood protection wall will be rehabilitated during the wall construction.
Rehabilitate Existing Old Retaining Wall	**Alternative 3**: Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal	Includes replacing part of existing steel sheet piles between Van Sommelsdijck Canal sluice gate and Fort Zeelandia; riprap stone will be added in the embankment to increase passive pressure and bearing capacity of existing piles. Other components include reprofiling clay dike, increasing steel sheet pile wall crest level, and making walkways for pedestrians.
Rehabilitation –Existing Flood Control Mechanicals	**Alternative 4**: Rehabilitate Van Sommelsdijck pumping station and sluice gates	The existing pumping station is old and only partially functioning. This alternative includes adding/refurbishing one pump capacity (4.5 m^3/s), upgrading existing mechanical and electrical system, upgrading sluice gates structures, widening the inland water storage area, and automating operation.
	Alternative 5: Rehabilitate sluice gate and pumping station at Knuffelsgracht Street	This alternative will require new pumps and new sluice gates, including new concrete structure and raising top level for high water level (HWL) protection.
	Alternative 6: Rehabilitate Jodenbree Street sluice gate near Central Market	Involves minor improvement of existing sluice gate near Central Market, adding new gates, raising top level for HWL protection.
Rehabilitate Drainage System	**Alternative 7:** Rehabilitate Van Sommelsdijck Canal	Van Sommelsdijck Canal will be rehabilitated starting from the canal pump station to a maximum of 700 meters up-gradient. The expansion includes removing sediments and debris from the existing canal, profiling/regrading the canal to gain appropriate capacity, lining the canal bottom with concrete, and installing concrete/brick retaining wall on both sides of the canal. To add functionality, walkways will be constructed on both sides of the expansion with parking facilities at certain locations. This component also includes rehabilitating drainage (culvert) at Tourtonnelaan Street crossing (upgradient end of the canal rehabilitation section).

Technology/ Alternatives	Site-Specific Alternatives	Description
	Alternative 8: Rehabilitate drainage system along waterfront between Knuffelsgracht and SMS Pier	Includes improving existing stormwater and sewer drainage system including pipes and inlet for approximately 300-meter segment of the Waterkant Street between Knuffelsgracht and SMS pier. Undersized/small diameter underground pipes and inlets/outlets will be removed and replaced with larger capacity pipes and inlet/outlet structures. After the pipes and inlet/outlet replacement, the overlying road will be repaved. This upgrade will ensure better collection and discharge through the Knuffelsgracht pump station and sluice gate.
	Alternative 9: Improve Viotte Kreek drainage system	Use large culverts or open “U” concrete channel structure to improve discharge/reduce maintenance for approximately 350 meters between Zwartehovenburg Street and Klipstenen Street.
Shoreline Erosion Protection/ Stabilization	**Alternative 10:** Riprap/gabions/ articulated concrete blocks along shoreline	This alternative focuses on erosion control by using riprap/gabions/articulated concrete blocks for approximately 300 meters of shoreline.
	Alternative 11: Create buffer with enhanced mangrove plantings	The existing mangrove area immediately south of the Van Sommelsdijck Canal pump station will be slightly expanded and enhanced by planting more trees and constructing other natural features (trapping units/wooden quays) to facilitate growth, sediment entrapment, and protection against erosion.
Stormwater Retention and Release	**Alternative 12**: Install underground stormwater retention system	Installation of stormwater retention system such as vaults and large diameter pipes to release water at a lower rate.
	Alternative 13: Construct aboveground stormwater retention and release system	Construction of swales, ponds, or similar features in open spaces. Approximately four such aboveground units are assumed.
	Alternative 14: Construct permeable pavements or similar alternatives to impervious surfaces	Reduction in surface runoff from impervious surfaces by converting existing surfaces to more permeable options. Permeable pavement is assumed to be installed in Keizer Street, Knuffelsgracht bus terminal, along Waterfront, along Viotte and other canals.

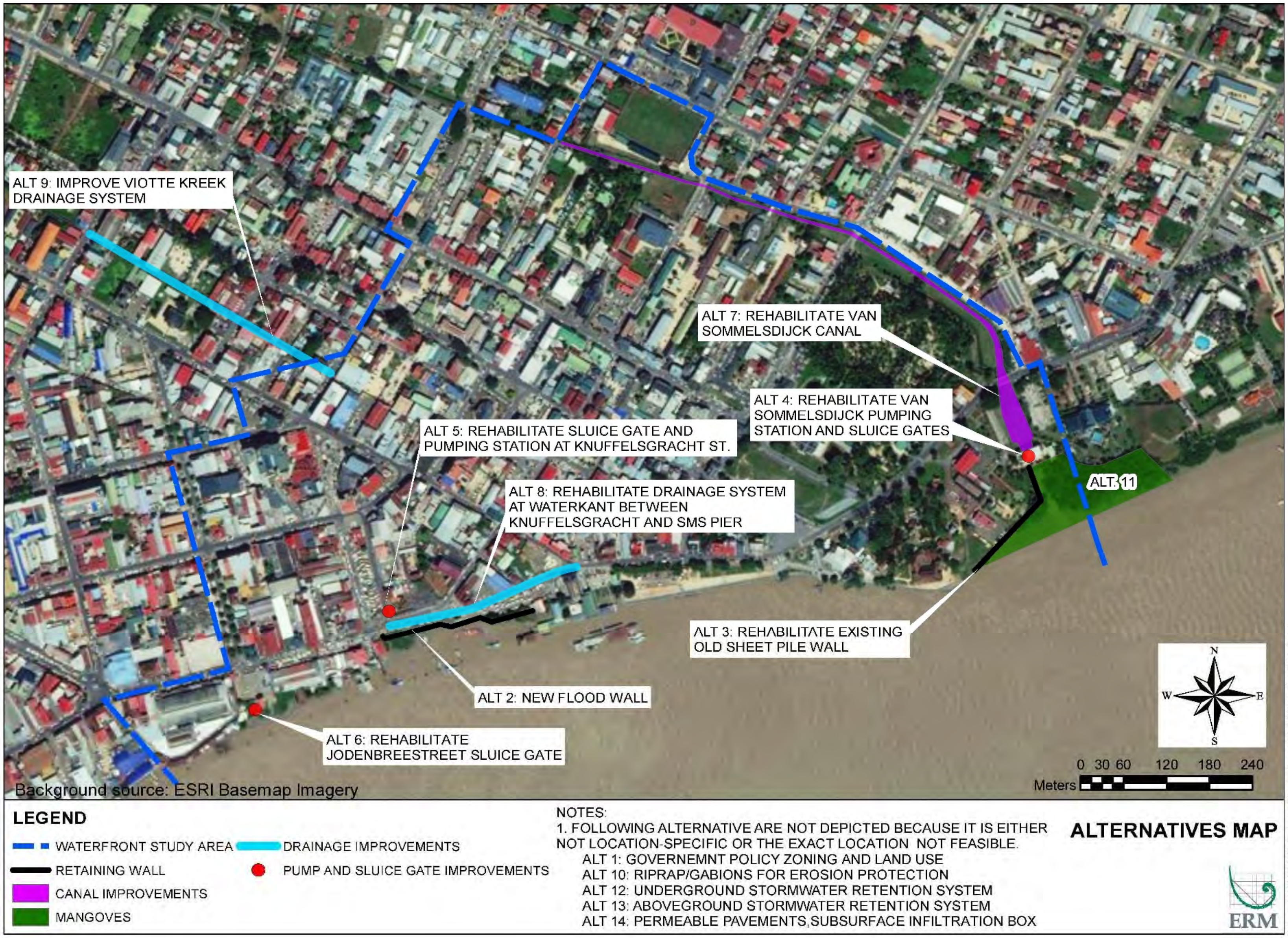

Figure 26: The Fourteen Targeted Site-specific Alternatives

57. A set of site-specific criteria were then developed to assist in evaluating the 14 alternatives identified. These evaluation criteria were broadly classified into four main categories.

i. Technological achievement
- Meeting flood protection through design life
- Technological approaches
- Integration of green technologies
- Compatibility with existing flood protection or drainage improvements
- Capital versus operation and maintenance (O&M)-intensive measures
- Long-term effectiveness

ii. Socio-political achievement
- Social consideration
- Regulatory and government involvement
- Compatibility with UNESCO World Heritage Site restrictions

iii. Environmental achievement
- Stabilization of the river and drainage systems
- Flood protection
- Naturalization of the river bank
- Ecosystem enhancement

iv. Programmatic achievement
- Implementability
- Cost

58. Using these evaluation criteria, a multi-criteria evaluation (weighted sum model) was performed to identify the preferred alternatives. Based on the method discussed in Annex II, the alternatives that scored highest were considered the preferred adaptation measures, as identified in Table 6, and these were submitted to further analysis.

Table 6: High Ranked Site-Specific Alternatives

Site-Specific Alternatives	
Alternative 2	New flood protection wall from Knuffelsgracht Street to SMS Pier
Alternative 3	Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal
Alternative 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates
Alternative 5	Rehabilitate sluice gate and pumping station at Knuffelsgracht Street
Alternative 7	Rehabilitate Van Sommelsdijck Canal
Alternative 8	Rehabilitate drainage system along the waterfront between Knuffelsgracht and SMS Pier
Alternative 11	Create buffer with enhanced mangrove plantings

59. These seven highest-ranked alternatives were then grouped into three groups that best represent the options to address the critical components of the project, i.e., address the

current and future expected flooding in the Stu dy Area, and also meet the cost re strictions associated with the Adaptation Fund. Table 7 summarises the groupings.

Table 7: Grouped Alternatives

Group	Alternative	Alternative Description	Benefits	Drawbacks
Group A	Alt 2	New flood protection wall from Knuffelsgracht Street to SMS Pier	• Strong measure for coastal flood protection • Adaptive to future by increasing wall height • Addresses critical flood area • Address both coastal and inland flooding	• May temporarily obstruct view • Inland flood control requires operation of pump and gates • Flood wall overlaps with existing water taxi business and may have impacts on livelihoods • Management of potentially impacted sediment • Resolution of historic land concession required
	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates		
	Alt 11	Create buffer with enhanced mangrove plantings		
Group B	Alt 3	Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal	• Minimal construction disturbance to rehabilitate existing wall • Added functionality along canal for walkways • Address both costal flood and limited (reduced segment of canal improvement)	• Critical flood area not addressed • Only portion of canal is rehabilitated • Inland flood control requires pump and gates operation • Management of potentially impacted sediment
	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates		
	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)		
	Alt 11	Create buffer with enhanced mangrove plantings		
Group C	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	• No view obstruction • Added functionality along canal for walkways • Address both coastal flood and limited (reduced segment of canal improvement)	• Critical flood area partially addressed by new pump station (PS) – Alt 5 • Construction disturbance at new PS – Alt 5 • Inland flood control requires pump and gates operation
	Alt 5	Rehabilitate sluice gate and pumping station at Knuffelsgracht Street		
	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)		
	Alt 11	Create buffer with enhanced mangrove		

Further Analysis of Potential Adaptation Measures

i. Further Flood Risk Analysis

60. The effectiveness of various alternatives was evaluated by modelling them using the baseline flood model setup (details contained in Annex A). For example, the flood modelling study results for Alternatives 2 and 3 and Alternative 4 show that there is significant improvement in the reduction of flood hazard along the river waterfront (using alternative 2 and 3, see Figure 27) and near the Van Sommeldijckse Canal for small return periods (alternative 4, see Figure 28). For future years of 2050 and 2080 with large return periods, effectiveness of flood control decreases due to the routing of flood water from neighbouring regions of the riverfront. A similar analysis holds good for the other alternatives identified.

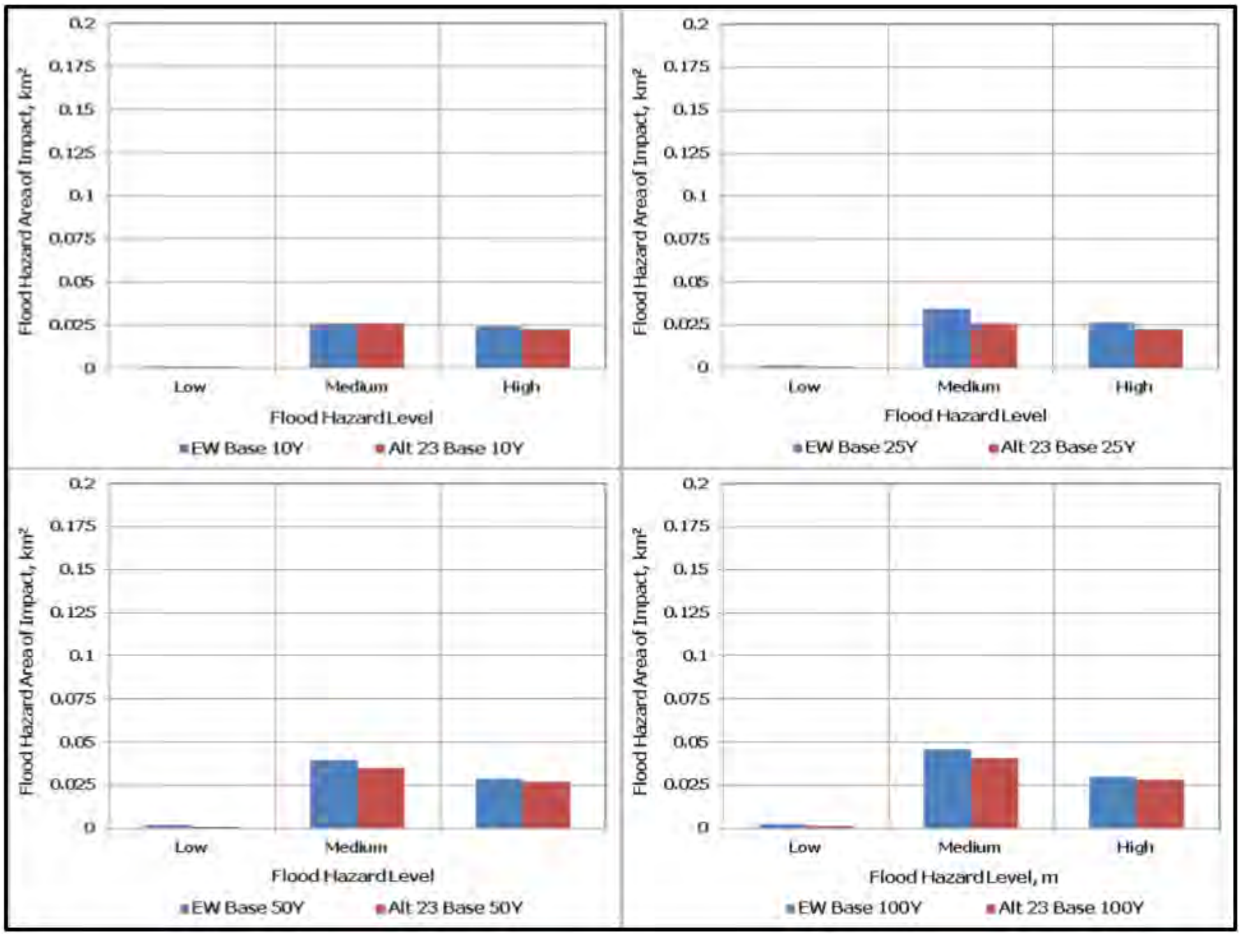

Figure 27: Comparison of coastal flooding hazard areas of impact within the Study Area between the existing floodwall (EW) and with the addition of the Alternative 2 and 3 conceptual design floodwalls for the baseline scenario at 10-, 25-, 50-, and 100- year return periods

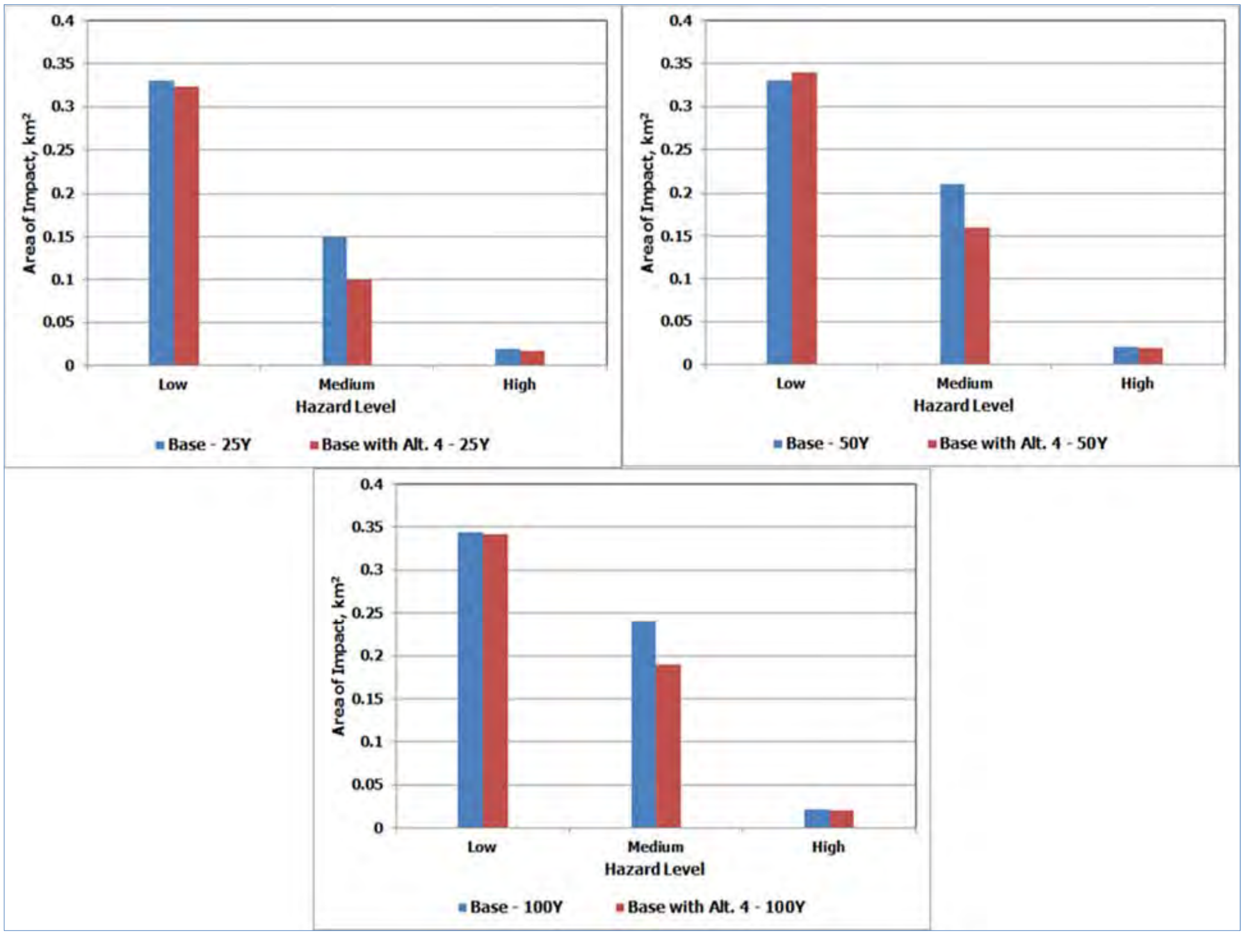

Figure 28: Graphical comparison of flood hazard areas of impact of the Canal and its surroundings between the existing configuration and with the addition of the Alternative 4 option at 25-, 50- and 100-year return periods

ii. Benefit Cost Analysis

61. The alternatives were also further assessed through a detailed benefit cost analysis (BCA). The detail behind the BCA is contained in the full **Benefit Cost Analysis report (dated July 2018) is contained in Annex C**. The BCA assessed which groups of projects provide the highest positive net present value (NPV). Benefits are principally measured as the reduction in total damages from floods with the adaptation measures compared to the damages that would occur without the projects, under the scenario where climate change increases the frequency and severity of floods over time. Costs include both capital and operating costs.

62. Table 8 shows that while all groupings have a positive NPV, Group A has the largest positive value.

Table 8 Net Present Value by Group of Alternatives ($millions)

Group Name	**PV Total Benefits**	**PV Total Costs**	**PV Net Benefits**
Group A (2,4)	$33.9	$8.0	$25.8
Group B (3,4,7)	$16.3	$8.2	$8.1
Group C (4,5,7)	$9.9	$8.9	$1.0

Confirmation of Proposed Adaptation Measures

63. Based upon the analyses performed, the three alternatives in Group A have been selected for this Proposed Project. They demonstrate confirmed benefits against the flooding and show a strong financial benefit. The three adaptation measures comprise (i) Construction of a new flood protection wall; (ii) Sommelsdijck Canal pump station and sluice gates rehabilitation; and (iii) Enhancement of mangroves. Figure 30 depicts the location of these components within downtown Paramaribo and the following sections describe each component in more detail. Further preliminary design proposals and details are contained in the **Design Details (dated July 2018) contained in Annex D**.

Figure 30: Location of Project Components

i. Construction of a New Flood Protection Wall

64. The existing shore protection consists of a brick retaining wall, which has collapsed in several areas, mainly because of erosion and wear and tear over time (see Figure 31 below). Although the exact date of construction for the wall is unknown, it was present in historic photographs dating back to the 1940's. As part of this Project, this historic flood wall on the south side of Waterkant Street will be replaced with a modern sheet pile wall extending approximately 250 meters from Knuffelsgracht Street to the SMS Pier along the south side of the waterfront (Waterkant Street, see Figures 32 and 33).

Figure 31: Existing Historic Flood Protection Wall – Note Extensive Disrepair

65. The proposed sheet piles will be coated to protect them against corrosion. The steel sheet pile wall will be reinforced along the river side with locally available riprap/stone and finished with a concrete/brick cap. The rip-rap provides erosion controls and sufficient passive pressure to keep the steel sheet piles stable. The rip-rap will be designed with a slope not steeper than 1 vertical (V): 3 horizontal (H). On the river side of the current wall, the existing shore level is high due to silt sedimentation, so a portion of the shoreline will be excavated to enable the placement of the rip-rap.

66. The existing sidewalk along the new flood protection wall will also be rehabilitated and extended to meet the new wall location (new flood wall will be located approximately 2-3 m from the existing brick retaining wall). Similarly, a new stormwater drainage system will be installed along the flood wall, under the new sidewalk, connected to the existing stormwater inlets. The drainage will then discharge collected stormwater to the river through two outlets

with check valves (non-return) to protect the area from inflow during high water levels in the river.

67. The existing landing for water taxis (small boats), including its roof, will be rehabilitated, and the entrance will be made suitable for use by the water taxis after construction of the new and taller flood protection wall. As part of early engagements with representatives from the water taxis, temporarily relocating the water taxi landing to the “old steel jetty” 100 meters east of their existing location was discussed, and the proposal appears to be satisfactory. Part of the nearby existing parking area for public transportation (see Figure 32) will be used during construction of the flood protection wall and rehabilitated after. As part of early engagements with representatives from the buses, temporarily relocating buses to the parking in the general area along Riverside/Broki and along the main road in close cooperation with the Traffic Police was discussed and appear to be satisfactory. This will also be further discussed as part of future engagements.

Figure 32: Aerial View of the Waterfront (Along Waterkant Street)

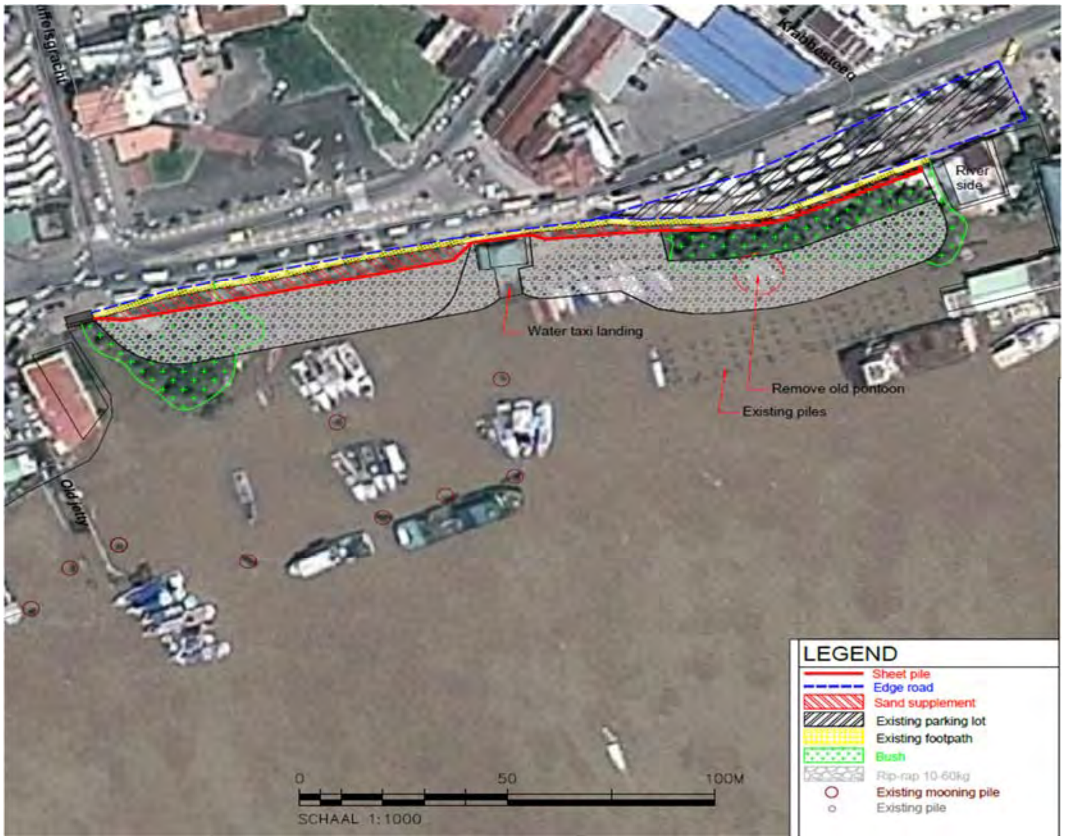

Figure 33: Concept for the New Flood Wall

ii. Sommelsdijck Canal Pump Station and Sluice Gates Rehabilitation

68. The catchment area of the Van S ommelsdijck creek (Canal) is about 700 hectar es and consists of mostly urban and semi-urban area. The rainfall run off and overflow of mostly domestic wastewater is collected through the main canal via side branches and conveyed to a basin up-gradient to the sluice and pumping station. The sluice/pumping station discharges water collected in the water basin to the Suriname River periodically by gravity (sluice gates) and/or pumping (pumps). The rehabilitation of t he sluice/pumping station Van Sommelsdijck consists of 3 main activities, as shown on Figure 34 and listed below:

- Improvement of the water basin;
- Rehabilitation of sluice gates and pumping station; and
- Improvement of the outflow.

Figure 34: Rehabilitation Components of Sluice/Pumping Station at Van Sommelsdijck Canal

69. Improvement of the water basin: The water basin consists of an area of approximately 1800 m^2. Currently, the basin bottom is too shallow to store enough water for regular operation due to sedimentation and plant/weed growth (see Figure 35). Improvement activities include excavation of the basin to approximately 1.5-meter depth to increase the volume of storage. The side slope of the basin will be graded to 1V:3H, and the top of the embankment will be restored with grass protection.

Figure 35: Existing Condition of Water Basin

70. Rehabilitation of sluice gates and pumping station: Currently, only one sluice gate and two pumps (out of three pumps) are operational, however the supporting control system is not operational (see Figure 36). The hydraulic system is faulty and the monitoring switches are not in operation. The sluice gate and pumps are operated manually. The proposed rehabilitation of the sluice gates and pumping station mainly includes the following activities:

- Rehabilitation of the valve control system, installation of a new electrical control system, rehabilitation of the electrical and instrumentation systems, and the rehabilitation of the automatic lubrication system.
- Complete overhaul of pump #1. Once pump #1 is rehabilitated, an inspection of pump #2 will be conducted, and depending on the results of this inspection, critical parts of pump #2 will be repaired. Similarly, pump #3 will also be inspected and repaired if needed.
- Rehabilitation of four vertical lift sluice doors and the hydraulics system.

Figure 36: Existing Pump House

71. Improvement of the outflow: The outflow channel is currently filled with sediment from the river (see Figure 37). The outflow channel will be dredged/excavated to ensure sufficient discharge from the gravity sluices.

Figure 37: Existing Condition of Outflow Area

iii. Enhancement of Mangroves

72. Mangrove trees protect the embankments and coastal lines because the roots of the mangrove not only dissipate wave strength, but also the water velocity before reaching land. The net amount of sediment deposition plays an important role in the maturation of mangrove trees. The absence of mangrove trees along the embankment or shoreline can disrupt the balance between sediment deposition and erosion, leading to problems such as sediment erosion. Mangrove areas also create a good habitat for different animal species.

73. An existing mangrove forest is immediately downstream of Sommelsdijck Canal pump station at the confluence of the canal and the Suriname River as shown in Figure 38. In order to create a better environment for mangrove trees to grow, the net sediment deposition has to be much larger than the amount of sediment that is being washed away by the river. The existing mangrove area will be slightly expanded and enhanced to facilitate growth, sediment entrapment, and protection against erosion. The OWTC is currently working with Professor Sieuwnath Naipal of the Anton de Kom Universiteit van Suriname, and other entities to design and construct green solutions along the coasts of Suriname to help with rising sea levels and to protect against erosion. Professor Naipal was consulted on the design and implementation of green solutions and the design proposed below was based on local experience and expert knowledge.

Figure 38: Mangroves North and South of the Canal Confluence

74. The enhancements will include constructing sediment trapping units (STU's). STU's are permeable structures that partly dissipate the energy of the waves, while water with lots of sediments is being "sieved". This way the sediment settles inside the structure. When enough sediment is settled and well consolidated, natural mangrove growth can take place.

75. The proposed STU's consist of wooden piles installed at specific distances along the shoreline. The space between the piles is filled with wood materials (such as bamboo) to trap sediments behind the STUs. A typical detail of an STU is shown on Figure 39.

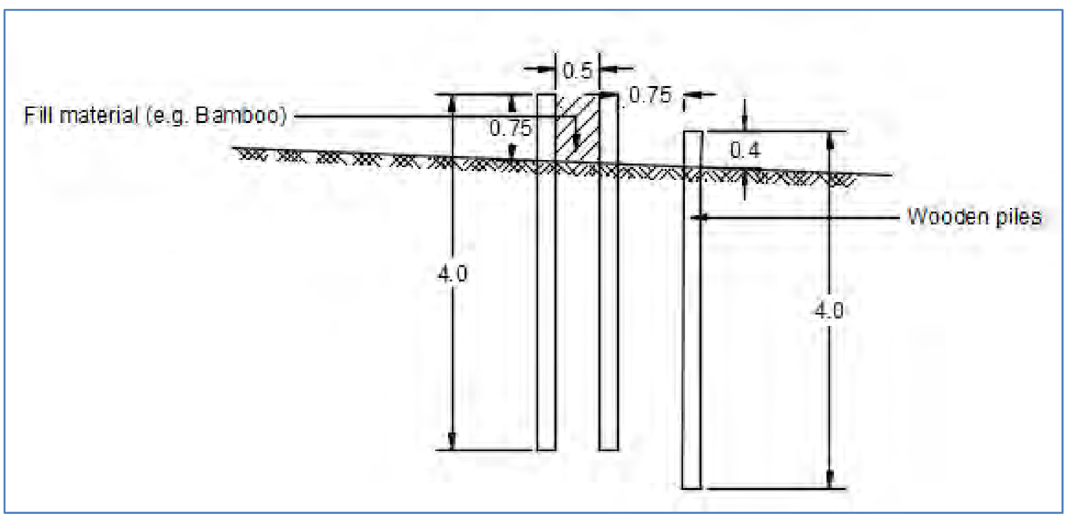

Figure 39: Typical Detail of Sediment Trapping Unit.

76. Based on the size and location, the mangrove enhancement areas are divided into two sub-areas, depicted in Figure 40 below. By implementing STU structures in the project area, the net amount of sediment deposition and mangrove growth is expected to increase significantly. The increased mangrove vegetation prevents erosion of the area. Currently, there is no protection at the outflow section of the pumping station which runs through the mangrove area (See Figure 40). A protection STUs will be installed along the either side of the outflow channels to prevent siltation of the outflow channel. During high flow periods silts and sediments carried by the flow will be deposited behind the STUs installed along the outflow channel.

Figure 40 Mangroves Enhancement Areas

iv. Surface Water Drainage Management Plan

77. In addition to the above three measures, a surface water Drainage Management Plan (DMP) for the urban area of Paramaribo will be developed with the following objectives in mind:

- To facilitate the coordinated management of stormwater and wastewater systems within catchments, and within the urban areas;
- To protect property and infrastructure against flooding by waterways;
- To reduce instances of local flooding by surcharging stormwater under storm event conditions;
- To reduce risks to the general public associated with stormwater and related infrastructure;
- To integrate management initiatives within other Government department management plans; and
- To manage the drainage assets so that they provide a satisfactory level of service for the life of the asset and within their design parameters.

78. The DMP will utilise existing information and studies held by the GoS, the IDB and also other interested stakeholders such as the World Bank. It will be developed to ensure the main surface water catchments are defined and understood, and appropriate management

initiatives identified to ensure appropriate functioning and maintenance of the drainage infrastructure. Key considerations to be built into the DMP include:

- Definition and linkage to community outcomes in terms of environmental, social and economic outcomes;
- Define key legislation and relevant policies;
- Overlay of the known and projected growth, demand and sustainability aspirations/objectives of the city;
- Define the key challenges and opportunities for stormwater drainage per catchment, and define focus areas, actions and associated outcomes;
- Define performance expectations for these actions including levels of service, performance measures and cost effectiveness;
- Define relevant long-term infrastructure strategies; significant infrastructure issues (e.g. climate change, aging networks, urban development etc.) and relevant significant planned projects;
- Provide operations, maintenance and renewals expectations; and
- Define cost implications for implementation.

Capacity Building Plan

79. In order to ensure strengthened awareness and ownership of adaptation and climate risk process by the GoS and other relevant stakeholders, a capacity building plan will also be developed and implemented. The aim of the plan will be to build capacity across the GoS stakeholders responsible for decision making in Paramaribo to ensure strong implementation and enforcement of the Adaptation Plan; development and implementation of Knowledge Management Plan and carry out training to technical and managerial staff on adaptation planning and management. The Knowledge Management Plan will capture information, data and lessons learned and ensure that it is appropriately managed and stored so that it is readily accessible and understandable to the appropriate stakeholders. This plan will be reviewed and evaluated in to ensure an effective data management process that evolves as the data and information sets develop.

80. At least three technical workshops to technical and managerial staff on the implementation of the Adaptation Plan will be undertaken, and special emphasis will be made to ensure a gender balance participation in the workshops.

81. The plan will include an evaluation, in conjunction with the GoS, of existing capacities, knowledge and understanding, and this gaps analysis will be used to define focus areas and needs, which may include:

- Need for focused training and education of relevant GoS officers and other identified stakeholders;
- As part of the plan implementation, provide supporting resource to work with and shadow GoS officers as part of their capacity building;
- Ensure that the plan is sequential and logical to ensure early successes;

- Workshops to work through the plan including basic introduction to adaptation terminology; overview of Paramaribo vulnerabilities; run through of prioritised actions; and the monitoring and evaluation framework.

82. All of the engagement activities shall be conducted in Dutch and where necessary other relevant local languages.

The Proposed Project Components

83. Table 9 below describes the proposed project components and details how these will contribute to climate resilience.

Table 9: Summary of the components forming the Proposed Project

Project Component	Description	Contribution to Climate Resilience
		-
City Adaptation Framework and Plan	Develop a city-wide Adaptation Plan including the dissemination of lessons learned that could be used in identifying strategies and programs that can be applied to future resilience programs Establish a framework for managing knowledge and disseminating lessons learned that could be used in future resilience programs for the city of Paramaribo and that could be part of a city-level Adaptation Plan	-The adaptation plan will provide a framework for managing, prioritizing and implementing adaptation and resilience measures along with a standardized approach. -Local vulnerable communities increase their knowledge about: (i) the evolution of floods and sea level rise associated-risks under climate change in Paramaribo and metropolitan areas and (ii) potential adaptation measures to cope with observed and anticipated changes in the local hydrology.
Downtown Adaptation Measures	Implement adaptation measures comprising (i) Construction of a new flood protection wall; (ii) Sommelsdijck Canal pump station and sluice gates rehabilitation; (iii) Enhancement of mangroves; and (iv) development of a surface water DMP (as shown in Figure 30).	These measures will provide: - Flood protection through physical adaptation measures along the west bank of the Suriname River; - Erosion control measures to minimize impacts in the subtidal zone; - Data knowledge and exchange with a greater understanding and data sets regarding hydrological and sediment transport in the Suriname River; and Sympathetic flood control measures through complementary green infrastructure measures.
Capacity Building	Build capacity across the GoS stakeholders responsible for decision making in Paramaribo to ensure strong implementation and enforcement of the Adaptation Plan	-Strengthened institutional capacity of GoS on adaptation; -Access to the use of materials and tools that facilitate the management, dissemination and transfer of knowledge on climate change adaptation issues for the city of Paramaribo and its metropolitan area.

Project Component	Description	Contribution to Climate Resilience
Monitoring and Evaluation	Ensure there is a robust plan and implementation structure to allow the Proposed Project to be implemented, monitored and evaluated	-Stepwise methodology/procedure to monitor and evaluate the successful implementation of proposed measures while building local capacity to monitor long term effectiveness of implemented measures to cope with observed and anticipated climate change impacts on floods and sea level rise.

A. Describe how the project / programme provides economic, social and environmental benefits, with particular reference to the most vulnerable communities, and vulnerable groups within communities, including gender considerations. Describe how the project / programme will avoid or mitigate negative impacts, in compliance with the Environmental and Social Policy of the Adaptation Fund.

84. With respect to Benefits, the proposed project will provide several prominent social, economic and environmental benefits as shown in Table 10:

Table 10: Summary of Proposed Benefits

Benefits	Contribution to Climate Resilience
Economic	- Prevention of damage and business interruption from flooding events; - Increase interest and use of the waterfront area; and - Facilitation of rehabilitation of the Downtown Historic Area, which in turn will attract more visitors and residents to the area as well as investment.
Social	- Reduced flooding impacts to homes and personal wellbeing; - Increased income and job opportunities in the waterfront area; - Facilitation of rehabilitation of the Downtown Historic Area which will increase the protection of the country's cultural heritage; - Improve safety of the waterfront area; - Improved public health through maintenance of drainage systems; and - The Downtown area is used by vulnerable populations such lower-income traders, and the measures will provide them with greater certainty on continuity of trading activities.
Environmental	- Protection of the Suriname River through sediment and erosion control; and - Better knowledge of the dynamics and parameters of the Suriname River.

85. In support of the Proposed Project, and Environmental and Social Impact Assessment (ESIA) has been prepared to align with local regulatory requirements, the IDB's environmental and social policies, and the Adaptation Fund's Environmental and Social Policy. The detail of this assessment is contained in the **ESIA in Annex E**. While the Proposed Project is anticipated to deliver benefits as described above, it is also acknowledged that the Proposed Project could also potentially lead to environmental and social impacts. Potential environmental and social impacts resulting from Project-related activities include:

- Emissions and noise from construction vehicles and equipment;
- Loss or disturbance of vegetation and wildlife;

- Wildlife injury or mortality;
- Habitat alteration (mangroves and aquatic);
- Loss of income for transport businesses and workers;
- Loss of view of the water (i.e., visual impacts);
- Disproportionate impacts on vulnerable groups;
- Decreased pedestrian and traffic safety;
- Increased traffic congestion and disruption;
- Decreased access to critical facilities, shopping, bus stops etc., resulting in the decrease of tourism;
- Loss of cultural heritage site authenticity and site value; and
- Damage to undiscovered archaeological sites.

86. In summary, the ESIA determined that the Proposed Project would likely result in some environmental and social impacts, but these impacts could be readily mitigated and managed, and the Proposed Project should ensure the actions identified in the ESMP are effectively implemented. In addition to implementing measures to minimize or avoid the potential adverse impacts of the Proposed Project, measures to enhance the positive effects of Project activities, as described in the ESMP, could be implemented (e.g., maximizing local construction jobs, increased intergovernmental coordination and institutional strengthening, etc.) to maximize the short- and long-term benefits of the Project. Ultimately, implementation of the Proposed Project would result in positive environmental and social outcomes because the Project components would address the significant flood and climate-change related risks that the historic city of Paramaribo and its residents face and this, in turn, would improve environmental and social conditions in the area. Table 11 summarizes the ESIA.

Table 11: ESIA Summary - Paramaribo Climate Change Adaptation Fund Project

Impact Significant Ratings

Negligible
Minor
Moderate
Major
Positive

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Air Quality				
Emissions from construction vehicles and equipment	Construction	Minor	• Maintain all construction equipment in accordance with manufacturer's specifications. • Suppress dust as needed in unpaved areas. • Avoid burning non-vegetative wastes (refuse, etc.) at construction sites. • Avoid unnecessary idling of construction equipment or delivery trucks when not in use.	Negligible

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Noise				
Noise generated by construction equipment and activities	Construction	Minor	• Maintain all construction equipment in accordance with manufacturer's specifications. • Schedule construction and rehabilitation work during daylight hours when increased noise levels are more tolerable. • Schedule construction and rehabilitation work to minimize activity during peak periods of tourism and recreation (weekends, holidays, etc.). • Develop and implement a Construction Communications Plan to inform adjacent receptors (e.g., commercial businesses, churches, and tourists) of construction activities. • Use vibratory or press-in piling instead of impact piling during shore-based construction activities to avoid generating impulsive noise and vibrations.	Negligible
Waste				
Waste generated by construction equipment and activities	Construction	Minor	• Provide appropriate waste bins, type, volume and service frequency to accommodate anticipated waste streams. • All loads arriving or leaving the site will be appropriately secured. • Provide information regarding waste management in site specific inductions, including waste separation and importance of securing vehicle loads. • Ensure licensed contractors are used to collect controlled wastes	Negligible
Biodiversity				
Loss or disturbance of vegetation	Construction	Minor	• When designing and planning work elements, minimize temporary and permanent construction footprints • Demarcate work area with fencing to minimize disturbance or removal of natural vegetation	Negligible

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Wildlife injury or mortality	Construction	Minor	• Proper disposal of dredged material to avoid wildlife exposure	Negligible
Disturbance and/or displacement of wildlife	Construction	Moderate	• Conducting canal- and mangrove-related works outside the waterbird breeding season (April – Sept) • Minimize lighting • Implement above measures to minimize noise and air pollution	Negligible
Habitat alteration – mangroves	Construction Operation	Positive	• Seasonal restriction (work to be done outside of bird breeding season which occurs from April-September)	Positive
Habitat alteration – aquatic	Construction Operation	Positive	• Implement sediment control procedures during in-water works to minimize the release of fine sediments to downstream waterways, particularly the Suriname River	Positive
Social				
Loss of income for transport businesses.	Construction	Moderate	• Execute construction activities from the water side to reduce impacts on land-based businesses. • Temporarily relocate land and water-based businesses to adjacent locations in the immediate Project Area. • Develop and implement a Traffic Management Plan (see Appendix H of the ESIA in Annex E). • Develop and implement a Livelihood Restoration Plan (see Appendix D of the ESIA in Annex E) for potentially Affected Persons. • Continue stakeholder engagement through Project implementation through the use of the Stakeholder Engagement and Communications Plan (see Appendix A of the ESIA in Annex E). • Implement a Grievance Mechanims to receive and respond to grievances (see Appendix A of the ESIA in Annex E).	Minor

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Loss of view of the water (i.e., visual impacts)	Construction	Negligible	• Develop and implement a Stakeholder Engagement and Communications Plan to keep stakeholders informed of Project-related activities (see Appendix A of the ESIA in Annex E).	Negligible
Loss of tourism	Construction	Negligible	• Develop and implement a Stakeholder Engagement and Communications Plan to keep stakeholders informed of Project-related activities (see Appendix A of the ESIA in Annex E).	Negligible
Impacts on Vulnerable groups, including women patrons and a disabled patron	Construction	Negligible	• Implement a Grievance Mechanims to receive and respond to grievances (see Appendix D of the ESIA in Annex E). • Install proper lighting in the Project Area for early-morning and late-evening commuting;Ensure safe conditions for mooring, including boardwalk with railings; • Ensure adequate ground surfaces for patron mobility (e.g., high heels and crutches); and • Conduct Gender Awareness Training for contractors and their staff.	Negligible
Boost to the local economy through provision of jobs to local companies and workers and locally sourced materials	Construction	Positive	• Implement job quotas for local employment and sourcing requirements for construction contractors based on the size and scope of the Project	Positive
Traffic				
Decreased pedestrian and traffic safety	Construction	Minor	• Implement Traffic Management Plan to include early notification of road closures, detour signage, and safety programs and measures for pedestrians and bicyclists (see Appendix H of the ESIA in Annex E).	Negligible
Increased traffic	Construction	Minor	• Incorporate public transportation	Negligible

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
congestion and disruption			alternatives (e.g., pedestrian and bus) into Traffic Management Plan	
Decreased access to critical facilities, shopping, bus stops etc.	Construction	Minor	• Implement Access Management Plan to maintain continuous access through careful staging and sequencing of construction activities and provision of alternatives where needed	Negligible
Cultural Resources				
Loss of cultural heritage site authenticity due to construction of Project	Construction Operation	Minor	• Consult with the relevant cultural heritage stakeholders and develop management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS.	Negligible
Loss of cultural heritage site value due to Project components changing the historic landscape of the Paramaribo WHS and diminished site view from historic buildings	Construction Operation	Minor	• Consult with the relevant cultural heritage stakeholders and develop management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS.	Negligible
Damage to undiscovered archaeological sites due to construction of subsurface Project components	Construction	Minor	• Implement a Project Chance Finds Procedure during all Project ground work (see Appendix F of the ESIA in Annex E).	Negligible
Health and Safety				
Impacts on health and safety of workers and public	Construction	Minor	• Develop and implement a Construction Health and Safety Plan (see Appendix E of the ESIA in Annex E).	Negligible
Disaster Risk				

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Flood risk due to current layout of locality and also projections for future changes in climate	Operation	Moderate	• Implementation of the Project itself.	Positive

87. Specific to vulnerable communities and vulnerable groups within communities, the ESIA includes a social impact assessment on potential social receptors including the following:

- Loss of income for businesses in the transport industry in the Project Area during construction;
- Loss of view of the water (i.e., visual impacts);
- Loss of tourism;
- Adverse and disproportionate impacts on vulnerable groups;
- Negative health and safety consequences;
- Reduced flooding; and
- Job creation.

88. As described in the ESIA, the significance of potential social impacts was evaluated by determining the magnitude of each change, including considerations of the type (direct, indirect, induced, or cumulative), nature of change, extent and scale (size of the change), and duration (temporary, short term, long term, or permanent) of each potential impact, and the sensitivity of the social receptor. These are summarized below.

89. <u>Loss of Income for Transportation Businesses</u>: The construction of a new flood protection wall, which is expected to last between 4 to 8 months, could directly impact businesses in the transport and hospitality industries in the Project Area. Although Waterkant Street will remain open, land-based transportation businesses limited to the two bus lines—PG and LIJN—and taxicabs would not be able to continue loading/unloading/parking immediately in front of the existing flood protection wall due to safety concerns during construction. Similarly, water-based transportation businesses (i.e., water taxis) would not be able to continue loading/unloading/docking at their current dock due to the same safety concerns. Riverside Bar/Terrace, the only identified restaurant in the hospitality industry in the Project Area, would be able to remain open and operational. Given the concentration of and the short duration of the potential impact, the magnitude has been determined to be small to medium

90. A small portion of the potentially Affected Persons identified in the census/socio-economic survey whose income could be impacted have low annual income levels (e.g., water taxis), an attribute associated with medium to high vulnerability. However, other Affected Persons far exceed the minimum wage in Suriname and have low vulnerability. In order to minimize the impacts to minor to moderate, the mitigations that follow below are recommended. It is important to note that these mitigations measures were developed taking into account the results of the stakeholder engagement activities carried out from November 2017 to May 2018. They were further consultedin three meaningful stakeholder engagements conducted in July 2018 to engage in two-way exchange on specific Project information and the planned mitigation measures.

91. The majority of construction activities will be executed from the water side. Buses that park along Waterkant Street remain in the general area and be temporarily relocated to the Bus Terminal, which is expected to remain open, 200 meters west of their existing location and 100 to 200 meters east and west along Knuffelsgracht Street. Water taxis will remain in the general area and be temporarily relocated to the "old steel jetty" 100 meters east of their existing location, and the old pier's current condition be improved in order to be of equal or better quality than their existing location. A Traffic Management Plan will be developed and implemented to help facilitate busing routes and alternative stops in the immediate study area as appropriate. In addition, a Livelihood Restoration Plan (LRP) has been developed and implemented for any stakeholder that is potentially impacted during construction in order to make them whole, although this is not expected after implementing the other mitigation measures.

92. A Stakeholder Engagement and Communication Plan has also been developed and will continue to be implemented, in addition to a Grievance Mechanism. This mechanism is designed to receive, facilitate investigation, and respond to grievances from Project stakeholders and Affected Persons; and it will be managed by designated personnel (e.g., Community and Social Coordinator for the GoS).

93. After construction, both land- and water-based businesses in the transport industry are expected to return to their preconstruction locations as proposed by each respective stakeholder group.

94. <u>Loss of Water View</u>: The new flood protection wall along Waterkant Street may temporary obstruct residents and tourists' view of the water during construction as a result of equipment, vehicles and construction fencing. This impact is concentrated between Knuffelsgracht Street and SMS Pier along Waterkant Street and there will remain water views outside of this small area. The disruption will be temporary in duration (i.e., 4 to 8 months); therefore, the magnitude has been determined to be negligible. This impact would equally and discriminatorily affect residents and tourists of ranging vulnerabilities.

95. After construction, and based on engineering plans, the new flood protection wall will be comparable to the existing flood protection wall north of the Site; and it will not impede residents or tourists' view. The location of the floodwall extension is also at a lower elevation than its surroundings, hence the reason for continual flooding. This impact is determined to be negligible and no mitigations are necessary.

96. <u>Vulnerable Groups</u>: As part of the census, a total of four individuals self-identified as Maroon or Indigenous, both of which can be labeled as Indigenous People in accordance with the IDB's policy OP-765. These Indigenous People are fully integrated into urban life in Paramaribo as identified in the baseline. The Project does not disproportionately impact them as a result of their identity, exclude them from participation, impede on their rights or claims to territorial or culturally significant lands, or prevent them from fulfilling traditional ways of life. As such, it is expected they will enjoy equal access to the Project's overall benefits, and that the Project's mitigation measures and ESMP will extend to them without discrimination.

97. Similarly, only two women were identified in the census and occupy roles in the transport industry similar to men. However, with relation to transport patrons, at a ratio of approximately 3:2, more women than men take water taxis and buses in the Project Area. It is important to highlight that women will not be disproportionately adversely impacted. Finally, only one patron in the Project Area was identified as having a physical disability at the time of baseline

studies, but he had physical mobility and could load/offload the water taxis without assistance. Despite not expecting disproportionate impacts for these groups, the Project will include the following measures to ensure that any potential risks are fully mitigated:

- Proper lighting in the Project Area for early-morning and late-evening commuting;
- Adequate ground surfaces to ensure patrons have ease of mobility (e.g., high heels or crutches); and
- Gender Awareness Training for contractors and their staff.

98. No additional mitigations are necessary. Vulnerable groups will have equal access to the Project and associated safeguards (e.g., entitlements as part of the LRP, grievance mechanism as defined in the Stakeholder Engagement and Communications Plan).

99. Reduced Flooding: Presently, flooding is a severe problem during rainfall and high tide in the Project Area, especially near and around Knuffelsgracht Street. The Project, as a result of the three selected components will reduce flooding, thereby improving hygiene, safety, and accessibility. This is consequently a positive impact.

100. Job Creation: Construction activities for all three components will likely provide jobs to local construction companies and workers, and the Project would likely source some materials from the local economy. This would have a positive impact on the Suriname economy.

101. The positive impact will be enhanced in the following ways:

- Adopt preferential contracting for local companies with capacity.
- Require international contractors to partner with local engineering firms.
- Require contractors to source locally where possible.

102. It is estimated that the construction of the project will utilize approximately 12 local laborers on average day and approximately 20 local laborers on peak periods.

B. Describe or provide an analysis of the cost-effectiveness of the proposed project / programme.

103. As summarised in paragraphs 55 and 56, and in Figure 29, a detailed benefit cost analysis (BCA) has been undertaken. The detail behind the BCA is contained in the full **Benefit Cost Analysis report (dated July 2018) is contained in Annex C**. The BCA demonstrated that the selected projects had the largest positive value against the options considered and yielded good cost-effectiveness.

C. Describe how the project / programme is consistent with national or sub-national sustainable development strategies, including, where appropriate, national or sub-national development plans, poverty reduction strategies, national communications, or national adaptation programs of action, or other relevant instruments, where they exist.

104. This project is fully aligned with Suriname's Multi-Annual Development Plan (Nationaal Ontwikkelingsplan) of 2012-2016, which calls for action to address the negative impacts of climate change and prioritizes the protection of Suriname's vulnerable coastal zone from sea

level rise through the effective implementation of adaptation measures, as highlighted in Suriname's Second National Communication to the United Nations Framework Convention on Climate Change. Proposed actions are also in line with priorities set forth in the National Climate Change Policy, Strategy and Action Plan and Suriname's Intended National Determined Contribution (INDC).

105. As previously emphasized, downtown adaptation measures will directly reduce flooding in Paramaribo's historical center (due to rising sea level). In addition, the project will enhance the GoS' capacity to properly identify and prepare climate change adaptation projects compatible with the Multi-Annual Development Plan.

D. Describe how the project / programme meets relevant national technical standards, where applicable, such as standards for environmental assessment, building codes, etc., and complies with the Environmental and Social Policy of the Adaptation Fund.

106. The Proposed Project will fully comply with the following applicable standards:

- Relevant Suriname legislation and policies as described and presented in the ESIA in Annex E;
- The IDB's social and environmental policies; and
- The Adaptation Fund's Environmental and Social Policy Statement.

107. Specific to the Adaptation Fund's Policy, Table 12 provides a summary of alignment.

Table 12: Project Compliance with Applicable Adaptation Fund Policies and Safeguards

Principle	Requirements for Funding	Applicability to the Paramaribo Project
1 - Compliance with the Law	Projects shall be in compliance with all applicable domestic and international law.	This Project would be conducted in compliance with all applicable local Surinamese regulations, international agreements, and IDB safeguards and policies as discussed previously in this Section.
2 - Access and Equity	Projects shall provide fair and equitable access to benefits in a manner that is inclusive and does not impede access to basic health services, clean water and sanitation, energy, education, housing, safe and decent working conditions, and land rights.	This Project is an infrastructure project designed to protect and enhance downtown Paramaribo by reducing flood risk and vulnerability to climate change. Its benefits are distributed across all users of the area equally and once construction activities are finalized, it would not negatively impact any of the stakeholders in the Area of Influence (see Section 5 of the ESIA).

Principle	Requirements for Funding	Applicability to the Paramaribo Project
3 - Marginalized and Vulnerable Groups	Projects shall avoid imposing any disproportionate adverse impacts on marginalized and vulnerable groups.	This ESIA analyzes Project-related impacts in relations to Indigenous People and women; however, neither group is expected to be disproportionately impacted in any way due to the magnitude of impacts. Preventative measures have been proposed to address any issues (e.g., Grievance Mechanism) as part of the Project's ESMP (see Section 6 of the ESIA).
4 - Human Rights	Projects shall respect and where applicable promote international human rights.	This Project is an infrastructure project designed to protect and enhance downtown Paramaribo by reducing flood risk and vulnerability to climate change. Human rights issues are not anticipated as a result of this Project.
5 - Gender Equality and Women's Empowerment	Projects shall be designed and implemented in such a way that both women and men 1) have equal opportunities to participate as per the Fund gender policy; 2) receive comparable social and economic benefits; and 3) do not suffer disproportionate adverse effects during the development process.	This ESIA analyzes Project-related impacts in relations to Indigenous People and women; however, neither group is expected to be disproportionately impacted in any way due to the magnitude of impacts. Preventative measures have been proposed to address any issues (e.g., Grievance Mechanism) as part of the Project's ESMP (see Section 6 of the ESIA).
6 - Core Labor Rights	Projects shall meet the core labor standards as identified by the International Labor Organization.	ILO's Core Conventions deal with freedom of association and right of collective bargaining (No. 87 and 98), forced labor (No. 29 and 105), child labor (No. 138 and 182), and equal remuneration (No. 100 and 111). Suriname has ratified all of these Conventions and has domestic laws to uphold such labor principles. The Project will incorporate contractual language to ensure Contractors meet this requirements and this will be monitored.

Principle	Requirements for Funding	Applicability to the Paramaribo Project
7 - Indigenous Peoples	Projects shall be consistent with the rights and responsibilities set forth in the UN Declaration on the Rights of Indigenous Peoples and other applicable international instruments relating to indigenous peoples.	This ESIA analyzes Project-related impacts in relations to Indigenous People and women; however, neither group is expected to be disproportionately impacted in any way due to the magnitude of impacts. Preventative measures have been proposed to address any issues (e.g., Grievance Mechanism) as part of the Project's ESMP (see Section 6 of the ESIA).
8 - Involuntary Resettlement	Projects shall be designed and implemented in a way that avoids or minimizes the need for involuntary resettlement.	No involuntary physcial resettlement would occur as a result of the implementation of this Project. The Project could result in economic displament of those in the transport and hospitality industries in the immediate Project Area; however, this risk has been mitigated by the Project's ESMP and related Livelihood Restoration Plan contained in the ESIA.
9 - Protection of Natural Habitats	The Fund shall not support projects that would involve unjustified conversion or degradation of critical natural habitats.	There are no critical natural habitats in the Area of Influence of the Project. Biological resources impacts and mitigation measures are discussed in Sections 5 and 6 of the ESIA.
10 - Conservation of Biological Diversity	Projects shall be designed and implemented in a way that avoids any significant or unjustified reduction or loss of biological diversity or the introduction of known invasive species.	No significant adverse impact to biodiversity would occur as a result of implementation of this Project, as discussed in Sections 5 and 6 of the ESIA.
11 - Climate Change	Projects shall not result in any significant or unjustified increase in greenhouse gas emissions (GHGs) or other drivers of climate change.	Project activities are only expected to result in insignificant increases to GHGs during the construction phase. Relevant mitigation measures are discussed in Sections 5 and 6 of the ESIA.

Principle	Requirements for Funding	Applicability to the Paramaribo Project
12 - Pollution Prevention and Resource Efficiency	Projects shall be designed and implemented in a way that meets applicable international standards for maximizing energy efficiency and minimizing material resource use, the production of wastes, and the release of pollutants.	The Project's ESMP and related plans provide mechanisms to ensure Project conformance with this policy. (see Section 6 of the ESIA).
13 - Public Health	Projects shall be designed and implemented in a way that avoids potentially significant negative impacts on public health.	As with Policy 2 above, this Project is an infrastructure project designed to protect and enhance downtown Paramaribo and once construction activities are finalized, would not negatively impact any of the stakeholders in the Area of nfluence (see Sections 5 and 6 of the ESIA).
14 - Physical and Cultural Heritage	Projects shall be designed and implemented in a way that avoids the alteration, damage, or removal of any physical cultural resources, cultural sites, and sites with unique natural values recognized as such at the community, national or international level.	Because downtown Paramaribo is a WHS, Cultural Heritage is thoroughly discussed in Sections 4 and 5 of the ESIA. Mitigation measures relative to cultural resources are presented in Section 6 of the ESIA.
15 - Lands and Soil Conservation	Projects shall be designed and implemented in a way that promotes soil conservation and avoids degradation or conversion of productive lands or land that provides valuable ecosystem services.	This Project will take place in the highly developed landscape of downtown Suriname. Soil conservation and land conservation are not applicable to this Project.

E. Describe if there is duplication of project / programme with other funding sources, if any.

108. There is no duplication of projects with other funding sources. There is one complementary project; IDB's Paramaribo Urban Rehabilitation Program (SU-L1046) which has been approved January 25, 2017. The Urban Rehabilitation Program aims to revitalize the city center and proposes the renovation of public spaces, restoration and rehabilitation of heritage buildings, creation of new housing projects to promote mixed-use, and the development of new business strategies with private sector participation. Parts of these interventions are located along the waterfront as is the Proposed Project. The urban interventions in this

Proposed Project will protect the city center, its users and residents from flooding and the effects of climate change while the Urban Rehabilitation Program focuses on spatial interventions and the reuse of heritage buildings. Close collaboration between IDB's teams responsible for the Proposed Project and the Urban Rehabilitation Program will prevent overlapping of the projects. Additionally, there are 3 IDB members participating in both teams to assure that the projects are complementary.

109. In addition, the World Bank is currently preparing the Saramacca Canal System Rehabilitation Project (SCSRP), aimed at reducing flood risk for the people living in the Greater Paramaribo area and improve the operation of the Saramacca Canal System for flood risk management and navigation. The Saramacca canal is located in an adjacent watershed to the proposed project to the Adaptation Fund. The expected results of the SCSRP are: (a) Improved capacity of the Saramacca Canal to discharge water efficiently into the Suriname and Saramacca Rivers; and (b) Establishment of a functioning monitoring, forecasting, and operational management system for the overall Saramacca drainage system. This makes it complementary to this proposed project by reducing the flood risk of Paramaribo.

F. If applicable, describe the learning and knowledge management component to capture and disseminate lessons learned.

110. A Knowledge Management Plan will be developed to capture information, data and lessons learned. This Plan will ensure that this information is:

- Appropriately managed and stored so that it is readily accessible and understandable;
- Appropriately shared among stakeholders; and
- Reviewed and evaluated to ensure the data management process is working effectively and also evolving as the data and information sets develop.

111. In addition, training to technical and managerial staff on adaptation planning and management will be delivered via technical workshops. Special emphasis will be made to ensure a gender balance participation in the workshops. Training plans and materials for key stakeholders in Paramaribo in adaptation planning and management will also be delivered.

G. Describe the consultative process, including the list of stakeholders consulted, undertaken during project preparation, with particular reference to vulnerable groups, including gender considerations, in compliance with the Environmental and Social Policy of the Adaptation Fund.

112. The GoS and the IDB have undertaken a series of consultation exercises to assess the potential impacts, gain views and insights from stakeholders and also to get technical inputs on the likely adaptation measures. These consultation events have included:

- Workshops with Government and non-Government stakeholders on hazards and risks and the potential impacts of climate change;
- A livelihoods survey of all businesses and traders in the waterfront area;

- Focused engagements and meetings with potentially affected parties through end of 2017 to June 2018; and
- Public consultation exercises.

Appendix A of the ESIA contained in Annex E contains the project's Stakeholder Engagement and Communications Plan. This plan details the consultation activities that have been undertaken over the last 2 years. Further consultations will be carried out during preparation stages associated with this project to guarantee that selected adaptation measures are approved by the benefited communities.

H. Provide justification for funding requested, focusing on the full cost of adaptation reasoning.

113. As previously highlighted, Paramaribo is susceptible to natural disasters exacerbated by climate change. One of main areas that get affected by these events is its city center including the historic inner city. The historic center was designated by the UNESCO as a World Heritage Site in 2002 and accommodates currently mainly governmental offices and institutes, banks, educational facilities and tourist attractions. However, the area has been undergoing physical, social, and economic deterioration, which has been a growing source of concern for the GoS, given that this area concentrates historical and cultural heritage buildings, monuments, and urban sites. In addition to the deterioration of the WHS, the area gets frequently flooded which also contributes to the decay of historic buildings, public spaces and exacerbates the accessibility from and to the city center. People residing, working in or traveling through this area experience mayor difficulties. On the latter, it's important to underline that the city center of Paramaribo is the city's mayor public transport hub.

114. As a result, the GoS asked for IDB's support to address some of these challenges and is currently executing a US$20 million loan –approved in early 2017-- to contribute to the revitalization of the area by means of (i) renewal of urban spaces and restoration of key heritage buildings; (ii) improvement in urban mobility; (iii) promotion of economic and residential activities; and (iv) strengthening the institutional framework for managing the area's sustainable development.

115. Therefore, funding for the adaptation measures included in this proposal is critical, as it would help deliver complementary interventions to those set forth in the IDB's Urban Rehabilitation Program for Paramaribo. In absence of funding from the Adaptation Fund, the GoS, which is currently under macro-fiscal stress, would need to resort to other sources of funding to invest in climate change adaptation in the downtown area.

I. Describe how the sustainability of the project/programme outcomes has been taken into account when designing the project / programme.

116. Sustainability of the Proposed Project has been a core element of the development of the project. The ESIA has assessed both the risks and benefits of the Proposed Project, and the fact the project itself focuses on climate adaptation, it naturally builds resilience when implemented. The main identified actions that need to be enforced during project preparation and execution to guarantee sustainability of project outcomes are:

- *Build capacity across the GoS stakeholders:* The Proposed Project will allow the GoS stakeholders responsible for decision making in Paramaribo to develop capacity to design, implement and monitor climate change adaptation measures. This build capacity will also allow the ownership of the project by GoS and local communities. Long term sustainability of project outcomes is guaranteed as long as these are aligned with current and planned strategies to urban development plans prepared for Paramaribo metropolitan area.

- *Prevent floods:* The Proposed Project will minimize and, in some cases eliminate flooding risk areas within the waterfront representing reductions in economic losses and create resilience against natural hazards and climate change. Also, the proposed project will improve the existing physical conditions of the west bank of the Suriname River and the Sommeldijckse drainage canal. The proposed project includes the incorporation of green infrastructure that will make the hard measures being more sympathetic and preserve its sustainable balance.

- *Contribute to different sectors in Paramaribo.* The Proposed Project will develop a more detailed picture of the vulnerabilities to floods of the different socio-economic sectors in Paramaribo urban area, particularly within the waterfront area. It also contributes to the national climate change policy and raise awareness of the issue of climate change among policy makers and the general public.

- *Maintenance of infrastructure (drainage and protection):* The central GoS has a maintenance program that provides resources to the Ministries. The Ministry of Public Works is responsible for the maintenance of the waterways, the dikes and river protection structures. A part of the team of the Ministry of Public Works in charge of maintenance will be trained and the Ministry will be equipped with the required machinery if special maintenance is needed.

- *The involvement of the local communities*: The GoS is responsible for informing and consulting the inhabitants that could be affected by large (infrastructural) constructions. Workshops, information sessions and consultation meetings are commonly used to gain ownership by the community. These events will be organized by the GoS during the preparation, design and implementation phase of the Proposed Project.

J. Provide an overview of the environmental and social impacts and risks identified as being relevant to the project / programme.

117. The environmental and social impacts and risks of the project have been presented in the previous sections. The following Table 13 presents the environmental and social impacts and risks of the project.

Table 13: Project Environmental and Social Impacts and Risks

Checklist of environmental and social principles	No further assessment required for compliance	Potential impacts and risks – further assessment and management required for compliance
Compliance with the Law	Will be compliant	n/a
Access and Equity		

Marginalized and Vulnerable Groups *Human Rights* *Gender Equity and Women's Empowerment*	Will be fair and equitable and respectful of marginalized/vulnerable groups, human rights and gender	The potential impacts are deemed to be at worst minor and at best positive. The Project's ESMP, including a Stakeholder and Engagement and Consultation Plan and a LRP will ensure any potentially affected party has due recourse
Core Labour Rights	Will be compliant	n/a
Indigenous Peoples	No significant impacts on Indigenous Peoples	The potential impacts on indigenous peoples is deemed negligible. The Project's ESMP, including a Stakeholder and Engagement and Consultation Plan and an LRP will ensure any potentially affected party has due recourse
Involuntary Resettlement	No physical resettlement will occur; however some temporary relocation of businesses will happen	The Livelihoods Restoration Plan drafted by the IDB includes a mechanism for ensuring that for the unavoidable temporary relocation of some businesses and potential associated economic displacement, due process is observed so that affected persons shall be informed of their rights, consulted on their options, and offered technically, economically, and socially feasible temporary resettlement alternatives or fair and adequate compensation
Protection of Natural Habitats	The Proposed Project will not involve unjustified conversion or degradation of critical natural habitats, and through the adoption of green solutions as part of the flood protection measures, it is the intent to enhance the biodiversity benefit of the Proposed Project	Biodiversity impacts have been assessed as negligible, and through the proposed mangrove restoration, positive benefits will accrue.
Conservation of Biological Diversity	No further assessments required	Biodiversity impacts have been assessed as negligible, and through the proposed mangrove restoration, positive benefits will accrue.
Water resources	Design and implement Environmental and Management Plans (ESMPs)	The Proposed Project will develop a Soil Erosion and Sediment Control Plan, including erosion controls such as minimizing the extent of disturbed areas and stabilizing/revegetating disturbed areas as soon as possible, and sediment controls such as hay bales, silt fences. Develop a Waste Management Plan that identifies acceptable methods for handling and disposing of solid and

		hazardous wastes, including any contaminated soils. Provide designated areas for fuelling and maintenance that have containment and spill control capabilities
Climate Change	No significant GHG emissions are expected	n/a
Pollution Prevention and Resource Efficiency	The project will have a net benefit through the drainage improvement measures. No impacts are expected	n/a
Public Health	The project will have a net benefit through the drainage improvement measures. No impacts are expected	n/a
Physical and Cultural Heritage	The project will have a net benefit on cultural heritage. No impacts are expected	Implementation of the Project's Cultural Heritage Management Plan
Lands and Soil Conservation	Design and implement Environmental and Management Plans (ESMPs)	Develop a Soil Erosion and Sediment Control Plan, including erosion controls such as minimizing the extent of disturbed areas and stabilizing/revegetating disturbed areas as soon as possible, and sediment controls such as hay bales, silt fences. Develop a Waste Management Plan that identifies acceptable methods for handling and disposing of solid and hazardous wastes, including any contaminated soils. Provide designated areas for fuelling and maintenance that have containment and spill control capabilities

PART III: IMPLEMENTATION ARRANGEMENTS

A. Describe the arrangements for project / programme implementation.

Summary of Implementation Arrangements

118. Project Execution. The beneficiary will be the Republic of Suriname. The Ministry of Public Works, Transport and Communication (MPW) through the Department of Civil Water Works (DCWW) will be responsible for the execution. The specific implementation arrangements will be as follows:

119. A Program Implementation Unit (PIU) will be established within the existing institutional structure of the DCWW. To this end, the DCWW will be strengthened through the hiring of qualified and specialized personnel dedicated to the program, including, inter alia, a program coordinator and specialists in procurement, financial management, social, and environmental, which will be financed with resources from the grant. Considering that the entire program will be

executed through a reduced number of contracts to be carried out during the first two years of execution, all specialists will be hired on a part- time basis, except the program coordinator who will be on a full-time contract.

120. The PIU will be responsible for carrying out all the operational and fiduciary obligations (including procurement, financial management and social and environmental safeguards) necessary for program execution and for maintaining all formal communication with the Bank. Among other responsibilities, the PIU will be: (i) performing technical and operational coordination of the program; (ii) programming, approving and financing all projects and activities; (iii) supervising the formulation, execution, and evaluation all interventions; (iv) preparing and updating the Pluri-annual Execution Plan (PEP), Annual Operational ¨Plan (AOP), Procurement Plan (PA), Risk Matrix (RM), and the Progress Monitoring Report (PMR); (v) submitting disbursement requests and preparing financial statements; and (vi) contracting and supervising the program's mid-term and final evaluation. The detailed responsibilities of the PIU will be presented in the POM, which will define the rules, eligibility criteria, procedures and responsibilities during execution.

121. The establishment of the Project Implementation Unit (PIU), including the selection or appointment of the specialized personnel, namely, project coordinator, financial management officer, procurement specialist, social specialist and environmental specialist; and the approval and entry into effective of the Program Operations Manual (POM), in the terms previously agreed with the Bank, is a special contractual clause prior to the first disbursement.

122. The undertaking of activities of Component I and III (related to development of the Adaptation Management Plan and Capacity Building, respectively) will be carried out with the support of the National Environmental Unit (NEU). To that end, at least one member of its technical personnel will be assigned to provide the necessary technical support to the PIU in matters concerning the effective implementation of such Components. In its capacity as the advisory body to the government to formulate and enforce a National Environmental Policy, the NEU will be also responsible for convening other government institutions and ministries in matters related to the plan development and capacity building activities. The signing of a collaboration agreement between the Ministry of Public Works, Transport and Communication and the National Environmental Unit, establishing their responsibilities during project execution is a special contractual clause prior to the disbursement of Component I and III.

123. Given the nature of the construction works to be executed in Component II (including the new flood wall located immediately east of the Knuffelsgracht Street and Waterfront), external supervision will be contracted. The fulfilment of conditions related to social and environmental matters, which will be detailed in the ESMR; and the evidence of non-objection on the part of UNESCO, or one of its designated advisory bodies, to the corresponding project's final designs, is a special contractual clause prior to the bidding of works in Component II.

124. Procurement and contracting. It will follow the Policies for the procurement of works and goods financed by the Bank (GN-2349-9), and the Policies for selection and contracting of consultants financed by the Bank (GN-2350-9), as well as the fiduciary arrangements included in Annex III.

125. Disbursement and financial management. The disbursement period is four years. The Bank will make disbursements in accordance with program liquidity needs as evidenced by its current and anticipated commitments and obligations following the advance of funds methodology. These advances, which will cover liquidity needs for a period not exceeding six

months, will be calculated based on the semi-annual cash flow projections for the period. Subsequent advances may be disbursed once 80% of the total accumulated balance pending justification has been submitted and accepted by the Bank.

The external audit of the program will be performed by an independent audit firm acceptable to the Bank. Audits will be performed in accordance with the Bank's guidelines for financial reporting and external audit. The PIU will be responsible for contracting of an eligible auditing firm to perform the program audit as follows: (i) annual financial audit reports to be submitted within 120 days of the end of each fiscal year; and (ii) one final financial audit report to be submitted within 120 days after the date of last disbursement.

B. Summary of Arrangements for Monitoring Results

The program's monitoring is based on the standard Bank instruments: (i) the PEP and AOP; (ii) the PA; (iii) the Results Matrix and Monitoring Plan (MP); and (iv) the PMR. Semi-annual progress reports will be presented within thirty (30) days after the end of the corresponding semester and should include the outcomes and outputs achieved in the corresponding execution period according to the Annual Operation Plan (AOP), the Procurement Plan, the Results Matrix, a description of the status of compliance of the environmental and social obligations, all according to the terms and conditions of the ESMM and this Contract. The PIU will maintain an administrative information system to register all relevant events in program implementation. This system will furnish all the required information for completing the financial and administrative reports and will be a key instrument for program monitoring.

Evaluation. Two evaluations will be performed: a midterm and a final evaluation. The midterm report will include: (i) the outcomes of the physical-financial execution; (ii) the degree of fulfillment of targets in the Results Matrix; (iii) the degree of fulfilment of environmental requirements; (iv) a summary of the results of the audits and of the improvement plans; and (v) a summary of the main lessons learned.

The final evaluation will adopt a reflexive approach, comparing the status of indicators in the Results Matrix before and after the program's interventions. In addition, an ex post economic analysis will be conducted to verify whether the program actually achieved the economic rates of return estimated ex ante (See Monitoring and Evaluation Arrangements).

B. Describe the measures for financial and project / programme risk management.

126. Following table presents project's identified risks and proposed mitigation activities for those classified as medium.

Table 14: Project Environmental and Social Risks and Mitigation Activities

Expanded Risk Assessment for the project[4]

Type of Risk *	Risk	Probability Classification	Impact Classification	Risk Classification (High, Medium or Low)	Means of Mitigation[5]	Compliance Indicator
Environmental and Social Sustainability	Civil works may be delayed, so it increases concerns raised by residents, business owners and public transport users during the construction phase.	2	2	Medium	The project will finance Livelihood Rehabilitation, Disaster Risk Management and Stakeholder Engagement and Consultation Plans, designed to improve both communication with stakeholders and reduction of risks in the historical center area. Additionally, mitigation measures have been included in the Environmental and Social Management Plan to reduce expected impacts to public transport users during construction phase	1. (i) Livelihood Rehabilitation Plan prepared; (ii) Disaster Risk Management Plan prepared; (iii) Stakeholder Engagement and Consultation Plan prepared; (iv) Communication seminars executed; (v) Mitigation measures included at the ESMP to reduce expected impacts to users executed. 2. (vi) Hiring a Social Specialist is part of the conditions for first disbursement, (vii) Compliance of the estimated timing for the construction works (from 6 to 12 months).
Environmental and Social Sustainability	Infrastructure investments could be affected by long-term flooding given that the area of intervention is a low-lying territory, vulnerable to climate-related risks. The project may not be	1	3	Medium	The interventions of this project form part of a series of interventions that the Government of Suriname is executing with different sources of financing, i.a. own resources and World Bank. These investments will be part of the City-	(i) City-level Adaptation Plan developed; and (ii) World Bank project approved.

4 Summary from the expanded risk assessment in accordance with the GRP procedures guide.
5 The principal means of mitigation defined with the Client will be included.

Expanded Risk Assessment for the project[4]						
Type of Risk *	**Risk**	**Probability Classification**	**Impact Classification**	**Risk Classification (High, Medium or Low)**	**Means of Mitigation[5]**	**Compliance Indicator**
	able to fully address flooding in the area.				level Adaptation Plan that will be financed with this project.	
Management and Governance	The poor administrative organization system of the Ministry of Public Works, Transport and Communication may influence the internal governance controls in relation to the independency of specific functions and corresponding separation and delegation of authority and responsibilities.	2	2	Medium	A Project Implementation Unit will be created to implement the project and is a condition prior to first disbursement. A Project Operations Manual will be adopted where the organizational structure, responsibilities and authorities will be presented emphasizing on the chain of command, span of control and lines of communication.	(i) Project Implementation Unit created; and (ii) Project Operations Manual approved.
Fiduciary	The Ministry of Public Works, Transport and Communication current staffing levels and capacity may be insufficient to efficiently manage the infrastructure works and provide proper oversight on fiduciary responsibilities.	2	2	Medium	A Project Implementation Unit will be created that consists of i.a. a Financial Management Specialist. A Project Operations Manual will be developed with clear financial management procedures considering the project's fiscal space, separation of duties, cash management, bank reconciliation, accounts payable, threshold signing	(i) Project Implementation Unit created; and (ii) Project Operations Manua2l approved.

Expanded Risk Assessment for the project[4]						
Type of Risk *	**Risk**	**Probability Classification**	**Impact Classification**	**Risk Classification (High, Medium or Low)**	**Means of Mitigation[5]**	**Compliance Indicator**
					rights, authorized signatures on bank accounts etc. Also, an accounting software complying with the Bank's policies will be procured. Additionally, staff of the execution unit will be trained in the Bank's financial management procedures and policies and reporting requirements.	
Monitoring and Accountability	The existing internal control system related to monitoring and evaluation and communication and social engagement of the Ministry of Public Works, Transport and Communication may be not sufficient for a critical success of the execution and management of the project	2	2	Medium	The project will incorporate a monitoring and evaluation plan that will be developed and managed by the Project Coordinator. Also, a strategic and pragmatic stakeholder communication and engagement strategy will be developed and deployed by the Social Specialist.	(i) Project Implementation Unit created that consists of i.a. a Project Coordinator and a Social Specialist; (ii) Monitoring and Evaluation Plan approve; (iii) ESMR and Livelihood Rehabilitation Plan approved.

* De velopment; Public Management and Go vernance; Macroeconomic and Fiscal Sustain ability; Environmental and Social Sustainability (According to IDB Policie s OP-703; OP-70 4; OP-710; OP-765; and GN-2531-10); Reputation; Monitoring an d Accountability; Fiduciary.

C. Describe the measures for environmental and social risk management, in line with the Environmental and Social Policy of the Adaptation Fund.

127. The ESIA in Annex E contains a detailed assessment of the potential environmental and social risks, and Table 15 (which is taken from the ESIA) summarizes the approach that the Project proponent and other involved parties (e.g., local contractors) would follow to manage, mitigate, and monitor the potential impacts of the Project. It includes the Project commitments and mitigation measures as identified in the ESIA, and also references a series of relevant management plans that have been prepared and are contained in the appendices.

Table 15: ESMP Measures and Related Management Plan and Monitoring Recommendations

Resource/Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
Air Quality					
Emissions from construction vehicles and equipment	Construction	See Appendix C for a Construction Environmental Management Plan, which includes the following: • Maintain all construction equipment in accordance with manufacturer's specifications. • Suppress dust as needed in unpaved areas. • Avoid burning non-vegetative wastes (refuse, etc.) at construction sites. • Avoid unnecessary idling of construction equipment or delivery trucks when not in use.	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Noise					
Noise generated by construction equipment and activities	Construction	See Appendix C for a Construction Environmental Management Plan, which includes the following: • Maintain all construction equipment in accordance with manufacturer's specifications. • Schedule construction and rehabilitation work during daylight hours and to minimize activity during peak periods of tourism and recreation (weekends, holidays, etc.). • Develop and implement a Construction Communications Plan to inform adjacent receptors (e.g., commercial businesses, churches, and tourists) of construction activities. • Use vibratory or press-in piling instead of impact piling during shore-based construction to avoid	Construction contractor	Site inspection during construction	Monthly progress reports during construction

Resource/Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
		generating impulsive noise and vibrations. • Limit construction noise levels to applicable standards such as BS 5228-1:2009+a1:2014 (British Standards Institution 2014), or FTA-VA-90-1003-06 (U.S. Federal Transportation Authority (FTA))			
Waste					
Waste generated by construction activities	Construction	See Appendix C for a Construction Environmental Management Plan, which includes the following: • Provide appropriate waste bins, type, volume and service frequency to accommodate anticipated waste streams. • All loads arriving or leaving the site will be appropriately secured. • Provide information regarding waste management in site specific inductions, including waste separation and importance of securing vehicle loads. • Ensure licensed contractors are used to collect controlled wastes	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Biodiversity					
Biodiversity management in general including the items below	Construction	See Appendix C for a Construction Environmental Management Plan, which includes the mitigation measures below.	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Loss or disturbance of vegetation	Construction	• When designing and planning work elements, minimize temporary and permanent construction footprints • Demarcate work area with fencing to minimize disturbance or removal of natural vegetation	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Wildlife injury or mortality	Construction	Proper disposal of dredged material to avoid wildlife exposure	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Disturbance and/or displacement of wildlife	Construction	• Conducting canal- and mangrove-related works outside the waterbird breeding season (April – Sept) • Minimize lighting • Implement above measures to minimize noise and air pollution	Construction contractor	Site inspection and interview of construction contractor	Monthly progress reports during construction

Resource/Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
Habitat alteration - mangroves	Construction Operation	Seasonal restriction (work to be done outside of bird breeding season which occurs from April-September)	Construction contractor	Site inspection	Monthly progress reports during construction
Habitat alteration - aquatic	Construction Operation	Implement sediment control procedures during in-water works to minimize the release of fine sediments to downstream waterways, particularly the Suriname River	Construction contractor	Site inspection	Monthly progress reports during construction
Social					
Loss of income for transport businesses	Construction	• Execute construction activities from the water side to reduce impacts on land-based businesses. • Temporarily relocate land and water-based businesses to adjacent locations in the immediate Project Area. • Develop and implement a Traffic and Pedestrian Management Plan (Appendix H). • Develop and implement a Livelihood Restoration Plan (see Appendix D) for potentially Affected Persons. • Continue stakeholder engagement through Project implementation through the use of the Stakeholder Engagement and Communications Plan (see Appendix A). • Implement a Grievance Mechanims to receive and respond to grievances (see in Appendix A).	Construction Contractor - Community Liaison Officer	Interviews with construction contractor and affected parties	Monthly progress reports during construction
Loss of water view	Construction	• See mitigations for "loss of income for transport businesses." No additional mitigations are necessary.	Construction Contractor - Community Liaison Officer	Interviews with construction contractor and affected parties	Monthly progress reports during construction
Loss of tourism	Construction	• See mitigations for "loss of income for transport businesses." No additional mitigations are necessary.	Construction Contractor - Community Liaison Officer	Interviews with construction contractor and affected parties	Monthly progress reports during construction
Provision of construction jobs to local companies and materials sourced from the local economy	Construction	Implement job quotas for local employment and sourcing requirements for construction contractors based on the size and scope of the Project	Construction contractor	Records review and interview of construction contractor	Monthly progress reports

Resource/Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
Potential vulnerable groups (gender or disability related)	Construction Operation	• Install proper lighting in the Project Area for early-morning and late-evening commuting; • Ensure adequate ground surfaces and associated infrastructure (such as ramps) for patron mobility (e.g., high heels and crutches) at both the temporary unloading dock and the rehabilitated location post construction; and • Conduct Gender Awareness Training for contractors and their staff.	Construction contractor	Records review and interview of construction contractor	Monthly progress reports
Traffic					
Decreased pedestrian and traffic safety	Construction	Implement Traffic and Pedestrian Management Plan to include early notification of road closures, detour signage, and safety programs and measures for pedestrians and bicyclists (Appendix H).	Construction contractor	Site inspection during construction	Monthly progress reports
Increased traffic congestion and disruption	Construction	Incorporate public transportation alternatives (e.g., pedestrian and bus) into Traffic and Pedestrian Management Plan (Appendix H)	Construction contractor	Site inspection during construction	Monthly progress reports
Decreased access to critical facilities, shopping, bus stops etc.	Construction	Implement Traffic and Pedestrian Management Plan to maintain continuous access through careful staging and sequencing of construction activities and provision of alternatives where needed (Appendix H)	Construction contractor	Site inspection during construction	Monthly progress reports
Cultural Resources					
Loss of cultural heritage site authenticity due to Project implementation	Construction Operation	Consult with the relevant cultural heritage stakeholders and develop and implement Cultural Heritage Management Plan (see Appendix F) to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS.	Construction contractor	Interviews with relevant stakeholders, site inspection	Monthly progress reports
Loss of cultural heritage site value due to Project changing the historic landscape of the Paramaribo WHS and diminished site view from historic buildings	Construction Operation	Consult with the relevant cultural heritage stakeholders and develop management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS (see Cultural Heritage Management Plan in Appendix F).	Construction contractor	Interviews with relevant stakeholders, site inspection	Monthly progress reports
Damage to undiscovered archaeological sites due to construction	Construction	Implement a Project Chance Finds Procedure (CFP) during all Project ground work (see Cultural Heritage Management Plan in Appendix F).	Construction contractor	Interviews with construction	Monthly progress reports

Resource/Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
of subsurface Project components				workers, site inspection	
Health and Safety					
Management of health and safety of both construction workers and the public	Construction	Develop and implement a Construction Health and Safety Plan (see Appendix E)	Construction contractor	Records review and interview of construction contractor	Monthly progress reports
Climate Change and Natural Hazards					
Climate change and natural hazards	Construction Operation	Implement a Construction Environmental Management Plan and a Health and Safety Plan	Construction contractor	Interviews with construction workers, site inspection	Monthly progress reports

D. Describe the monitoring and evaluation arrangements and provide a budgeted M&E plan.

I. Monitoring

128. The purpose of monitoring activities is to follow up program progress in achieving the expected results, as expressed in the Results Matrix (RM) and identify issues and problems during execution that can be corrected in due time. The monitoring program will be based on the RM, on the of activities described in the Annual Operating Plan (AOP), on the Multiyear Execution Plan (PEP), in the detail of the physical and financial performance of the products contained in the semiannual progress reports, and on the procurement, procedures contained in the Procurement Plan (PP). The beneficiary will submit semiannual progress reports to the Bank. The beneficiary agreed to use the RM and the activities defined in the Program Monitoring Report (PMR), as the basis to monitor the program's implementation. Monitoring activities include also annual financial audits to verify the compliance with financial and administrative procedures required by the Bank.

A. Indicators

129. Monitoring activities will be guided by the indicators expressed in the program's Results Matrix, specifically those classified as output indicators. The following table includes these indicators, frequency of measurement and source of verification.

Table 16: Output Indicators

Indicator	Unit of measure	Frequency of Measurement	Means of Verification
Component 1 - City-level Adaptation Framework and Plan			
City-wide Adaptation Plan for Paramaribo developed	Plan	Annually, Year 2 - 3	Acceptance by Program Implementation Unit (PIU).

Indicator	Unit of measure	Frequency of Measurement	Means of Verification
			Final version of the Adaptation Plan available on the web page of the MPW
Dissemination Strategy designed	Strategy	Annually, Year 3 – 4	Acceptance by PIU. Final version of the Dissemination Strategy and copies of the training materials available on the web page of the MPW.
Component 2 - Downtown Adaptation Measures			
Flood protection wall from Knuffelsgracht Street to SMS Pier with roadside drainage improvements, built	mts.	Annually, Year 3 – 4	Acceptance of Work (AW) by PIU Field reports from external supervision activities.
Van Sommelsdijck pumping station rehabilitated	Pumping station	Annually, Year 3 – 4	AW by PIU. Field reports from external supervision activities.
Mangroves restored in the outlet of Van Sommelsdijck canal	Ha.	Annually, Year 2 -3	AW by PIU. Field reports from external supervision activities.
Drainage Management Plan for urban Paramaribo, designed and implemented	Plan	Annually, Year 3 – 4	AW by PIU. Field reports from external supervision activities.
Component 3 - Capacity Building			
Knowledge Management Plan developed	Plan	End of Year 1	Acceptance by PIU. On-line training modules operational.
Capacity Building Plan on adaptation planning and management developed and implemented.	Training	Annually, Year 2- 3 – 4	AW by PIU. Workshops' list of participants.

Table 17: Output Annual Costs (in US$000)

Output	Year 1	Cost	Year 2	Cost	Year 3	Cost	Year 4	Cost	End of project	Cost
City-wide Adaptation Plan for Paramaribo developed			1	275					1	275
Dissemination Strategy designed							1	275	1	275
Flood protection wall from Knuffelsgracht Street to SMS Pier with roadside					250	3,964			250	3,964

Output	Year 1	Cost	Year 2	Cost	Year 3	Cost	Year 4	Cost	End of project	Cost
drainage improvements, built										
Van Sommelsdijck pumping station rehabilitated					1	2,741.5			1	2,741.5
Mangroves restored in the outlet of Van Sommelsdijck canal			0.16	290.5					0.16	290.5
Drainage Management Plan for urban Paramaribo, designed and implemented					1	576			1	576
Knowledge Management Plan developed	1	150							1	150
Training to technical and managerial staff on adaptation planning and management carried out.			1	77	1	77	1	76	3	230

B. Data Collection Instruments

130. The data on the program outputs will be coll ected as in dicated in t he Table 18. The Coordinator of the PIU, that will also be responsible for the planning and monitoring activities of the program, will prepare a Program Monitoring Plan (P MP) that will detail the source of information, data, indicators, statistics and methodology to be used for the supervision of each one of the activities of the program. It will also prepare semiannual progress reports for review by the Bank. The information for monitoring pr ogram progress will be pr ovided to the Bank following the formats and indicators included in the Result s Matrix (RM), Acquisitions Plan (AP), Multiyear Execution Plan (PEP) and Annual Operative Plan (AOP).

131. Most information will begenerated by either: (a) acceptance of works documents presented by contractors to the PIU; (b) direct inspection visits by PIU personnel; and (c) certification of field reports from external supervision activities presented by consultants to the PIU for their corresponding payment. This information will be consolidated by the PIU in the program´s MP and reported semi-annually to the Bank. Annually, the information will be included in the AOP presentation and discussion proce ss with the B ank. This will allow per iodic evaluations to compare progress in achieving RM goals, including explanations whenever any distortion is identified.

132. The expected cost for data collection is $USD98.000[6], covered by the Program.

[6] This is the estimated costs for the Program Coordinator who will also be responsible for the planning and monitoring activities of the program.

Table 18: Data Collection Activities and Schedule

Monitoring Activities	Year 1				Year 2				Year 3				Year 4				Responsible
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Collection of Indicators																	PIU
City-wide Adaptation Plan for Paramaribo developed[7]																	PIU
Dissemination Strategy designed[8]																	PIU
Flood protection wall from Knuffelsgracht Street to SMS Pier, with roadside drainage improvements. constructed																	PIU
Van Sommelsdijck pumping station rehabilitated																	PIU
Mangroves restored in the outlet of Van Sommelsdijck canal																	PIU
Drainage Management Plan for urban Paramaribo, designed and implemented																	PIU
Knowledge Management Plan developed																	PIU
Trainings on adaptation planning and management implemented.																	PIU

C. Progress Reporting

133. The PIU will present periodic monitoring reports, based on consolidated information gleaned from the program's AIS. Reports based on this information will be used to update the Semi-Annual Progress Report and the Bank's Program Monitoring Report (PMR). A midterm evaluation will be undertaken. It will include: (i) the outcomes of the physical-financial execution; (ii) the degree of fulfillment of targets in the results matrix; (iii) the degree of fulfillment of environmental requirements and works maintenance; (iv) a summary of the results of the audits and of the improvement plans; (v) a summary of the main lessons learned. The midterm evaluation will be conducted in the second six months of the second year of implementation. The costs of preparing these products are included in the Program Administration Costs, used to pay for PIU personnel, auditing and program evaluation.

134. The beneficiary shall submit to the Bank annual Audited Financial Statements (EFA) within 120 days of the close of each fiscal year, duly audited by an independent auditing firm and semiannual progress reports prepared by the auditing firm hired.

135. The PIU will prepare and send to the Bank a final evaluation report which will serve as input for the Completion Report Project (Project Completion Report-PCR), 90 days counted from the date 90% of the loan has been disbursed.

D. Coordination and Monitoring Work plan

136. The MPW will hire a systems operations and program monitoring specialist as program coordinator, who will be responsible for monitoring program activities, which include: (i) to

[7] This will include the development of a survey before the formulation of the Plan, with the aim to identify and include the concerns of the population in the Adaptation Plan ($25,000).

[8] This will include the development of a survey after the dissemination process to verify if the main concerns raised during the consultations with the population have been included to the Plan ($25,000).

develop, maintain and update the data regarding monitoring indicators; (ii) coordinate the collection and processing of information on program actions and prepare semiannual progress reports; (iii) identify problems, delays and external factors affecting the program proposing, where appropriate, remedial measures; and (iv) support monitoring internal meetings and program evaluation and supervision missions and evaluation of the Bank.

137. The Bank and the PIU will hold meetings twice a year to monitor jointly the progress in implementing the operation. Also, the PIU, in conjunction with the Bank, will hold official inspection visits at least twice a year to assess the progress of the program.

138. When inspection visits identify delays in physical and financial implementation, appropriate measures will be established to identify: (i) the main difficulties in implementation, (ii) actions to overcome the difficulties; and (iii) the time and costs thereof.

Table 19: Monitoring Work Plan

Monitoring Activities	**Year 1**				**Year 2**				**Year 3**				**Year 4**				**Responsible**	**Source / Cost (US$000)**
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
Program Monitoring Plan (PMP) is established																	PIU Coordinator	Program/ US$100.8[9]
Information Collection and updating of the PMP																	PIU	
Inspection Visits to ongoing works by PIU personnel																	PIU	
Consolidation of Information and presentation of semi-annual reports																	PIU	
Annual Operation Plan discussion with IDB Staff																	PIU/IDB	
Meeting with IDB staff																	PIU/IDB	
Survey before the formulation of the Adaptation Plan for Paramaribo, with the aim to identify and include the concerns of the population in the Adaptation Plan																	PIU	Program/ US$25[10]
Survey after the dissemination process to verify if the main concerns raised during the																	PIU	Program/ US$25[11]

9 Corresponds to the Program Coordinator´s remuneration. Included in the Personnel costs.
10 Included in the Activity 1.1; Component 1, budget.
11 Included in the Activity 1.2; Component 1, budget.

Monitoring Activities	Year 1				Year 2				Year 3				Year 4				Responsible	Source / Cost (US$000)
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
consultations with the population have been included to the Adaptation Plan																		
Financial Audits																	PIU/ consultancies	Program/ US$100
Total Costs																		Program/ US$250.8

II. Evaluation

139. The evaluation of the program will be done once the program has been completed in order to determine if its objectives have been achieved. The questions the evaluation will answer are listed below.

A. Evaluation Questions

140. The evaluation will answer the following questions:

- Did awareness of the Paramaribo citizens related to predicted adverse impacts of climate change on flooding increased after program completion?
- Was there significant participation on women in consultation activities of the City-wide Adaptation Plan?
- Was the modeled expected coastal and inland inundation area in the Paramaribo Historic center reduced after the interventions?
- Were the modeled expected annual economic losses from flooding in the waterfront area reduced after the interventions?
- Did the selected institutions increased their capacity to minimize exposure to climate change from flooding in the historic area of Paramaribo?
- Was there significant completion of trainings from women (technical and managerial staff) across GoS stakeholders?

B. Evaluation's Outcome Indicators.

141. The following indicators are used for the evaluation:

Table 20: Outcome Indicators

Indicator	Unit	Frequency	Means of Verification
Paramaribo citizens living or working in the historic area aware of predicted adverse impacts of climate change on flooding, and of appropriate responses over the number of unaware citizens.	Surveyed citizens with appropriate responses / Surveyed citizens	End of year 1 and 4	Results of baseline and end of project surveys available on the Web page of the MPW. Acceptance by PIU
Women participating in consultation activities of the City-wide Adaptation Plan over number of total participants.	Female participants / Total participants	End of year 1 and end of project	Gender participation lists of consultation activities
Reduction in modeled expected coastal and inland inundation area in the Paramaribo Historic area.	Square meters	End of year 1 and end of project	Model developed for the project will be run using a specialized software package to assess flooding risks.
Reduction in modeled expected annual economic losses from flooding per square meter in the waterfront area.	Surinamese Dollar (2018) per square meter	Model developed for the project will be run using a specialized software package to assess flooding risks.	Model developed for the project will be run using a specialized software package to assess flooding risks.
Institutions with increased capacity to minimize exposure to climate change induced flooding in the historic area of Paramaribo	Number of Institutions	Years 2, 3 and 4.	List of institutions participants Acceptance by PIU
Number of female technical and managerial staff across GoS stakeholders that completed the trainings over number of total training participants.	Female participants that completed the trainings / Total participants that completed the trainings	End of project.	Lists of participants by gender Acceptance by PIU

142. The program's evaluation will determine if the program's objectives were achieved by answering the evaluation questions. This will be done by analyzing if the outcome indicators in the results matrix achieved their expected targets. In addition, an economic ex post cost-benefit analysis will be carried out at the end of the program, to determine the actual economic rate of return of the program and establish whether the program generated more benefits than costs to Suriname.

143. In order for the survey to measure the results indicator 1 (awareness), the sample size (n) should be at of at least 384 effective surveys. This sample size was estimated using a 95 percent confidence level and a 5 percent sample error (e):

$$n = \frac{Z_{\alpha}^{2} N p (1-p)}{e^{2}(N-1) + Z_{\alpha}^{2} p(1-p)}$$

Where:

N: 250.000 (Paramaribo's population)

Z: 1.96

p: 0.5

e: 0.05

C. Reflexive Evaluation:

144. A reflexive evaluation will be undertaken to answer the evaluation questions and thus if the program achieved its development objectives. This will be done by comparing the outcome indicator before and after the program and determining whether each outcome reached their expected targets. The data on the outcome indicators will be collected as specified in table above.

145. The outcome indicators related to awareness of climate associated risks require a survey of Paramaribo citizens at the end of the project. The survey will the level of awareness of predicted adverse impacts of climate change on flooding after the program and compare it to the time prior to the program intervention.

146. The reduction for both inundation area and annual economic losses will be derives from flood risks models, which will be updated with the end of project delivered downtown adaptation measures and complemented with an ex-post economic analysis (see ex-ante economic analysis in the following link).

D. Economic Ex Post Evaluation

147. The aim of the ex post evaluation is to verify if the estimated economic rate of return (ERR) and the Net Present Value (NPV) as well as the assumptions used in the ex-ante cost benefit analysis were robust and accrued after program implementation. The results of the ex-ante analysis yielded the following: Using a discount rate of 12%, the program generated a Net Present Value (NPV) of US$25.8 millions.

148. The ex post cost benefit analysis will use the same methodology employed in the ex-ante analysis and is described below. For the ex-post cost-benefit analysis, a new ERR and NPV will be calculated using the investment costs and maintenance costs incurred. Likewise, the economic benefit will be the property value differential that accrued in the historic city center after the program interventions were completed.

E. Coordination and Evaluation Work Plan

149. The final evaluation will be conducted in the final six months of program implementation. It will combine the ex post economic analysis and the evaluation of the results indicators of the Results Matrix. These evaluations will be contracted to an independent consultant who may hire a research team to conduct specific data collection activities related to the mobility component and to the property valuation data.

150. The evaluation activities by the consultant will be carried out in direct coordination with the Bank and the PIU and will include:

- Collect the information on the outcome indicators included in the results matrix.
- Collect all information necessary to answer the evaluation questions an d undertake the ex-post cost benefit analysis.
- Undertake the cost-benefit economic analysis of the program following the methodology used in the ex-ante analysis and presented above.
- Write an evaluation rep ort that answers the evaluation que stions substantiated by data and presents the ex post cost benefit analysis of the program.
- Hold meetings with Bank / PIU and the main actors involved in the design and execution of the operation to obtain the necessary information to carry out the evaluation and to keep them informed of the its progress, results and findings.

F. Data Collection and Evaluation

151. The information will be compiled based on the Results Matrix and the ex-ante Economic Analysis. Table 21 presents the evaluation activities schedule.

Table 21: Evaluation Activities and Schedule

Activities	**Year 1**				**Year 2**				**Year 3**				**Year 4**				**Responsibilities / Cost**
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	
Hiring of Consultant to undertake midterm evaluation								■	■	■							PIU/ US$20.000
Hiring of Consultant to undertake final evaluation inclu ding data collection.															■		PIU/ US$25.000
Hiring of Consultant to undertake PCR (includes CBA ex post)																■	PIU/ US$35.000
Total																	**US$80.000**

G. Presentation of Evaluation Reports

152. The PIU will prepare a nd submit to the Bank an evaluation report based on th e two (2) assessment methodologies at the end of the program. Once they have been accepted by the Bank, these two evaluation reports will b e made available to th e public thr ough the websites of the PIU. Th ese evaluations will be conducted b y consulting firms, which will be hired by the PIU and financed with investment grant proceeds.

153. The beneficiary has agr eed with th e methodologies for all the evaluat ions and ex po st economic evaluation. The budget of US$80.00 0 is include d in the program as pa rt of the program administrative costs.

E. Include a results framework for the project proposal, including milestones, targets and indicators.

154. Table 22 presents a results matrix for the project.

Table 22: Results Matrix

Results Matrix									
Project objective	The main objective of the project is to contribute to increasing the adaptive capacity of communities living in Paramaribo city and in particular historic downtown vulnerable areas to cope with observed and anticipated impacts of climate change on floods and sea level rise.								
OUTCOMES									
Component 1: City-level Adaptation Framework and Plan									
Outcome 1: Strengthened awareness of climate associated risks and ownership of adaptation process by Paramaribo citizens including the metropolitan area									
Indicator	**Unit of measure**	**Baseline**	**Baseline year**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**End of project**	**Comments/ Means of verification**
Paramaribo citizens living or working in the historic area aware of predicted adverse impacts of clim ate change on flooding, and of appropriate responses over the number of unaware citizens.	Surveyed citizens with appropriate responses / Surveyed citizens	TBD	2018						Comments: (i) Aware citizens will be those that understand flooding inundation hazard and risk maps for the historical area and are able to use this information to recognize critical levels of risks; (ii) baseline data will be obtained through a survey before starting project implementation. At the end of the project a second survey will be carried out together with a simple test. (iii) Country official population data for the historic area will be used to estimate targeted population. Means of verification: Results of baseline and end of project surveys.
Women participating in consultation activities of the City-wide Adaptation Plan over number of total participants.	Female participants / Total participants	0.0	2018	40	0.0	0.0	0.0	40	Comments: (i) The Adaptation Plan (AP) will cover all the city of Paramaribo and its metropolitan area. (ii) the AP is a dynamic document that will need to be revised periodically and should be connected to the national priorities established in the country's National Determined Contribution (NDC) and the National Adaptation Plan; (iii) At least 40% of women participation is considered to be a "gender-balanced" for UN/EU. Means of verification: Participation lists of consultation activities.

Component 2: Downtown adaptation hard measures									
Outcome 2: Population and businesses serving historic downtown Paramaribo reduce their exposure to flood events									
Indicator	**Unit of measure**	**Baseline**	**Baseline year**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**End of project**	**Comments/ Means of verification**
Reduction in modeled expected coastal and inland inundation area in the Paramaribo Historic area.	Square meters	473,472	2018			471,584		470,472	Comments: (i) Results from flood risk models, considering the effect of project mitigation work at the w aterfront area using historical storms data but also including future storms and h ydrographs with data extracted from the R CP 6.0 climate change scenario. (ii) Paramaribo Historic area re fers to protected areas within the historic center adjacent to th e waterfront and the Sommelsdijck Canal. Means of Verification: Model developed for the pr oject will be r un using a specialized software package to assess flooding risks.
Reduction in modeled expected annual economic losses from flooding per square meter in the waterfront area.	U.S. Dollars (2018) per square meter	330	2018					343 (347 expected without project)	Comment: (i) Results from flood risk models, considering the effect of project mitigation work at the waterfront area using historical storms data but also including future storms and hydrographs with data e xtracted from the R CP 6.0 climate change scenario. (ii) Ha bitants and business projections will be concentrated to the areas adjacent to the waterfront and Sommelsdijck Canal. Means of Verification: Model developed for the pr oject will be r un using a specialized software package to assess flooding risks.
Outcome 3: Strengthened GoS institutional capacity to reduce risks associated with climate-induced socioeconomic and environmental losses caused by flooding and sea level rise.									
Institutions with increased capacity to minimize exposure to climate change induced flooding in the historic area of Paramaribo	Number of Institutions	0.0	2018	0.0	1.0	0.0	2.0	3.0	Comments: (i) Priority will be giv en to the Ministry of Public Wor ks given its key leading role du ring implementation; (ii) Increased capacity is understood as participants completing the training; Means of verification: Lists of participants.

Number of female technical and managerial staff across GoS stakeholders that completed the trainings over number of total training participants.	Female participants that completed the trainings / Total participants that completed the trainings	0.0	2018	0.0	0.0	0.0	40	40	Comments: (i) Main objective of training activities will be to build capacity across the GoS stakeholders responsible for decision making in Paramaribo to ensure strong implementation and enforcement of the Adaptation Plan; (ii) Trainings will be customized to the types of users and their needs for what a Knowledge Management Plan will be developed. Means of verification: List of participants that completed the trainings.

Products

Component 1: City-level Adaptation Framework and Plan

Product	Unit of measure	Associated results	Cost (US$)	Baseline	Year 1	Year 2	Year 3	Year 4	End of project	Comments/ Verification means
City-wide Adaptation Plan for Paramaribo developed	Plan	1	275.000	0.0	0.0	1.0	0.0	0.0	1.0	Comments: (i) "Developed" means that there is a written version that has been consulted and is ready for major's consideration for approval and further dissemination. (ii) The Adaptation Plan will provide a framework for managing, prioritizing and implementing adaptation and resilience measures along with a standardized approach. It will be socialized with local vulnerable communities and shall be endorsed by city major before it is presented for approval to the ministries' council. (iii) It will also include a participatory process with consultation to civil society. Means of Verification: Final version of the Adaptation Plan
Dissemination Strategy of Adaptation Plan and knowledge generated by its development designed	Strategy	1	275.000	0.0	0.0	0.0	1.0	0.0	1.0	Comments: (i) The dissemination strategy will include different means to share lessons learned from the development and implementation of the Adaptation Plan such as brochures, videos, technical notes, workshops, among others; (ii) The workshops will have a focus on gender-equality and local vulnerable communities in the metropolitan area. Means of verification; Final version of the Strategy and copies of the training materials.

Component 2: Downtown Adaptation measures										
Flood protection wall from Knuffelsgracht Street to SMS Pier with roadside drainage improvements, built	mts	2	3.964.000	0.0	0.0	0.0	250	0.0	250	Comments: (1) Wall made from steel sheet piles with coverage of bricks or concrete. Use of stone in the embankment to avoid debris accumulation. (2) Includes: walkway of 2- 4 meters and road side drainage and add trees/green. (3) Historic landing for small boats to be rehabilitated. (4) Old steel jetty to be used by boat taxis during execution to be rehabilitated. Means of Verification: Field report
Van Sommelsdijck pumping station rehabilitated	Pumping station	2	2.741.500	0.0	0.0	0.0	1.0	0.0	1.0	Comments: (i) The rehabilitation of the Van Sommelsdijck pumping station entails: **1)** the acquisition of a new 4.5 m^3/seg pump; **2)** the repair of two existing pumps that are not currently operational; **3)** Sluice gates rehabilitated and automate control in operational condition; **4)** restoration of the basin upstream of the canal before entering the pumping station. Activities to restore the basin are aimed at increasing existing water storage capacity to act as a buffer area. Means of Verification: Field Report
Mangroves restored in the outlet of Van Sommelsdijck canal	Ha	2	290.500	0.0	0.0	0.16	0.0	0.0	0.16	Comments: (i) Restoration activities relates to those that aim at assisting the recovery of resilience and adaptive capacity of ecosystems that have been degraded, damaged or destroyed; (ii) Mangroves to act as a buffer area and to catch sediments; (ii) restoration activities will include also the planting of new plants and sediments catchment. Means of Verification: Field reports from supervision activities.
Drainage Management Plan for urban Paramaribo, designed and implemented	Plan	2	576.000	0.0	0.0	0.0	1.0	0.0	1.0	Comments: (i) The design of the plan will cover all the city, but the implementation will cover only the historic center; (ii) The Plan will include roles, responsibilities and frequency of actions; (iii) It must be synchronized with existing and future urban development plans and storm and water management activities and plans conducted by the Ministry of Public Works. Means of Verification: Final version of the Plan and field reports.

Component 3: Capacity Building										
Knowledge Management Plan developed	Plan	3	150.000	0.0	1.0	0.0	0.0	0.0	1.0	Comments: (i) "Developed" means that the document is ready to be used and contains the following sections: definition of target audience, identification of K&L needs and organization and prioritization of those needs; (ii) The Knowledge Plan (KMP) will help customize training modules so that they respond to the needs of identified main users of clima te risk and a daptation information as well as lessons learned from the implementation of this pr oject; (iii) In addition, the K MP will also include an Institutional Capacity Assessment which is aimed at identifying specific actions to enhance the GoS capacity to mainstream climate change adaptation into policies, regulations and development planning at the city level. Means of verif ication: On-line training modules operational.
Training to technical and managerial staff on adaptation planning and management carried out.	Training	3	230.000	0.0	0.0	1.0	1.0	1.0	3.0	Comments: (i) Based upon the final structure of the Paramaribo Adaptation Plan, the Kno wledge Management Plan and the Instituti onal Evaluation, the ke y need for capacity building within the GoS will be identified; (ii) Special emphasis will be made to ensure a gender balance participation in the workshops; (iii) It is envisioned that the training will include among other topics, data and information of climate change p rojections and expected impacts for Suriname, flood hazard and risk maps, methods and tools to assess flooding risks among others. Means of verification: Trainings' list of participants.

F. Demonstrate how the project / programme aligns with the Results Framework of the Adaptation Fund

155. Table 23 below also provides relevant commentary against the Adaptation Fund's results matrix.

Table 23: Adaptation Fund Results Matrix

Project Objective(s)[12]	Project Objective Indicator(s)	Fund Outcome	Fund Outcome Indicator	Grant Amount (USD)
City-level Adaptation Framework and Plan	City-wide Adaptation Plan for Paramaribo developed	**Outcome 3:** Strengthened awareness and ownership of adaptation and climate risk reduction processes at local level	**3.1.** Percentage of targeted population aware of predicted adverse impacts of climate change, and of appropriate responses	275,000
	Dissemination Strategy of Adaptation Plan and knowledge generated by its development designed and implemented	**Outcome 3:** Strengthened awareness and ownership of adaptation and climate risk reduction processes at local level	**3.1.1** No. and type of risk reduction actions or strategies introduced at local level	275,000
Downtown Adaptation measures	Flood protection wall from Knuffelsgracht Street to SMS Pier, with roadside drainage improvements. constructed	**Outcome 4:** Increased adaptive capacity within relevant development and natural resource sectors	**4.1.2.** No. of physical assets strengthened or constructed to withstand conditions resulting from climate variability and change (by asset types)	3,964,000
	Van Sommelsdijck pumping station rehabilitated	**Outcome 4:** Increased adaptive capacity within relevant development and natural resource sectors	**4.2.** Physical infrastructure improved to withstand climate change and variability-induced stress	2,741.5
	Mangroves restored in the outlet of Van Sommelsdijck canal	**Outcome 5:** Increased ecosystem	**5.1.** No. and type of natural resource assets	290,500

[12] The AF utilized OECD/DAC terminology for its results framework. Project proponents may use different terminology but the overall principle should still apply

		resilience in response to climate change and variability-induced stress	created, maintained or improved to withstand conditions resulting from climate variability and change (by type of assets)	
	Drainage Management Plan for urban Paramaribo, designed and implemented	**Outcome 3:** Strengthened awareness and ownership of adaptation and climate risk reduction processes at local level	**3.1.** Percentage of targeted population aware of predicted adverse impacts of climate change, and of appropriate responses	576,000
Capacity Building	Knowledge Management Plan developed	**Outcome 2:** Strengthened institutional capacity to reduce risks associated with climate-induced socioeconomic and environmental losses	**2.1.2.** Capacity of staff to respond to, and mitigate impacts of, climate-related events from targeted institutions increased	150,000
	Trainings on adaptation planning and management implemented	**Outcome 2:** Strengthened institutional capacity to reduce risks associated with climate-induced socioeconomic and environmental losses	**2.1.1.** No. of staff trained to respond to, and mitigate impacts of, climate-related events	230,000
Project Outcome(s)	**Project Outcome Indicator(s)**	**Fund Output**	**Fund Output Indicator**	**Grant Amount (USD)**
Outcome 1. Strengthened awareness of climate associated risks and ownership of adaptation process by Paramaribo citizens including	Paramaribo citizens living or working in the historic area aware of predicted adverse impacts of climate change on flooding, and of appropriate responses over the number of unaware citizens.	**Output 3**: Targeted population groups participating in adaptation and risk reduction awareness activities	**3.1.1** No. and type of risk reduction actions or strategies introduced at local level	500,000
	Women participating in consultation activities of the City-wide Adaptation			

the metropolitan area.	Plan over number of total participants.			
Outcome 2. Population and businesses serving historic downtown Paramaribo reduce their exposure to flood events	Reduction in modeled expected coastal and inland inundation area in the Paramaribo Historic area.	**Output 6:** Targeted individual and community livelihood strategies strengthened in relation to climate change impacts, including variability	**6.1.1.** No. and type of adaptation assets (physical as well as knowledge) created in support of individual or community-livelihood strategies	
	Reduction in modeled expected annual economic losses from flooding per square meter in the waterfront area.			
Outcome 3. Strengthened GoS institutional capacity to reduce risks associated with climate-induced socioeconomic and environmental losses caused by flooding and sea level rise.	Institutions with increased capacity to minimize exposure to climate change induced flooding in the historic area of Paramaribo	**Output 2.1:** Strengthened capacity of national and regional centres and networks to respond rapidly to extreme weather events	**2.1.1.** No. of staff trained to respond to, and mitigate impacts of, climate-related events	
	Number of female technical and managerial staff across GoS stakeholders that completed the trainings over number of total training participants.	**Output 2.2:** Targeted population groups covered by adequate risk reduction systems	**2.1.2.** Capacity of staff to respond to, and mitigate impacts of, climate-related events from targeted institutions increased	

G. Include a detailed budget with budget notes, a budget on the Implementing Entity management fee use, and an explanation and a breakdown of the execution costs.

156. Table 24 presents the budget details for the proposed Project.

Table 24 – Project Budget

Project Components	Cost
1. City-Level Adaptation Framework and Plan	USD 550,000.00
2. Downtown Adaptation Measures	USD 7,572,000.00
3. Capacity Building	USD 380,000.00
4. Project Administration	USD 400,000.00
Auditing costs	USD 100,000.00
Monitoring and evaluation	USD 80,000.00
Project Cycle Management Fee	USD 768,000.00
Total	**USD 9,850,000.00**

1. Total Project Cost (TPC) - Total of (1) to (3) and monitoring and evaluation above	**$8,582,000**
2. Total Project Management (TPM) Cost – total of Project Administration and Audit costs (max. 9.5% of TPC)	**$500,000**
3. Project Cycle Management Fee charged by the Implementing Entity (max. 8.5% of TPC + TPM))	**$768,000**
Amount of Financing Requested	**$9,850,000**

H. Include a disbursement schedule with time-bound milestones.

157. The Project Execution Plan which details the disbursement schedule as well as the time-bound milestones is included as Annex F. A recap of the disbursement is provided in the table below.

Table 25 – Disbursement Schedule

TOTAL PER YEAR	
YEAR 1	**$660,500**
disbursement 1	*$112,500*
disbursement 2	*$558,000*
YEAR 2	**$4,936,400**
disbursement 3	*$1,796,300*
disbursement 4	*$3,140,100*
YEAR 3	**$3,140,100**
disbursement 5	*$2,773,400*
disbursement 6	*$366,700*
YEAR 4	**$345,000**
disbursement 7	*$130,000*
disbursement 8	*$215,000*
Total (excluding Project Cycle Management Fee)	**$9,082,000**

PART IV: ENDORSEMENT BY GOVERNMENT AND CERTIFICATION BY THE IMPLEMENTING ENTITY

A. Record of endorsement on behalf of the government[1] *Provide the name and position of the government official and indicate date of endorsement. If this is a regional project/programme, list the endorsing officials all the participating countries. The endorsement letter(s) should be attached as an annex to the project/programme proposal. Please attach the endorsement letter(s) with this template; add as many participating governments if a regional project/programme:*

Winston G. Lackin, Designated Authority of Suriname, Member of the High Council of Advisors to the President of the Republic of Suriname	Date: 1 augustus 2018

B. Implementing Entity certification *Provide the name and signature of the Implementing Entity Coordinator and the date of signature. Provide also the project/programme contact person's name, telephone number and email address*

I certify that this proposal has been prepared in accordance with guidelines provided by the Adaptation Fund Board, and prevailing National Development and Adaptation Plans: National Climate Change Policy, Strategy and Action Plan of 2015, Multi-annual Development Plan 2012-2016 and subject to the approval by the Adaptation Fund Board, commit to implementing the project/programme in compliance with the Environmental and Social Policy of the Adaptation Fund and on the understanding that the Implementing Entity will be fully (legally and financially) responsible for the implementation of this project/programme.	
Sonia Rivera, Focal Point IDB to Adaptation Fund *Implementing Entity Coordinator*	Sonia Ma. Rivera
Date: August 2, 2018	Tel. and email: 202-623-2018 SONIAR@IADB.ORG

[6] Each Party shall designate and communicate to the secretariat the authority that will endorse on behalf of the national government the projects and programmes proposed by the implementing entities.

Date: 8/6/2018	Tel. and email: jesusn@iadb.org, +1 202 566-4556
Project Contact Person: Jesus Navarrete, Team Leader / Alfred Grundwalt, Alternative Team Leader	
Tel. And Email: alfredg@iadb.org, +1 202 623-3798	

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Annex A - Site-Specific Risk Analysis for the Paramaribo Climate Change Adaptation Fund Project

Prepared For:

Inter-American Development Bank

Site-Specific Risk Analysis for the Paramaribo Climate Change Adaptation Fund Project

July 2018

Environment Safeguards Unit
Inter-American Development Bank
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Washington, DC 20577

Environmental Resources Management
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Washington, DC 20006

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Prepared for:
Inter-American Development Bank

Site-Specific Risk Analysis for the Paramaribo Climate Change Adaptation Fund Project

July 2018

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Partner

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Washington, DC 20006

http://www.erm.com

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EPA	Environmental Protection Agency
DTM	Digital Terrain Model
DEM	Digital Elevation Model
ERM	Environmental Resources Management, Inc.
GEV	Generalized Extreme Value
GUI	Graphical User Interface
GCM	General Circulation Model
hr	hour
HHWL	Higher High Water Level
HHW	Higher High Water
IDB	Inter-American Development Bank
IDF	Intensity Duration Frequency
IPCC	Intergovernmental Panel on Climate Change
MPW	Ministry of Public Works
NCCR	National Coordination Center for Disaster Relief
km^2	square kilometers
m^2	square meters
m	meters
m/s	meters per second
m^3/s	cubic meters per second
mm	millimeters
MAS	Maritime Authority Suriname (*Maritieme Autoriteit Suriname*)
NSP	Normaal Surinaamse Peil
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
SRES	Special Report on Emissions Scenarios
SLR	Sea Level Rise

1.0 INTRODUCTION

The IDB, in conjunction with the Government of Suriname, prepared and submitted a concept note proposal to the Adaptation Fund to finance the development of a series of projects that would contribute towards increasing the adaptive capacity of communities living in Paramaribo city and the adjacent metropolitan areas to cope with observed and anticipated impacts of climate change on floods and sea level rise. The main objectives of this proposal were to implement a group of strategic and cost-effective hard adaptation measures in the historic downtown area of Paramaribo that illustrate the benefits of building climate resilience as part of a long-term planning strategy for the city and its metropolitan area. It will also establish a framework for managing knowledge and disseminating lessons learned that could be used in future resilience programs for the city of Paramaribo and that could be part of a city-level Adaptation Plan.

As part of this overall strategy, an extensive site-specific risk analysis related to flooding in the historic center of Paramaribo (the Study Area as shown in Figure 1) was conducted. ERM evaluated the physical hazards due to flooding from extreme climate events and assessed vulnerability based on asset, population density, and land use information (See Figure 2). Maximum water levels and precipitation for 10-, 25-, 50-, and 100-year return periods were used to inform this analysis as well as future climate change projections. The physical hazards from flooding were evaluated using high resolution numerical modelling of the Study Area and estimating risk using analytical approaches developed by ERM along with a geospatial data analysis (GIS) system. In addition to the baseline flood assessment of the Study Area, a flood modelling study was conducted by applying infrastructure improvement alternatives to evaluate the effectiveness of these alternatives as well as assess the need for additional flood management measures.

Figure 1: Study Area

Figure 2: Study Area showing monumental assets and social receptors

2.0 *HISTORICAL FLOODS*

According to the Environment Statistics (2016), Suriname experiences frequent floods in the coastal plain and rivers. Floods at the Study Area occur when sea level rises during spring tide and during tropical storms by impacting low-lying riverine development and infrastructure. In addition, flooding is caused by rainfall-induced accumulation of water due to its outdated and insufficient drainage system. The UNDP considers Suriname in the list of the ten vulnerable countries with low-lying coastal plains that are threatened by Sea Level Rise (SLR) in this century. According to Environmental Statistics (2016) and NCCR[1]

[1] NCCR – National Coordination Center for Disaster Relief is a disaster management organization of Suriname.

Situation Analysis, 31 flood disasters have occurred in Suriname between 2004-2015 and 50% of them affected the city of Paramaribo and neighboring districts.

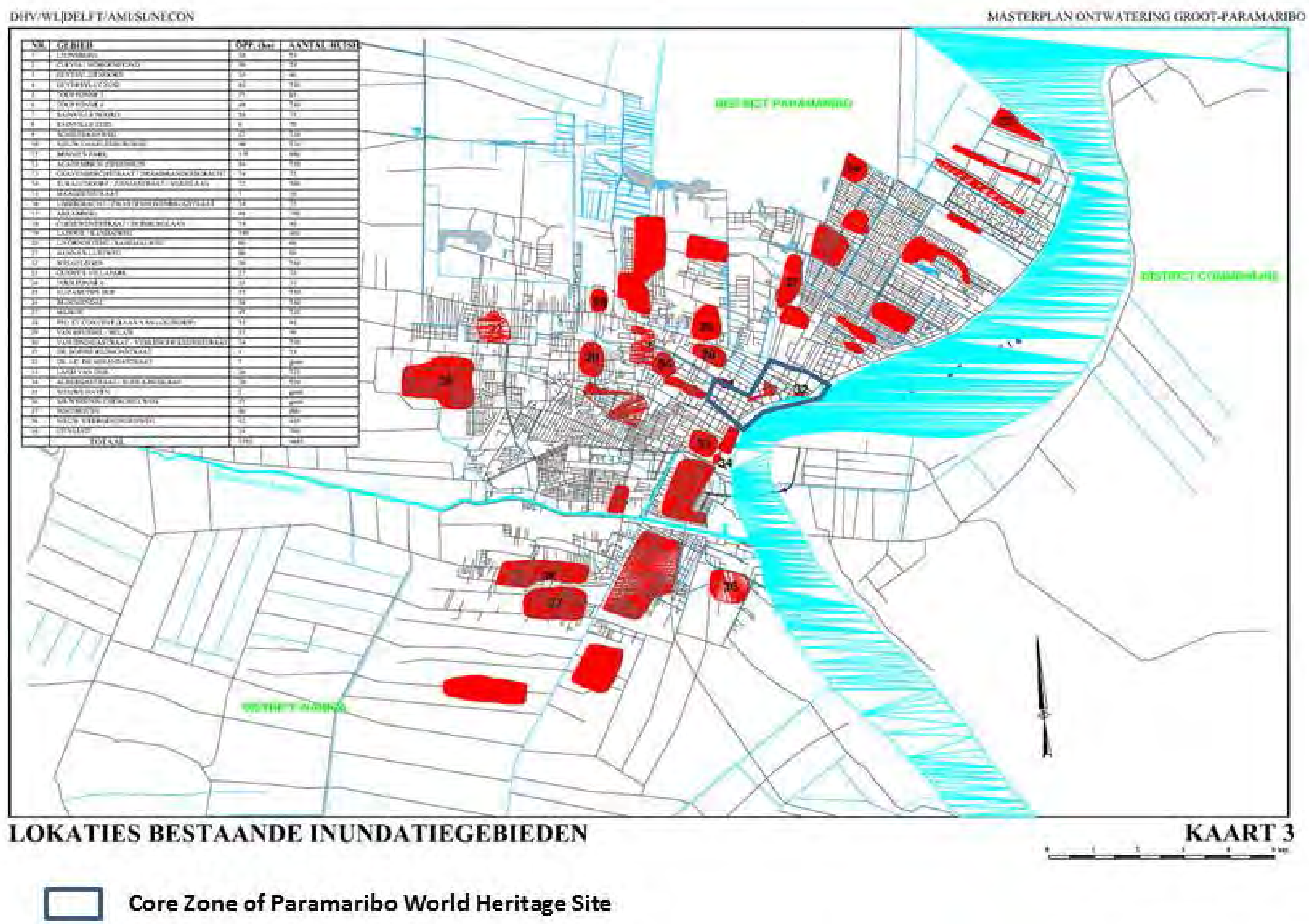
The urban area of Paramaribo is considered highly vulnerable to floods due to sea level rise and increasing of intensity of precipitation **(*see*** Source: Adapted from MOGP, 2001

Figure 3); loss of land due to coastal and riverbank erosion; longer and frequent severe dry periods; and uncontrolled urbanization towards the North area (Noordam, 2007). At the east side of Paramaribo City flows the Suriname River, which is a tidal influenced river with a catchment area of 16,500 square kilometers (km2). Its waters are discharged into the Atlantic Ocean and its flow has been regulated by the hydropower Afobaka Dam (Prof. van Blommenstein reservoir) since 1964 located approximately 194 km upstream of Paramaribo.

According to Karijokromo (2011), before the flood of May 2006, natural disasters were not frequent in Suriname. There were some historical normal floods produced by an outdated drainage system in different areas of Paramaribo City. The impacts of these normal floods were not as damaging as the flood that occurred on 2006. The Preventionweb (2016) reports that flooding represent an Average Annual Loss (AAL) of USD $53.81M for Suriname.

Inland and coastal flooding in urban areas of Paramaribo is produced from high volume of precipitation, poor drainage, and rising sea and river water levels. According to MOGP (2002), in 2002, approximately 13% of the total urban area of Paramaribo was affected by this hazard causing economic damage and health conditions associated with stagnant water. The most recent severe floods in Paramaribo occurred in 2006 and 2008 but no records of economic or lives losses were available. Floods in Paramaribo are principally caused because large parts of the city were built on low-lying lands and the lack of an updated storm water drainage system (see Figure 2). The Study Area is prone to floods because it is located at low-lying lands and it is part of the left bank of the Suriname River. This river is tidal influenced and when high water level of the Suriname River is combined with runoff from, impermeable areas produce floods affecting properties within the Study Area.

Most of the floods in the Study Area occur during spring tide. Breaching or overtopping of defensive structures, results in tidal flooding by saline or brackish water. At the mouth of Suriname River, the mean tidal range is 1.8 m between neap tide and spring tide. A slightly positive increase of +0.6 mm/year on water levels in the Suriname River has been observed based on historical annual water level measured at Paramaribo station located at km 52 in Suriname River (Amatali, 2012). The inhabited areas along Suriname River banks, the land level is lower than the 10-year return water level (Refer to HHWL Table 4) producing potential risk for inundation from the river. Some of these flooding areas are shown in Figure 4, which also includes frequent inland flooding areas in Paramaribo.



Source: Adapted from MOGP, 2001

Figure 3: Frequent flood prone regions in the city of Paramaribo (in red)

Source: Amatali, 2007

***Figure 4:** Frequent and Seasonal Inundated Areas in Paramaribo based on Data from Masterplan Study Ontwatering Groot Paramaribo*

3.0 *NATIONAL STANDARDS ON FLOOD LIMITS*

There are no legal and national standards allowable flood levels and duration for Suriname. However, the Drainage Masterplan for Greater Paramaribo (accepted by MPW) from 2001 defines some flood inundation levels for the main drainage systems:

1) There should not be any water logging in and around the houses. The ground floor should be about 20 to 25 cm above street level.

2) The water logging on any street ("Water on street") should be up to a maximum of 60 minutes

3) The design rainfall duration of 12 hours with a return period of one year

4) The rainfall duration curve during the greater rainy season is used. In addition, the peak rainfall intensity is assumed to take place during high tide.

5) The discharge of collected rainfall in canals and basins should happen within 12 hours (one tidal cycle)

If we consider that the normal road structures are made of side curbs, then one can say that the level of flooding acceptable is 20 cm during maximum 1 hour for rainfall with a return period of 1 year. However, there are no specific flood level standards related to the high water levels in the river. New regulations related to river flooding proposed in 2010 and accepted by the MPW is given below.

1) No flooding for a HHWL with 1: 50 years return period.

2) Overtopping is allowed, but should be drained within the same drainage standards as above.

4.0 *MODELLING METHODOLOGY FOR HAZARD ANALYSIS*

4.1 *SELECTION OF MODELS*

The main factors that affect flooding in the Study Area are the water levels of the Suriname River flow and runoff from neighboring watersheds and atmospheric precipitation. The Suriname River flows, and hence water levels, are regulated by the Brokopondo Reservoir and tides from the Atlantic Ocean, upstream and downstream of Paramaribo, respectively. Other main inflows to the Study Area are through a series of canals, which are used to route the storm water and wastewater from the district which eventually discharge into the Suriname River through a series of sluice gates and pumps at three locations.

The water levels along the river bank adjacent to the Study Area were obtained by using 1-D HEC-RAS[2] model for the Suriname River using Higher High Water Levels (HHWLs) for the baseline conditions at various return periods, obtained using Government of Suriname water level monitoring data sets at various locations along the Suriname River (Amatali, 2012). It is an integrated system of software, designed for interactive use in a multi-tasking environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities. HEC-RAS model uses the Suriname River and its adjacent flood plain geometrical data in the form of cross-sections and computes a single water surface across each cross-section. As per the literature (HEC,2017) this one-dimensional modelling procedure holds good for the main river system and hence, addresses the objectives of the HEC- RAS Suriname model set up to compute water levels along the shoreline adjacent to the Study Area.

However, HEC-RAS does not perform a higher level of hydrodynamic fidelity in the Suriname River flood plain region where flow routing is affected by obstructions due to buildings, infiltration and storm-water drainage. This limitation was addressed by using the FLO-2D[3] model for the Suriname River flood plain region. It is a volume conservation flood routing model on the U.S. Federal Emergency Management Agency's list of approved hydraulic models for flood plain zoning analysis. This model is a valuable tool for delineating flood hazards, regulating floodplain zoning or designing flood mitigation. In addition, a HEC-RAS model was setup for the Sommeldijckse Canal to evaluate localized flooding. These models provide detailed flooding information along the Sommeldijckse Canal and at the riverine side (Suriname River) of the Study Area. These models will also serve to evaluate the effects in the area for upgrading the canal and designing adaptation measures such as extension of the existing flood wall at the left bank of the Suriname River (See Figure 1 for a map of the modelled region).

4.2 DEVELOPMENT OF BASELINE AND CLIMATE CHANGE SCENARIOS

The rainfall intensity and Suriname River water level are the primary factors that are used to develop baseline scenarios using extreme event analysis.

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[2] HEC-RAS is the U.S. Army Corps of Engineers' River Analysis System developed by the Hydraulic Engineering Center (HEC), California, USA. www.hec.usace.army.mil/software/hec-ras/

[3] FLO-2D is a flood routing model developed by FLO-2D Software, Inc., Arizona, USA. www.flo-2d.com

4.2.1 Baseline Rainfall Analysis

The rainfall information was obtained by developing Intensity-Duration-Frequency (IDF) curves using historic multiyear data from meteorological stations in the Study Area. According to Meteorologische Dienst Suriname, IDF curves have not been created for any meteorological station located in Paramaribo. IDF curves are developed using multiyear precipitation hourly/daily data and Generalized Extreme Value (GEV) distributions. As part of this project, ERM developed IDF curves for three stations in the vicinity of the Study Area as shown in Figure 5**Error! Reference source not found.**. The data statistics for these three stations are shown in Table 1.

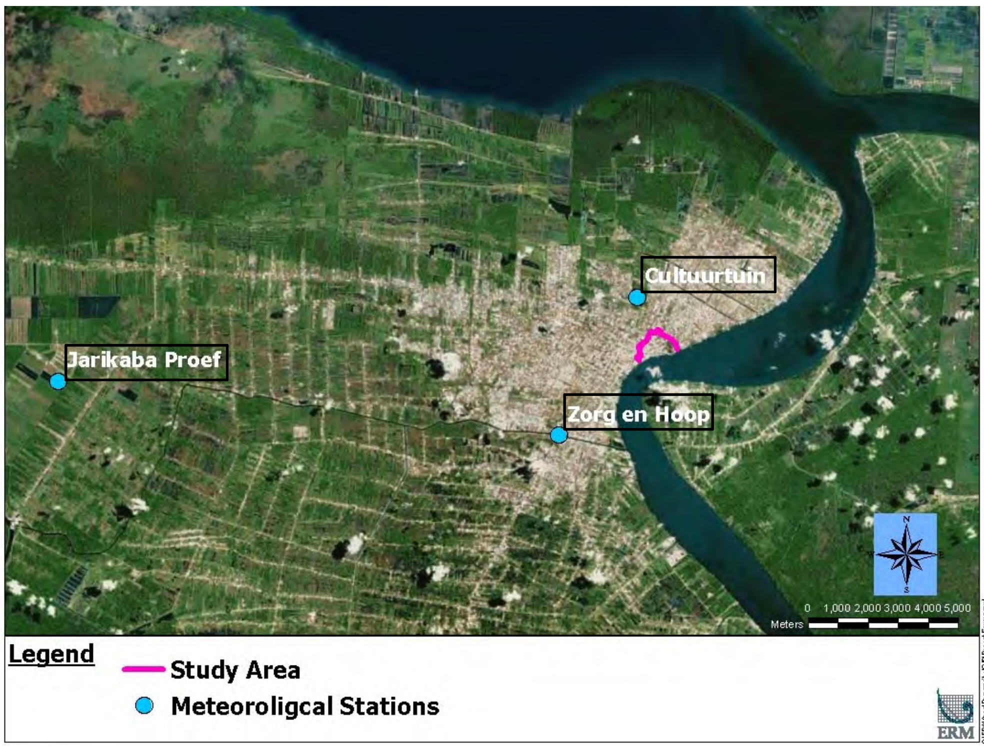


Figure 5: Three Meteorological Stations in the Vicinity of the Study Area

Table 1: Rainfall Data availability at the Three Selected Meteorological Stations

Data Statistics	Meteorological Stations		
	Cultuurtuin	**Jarikaba Proef**	**Zorg en Hoop**
Period	1981-1 to 2015-12	1969-01 to 1995-12	1981-1 to 2015-12
Data Availability	Missing 13 months of data between 1987-12 and 1988-12	Missing data between 1988-01 and 1988-12	Missing data between 1987-10 and 1990-12
Other Missing Data	Additional nonconsecutive missing data <2% of remaining data points		

4.2.1.1 Data Availability

The missing time series data from Table 1 was filled with various data sources and are listed in Table 2. In addition to filling the observed data, satellite-based multiyear precipitation data from PERSIANN[4], and TRMM[5] data were used as standalone data in developing the IDF curves.

Table 2: List of Precipitation Data Sources used for the Current Study

Data Source	Time Period	Website
NCEP - CFSR The Climate Forecast System Reanalysis (CFSR) was designed and executed as a global, high resolution, coupled atmosphere-ocean-land surface-sea ice system to provide the best estimate of the state of these coupled domains over this period	1/1/1979 - 7/31/2014	https://rda.ucar.edu/pub/cfsr.html
PERSIANN Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks and Climate Data Record	1/1/1983 - 12/31/2015	http://chrsdata.eng.uci.edu/
NASA OpenNEX The NEX-GDDP dataset includes downscaled projections for RCP 4.5 and RCP 8.5 from the 21 models and scenarios for which daily scenarios were produced and distributed under CMIP5. Each of the climate projections includes daily maximum temperature, minimum temperature, and precipitation for the periods from 1950 through 2100.	1/1/1950 - 12/31/2100	https://nex.nasa.gov/nex/static/htdocs/site/extra/opennex/
AgMERRA NASA Modern-Era Retrospective Analysis for Research and Applications (MERRA). AgMERRA corrects to gridded temperature and precipitation, incorporates satellite precipitation, and replaces solar radiation with NASA/GEWEX SRB to cover the 1980-2010 period	1/1/1980 - 12/31/2010	https://data.giss.nasa.gov/impacts/agmipcf/agmerra/
CCAFS The Climate Change Agriculture and Food Security (CCAFS) Climate data portal provides global and regional future high-resolution climate datasets that serve as a basis for assessing the climate change impacts and adaptation in a variety of fields including biodiversity, agricultural and livestock	1/1/1970 - 12/31/2100	http://ccafs-climate.org/

[4] PERSIANN is Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks and Climate Data Record developed by developed by the Center for Hydrometeorology and Remote Sensing (CHRS) at the University of California, Irvine, USA.

[5] The Tropical Rainfall Measuring Mission (TRMM), a joint mission of NASA and the Japan Aerospace Exploration Agency, was launched in 1997 to study rainfall for weather and climate research

Data Source	Time Period	Website
production, and ecosystem services and hydrology		
TRMM The Tropical Rainfall Measuring Mission (TRMM), a joint mission of NASA and the Japan Aerospace Exploration Agency, was launched in 1997 to study rainfall for weather and climate research.	1/1/1998 - present	https://disc.gsfc.nasa.gov/datasets/TRMM_3B42_V7/summary?keywords=TRMM_3B42_007

4.2.1.2 Generation of Synthetic Rainfall Data

For the present study, ERM used a non-parametric K-Nearest Neighbor (KNN) weather generator algorithm (Sharif and Burn, 2007; Rajagoplan and Lall, 1999) to synthetically create long time series of daily precipitation data based on the historically available data described in the previous section for the three stations located in the vicinity of the Study Area. The advantage of the KNN approach is that unprecedented precipitation amounts can be generated that is important for the simulation of extreme events. However, in the current analysis, KNN was used such that they do not produce new values but merely restore the historical data to generate realistic precipitation sequences. These updated precipitation time series were used in combination with the GEV analysis tool to recreate/update IDF curves that will serve as inputs for FLO-2D and HEC-RAS models. The KNN method was applied using the nonparametric tool KNNCAD (developed by Sohom et al. 2017). The nonparametric KNNCAD weather generator simulates daily precipitation amounts by reshuffling the historical daily values from within a temporal window centered on the current day (Eum et al. 2010). A set of 10 synthetic scenarios were simulated using KNNCAD tool and daily maximum value from this set was used in developing the final IDF curve for a specific station.

4.2.1.3 Intensity-Duration-Frequency Curves (IDF)

The IDF curves developed using GEV method for Cultuurtuin, Jarikaba Proef and Zorg en Hoop meteorological stations using synthetic multi-year rainfall data obtained from KNN method are shown in Figure 6, Figure 7, and Figure 8, respectively.

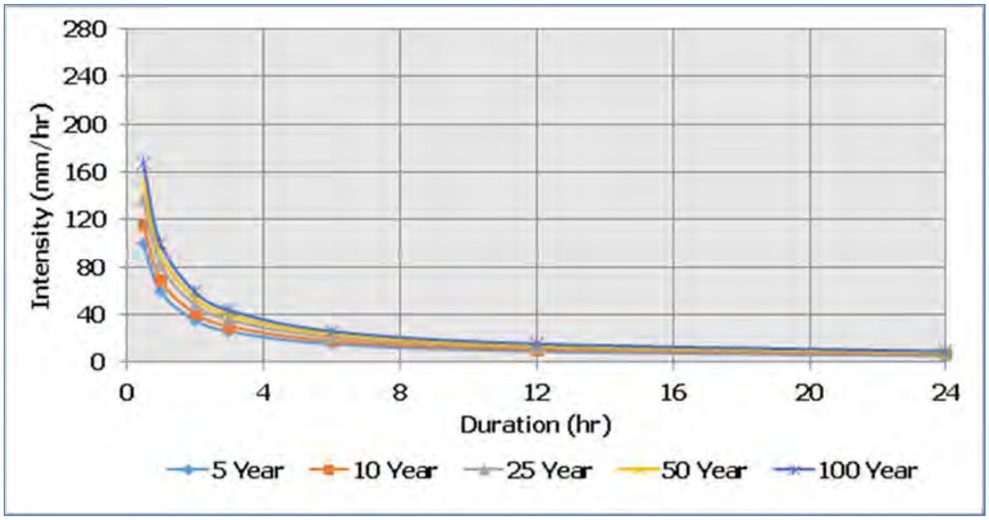


Figure 6: IDF Curves for Cultuurtuin meteorological station

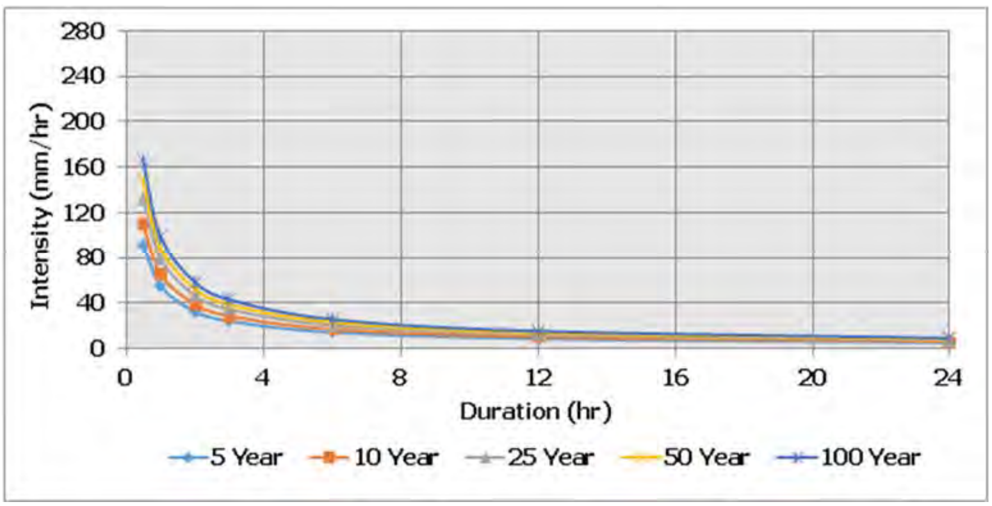


Figure 7: IDF Curves for Jarikaba Proef meteorological station

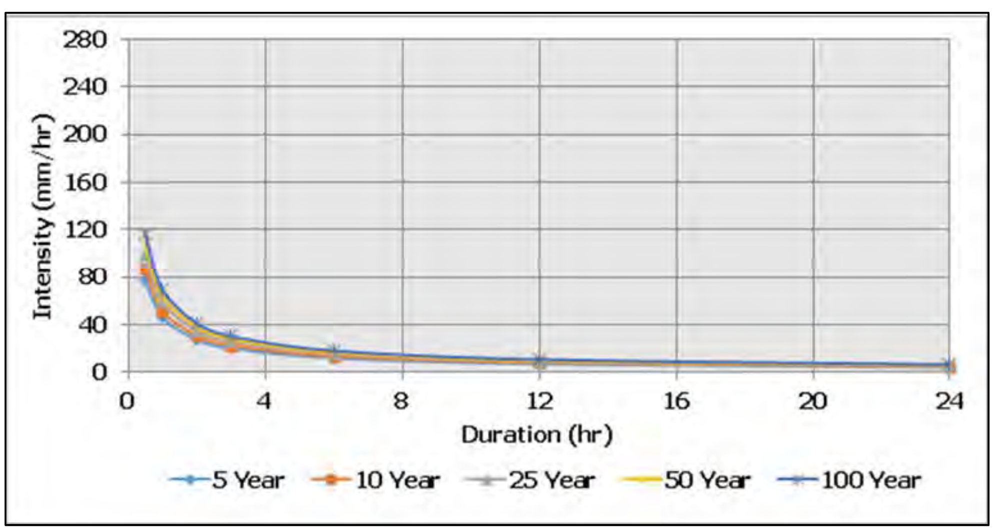


Figure 8: IDF Curves for Zorg en Hoop meteorological station

The 24-hour maximum precipitation computed for all the three meteorological stations at 5-, 10-, 25-, 50-, and 100-year return periods using GEV method is shown in Table 3.

Table 3: 24-hour Maximum Precipitation Computed for the Three Meteorological Stations Using GEV Method

Return Period (years)	**24-hour Precipitation Maximum, mm**		
	Cultuurtuin	**Jarikaba Proef**	**Zorg en Hoop**
5	120	121	102
10	139	145	114
25	165	174	130
50	183	196	141
100	202	218	153

For a certain frequency or return period, the mean rainfall intensity increases over short durations for all the three meteorological stations. However, there is not much change in the rainfall intensity for longer durations with varying return periods for all the three meteorological stations. The daily computed maximum precipitation is larger for the Jarikaba Proef station than the Cultuurtuin and the Zorg en Hoop stations. This is due to large spread (high standard deviation) of the historical daily maximum precipitation data from the mean as compared to the other two stations.

4.2.2 Baseline Suriname River Water Levels

Amatali (2012) analyzed historic water levels at various locations along the Suriname River and developed Higher High Water Levels (HHWLs) for various return periods of 10-, 25-, 50-, and 100-years and is shown in Table 4.

Table 4: Higher High Water Level (HHWL) in Suriname River

Station	**Station Annual HHW in cm NSP**			
	Tr = 10-years	**Tr = 25-years**	**Tr = 50-years**	**Tr = 100-years**
Geleidelicht	185	198	207	216
New Amsterdam	193	203	210	217
Paramaribo	201	211	219	226
Domburg	198	203	207	212
Paranam	155	175	190	204

Tr = Return Period; HHW = Higher High Water; cm = centimeters; NSP = Normaal Surinaamse Peil.
Source: Adapted from Amatali, 2012

The HHWLs available at Paramaribo were used in the Suriname River HEC-RAS model to compute water level variations along the shoreline adjacent to the Stud Area.

4.2.3 *Climate Change*

The climate change scenarios were developed by superimposing future year climate change projections for inland precipitation and water surface levels (HHWLs) in the Suriname River. Future projected changes for 2050 and 2080s in precipitation and sea level rise were used as the main climate change parameters to conduct this evaluation. The projected changes in precipitation and sea level were applied to baseline historical precipitation time-series to create climate change adjusted precipitation IDF curves and adjusted High Water Level Suriname River values for 25-, 50-, and 100-year return periods. ERM used climate change projections available for Suriname published in the Second National Communication to the United Nations Framework Convention on Climate Change (SNC, 2013) which come from Regional Climate Models (driven by HadAM3[6] and ECHAM4[7]) to evaluate how climate change projections can influence on the level of flooding impacts on the Study Area.

4.2.3.1 Review of Selected RCM Climate Models

HadAM3 is a Global General Circulation model (GCM) model of version 3, developed by the Hadley Center for Climate Prediction and Research located at Exeter in United Kingdom. HadAM3 is a grid point model that has a horizontal resolution of 3.75 × 2.5 degrees in longitude × latitude. This corresponds to a spacing between points of approximately 300 km. There are 96 × 73 grid points on the scalar (pressure, temperature and moisture) grid; the vector (wind velocity) grid is offset by 1/2 a grid box. There are 19 levels in the vertical using a hybrid (sigma and pressure) coordinate system. The time step is 30 minutes (with three sub-time steps per time step in the dynamics).

ECHAM4 is a General Circulation Model (GCM) of Version 4, developed by the Max Planck Institute for Meteorology, one of the research organizations of the Max Planck Society. The model is a spectral transform model with 19 atmospheric layers with a spatial resolution of about 2.8^{o} longitude/latitude resolution that corresponds to 300 to 500 km and spanning the entire earth with 64 latitudes and 128 longitudes. The semi-implicit time step of 20 to 40 minutes is used with an inclusion of time filter to inhibit the growth of spurious computational modes.

[6] HadAM3 (abbreviation for Hadley Centre Atmospheric Model, version 3) is a global atmospheric model developed at the Hadley Centre in the United Kingdom. This is the model behind PRECIS (Providing Regional Climates for Impacts Studies). It was one of the major models used in the IPCC Third Assessment Report in 2001

[7] ECHAM4 is a general circulation model (GCM), version 4, developed by the Max Planck Institute for Meteorology, one of the research organizations of the Max Planck Society. The model was given its name as a combination of its origin (the 'EC' being short for 'ECMWF (European Centre for Medium-Range Weather Forecasts)') and the place of development of its parameterization package, Hamburg.

The skill of the selected climate models, HadAM3 and ECHAM4 (CCCRA, 2012) to describe climatology with respect to the ensemble for the Study Area was evaluated using the ClimateWizard[8] tool developed by the Nature Conservancy in collaboration with the University of Washington and the University of the Southern Mississippi. In CCCRA (2012) study, temperature and precipitation data from RCM model was presented (Urrutia & Vuille, 2009). The RCM used was PRECIS[9] covering a domain over tropical South America and driven by the HadAM3 GCM. Urrutia and Vuille (2009) presented only RCM model results for temperature and precipitation since these two parameters are considered to be of highest relevance to society, ecosystem integrity and glacier mass balance in the tropical Andes. Combining the results of GCM and RCM experiments allows the use of high-resolution RCM projections in the context of the uncertainty margins that the 15-model GCM ensemble provides. However, there was no RCM model developed for the tropical South America using ECHAM4 model (CCCRA, 2012). RCM model driven by HadAM3 indicate large decreases in rainfall in all seasons; up to a 34% decrease in mean annual rainfall by the 2080s (relative to the 1980-1989 mean) under the A2 scenario. The HadAM3 RCM projected the maximum decrease (of 74%) for the SON (September, October and November) season.

The climate change data for future years clearly show that there will be a decrease in the rainfall intensity resulting in reduced inland flooding. However, for the evaluation of flood risk, ERM used extreme precipitation as compared to normal precipitation and based on extreme value theory, the impact will be most severe when there is a combination of such extreme events with high tides, storm surge and SLR. Extreme rainfall event sometimes referred as 'Heavy rain' was determined by the daily rainfall totals that exceeded on 5% of wet days in the 'current' climate or reference period, relative to the particular climate of a specific region or season (CCCRA, 2012). The heavy rainfall event analysis was not available for selected RCM models and so, we relied on data from GCM projections since the normal precipitation analysis of selected RCM models show similar trend as the GCM projections. The proportion of total rainfall that falls in heavy events increases in most model projections, with an annual maximum of +11% and a monthly maximum of +24% in the month of December, by the 2080s.

[8] ClimateWizard enables technical and non-technical audiences alike to access leading climate change information and visualize the impacts anywhere on Earth. The first generation of this web-based program allows the user to choose a state or country and both assess how climate has changed over time and to project what future changes are predicted to occur in a given area. http://www.climatewizard.org/

[9] PRECIS (Providing REgional Climates for Impacts Studies, pronounced pray-sea) is developed at the Hadley Centre at the UK Met Office. PRECIS is a regional climate modelling system designed to run on a Linux-based PC. PRECIS can be applied to any area of the globe to generate detailed climate change projections. https://www.metoffice.gov.uk/research/applied/international-development/precis

This information is further examined on a monthly basis in the calculation of IDF curves for climate change years in the next section.

4.2.3.2 Estimation of IDF Curves With Climate Change Projections

The seasonally varying extreme precipitation data for the SRES[10] Scenario A2 (Equivalent to RCP 8.5[11]) computed from RCM models ECHAM4 and HadAM3 (CCCRA, 2012) is shown in Table 5 and presented graphically in Figure 9. The monthly climate change projection of extreme precipitation was used along with synthetic time-series precipitation data obtained from KNN weather generator to develop IDF curves for future years of 2050 and 2080s. Extreme precipitation in the current study refers to maximum percent change in rainfall intensity based on 1-day rainfall total from an ensemble of GCM projections.

Table 5: Precipitation Change in % for Climate Change Scenario A2 (≈ RCP 8.5)

% Change in Precipitation for Climate Change Scenario A2 (≈ RCP 8.5)		
Month	**Climate Change 2050**	**Climate Change 2080**
Jan	10	8
Feb	10	8
Mar	9	13
Apr	9	13
May	7	13
Jun	7	16
Jul	7	16
Aug	7	16
Sep	21	24
Oct	21	24

[10] SRES refers to the Special Report on Emissions Scenarios is a report published in 2000 by the Intergovernmental Panel on Climate Change (IPCC). The greenhouse gas emissions scenarios described in the Report have been used to make projections of possible future climate change. SRES emission scenarios were used until the 4th IPCC Assessments. Scenario A2 describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change is more fragmented and slower than in other SRES Scenarios.

[11] Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. RCP 8.5 refers to "Business as Usual" scenario that combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and GHG emissions in absence of climate change policies resulting in rising radiative forcing pathway leading to 8.5 W/m^2 in 2100.

% Change in Precipitation for Climate Change Scenario A2 (≈ RCP 8.5)		
Month	Climate Change 2050	Climate Change 2080
Nov	21	24
Dec	10	8

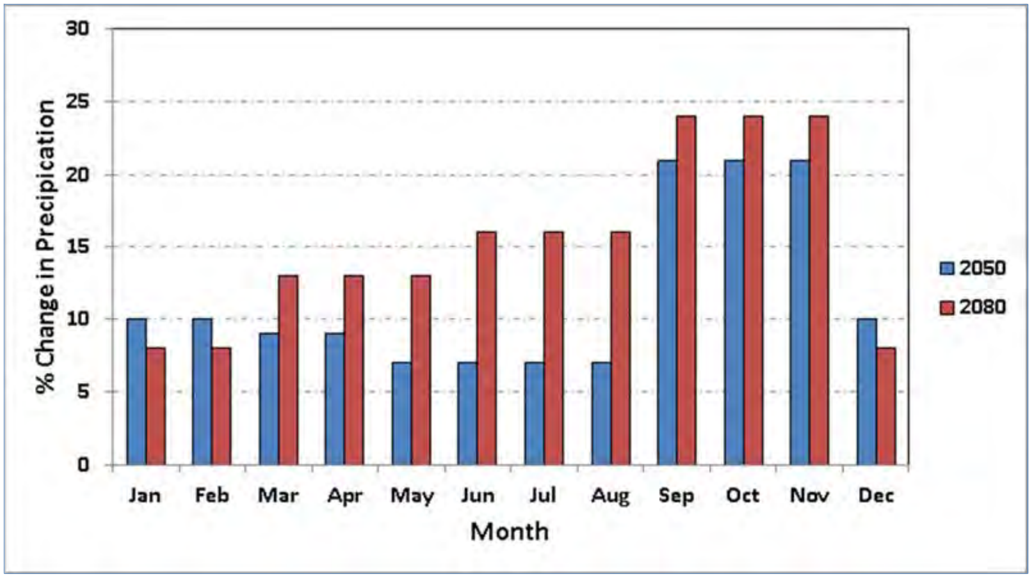


Figure 9: Monthly Variation of Extreme Precipitation Climate Change Projection for the Years 2050 and 2080.

The IDF curves computed for the year 2050 using the climate change projections listed in Table 5 are shown in Figure 10, Figure 11, and Figure 12 for Cultuurtuin, Jarikaba Proef and Zorg en Hoop meteorological stations, respectively. The 24-hr maximum precipitation for the year 2050 is shown in Table 6. Also shown in the same table is the increase in precipitation (shown in brackets) for each return period compared to the baseline shown in Table 3.

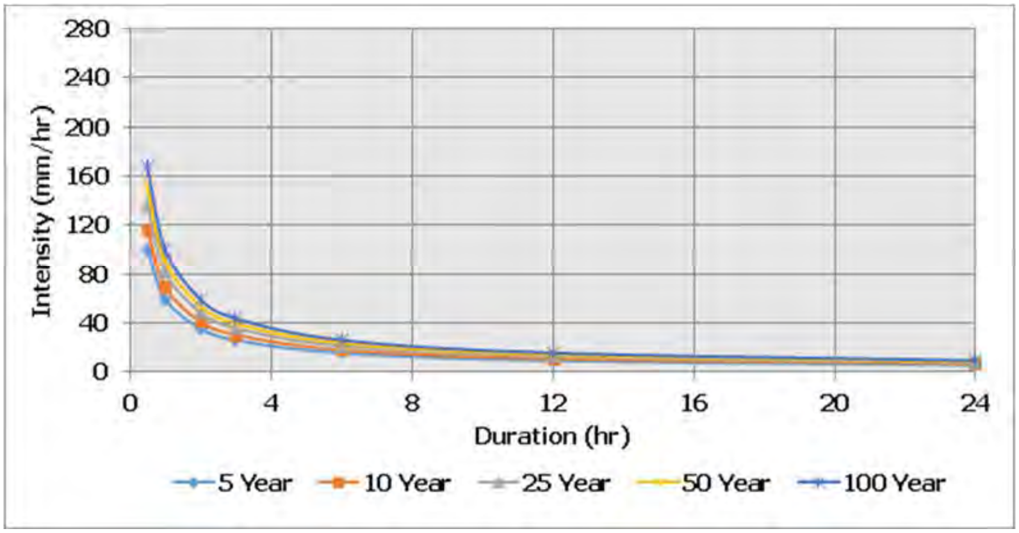


Figure 10: Year 2050 IDF curves for Cultuurtuin meteorological station

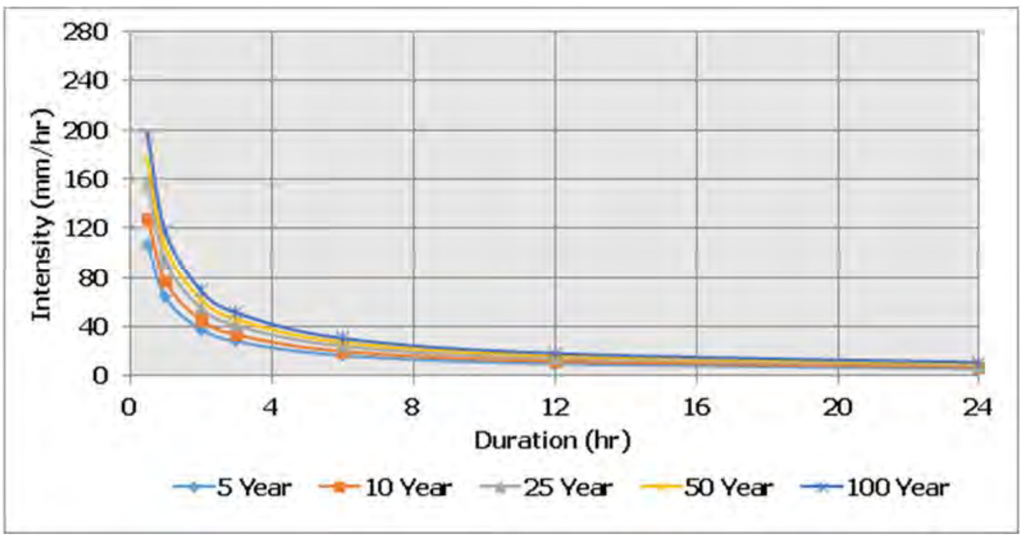


Figure 11: Year 2050 IDF curves for Jarikaba Proef meteorological station

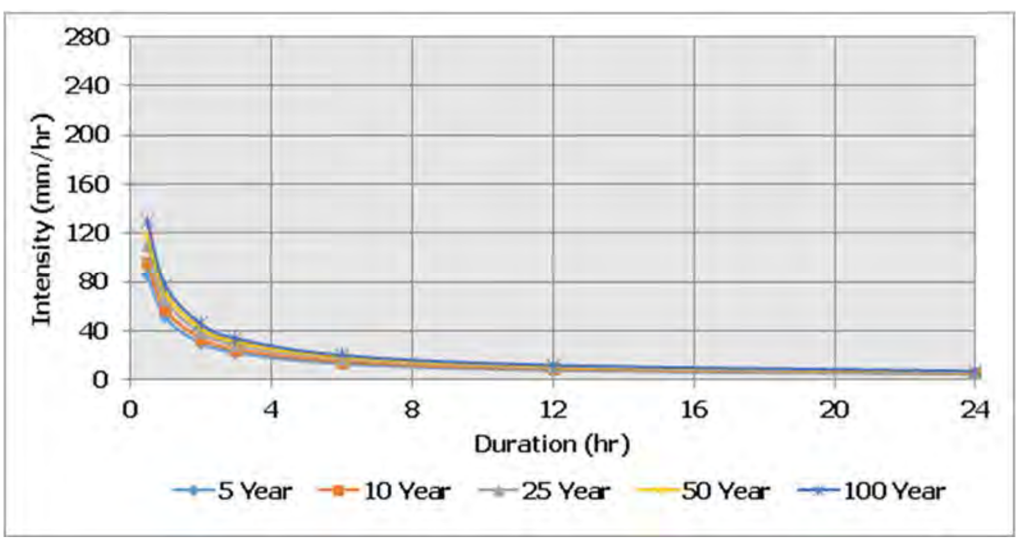


Figure 12: Year 2050 IDF curves for Zorg en Hoop meteorological station

Table 6: Year 2050 daily maximum precipitation and increase over the baseline data shown in brackets for all the three selected meteorological stations computed using GEV method

Return Period (years)	**24-hour Precipitation Maximum, mm**		
	Cultuurtuin	**Jarikaba Proef**	**Zorg en Hoop**
5	131 (10)	140 (19)	113 (11)
10	153 (14)	168 (23)	127 (13)
25	180 (15)	205 (31)	144 (14)
50	200 (17)	232 (36)	157 (16)
100	220 (18)	258 (40)	170 (18)

The IDF curves computed for the year 2080 using the climate change projections listed in Table 5 are shown in Figure 13, Figure 14 and Figure 15 for Cultuurtuin, Jarikaba Proef and Zorg en Hoop meteorological stations, respectively. The 24-hr maximum precipitation for the year 2080 is shown in Table 7. Also shown in the same table is the increase in precipitation (shown in brackets) compared to the baseline data shown in Table 3.

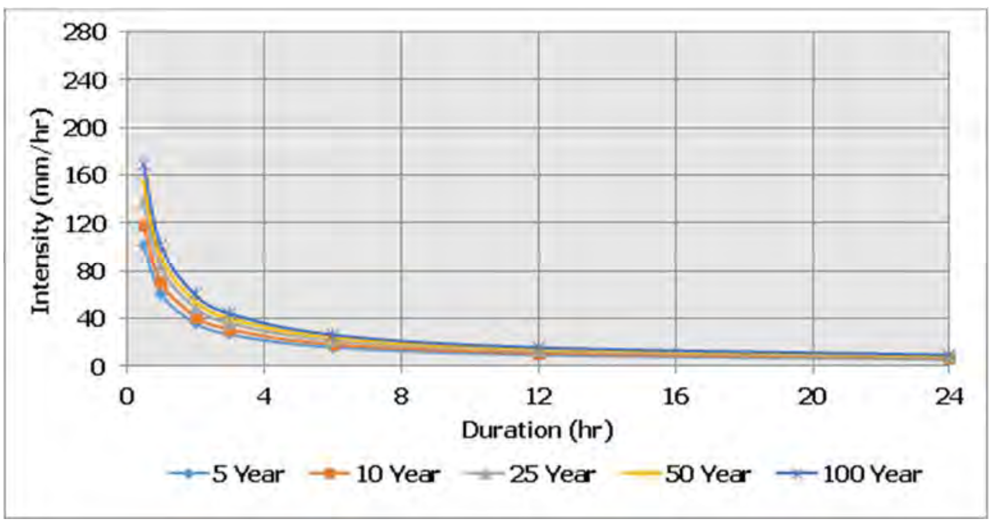


Figure 13: Year 2080 IDF curves for Cultuurtuin meteorological station

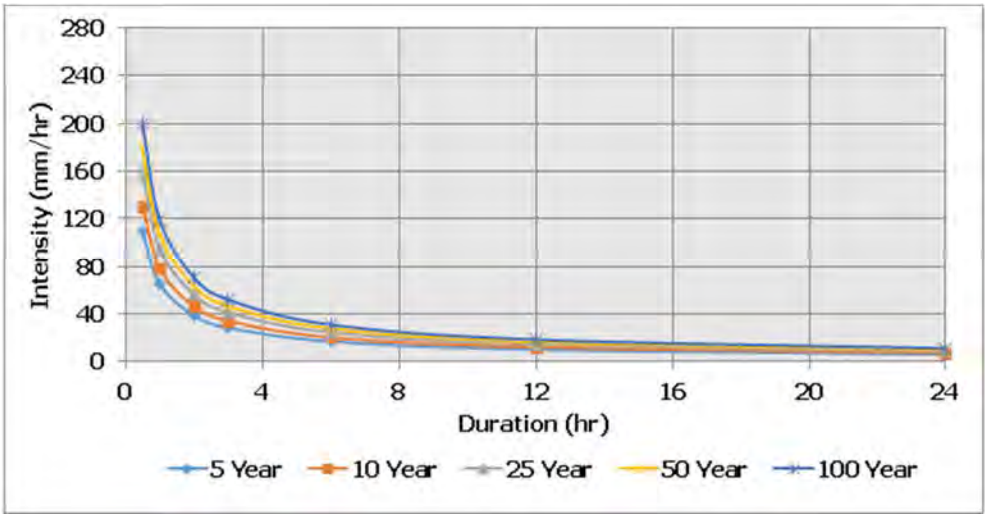


Figure 14: Year 2080 IDF curves for Jarikaba Proef meteorological station

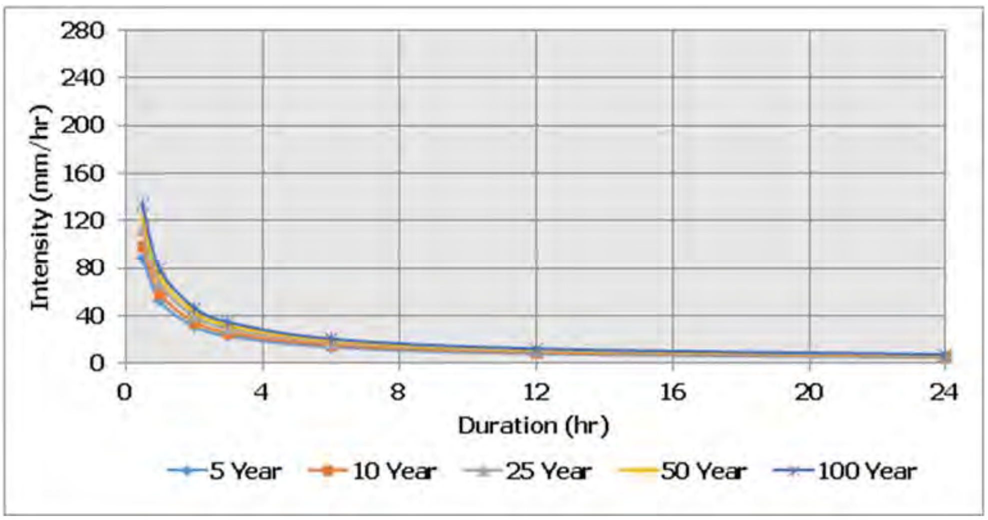


Figure 15: Year 2080 IDF curves for Zorg en Hoop meteorological station

Table 7: Year 2080 daily maximum precipitation and increase over the baseline data shown in brackets for all the three selected meteorological stations computed using GEV method

Return Period (years)	24-hour Precipitation Maximum, mm		
	Cultuurtuin	Jarikaba Proef	Zorg en Hoop
5	134 (14)	143 (22)	116 (14)
10	155 (16)	172 (27)	130 (16)
25	182 (17)	208 (34)	148 (19)
50	202 (19)	235 (39)	161 (20)
100	222 (20)	262 (44)	174 (21)

The maximum daily precipitation computed using the GEV method, increases for all the three meteorological stations compared to the baseline data shown in Table 3 for both the years 2050 and 2080 due to climate change. For the year 2050, the maximum GEV computed daily precipitation increases in the range of 10 mm to 19 mm, 19 mm to 40 mm, and 11 mm to 18 mm for the Cultuurtuin, Jarikaba Proef, and Zorg en Hoop, respectively. For the year 2080, the maximum GEV computed daily precipitation increases in the range of 14 mm to 20 mm, 22 mm to 44 mm, and 14 to 21 mm for the Cultuurtuin, Jarikaba Proef, and Zorg en Hoop, respectively. However, the increase is much larger at the Jarikaba Proef station than the other two stations. This is due to the increase in the spread (high standard deviation) of the climate change adjusted synthetically derived rainfall data for the Jarikaba Proef station as compared to the other two stations. The comparison among all the three meteorological stations for the GEV computed daily precipitation and the corresponding increase over the baseline precipitation for the years 2050 and 2080 due to climate change is shown in Figure 16.

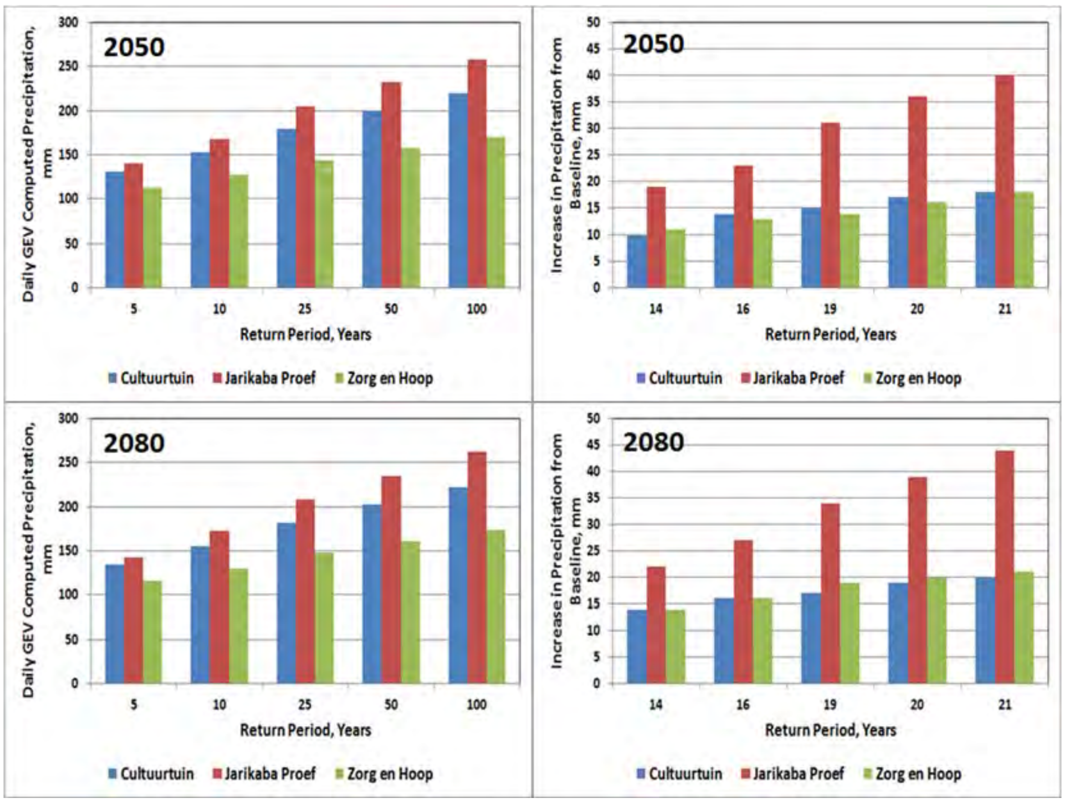
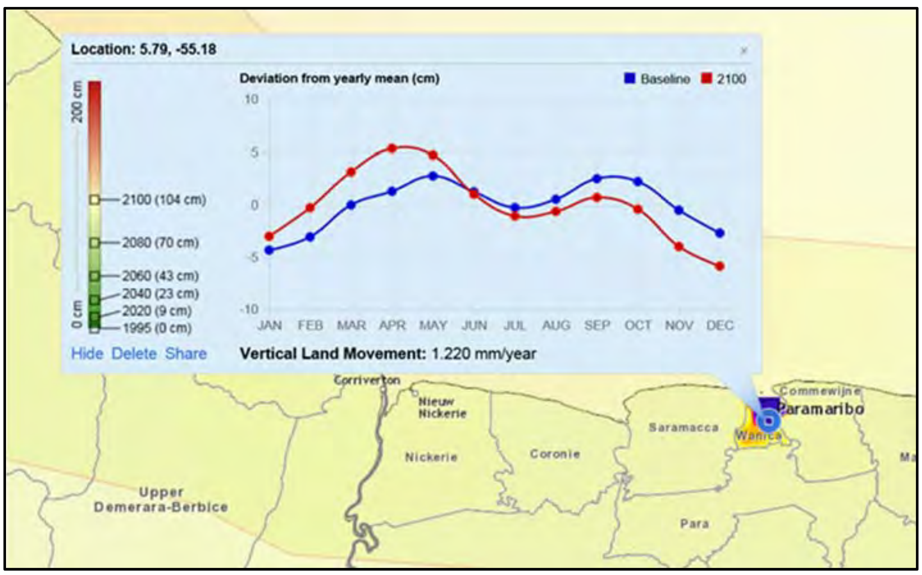


Figure 16: Comparison of GEV computed daily precipitation of all the three meteorological stations and the corresponding increase in precipitation over the baseline for the years 2050 and 2080 due to climate change.

Since Cultuurtuin meteorological station is in close proximity to the Study Area as compared to other two stations (See Figure 5), IDFs generated for this station were used for all the models used in the current study. For inland flood modeling analysis, only the years 2050 and 2080 climate change scenarios were considered since there is no climate change projection data for precipitation available for the year 2020.

4.2.3.3 Estimation of the Suriname River Water Levels With Climate Change Projections

The water surface elevation changes due to storm surge and sea level rise (SLR) are usually added linearly to the baseline water surface elevation to obtain future climate change scenarios. In this study, however, the Suriname River HHWL extreme event analysis performed by Amatali (2012) already includes storm surge effects. Therefore only SLR is added to the baseline Suriname River HWL to develop climate change scenarios for coastal flooding analysis. SLR was evaluated from various sources that include the CARIBSAVE report (CCCRA, 2012) and the CLIMSystems online sea-level rise tool (www.Climsystems.com). The CARIBSAVE report provides SLR projection only for 2100. Consequently, SLR data for every 2 decades were obtained from the CLIMsystems online tool and is shown in Figure 17. A regression analysis was performed to obtain yearly variation so that SLR for future years can be estimated correctly. The SLR values for 2020, 2050 and 2080 are shown in Figure 18.



Source. http://www.climsystems.com/slr-cities-app/

Figure 17: SLR for the City of Paramaribo

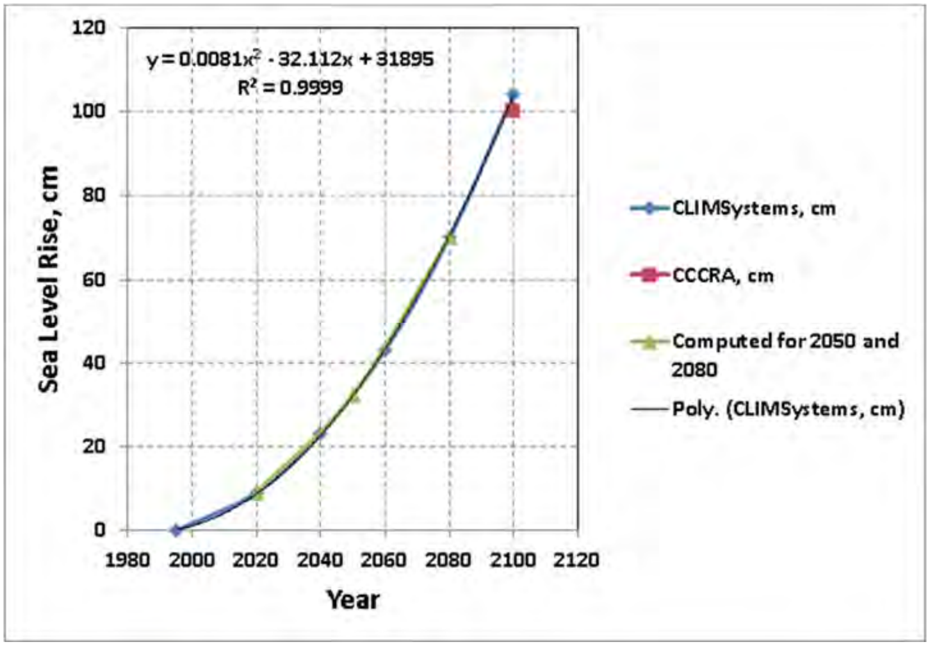


Figure 18: Regression Analysis for SLR Variation with Future Years

Table 8: SLR for the Years 2020, 2050, and 2080

Year	SLR, cm
2020	9.0
2050	32.3
2080	70.0

Both the modified IDFs and SLR obtained for the climate change years 2020, 2050, and 2080 were then used to evaluate associated flooding inundation and risk maps for subsequent impact assessment.

4.3 HYDROLOGICAL MODELLING OF SURINAME RIVER USING HEC-RAS

The HEC-RAS model was used to predict the water surface elevation along the Suriname River adjacent to the Study Area and this serves as input to FLO-2D flood routing model.

4.3.1 Model Setup

The major inputs needed for the HEC-RAS model setup are the Suriname River bathymetry and associated flood plain and flow data. Bathymetry data were obtained from the Suriname River cross-sectional information provided by the Maritieme Autoriteit Suriname (MAS) and flood plain data were obtained from the 2m Digital Elevation Model (DEM). HEC-GeoRAS[12] was used to prepare the Suriname River geometric data for import into HEC-RAS. Since the measured river bathymetry data was only available at discrete cross-section locations, a continuous bathymetry data was obtained by interpolating linearly in ArcGIS using an inverse distance weighting method and is shown in Figure 19.

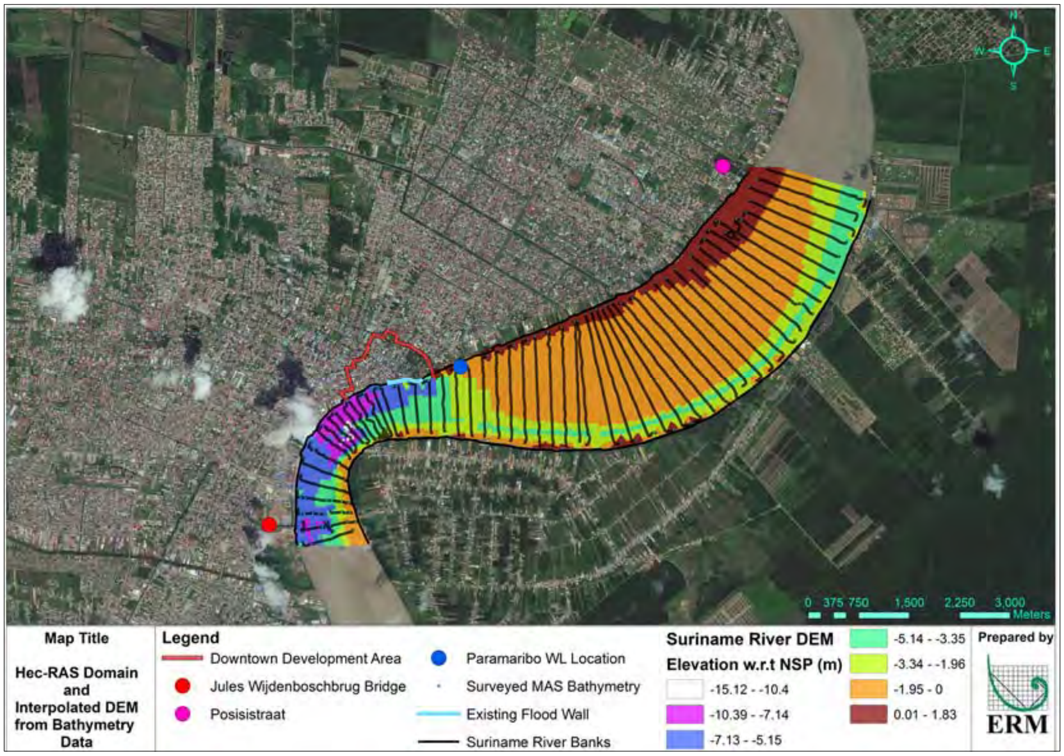


Figure 19: Suriname River bathymetry refined using measured cross-sectional data

The flood plain elevation data on either side of the Suriname River were obtained from the Study Area high resolution 2 m resolution DEM and combined with continuous bathymetry data shown in Figure 19 to obtain a continuous integrated geometric data as shown in Figure 20.

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[12] HEC-GeoRAS is a set of procedures, tools, and utilities for processing geospatial data in ArcGIS using a graphical user interface (GUI). The interface allows the preparation of geometric data for import into HEC-RAS and processes simulation results exported from HEC-RAS. It is developed by the Hydraulic Engineering Center of the U.S. Army Corps of Engineers, USA.

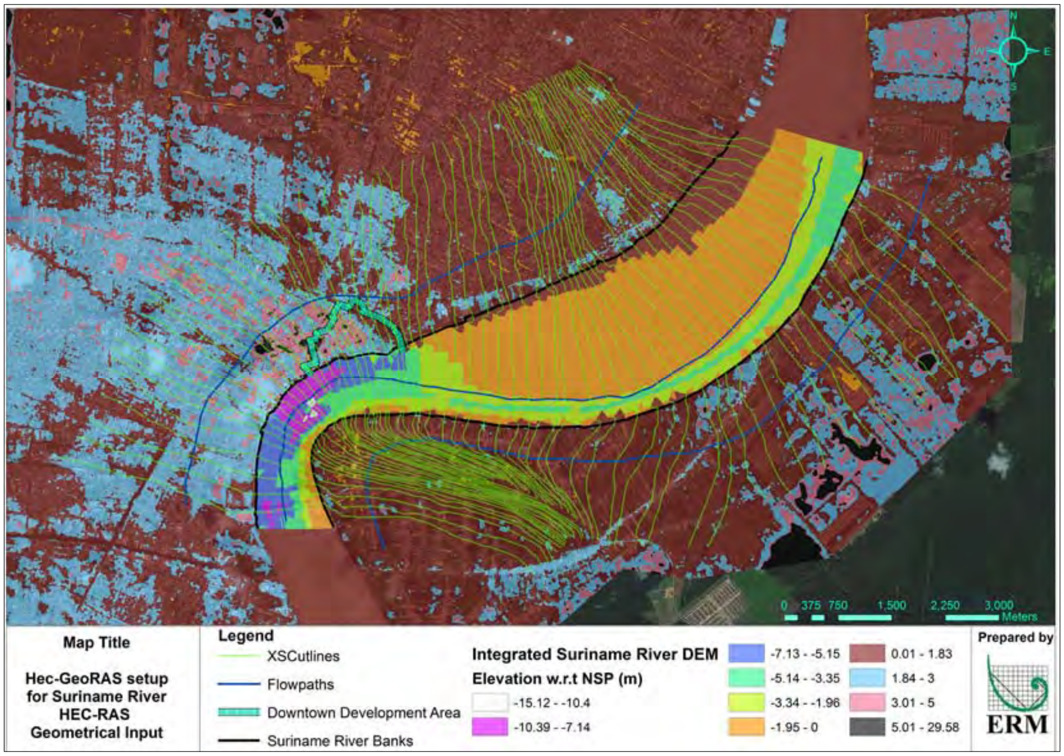


Figure 20: The Suriname River synthesized geometry data used in HEC-RAS

The Suriname River geometric information that was entered into the HEC-RAS model included 1) river reach and station identifiers; 2) cross-sectional cut lines; 3) cross-sectional bank stations; 4) downstream reach lengths for the left overbank, main channel and the right overbank; and 5) cross-sectional roughness coefficient. Figure 21 and Figure 22 shows cross-sectional cut lines and an example cross-section graphic obtained from the HEC-RAS model.

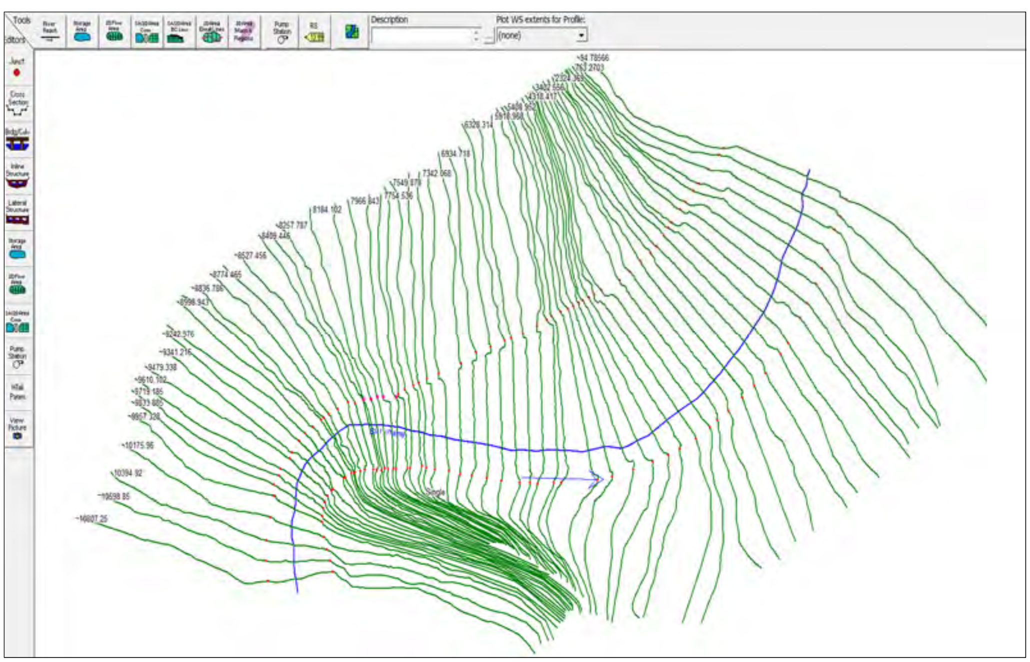


Figure 21: HEC-RAS Suriname River cross-sectional cut lines

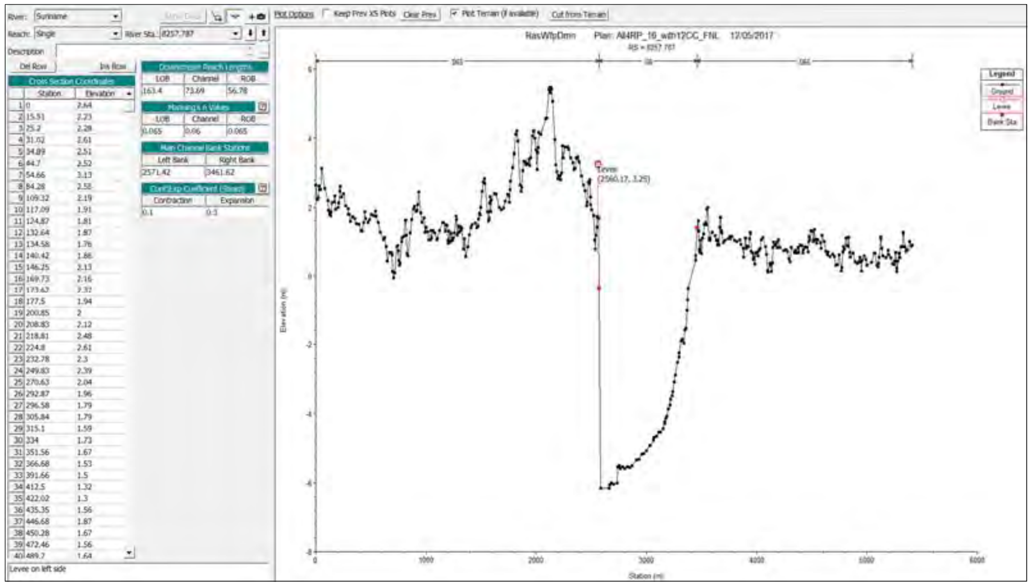


Figure 22: Example Suriname River cross-sectional data display

Flow data available at the outlet of the Afobaka Dam for the Brokopondo Reservoir, obtained from the Hydraulic Research Division of the Suriname Ministry of Public Works are presented in Figure 23. The HHW levels in the Suriname River were obtained from Amatali (2012) which is shown in Table 4. The Suriname River is tidally influenced in the downstream portion including adjacent to the Study Area and the Brokopondo Reservoir regulates the flow in the upstream reaches.

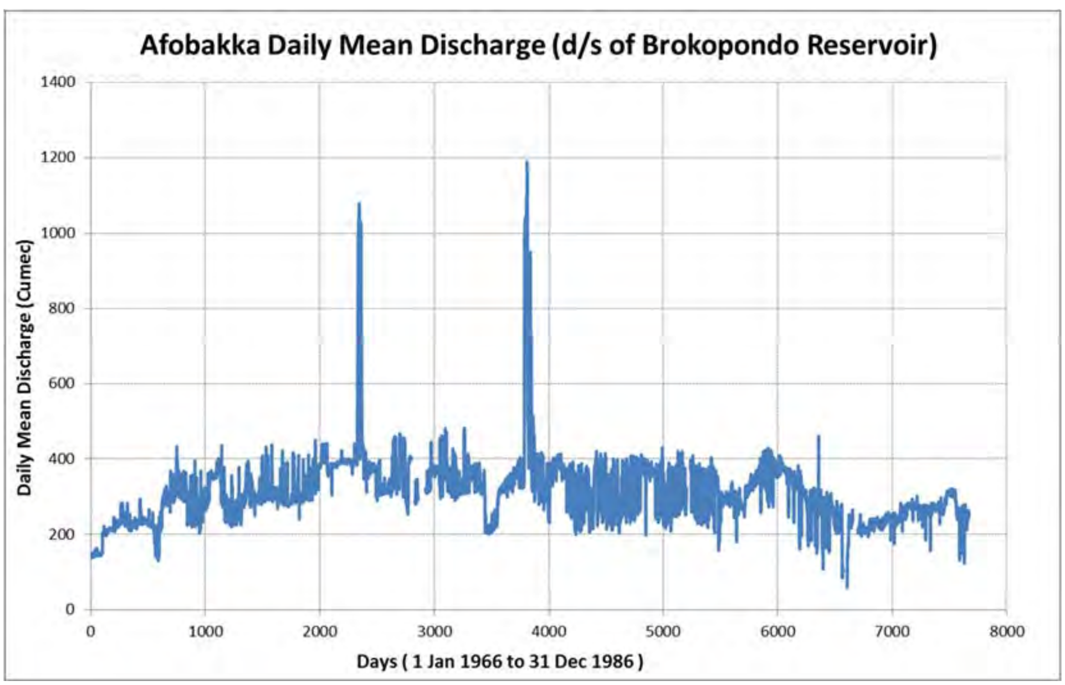


Figure 23: Historical Brokopondo Reservoir daily mean flows

Initially, the Brokopondo Reservoir maximum discharge was defined in the HEC-RAS model as the upstream flow boundary condition. The Paramaribo water level location data (see Table 4**Error! Reference source not found.**) were used to calibrate the upstream flow in the HEC-RAS model for 10-, 25-, 50-, and 100-year return periods. A total of 16 scenarios were performed using four return periods for the following: 1) baseline, 2) climate change 2020 (SLR available, see Table 8 and Figure 18), 3) climate change 2050 and 4) climate change 2080 for coastal flooding analysis.

4.3.2 Analysis of Model Results

A steady state[13] hydraulic analysis was performed using the HEC-RAS model for both the baseline and climate change induced sea level rise scenarios for all return periods. HEC-RAS was set up using geometrical and flow data as mentioned in the previous sections for various return time periods.

The water surface elevation predicted by the HEC-RAS model along the Study Area, which was examined to provide as input to the FLO-2D model. The spatial location of the HEC-RAS model cross-sections along the FLO-2D model extent are shown in Figure 24 and the corresponding water surface elevations are shown in Figure 25 for a 100-year return period baseline simulation.

Figure 24: HEC-RAS cross-sections along the Suriname River adjacent to the Study Area

[13] Steady state HEC-RAS modeling refers to water surface profile computations for steady gradually varied flow or using constant flow.

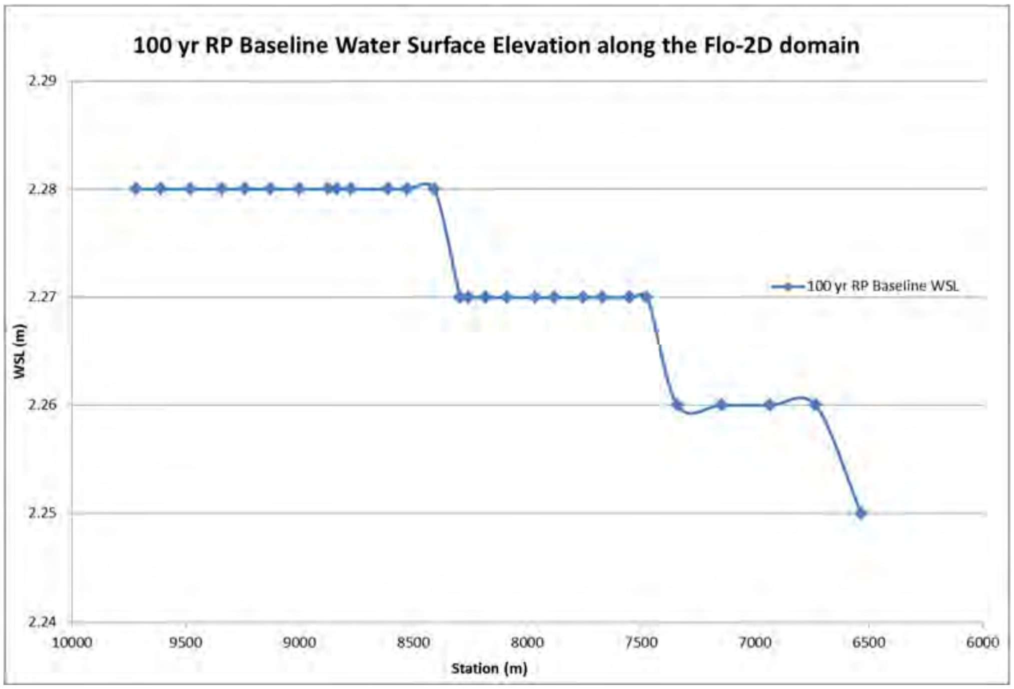


Figure 25: HEC-RAS water surface elevation for 100-year baseline return period along the FLO-2D model domain.

For all return period scenarios, the water level varies by 2 to 3 cm along the 3 km long section of the Suriname River that is adjacent to the Study Area. The HEC-RAS water surface elevation data was saved as shapefiles which were then embedded into the FLO-2D model for detailed coastal and inland flooding analysis in the Study Area.

4.3.3 Assumptions and Limitations

The following assumptions and limitations were made during the application of HEC-RAS model for the computation of water surface elevation in the Suriname River.

- HEC-RAS is a one-dimensional hydraulic analysis model with steady and subcritical flow regime and was used to compute the water surface elevation along the shoreline of the Suriname River adjacent to the Study Area. This assumption typically holds for the peak flood scenario in Suriname River because the flow is steady, gradually varying, and one-dimensional in nature.
- Measured flow/discharge rate in the Suriname River were not available near the Study Area. Hence the Brokopondo Reservoir flow was used as the initial condition for the upstream boundary condition in the HEC-RAS model. The Brokopondo Reservoir is located about 132 km upstream of the Study Area. Therefore, the area between the reservoir and the Study Area contributes significant runoff to the Suriname River. The upstream flow was calibrated with the available water level data at

Paramaribo for all return periods, thus reducing the uncertainty associated with the initial flow assumption at the upstream boundary.

- Standard Manning's coefficient (n) values for Suriname River and its adjacent flood plain were assumed to be 0.04 and 0.030 respectively. These values are obtained from the HEC-RAS manual.
- The HEC-RAS model domain for the Suriname River extends from Jules Wijdenboschbrug Bridge (upstream of the study area) to a location near the Posisi Straat (downstream of the Study Area).
- HEC-RAS model uses the river and its adjacent flood plain geometrical data in the form of cross-sections and computes a single water surface across each cross-section. As per the literature (HEC,2017) this one-dimensional modelling procedure holds good for the main river system and hence, addresses the objectives of the HEC- RAS Suriname River model set up. However, HEC-RAS does not perform a higher level of hydrodynamic fidelity in the Suriname River flood plain region where flow routing is affected by obstructions due to buildings, infiltration and storm-water drainage. This limitation was addressed by using the Flo-2D model for the Suriname River flood plain region.

4.4 FLOOD MODELLING OF THE STUDY AREA USING FLO-2D

The Study Area flood depths and hazards were modeled using FLO-2D model. It is an effective model for evaluating flood hazards by simulating flow routing through channels, unconfined over lands, and streets over complex topography. The model also routes flood hydrographs and rainfall runoff with many rural and urban detail features including levees, walls, and hydraulic structures.

FLO-2D simulates two-dimensional overland flow across a floodplain by conducting volume conservation. Flow within stream channels is modelled as one-dimensional. The model is set up with uniform, square grid elements. Inflow to the model occurs at inflow nodes with a specified hydrograph. Water surface elevations, velocities and flow rates are computed for each grid element based on inflow water surface elevation, ground surface elevation, and Manning's roughness coefficient. The transfer of water mass between grid elements occurs in eight directions: E, S, W, N, NE, SE, SW, and NW. The details of setting up the FLO-2D model are given in the following sections.

4.4.1 Model Setup

The FLO-2D model domain along with the Study Area and existing flood wall is shown in Figure 26. The input data to setup the FLO-2D model are listed in Table 9. The Study Area was discretized with a 2-D rectangular grid with a constant width of 4 m. The discretized FLO-2D model grid shown in Figure 27 and Figure 28 provides highly detailed information about flooding and is the best practical resolution for the Study Area. The several types of data listed in Table 9 were imported into the Study Area model grid. The digital terrain model (DTM) with 2 m resolution defines the land surface elevation. The DTM vertical datum was adjusted by +0.22 m to account for the conversion from EGM96 to NSP[14] (Patandin, 2017) was made to the final DTM. Elevations typically range from 0 m at the shoreline to 4 m further inland.

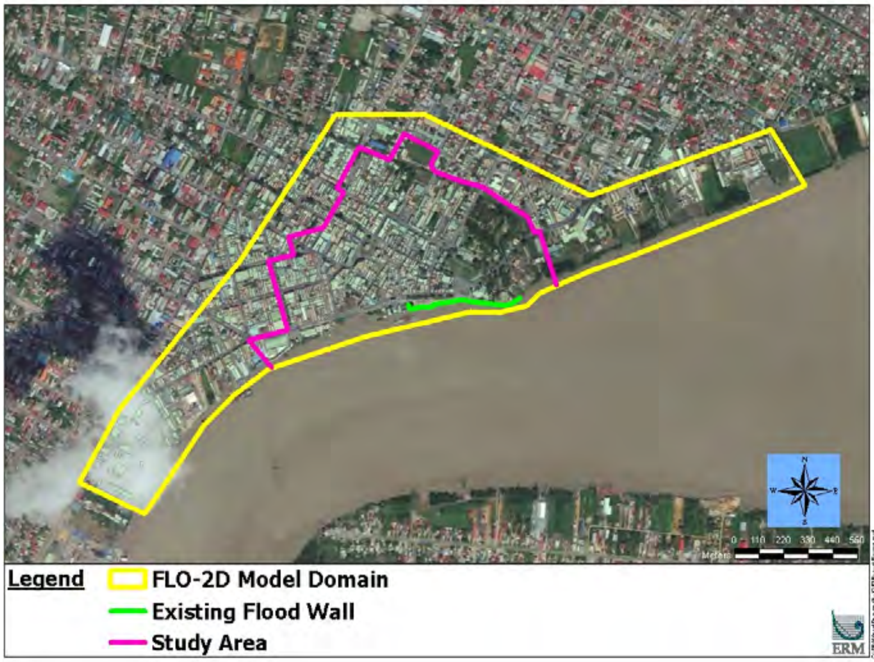


Figure 26: FLO-2D model grid domain. Also shown in the same figure are the Study Area and the existing wall

Table 9: Data Inputs for the FLO-2D model

Data Input	Purpose	Data Source
Topography	Water flow routing in the Study Area	2 m Digital Terrain Model (DTM) Data from TRIMBLE (https://geospatial.trimble.com/where-to-buy/gissat)
Urban City Layout	Flow obstruction due to buildings and levees	OpenStreetMap (http://www.openstreetmap.org/)
Drainage Layout	Storm water routing in the Study Area	CAD diagram from Suriname Public Works Department
Land Cover/Use	flow resistance due to friction	GISSat and ESRI (http://surinameonline.maps.arcgis.com/home/index.html)

[14] N.S.P. is a uniform datum referred to as the Normal Suriname Datum, being mean sea level, as measured at the mouth of the Suriname River in 1956 (Rijkscommissie voor Geodesie, 1983). The conversion between EGM96 and NSP depends on how much sea level rise has occurred since 1956. The estimated SLR from 1961-2003 is 1.8 (+/- 0.5) mm/year (CCCRA 2012), resulting in +0.11 m from EGM96 to NSP.

Data Input	Purpose	Data Source
		FLO-2D Reference Manual (FLO-2D, 2004)
Soil	Infiltration	Van der Eyk (1958)
Climate	IDF curves and SR HHWLs	Meteorologische Dienst Suriname (http://www.meteosur.sr/) and Amitas (2012)
Climate Change	Future projections of IDF curves and SR HWLs	CCCRA (2012) and www.Climsystems.com

Figure 27: FLO-2D model grid covering the Study Area with a high resolution of 4 m cell size

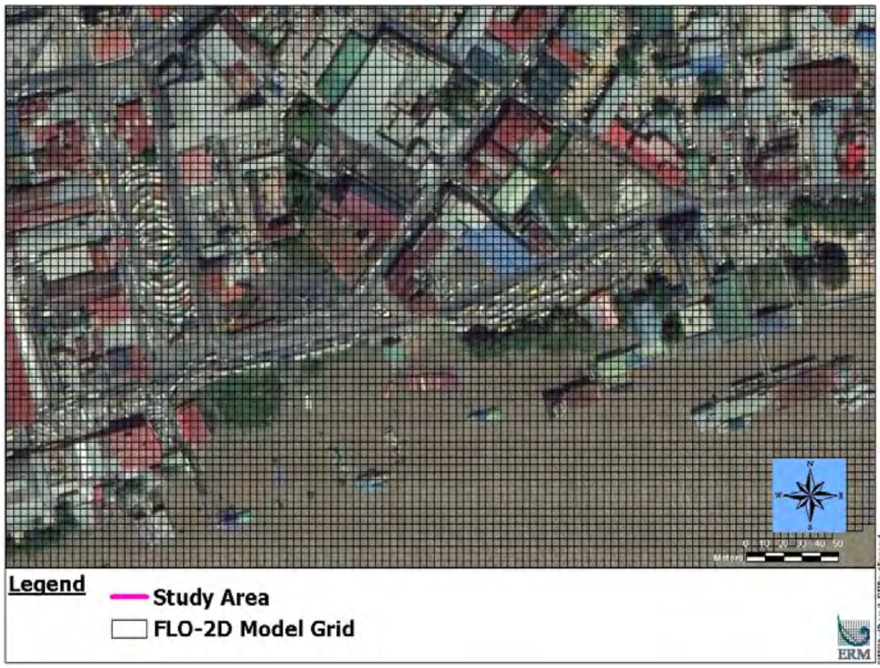


Figure 28: 4 m grid cell resolution at the waterfront capturing all details of the buildings in the Study Area

Buildings in the downtown area will affect and be affected by flooding. The building footprints shapefile was obtained from OpenStreetMap website. As obstructions, buildings cause reduced area for flood waters, while increasing depths and flow velocities. The combination of high depths and velocities is a hazard to buildings and can cause significant damage.

Land use also affects flooding. Flood water moves at a higher velocity along paved surfaces, however highly vegetated areas can absorb some of the impacts of flooding. Land use data was obtained from the Suriname Online Portal[15] and incorporated in the FLO-2D model grid. For this study, the SCS Curve Number method (USDA, 1986) was selected to represent rainfall infiltration into the soil. Areas with a higher curve number (CN) have reduced infiltration due to greater impermeability, and therefore have a higher potential for flooding. A CN was assigned to each grid cell based on soil type and land use in the Study Area. The land use and soil type determine the curve number and Manning's roughness parameters which are shown in Table 10 . Greater vegetative cover will have a lower curve number, faster infiltration.

[15] Suriname Online Portal (http://surinameonline.maps.arcgis.com/home/index.html) is a joint initiative of GISSat and ESRI. Suriname Online is a so-called "one stop window" where spatial digital and geographical data from various stakeholders from the GIS community in Suriname are available for public use.

Table 10: Land use parameters for the FLO-2D application of the Study Area

Land Use	Manning's n value	Curve Number
Low Density Residential	0.12	90
Medium Density Residential	0.12	90
High Density Residential	0.12	90
High Density Housing - Low Income	0.12	90
Agriculture and Livestock	0.35	86
Medium/Low Density farmstead residential	0.12	90
Commercial	0.08	95
Institutional (Schools, Government, etc.)	0.08	95
Industrial	0.05	93
Park/Reserve/Roundabout	0.40	79
Cultural Heritage	0.08	92
Cemetery	0.40	79
Open Field Some Vegetation	0.40	79
Field Where Development is Prevalent	0.12	90
Dense Vegetation and Forest	0.40	77
Water - Includes Larger Canals	0.04	98

The downtown flood wall was incorporated into the FLO-2D model grid as shown in Figure 26. Design drawings, aerial imagery, and shapefiles delineated the extent and height of the flood wall. It is approximately 0.5 km in length and has a top elevation of 3.25 m NSP. In addition, land elevation along the shoreline of the Suriname River adjacent to the Study Area within the model domain was ground truthed based on information gathered during site visits and from other published information related to prior flooding in the Study Area.

Based on the site visit, we identified that the sluice gate and pumping station at Knuffelsgracht Street does not work. Similarly, the sluice gate near Central Market (no pumps) also does not work. Because of this, they were not included in the baseline and climate change scenarios for the Study Area existing conditions. Only the sluice gates and pumps for the Van Sommeldijckse Canal were included in the Flo-2D model setup. We assumed that the entire canal system within the Study Area is fully functional for the baseline and climate change scenarios. Since FLO-2D model cannot handle head controlled operation of sluice gate and pump, we assumed continuous operation of two pumps with a total capacity of 9.0 m^3/sec in the Van Sommeldijckse Canal. However, FLO-2D model limits the pump operating capacity when Suriname River water level is larger than the operating head of the pump and hence the model indirectly emulates the head controlled gate and pump operating mechanisms. However, in the detailed flooding analysis of the Van Sommeldijckse Canal, the actual operating mechanism of sluice gates and pumps were implemented in the HEC-RAS model that was described in Section 4.5.

FLO-2D model simulations were performed using two methods 1) coastal flooding; and 2) inland flooding. We adopted this approach to understand the individual contribution to flooding in the Study Area instead of combining them together. Based on our previous metropolitan Paramaribo city side hazard risk assessment study (ERM, 2017), we identified the flooding in different regions can be clearly distinguished between coastal flooding due to storm surges and inland flooding due to rainfall. Further, we found that the coastal flooding is predominately high near the riverbank of the Suriname River. Therefore, in the site specific flood hazard risk analysis report we described in detail the coastal flood modeling analysis in the main section and moved the inland flood modelling results to the Appendix section. In both these methods, the driving force was applied only to evaluate the maximum flood impact. This approach also helped us to evaluate the as which driving forces are the major contributor to the Study Area flooding. The model was not run to evaluate the time it takes to drain after the completion pf an extreme flood or rainfall event. However, it can be approximately estimated from the model predicted flood inundation maps.

For coastal flooding, the Suriname River HEC-RAS model computed HHWLs along the shoreline adjacent to the Study Area for baseline and climate change scenarios at 10-, 25-, 50-, and 100- year return periods. We adopted extreme value theory approach to get the worst case conditions. The HHWLs (See Table 4) for various return periods were obtained by the statistical analysis of long time period of available data on water levels at various locations along the Suriname River. This approach includes the effect of spring tide, waves and surge heights due to various storms that would have occurred during the long time horizon used for the statistical analysis. A 12-hour linear flood hydrograph derived from HHWLS (Table 4) was applied along the riverbank boundary of the model domain (Figure 26). In coastal flood modelling, rainfall hydrographs were not included so that we can predict the impact of flooding solely due to the river flood hydrograph.

Similarly, for inland flooding, IDF curves were generated using the methodology described in Section 4.2.1.3 and 4.2.3.2 for baseline and climate change scenarios at 10-, 25-, 50-, and 100- year return periods, respectively. Rainfall hydrograph of 24-hour SCS Type III storm with various intensities (IDF analysis) and return periods were used to represent the worst-case rainfall events. For inland flood modelling, we applied only rainfall hydrographs while keeping the river stage using typical tide hydrograph.

A delineated watershed map of the Study Area is shown in Figure 29. The water flow directions shown in Figure 29 depicts the drainage direction of storm/flood water from the Study Area into the Suriname River. The modeling domain (highlighted in yellow color) was extended on all the inland boundaries of the Study Area to take into account additional run off coming from neighboring watersheds. We performed sensitivity analysis to obtain the present optimized hydrological model boundaries of the Study Area. We used this approach to reduce the computation time due to the usage of very high-resolution model grid (2 m grid cell size).

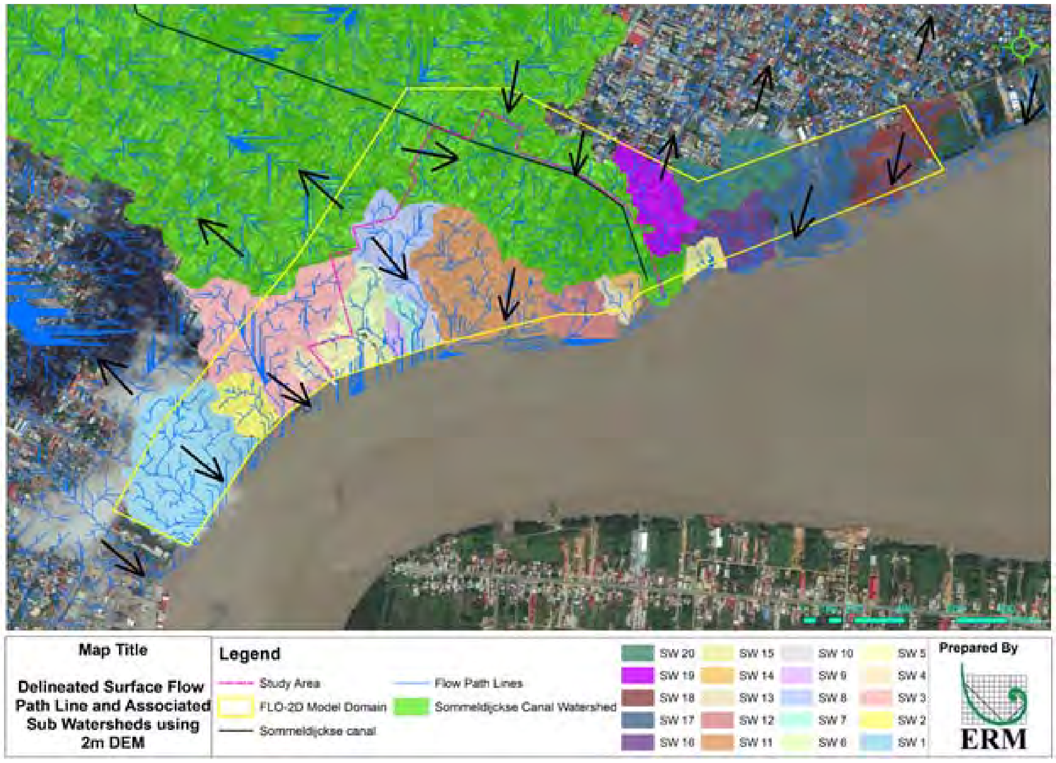


Figure 29: Delineated watershed domains in and around the Study Area. Also shown is runoff flow directions

Water depth and velocity at each model grid cell was obtained as output from FLO-2D model simulations and were used for hazard calculations and impact analysis. Table 11 summarizes the criteria used to determine flood hazard levels by considering water depth and velocity parameters.

Table 11: Definitions of flood intensity used for developing hazard flood maps

Flood Intensity	**Maximum depth [h] (m)**		**Maximum depth h times maximum velocity [v] (m^2/s)**	**Hazard Level**
High	h > 1.5 m	OR	v * h > 1.5 m^2/s	High
Medium	0.5 m < h < 1.5 m	OR	0.5 m2/s < v * h < 1.5 m^2/s	Medium
Low	0.1 m < h < 0.5 m	AND	0.1 m2/s < v* h < 0.5 m^2/s	Low

h=water depth; m= meters; m^2/s= square meters per second; v=water velocity.
Source: Adapted from FLO-2D Reference Manual, 2004

4.4.2 *Implementation of Canal Drainage System in the Study Area*

The Flo-2D model setup described in previous sections was linked with the U. S. EPA's Storm water Management Model, SWMM[16] (EPA 2014) to determine the capacity of the drainage system. This approach allows the FLO-2D to predict the extent and depth of ponded areas caused by overflow from the drainage system.

The SWMM (EPA, 2014) model is routinely used to determine the drainage system capacity and flood hydrographs for a storm water analysis of an urban region. SWMM model routes rainfall through the storm water drainage system by simulating rainfall-runoff from primarily developed areas and routes the runoff through pipes, storage/treatment devices, and other components of a system. In addition, the SWMM model tracks the quantity of runoff generated within each sub catchment, and the flow rate and depth of water in each pipe of the drainage system. Flow through pipes may be simulated as steady flow, utilizing Manning's equation, or as dynamic wave, utilizing the Hazen-Williams or Darcy-Weisbach equations. The drainage network area is divided into small sub catchments each containing various amounts of pervious and impervious surfaces. The runoff from each sub catchment feeds into a series of nodes representing manholes and links representing pipes connecting the nodes.

The storm water drainage network was input to SWMM model with information from design drawings supplied to us in AutoCAD format by the Suriname Public Works Department. Details about pipe sizes, invert elevations, and outfall locations were included in the diagram as annotations. The CAD design drawing was in an unknown coordinate system and it was converted to the right coordinate system using ArcGIS after several tryouts. Because of the large number of manholes and pipes in the Study Area, only major junctions were included in the SWMM model. A map of the drainage network that was imported into SWMM is shown in Figure 30.

[16] SWMM refers to Storm Water Management Model, developed by U. S. EPA (United States Environmental Protection Agency) is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of rainfall runoff from primarily urban areas.

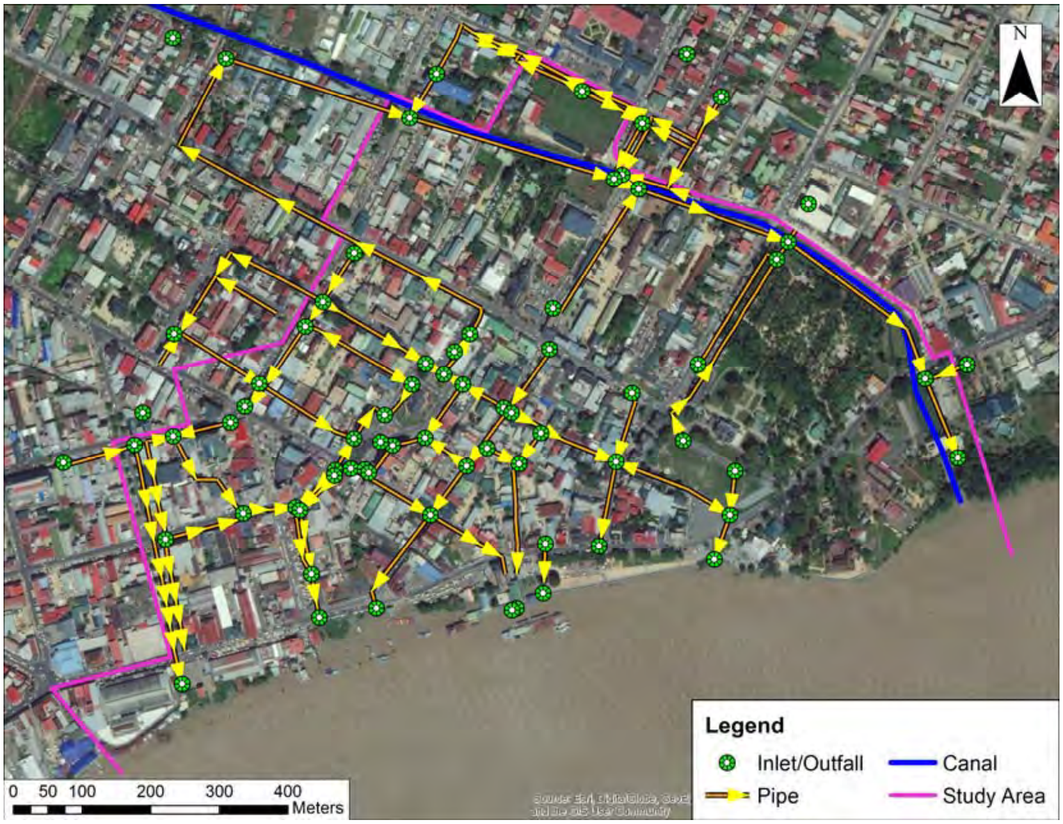


Figure 30: Drainage system network improvised in GIS for SWMM model

Results from SWMM were used to model the extent and depth of ponded areas in FLO-2D. Storm sewer overflow hydrographs at various nodes in the drainage system were computed in SWMM. The 10-, 25-, 50-, and 100-yr event overflow hydrographs were used as input in the FLO-2D model. Drainage inlets which are not flooded are set as outflow cells in FLO-2D. Water entering these inlet cells from the inlet sub catchment will go out of the system. Some of that water is returned to the surface through inlets that are flooded, and the rest through outfalls. Flooded inlets are given a 1-hr inflow hydrograph equal to the total volume of flooded water. Outfalls are given a 24-hr inflow constant hydrograph equal to the total volume of outfall water loading.

Results show that the drainage system will overflow at certain locations. The flooding at these locations caused by low elevation points in the Study Area. Figure 31 to Figure 34 show drainage pipe flow rate and inlet flooding for the baseline scenario at 10-, 25-, 50- and 100- year return periods. In all these figures, red nodes and pipes indicate that the system has insufficient capacity. The invert elevation of the most flooded inlet is -0.4 m NSP. Flow rates at this location are provided in Table 12. The invert elevation in that area is below sea level and unable to efficiently drain without any pumping.

Based on the site visit, we identified that the sluice gate and pumping station at Knuffelsgracht Street does not work. Similarly, the sluice gate near Central Market (no pumps) also does not work. Because of this, they were not included in the baseline and climate change scenarios for the Study Area as-is conditions (no adaptation alternatives). The outfalls discharge directly goes through the gates as open sluice. Adaptation alternatives 5 and 6 refers to the rehabilitation of these two locations (See Adaptation Alternatives report).

Figure 31: Pipe flow and inlet flooding for a baseline 10-year event. Flow rate in cubic meters per second (CMS)

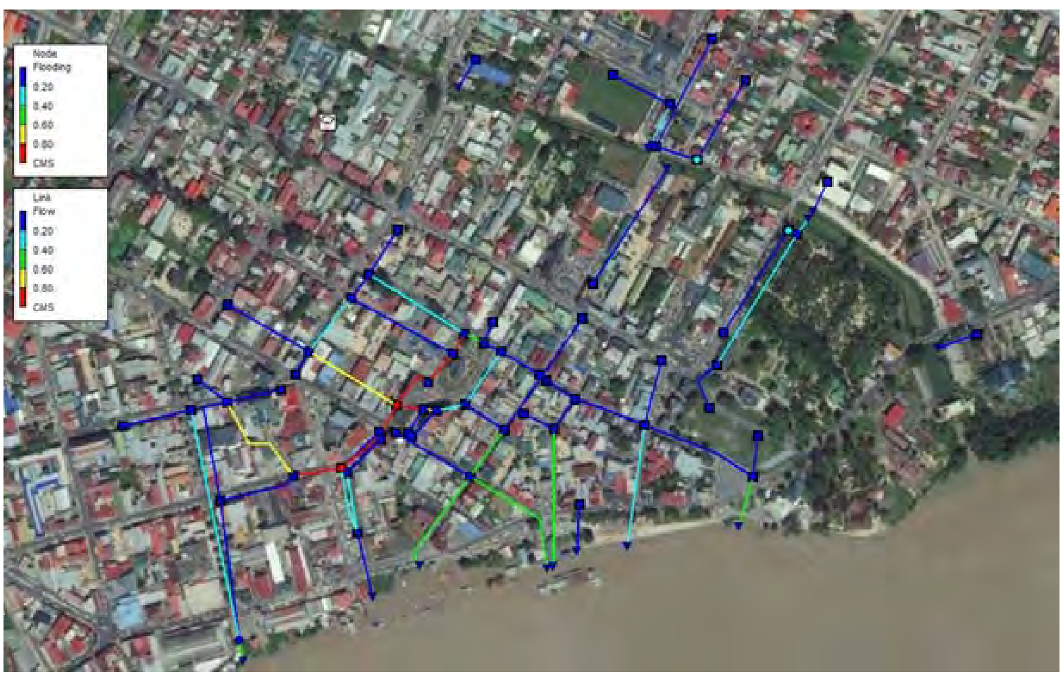


Figure 32: Pipe flow and inlet flooding for a baseline 25-year event. Flow rate in cubic meters per second (CMS)

Figure 33: Pipe flow and inlet flooding for a baseline 50-year event. Flow rate in cubic meters per second (CMS)

Figure 34: Pipe flow and inlet flooding for a baseline 100-year event. Flow rate in cubic meters per second (CMS)

Table 12: Drainage flooding flow rate for the Baseline Scenario

Return Period	Maximum Flooding Rate (m^3/s)
10	7.41
25	9.02
50	10.23
100	11.43

4.4.3 Analysis of the Study Area Flood Modelling Results

The flooding impacts in the study region was analyzed in terms of inland flooding due to rainfall and inefficient drainage systems and coastal flooding due to the HHWLs in the Suriname River due to the combined action of river inflows, tides, waves and storm surges. These two flooding scenarios were run separately to evaluate individual maximum impacts. This approach though highly conservative, it is a good practice so that localized adaptation measures can be identified for the Study Area. A detailed description of all the coastal and inland flood modelling scenarios for the Study Area with the existing flood wall is provided in Appendix A1 and A2.

In order to understand as where flooding occurs in the Study Area, an aerial satellite image of the Study Area along with key assets locations is shown in Figure 35. The coastal flood modelling results show that most of the flooding occurs in the vicinity of the Water Taxi and Fort Zeeland regions and along the Van Sommeldijckse Canal. The inland flood modelling results show that most of the flooding occurs in the vicinity of Hotel Palacio, CetrumKerk and Roopram Rotishop and watershed regions on either side of the Van Sommeldijckse Canal adjacent to the shoreline of the Suriname River. To illustrate how the intensity of flooding changes for different return periods and how climate change further exacerbates the situation, two critical areas in the Study Area were chosen to evaluate flood impacts. The first area is the Water Taxi area along the Suriname River and the second is the Fort Zeelandia area also along the Surinam River but adjacent to the Van Sommeldijckse Canal. These areas are of economic and historic importance and both are outside the existing flood wall in the Study Area. These two areas were used to analyze the results for all coastal flooding scenarios.

In section 4.4.3.1, the coastal flooding inundation results were described for the Study Area baseline configuration. Coastal flooding inundation due to Climate Change Scenarios (2050 and 2080) were discussed for the Study Area in section 4.4.3.2. In section 4.4.3.3 and 4.4.4.4, the corresponding flooding hazard results were described for the Study Area baseline and climate change scenarios, respectively.

Flooding Inundation – Baseline (

4.4.3.1 Figure *36*)

As discussed previously, FLO-2D was used to model higher level hydrodynamic fidelity in the Suriname River flood plain region where flow routing is affected by obstructions due to buildings, infiltration and storm-water drainage. Maximum water levels and precipitation for 10-, 25-, 50-, and 100-year return periods were used to inform the baseline analysis.

In the Water Taxi Area (See Figure 35 for location identification), the elevation of Waterkant Street is above the 10-year flood level and consequently little, if any flooding occurs inland. In the 25-year return period, however, the flood elevation is greater than the elevation of Waterkant Street and flooding occurs from the Paramaribo Central Market to the Water Taxi area. This area is approximately 750 m long by approximately 100 m wide at its widest point. Flood elevations in this area range from < 0.1 m to 2.0 m with the majority of the area flooded to depths ranging from 0.1 m to 0.5 m. The area of impact related to the 50-year return period is only slightly greater than that area impacted in the 25-year return period, with a small area inundated at the intersection of Keizer Street and Waterkant Street where flood depths range from 0.1 m to 0.5 m. The flooding impact in this area ranges from 0.1 m to 1.0 m. For the 100-year return period, flooding continues to increase to the east and west of the Water Taxi Area. Inundation occurs in an area at the southern end of Jodenbree Street with flood levels ranging from 0.1 m to 1.0 m. A small area near the western end of the flood wall is also impacted with flood levels ranging from 0.1 m to 1.0 m. In summary, the elevations along Waterkant Street tended to be greater than the flood levels for the 10-year return period. However, the increasing flood elevations in the 25-, 50-, and 100-year return periods exceeded the elevations along Waterkant Street, resulting in flooding that first spreads inland and then expands east and west of the Water Taxi Area.

Around Fort Zeelandia (See Figure 35 for location identification) to the east of the Water Taxi Area, the elevation of the area is higher and generally above the 10-year flood level; consequently little, if any flooding occurs inland. The only flooding occurs in a small wooded area near the mouth of the Van Sommeldijckse Canal. For the 25-, 50-, and 100-year return periods flooding in the area is essentially that same as the 10-year return period. The ground elevation in the area of Fort Zeelandia, therefore, is sufficient to withstand even a 100-year event.

Figure 35: Study area with historic assets and cultural heritage areas

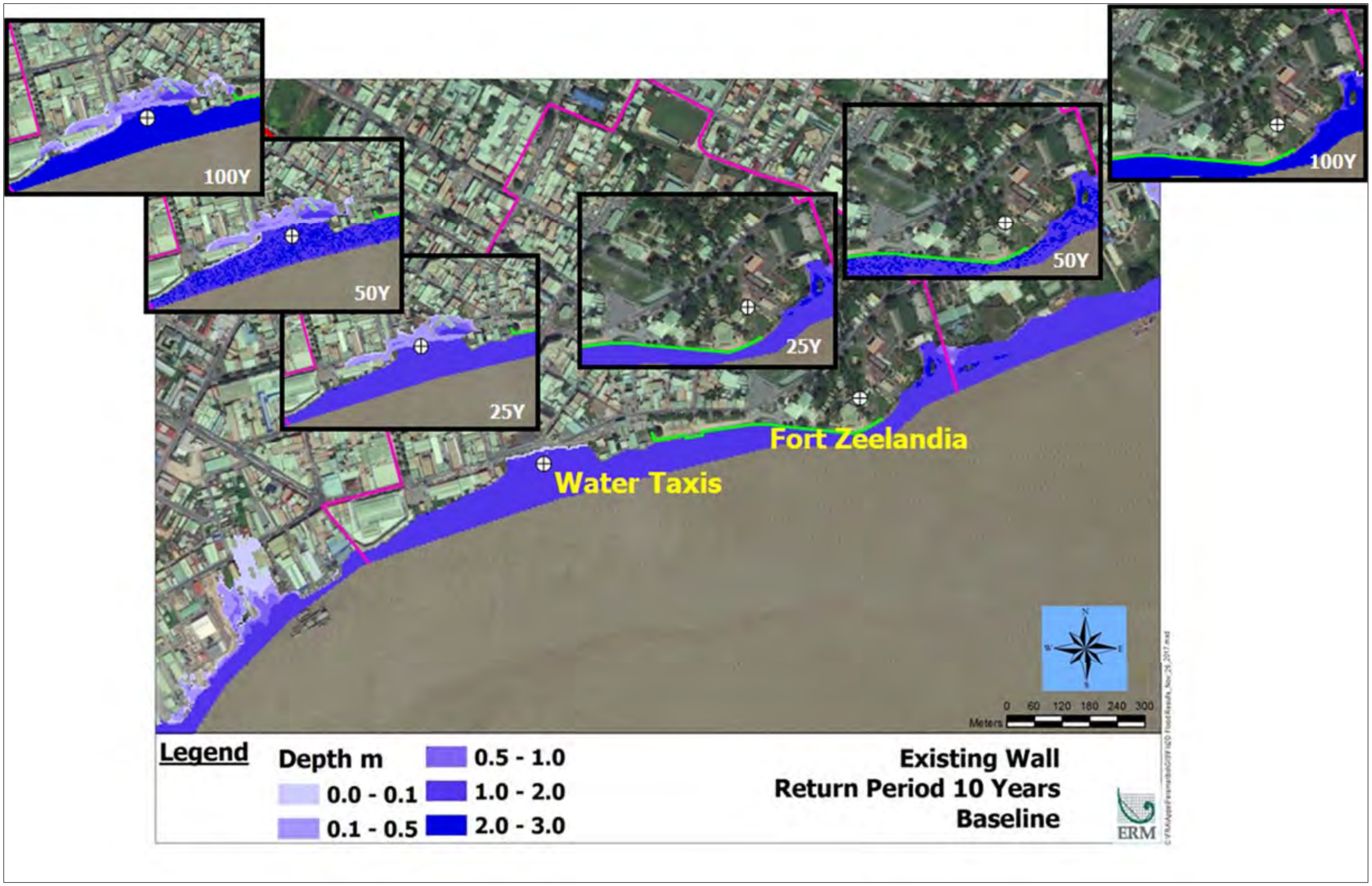


Figure 36: Comparison of coastal flooding at the Water Taxi and Fort Zeelandia regions for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

4.4.3.2 Flooding Inundation – Climate Change

The impacts from climate change were then evaluated for the years 2020, 2050, and 2080. However, because climate change impacts for the year 2020 are relatively small, the years 2050 and 2080 are evaluated below to demonstrate how climate change will likely impact the Study Area.

2050 Climate Change Scenario (

Figure 37)

In the western portion of the Study Area near the Water Taxi area (See Figure 35 for location identification), the 2050 climate change scenario significantly exacerbates flooding along the bank of the Suriname River above the baseline. The elevation of Waterkant Street is below the 10-year flood level for the 2050 climate change scenario and significant flooding occurs along this region of the Suriname River. The area from the Paramaribo Central Market to the western end of the existing flood wall is inundated with water depths ranging from 0.1 m to 2.0 m. In addition, flood levels for the 10-year return period under the 2050 climate change scenario also are high enough to flood low lying areas immediately behind the existing flood wall. For the 25- and 50-year return periods, flooding inundation occurs over a larger area with flooding extending to the north of Keizer Street and into the southern portion of Kromme Elleboog Street in the 50-year return period. The area surrounding Bodega & Grill De Waag is inundated with 0.1 m – 0.5 m of water. As expected, some additional areas are inundated for the 100-year return period; however, increase in the area of impact is small. The main difference is an increase in general water depths along the riverfront area.

In the eastern portion of the Study Area, near Fort Zeelandia (See Figure 35 for location identification), the 2050 climate change scenario with a 10-year return period leads to flooding along the western side of the Sommeldijckse Canal. The elevation at Fort Zeelandia, however, is still above the HHWL and little or no flooding occurs. For the 25-year return period additional areas are inundated, particularly along the Sommeldijckse Canal immediately to the northeast of Fort Zeelandia. These areas are inundated with 0.1 m to 1.0 m of water. Of particular note is that flood waters also occur in the inland side of the existing flood wall at depths ranging from < 0.1 m to 2.0 m. For the 50- and 100-year return periods, the area impacted by flooding increases significantly. Most prominent is the flooding that occurs along the Sommeldijckse Canal. Flooding occurs along both bank of the canal and extends inland approximately 150 m west of the canal with depth ranging from 0.1 m to 1.0 m. Along the Suriname River, the area immediately surrounding Fort Zeelandia (See Figure 35 for location identification) is inundated by 0.1 m to 2.0 m of water. The elevation of the Fort itself, however, is above the HHWL for the 100-year return period. The area of flooding on the land side of the existing flood wall also increases with increasing return period. In summary, although the elevation of Fort Zeelandia places it out of harm for the 100-year return period, a substantial area in the eastern portion of the Study Area will be impacted by both 50- and 100-year flooding event.

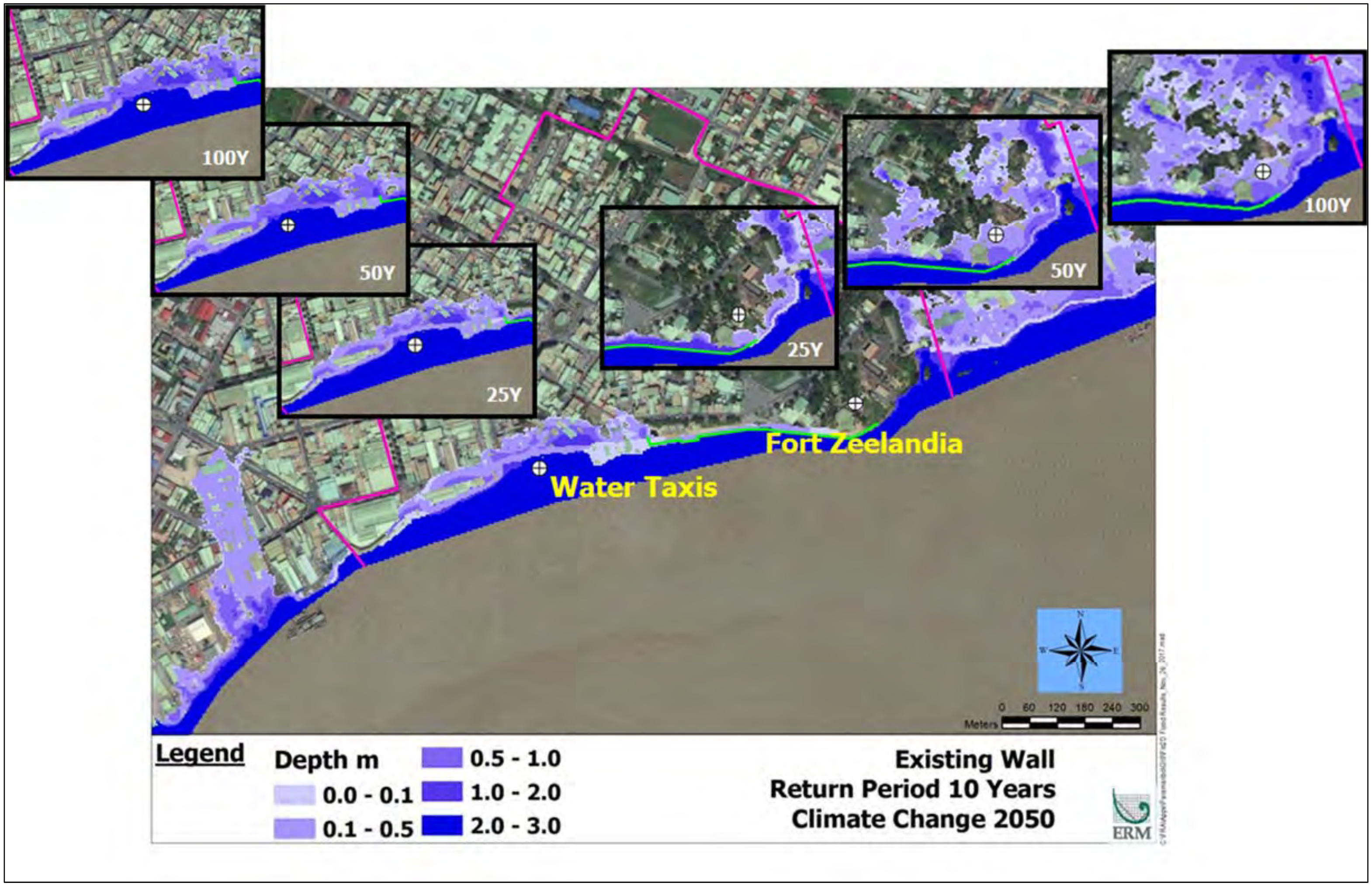


Figure 37: Comparison of coastal flooding at the Water Taxi and Fort Zeelandia regions for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods

2080 Climate Change Scenario (Figure 38)

As expected, the 2080 climate change scenario for the 10-year return period exacerbates flooding above the baseline 10-year return period. The areas along the bank of the Suriname River in the western portion of the Study Area near the Water Taxi Area are particularly impacted. To put these impacts into context, the affected area of impact for the 2080 climate change scenario for the 10-year return period is approximately double the area impacted under the 2050 climate change scenario for the 10-year return period in the western portion of the Study Area. For the 25-, 50-, and 100-year return periods, there is some increase in the affected area in the western portion of the Study Area at the HHWL for these events. What is significant is that the primary increase in the area affected by flooding occurs with the 10- and 25-year return period, with only marginal increases occurring during the 50- and 100-year return periods.

In the eastern portion of the Study Area (See Figure 35 for location identification), extreme flooding impacts above the baseline occur with the 2080 climate change scenario for the 10-year return period. Whereas essentially no flooding in the Fort Zeelandia Area occurs with the baseline 2050 climate change with a 10-year return period, significant flooding occurs in the majority of the eastern portion of the study area. Flooding extends from the area around the Walter Amo Sporthal on Koninginne Street to the mouth of the Sommeldijckse Canal. Although the areal extent of flooding increases for the 25-, 50-, and 100-year return periods, the areal increases associated with these events are relatively small compared to the change that occurs above the baseline for the 10-year return period.

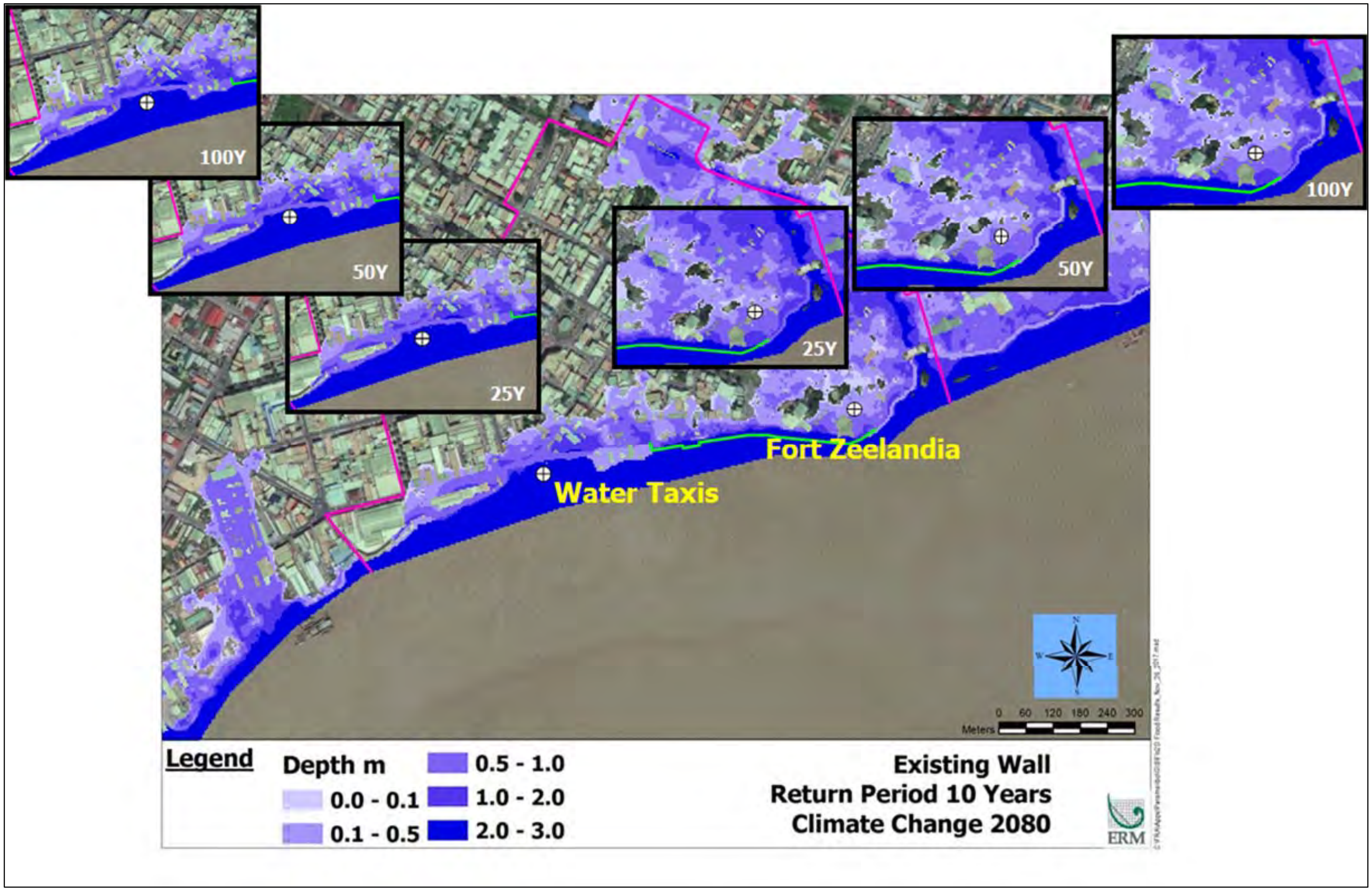


Figure 38: Comparison of coastal flooding at the Water Taxi and Fort Zeelandia regions for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

Flooding Hazard – Baseline (

4.4.3.3 Figure 39)

Flood hazard levels were determined based on water depth and velocity obtained as output from the FLO-2D model. As noted previously, the elevation of Waterkant Street in the Water Taxi Area (See Figure 35) is above the baseline 10-year flood level and consequently little, if any flooding occurs inland. Therefore, flood hazards are high only along the bank of the Suriname River in the western portion of the Study Area. Small areas with a medium hazard level can be seen on the immediately to the west of the Water Taxi Area. For the 25-, 50-, and 100-year return periods, hazard levels essentially mirror inundation levels in this region of the Study Area. Areas inundated with 0.0 m to 0.5 m of water correspond to low hazard; areas inundated with 0.5 m to 1.0 m of water correspond to medium hazard and areas inundated with greater than 1.0 m of water tend to correspond to high hazard levels.

Because the elevation of the Fort Zeelandia area (See Figure 35 for location identification) to the west of the Water Taxi Area is generally above the baseline 10-year flood level, medium and high hazard levels are associated only with the bank of the Suriname River and the mouth of the Sommeldijckse Canal. The hazards associated with the 25-, 50-, and 100-year return periods with the existing flood wall generally mirror inundation levels in this region of the Study Area with medium hazards associated with shallower water along the bank and deeper water in the mouth of the Sommeldijckse Canal.

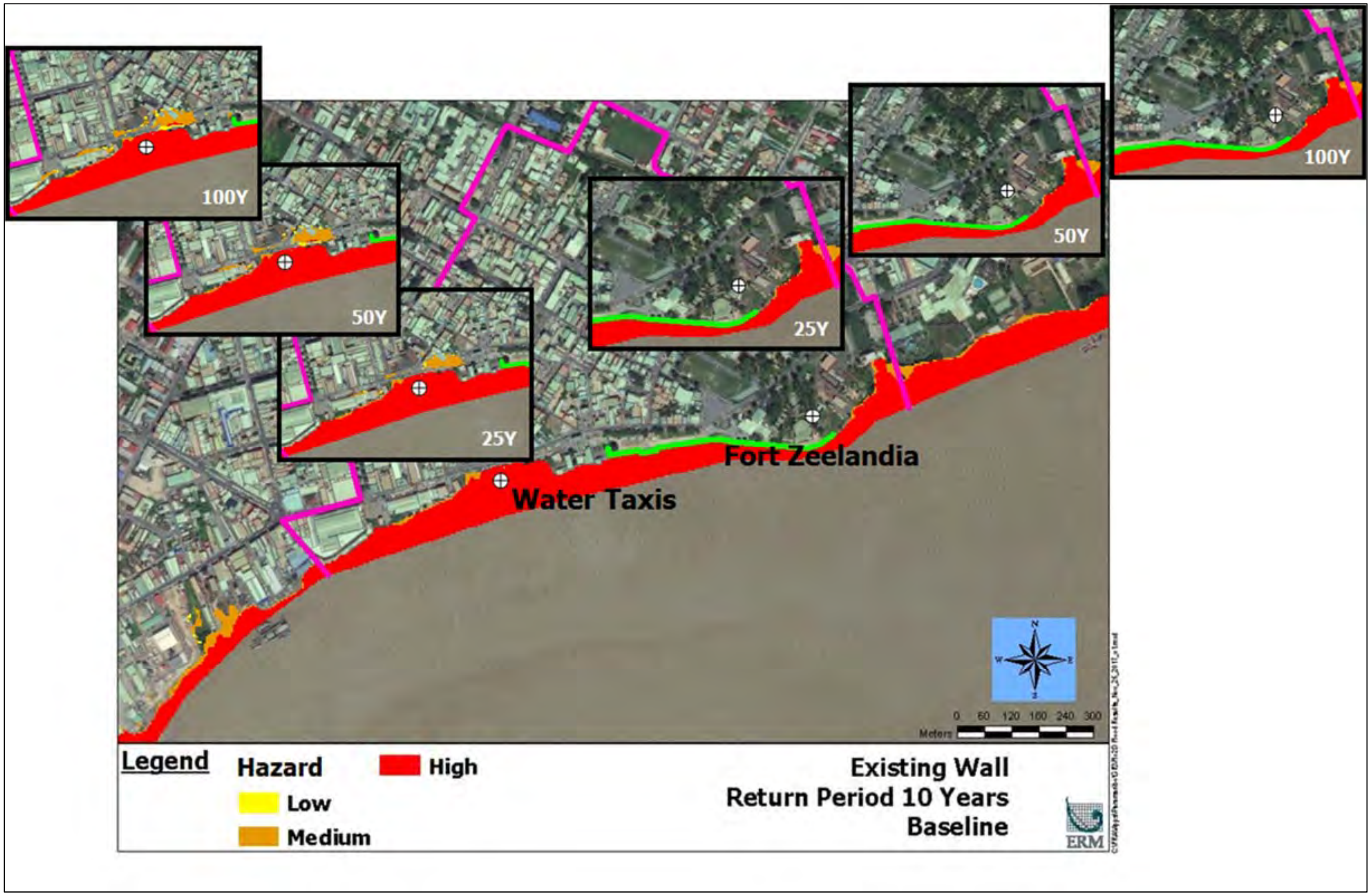


Figure 39: Comparison of coastal flooding hazard at the Water Taxi and Fort Zeelandia regions for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

4.4.3.4 Flooding Hazard – Climate Change

The impacts from climate change are evaluated for the years 2050 and 2080.

2050 Climate Change (Figure 40)

As noted above, in the western portion of the Study Area near the Water Taxi Area (See Figure 35 for location identification), the 2050 climate change scenario significantly exacerbates flooding along Waterkant Street and the bank of the Suriname River above baseline. With the elevation of Waterkant Street below the 10-year flood level for the 2050 climate change scenario with a 10-year return period, significant flooding occurs along this region of the Suriname River. Low hazard levels are generally found where flood water levels are less than 0.1 m deep, with the exception of a narrow low hazard band in an area inundated with 0.5 m – 1.0 m of water located along Waterkant Street immediately adjacent to the Water Taxi Area. A small high hazard area can be found immediately adjacent to this low hazard area. Medium hazards are generally located in areas with 0.5 m – 1.0 m of water. Flood hazards associated with the 25-year return period do not change appreciably from those seen with the 10-year return period. For the 50- and 100-year return period, the extent of medium hazard areas increases appreciably above that for the 25-year return period. The area of high hazard does not increase significantly with the 50- and 100-year return period.

In the eastern portion of the Study Area, flooding occurs almost exclusively along the western side of the Sommeldijckse Canal with the 2050 climate change scenario with a 10-year return period. Medium hazards are seen mainly in this area. Small pockets of low hazard areas are associated with shallow flooded areas (< 0.1 m) and relatively larger pockets of medium hazard are found associated with areas between 0.5 m and 2.0 m deep. The only high hazard areas were found in the Suriname River at the mouth of the Sommeldijckse Canal. For the 25-year return period additional areas are inundated, particularly along the Sommeldijckse Canal immediately to the northeast of Fort Zeelandia (See Figure 35). These areas are associated with medium hazards; however, several small high hazard areas are found in areas with flood depths of 1.0 m to 2.0 m. This pattern grows in areal extent with 50 and 100-year return periods. In addition, as noted above, flood waters also extend to the inland side of the existing flood wall. The extent of medium and high hazard areas increases significantly above baseline in the 25-, 50-, and 100-year return periods.

2080 Climate Change (Figure 41)

2080 climate change scenario for the 10-year return period exacerbates flooding above the baseline 10-year return period, as noted above. In the western portion of the Study Area near the Water Taxi Area (See Figure 35 for location identification), the areas along the bank of the Surname River are particularly impacted. The area is characterized primarily as a medium hazard area a few pockets characterized as high hazard. Medium hazard areas generally occur along Waterkant Street (See Figure 35) and immediately inland where water depths are range from 0.1 m 1.0 m. The high hazard areas are associated with depths between 1.0 m and 2.0 m. One large area of high risk is located immediately adjacent to the Bodega & Grill De Waag (See Figure 35 for location identification). As discussed previously, the areas impacted by flooding from 25-, 50-, and 100-year events are not significantly different from that found with the 10-year return period climate change scenario. Likewise, flood hazards associated with the 25-, 50-, and 100-year return periods were not appreciably different from conditions found with the 10-year return period. Medium hazard areas generally occur along Waterkant Street and immediately inland where water depths are range from 0.1 m 1.0 m. The high hazard areas are associated with depths between 1.0 m and 2.0 m.

In the eastern portion of the Study Area, extreme flooding impacts above baseline occur with the 2080 climate change scenario for the 10-year return period, whereas essentially no flooding in the Fort Zeelandia Area (See Figure 35 for location identification) occurs with the baseline 10-year return period. The Sommeldijckse Canal and the area immediately adjacent to it are characterized as high risk. Similarly, the Suriname River at the mouth of the Sommeldijckse Canal and the area immediately behind the existing flood wall are also characterized as high risk. The rest of the inundated area is characterized as medium risk. Although the areal extent of flooding continues to increases for the 25-, 50-, and 100-year return periods, the areal increases associated with these events is relatively small compared to the change that occurs above baseline for the 10-year return period. Therefore, there is little change in the size of medium and high hazard areas.

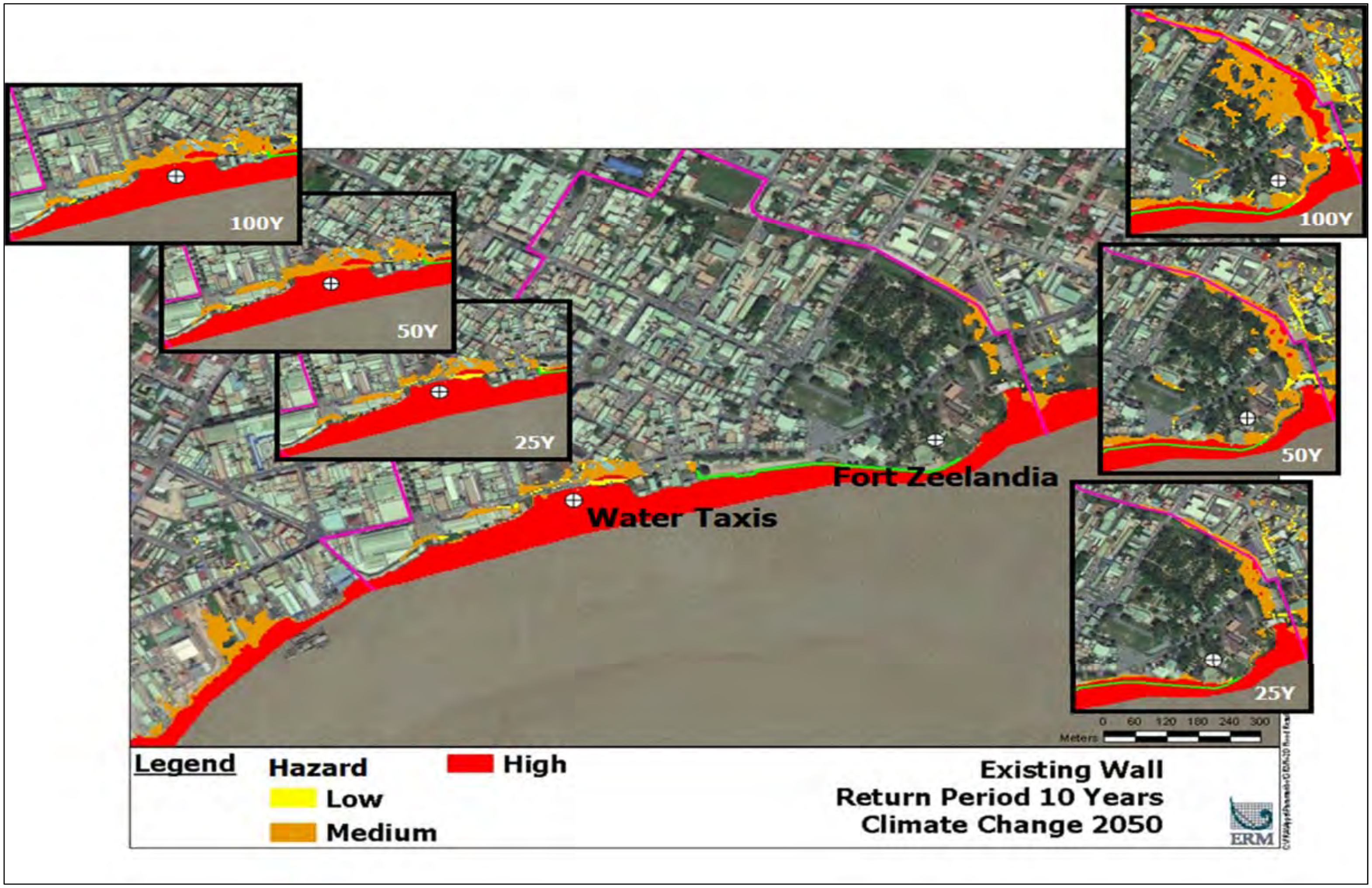


Figure 40: Comparison of coastal flooding hazard at the Water Taxi and Fort Zeelandia regions for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods

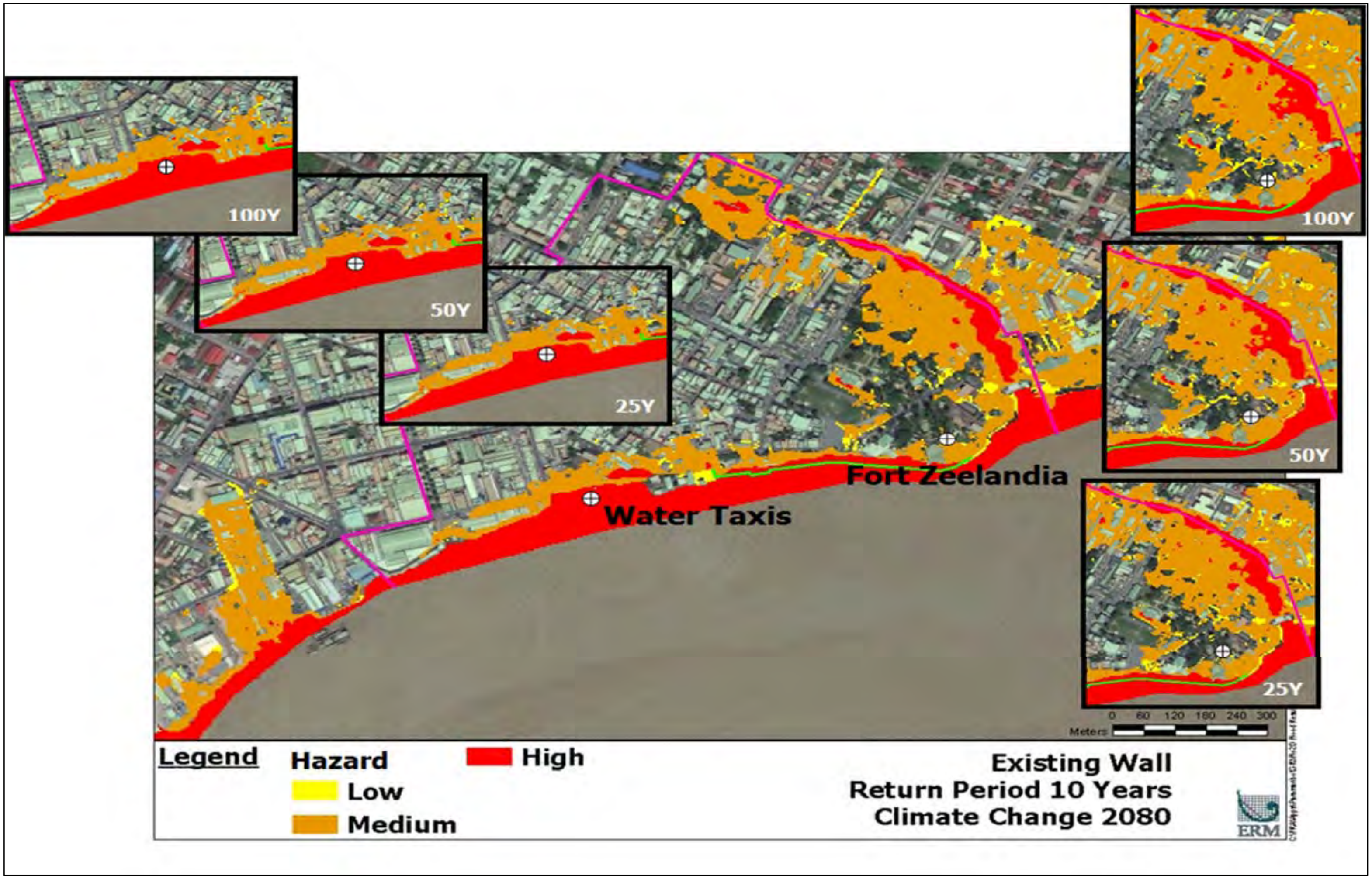


Figure 41: Comparison of coastal flooding hazard at the Water Taxi and Fort Zeelandia regions for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

Majority of the flooding in the study area appears to be from the Suriname River (coastal flooding) than from precipitation/runoff from inland (inland flooding). The inland flooding, rather than significantly occurring at any location, is sparsely distributed throughout the study area, although the inland flooding appears to be increasing along the river bank of both Suriname River and Van Sommeldijckse canal (ultimate drainage outlets) as the storm return period increases. Based on the modelling runs for both baseline and future scenarios, there are two general locations that are comparatively more prone to flooding than other locations of the study area. One area is the low spot along the bank of Suriname River that is immediately east of Knuffelsgracht Street and Waterfront (Waterkant) Street intersection. The second general area of concern is the Van Sommeldijck canal, immediately upstream of Van Sommeldijckse Canal pump station.

Landing for small boats and a steel jetty are located in this low area immediately east of Knuffelsgracht Street and Waterfront (Waterkant) Street intersection (See Figure 35 for location identification). This area is prone to significant coastal flooding even for baseline conditions (See Appendix A1 of this Report). As the modelling progresses to climate change scenarios, coastal flooding is also observed along the Van Sommeldijckse Canal (See Figure 35 for location identification). Flooding starts to appear immediately at north of the inlet side of the Van Sommeldijck pumping station, for climate change 2020 scenario, and then progresses further upstream along the canal for 2050 and 2080 climate chance scenarios.

The detailed flooding analysis described above suggests that the flood adaptation measures are needed along the Suriname River shoreline to minimize the influx of its water entering into the Study Area due to high water levels caused by storm surge and sea level rise superimposed over tides. Additional flood adaptation measures are also needed to deplete the runoff out of the Study Area during high intensity rainfall periods and coastal flooding by improving/enhancing the existing drainage system in the Study Area.

4.4.4 Dynamics of Flooding in the Study Area

The dynamics of flooding in any place follows the principle of least resistance. The driving forces are intensity, duration and frequency of precipitation events, storm surge over high tides, waves and SLR. The resistance to flooding comes from physical configuration (elevation and slope), infiltration (soil and land configuration) into the ground and natural and constructed drainage system (holding and draining capacity) of a region.

4.4.4.1 Coastal Dynamic Characterization

Coastal flooding occurs when the sea water level rises during tropical storms and hurricanes have the potential to severely impact low-lying coastal settlements such as cities, villages and infrastructures. The United States National Oceanic and Atmospheric Administration (NOAA) identifies the rise in sea water level during storm conditions as storm surge, which is defined as an abnormal rise of water generated by a storm, over and above the predicted astronomical high tide (NOAA, 2015). The raised sea water can inundate the coastal land via two major paths:

- Direct inundation, where the sea level exceeds the elevation of the land; or
- Overtopping of a barrier, where the sea level overtops or breaches a natural or artificial barrier.

Coastal flooding is largely a naturally occurring event. However, human influence on the coastal environment can facilitate the sea level rise and exacerbate the damage. For example, extraction of water from groundwater reservoirs in the coastal zone can enhance subsidence and increase the risk of flooding.

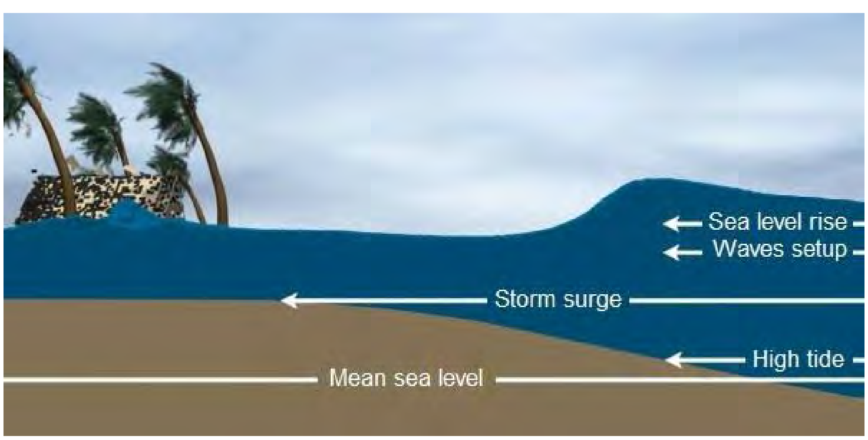
In Paramaribo, coastal flooding is a hazard of concern in particular when downbursts from thunderstorms are experienced, and predictions of climate change and global warming indicate an increase in flooding due to a rise in sea level (USACE, 2001).

4.4.4.2 Processes Contributing to Total Storm Surge

Coastal flooding occurs mostly because of the storm surge created by hurricanes and its backwater effects on inland rivers and stormwater systems. Other processes also contribute to coastal flooding and each needs to be assessed separately. These processes include:

1. Storm surge;
2. High tides;
3. Waves setup; and
4. Sea level rise (SLR).

These processes contributing to the total storm surge are shown in the following Figure.



Source: Adapted from NOAA, 2015

Storm surge is the combination of wind setup and pressure setup during hurricanes and tropical storms. High tides depend on the combined effects of the gravitational forces exerted by the Moon and the Sun and the rotation of the Earth. Wave setup is the increase in mean water level due to the presence of waves. Wave setup is largest during tropical storms and hurricanes. In general, surges produced by wind are larger than surges due to pressure.

Tropical cyclones are rapidly rotating storm systems characterized by a low-pressure center and a spiral arrangement of thunderstorms. These tropical cyclones usually bring strong winds and produce heavy rain. Depending on the storm intensity, tropical cyclones are classified as tropical depressions, tropical storms, and hurricanes. The hurricane category is particularly dangerous and has the potential of producing heavy coastal flooding.

Hurricanes gain their energy from warm waters as they move across the Atlantic Ocean. At the system moves inland, the system loses strength and dissipates. Hurricanes as well as tropical storms typically have enough moisture to cause extensive flooding throughout a large geographical area. In addition to flooding, hurricanes and tropical storms can bring severe winds, extensive coastal erosion, extreme rainfall, thunderstorms, lightning, and tornadoes (USACE, 2008).

Higher ocean water levels can have devastating effects on coastal and near-shore habitats. As seawater reaches farther inland, it causes destructive erosion, flooding of wetlands, contamination of aquifers and agricultural soils, and lost habitat for fish, birds, and plants. When tropical storms make landfall, higher sea levels induce larger and more powerful storm surges that can propagate further inland.

4.4.4.3 Study Area Flood Characterization

In the Study Area, most of the flooding occurs due to HWLs in the Suriname River caused by storm surges occurring at spring high tide conditions. The baseline simulations clearly show that flooding in the Study Area begins at the low ground elevation level of the Waterkant Street and Paramaribo Central Market, spreads inland and then expands east and west of the Water Taxi area towards the existing flood wall. The ground elevation near the Fort Zeelandia and the Van Sommeldijckse Canal area well above the 100-yr baseline HHWL resulting in no flooding. Inland flooding in the Study Area is caused by precipitation and water logging shows up in various regions, spread out sporadically with more inundation occurring along the Van Sommeldijckse Canal. The inland flooding happens due to overflow from the drainage system at the Canal and various manholes in the street and non-operating condition of sluice gates and pumps at Knuffelsgracht Steet and near Central Market (see Section 4.4.2).

The maximum water level in the Study Area for a 100-yr event is 226 cm NSP. The existing floodwall elevation is 325 cm NSP. Most of the Brokopondo Reservoir regulates the flow in the upstream reaches of the Suriname River resulting in the influence of tides along the downstream portion including adjacent to the Study Area. It has an average value of 312 m^3/sec with two high flows, one in 06/02/1972 (1080 m^3/sec) and the other in 06/08/1976 (1190 m^3/sec) based on the time period 1966 to 1986 data. During HEC-RAS modelling, the Suriname River flow used as upstream boundary condition was calibrated to a value of 1150 m^3/sec to obtain an water surface elevation of 226 cm at the Paramaribo station for the 100 year return period (See Table 4). This clearly shows that the discharge from Brokopondo Reservoir does not contribute to any flooding in the Study Area. For the current existing conditions, most of the flooding occurs very close to the shoreline in the vicinity of the Waterkant Street for all return periods, which becomes more pronounced during spring tides. During these conditions, most of the flooding will be caused by inland precipitation with poor drainage system and existence of high water level at the Suriname River inhibiting the runoff from the inland resulting in many areas in the inland region of the Study Area getting flooded.

With climate change, coastal flooding occurs more frequently causing more damage and disruption due to sea level rise. As sea level rises, coastal flooding events will shift from being minor to more extensive, resulting in more damages. Sea level rise occurrence is a slow, multi-decadal process that alone results in gradual coastal erosion, subsidence and saline intrusion. However, when we use extreme value theory to combine sea-level projections with wave, tide and storm surge, the intensity and frequency of coastal flooding increases to a catastrophic level (due to gradual destabilization of the coastal region by sea level rise being impacted by extreme flood waves). Even regions with limited water-level variability will be subjected to unusual flood events.

In the current study, projected SLR increase is 30 cm in 2050 and 70 cm in 2080. The increase in SLR over baseline conditions results in most of the shoreline region along the Suriname River in the Study Area will get flooded resulting in large intrusion of coastal flood wave into the inland, thereby making much large impact than from the inland rainfall flooding. The increase in SLR is much larger than the increase in rainfall intensity for 2050 and 2080. In addition, the increase in SLR further pushes the runoff and drainage water in canals into inland resulting in much large flooding as compared to inland flooding due to rainfall. This can be clearly seen in the hazard maps of the Study Area (see

Figure 37 and Figure 38) developed for climate change scenarios at various return periods. The general flooding coastal flooding pattern remains the same near the Water Taxi area for future years due to climate change. However, the flooding spreads to a larger region on the east and west of the Water Taxi area resulting in more inundation along the rear of the existing flood wall. In addition, more flooding happens in the Fort Zealandia area and on either side of the Van Sommeldijckse Canal for future years due to climate change. This happens because of the limited storage and drainage capacity of the Canal, small-sloped flood plain regions on either side of it. There is not much change in the inland flooding for future years because of small percent increase in precipitation due to climate change.

Based on the current study, we can conclude that two important topographical features of the riverbank controls the coastal flooding dynamics in the Study Area: 1) the inland elevation and 2) the inland slope. The first one restricts the onset of flooding and the second one restricts the spread of flooding. For inland flood dynamics, slope initiates the flooding (run off) and low infiltration and inefficient natural and constructed storm water drainage system spreads the flooding resulting in human and property risks.

The current study results clearly show that the most of the flooding in the Study Area is caused by the combined influence of storm surge, tides and sea level rise, using extreme value theory. In addition, the increase in sea level rise, intensity and duration of storm surge (See Section 4.2.3.3) is much larger than the corresponding increase in extreme precipitation (see Section 4.2.3.2) resulting in less inland flooding as compared to coastal flooding.

4.4.5 Flood Adapation Options for the Study Area

It is to be noted that there is no single solution to address various flooding scenarios described in this report. A range of solutions should be selected to address the different mechanism of flooding which occurs at various locations. The adaption measures should address the two key critical areas that are identified to be prone to flooding.

Various alternatives are considered for the adaption measures to address the two main flood prone areas as identified through the modelling. The details of adaptation options were included in a separate report submitted to IDB (Alternatives Selection: Urban Investments for the Resilience of Paramaribo). However, a brief description of various adaptation alternatives is included here.

4.4.5.1 Adaptation Alternatives Selection

The 14 site-specific alternatives identified in Section 2.2 of the alternative selection report were evaluated in detail using scoring method on criteria that were classified into four main categories: 1) Technological achievement, 2) Socio-political achievement, 3) Environmental achievement and 4) Programmatic achievement. Based on the scoring analysis, the following set of preferred adaptation measures were considered for the development of alternative groups.

1) Alternative 2 - New flood wall immediately east of Knuffelsgracht Street and Waterfront (Waterkant) Street intersection along the bank of Suriname River to address both the baseline and future flooding in these areas
2) Alternative 3 - Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommeldijckse Canal to address both the baseline and future flooding in these areas.
3) Alternative 4 - Rehabilitate Van Sommeldijckse pumping station and sluice gates to increase discharge to the Suriname River. We assumed that

with the suggested improvements, the entire canal system within the Study Area will be fully functional.

4) Alternative 5 - Rehabilitate sluice gate and pumping station at Knuffelsgracht Street

5) Alternative 7 - Rehabilitate Van Sommeldijckse Canal to increase water storage capacity

6) Alternative 8 - Rehabilitate drainage system along Waterfront between Knuffelsgracht and SMS Pier

7) Alternative 11 - Create buffer with enhanced mangrove plantings to reduce the flood velocity and erosion

Formulation of the proposed adaptation measures consists of assembling the seven highest-ranked alternatives (Alternatives 2, 3, 4 5, 7, 8, and 11) listed above into three groups as A, B and C, defined in Table 13 that represent options that best address the critical components of the project, i.e., address the current and amics future expected flooding in the project area. Flood walls are vulnerable to erosion on a longer time horizon due to increase in hydraulic head and water velocities from HHWLs due to sea level rise in a tidal system. The drainage canal system fails over the years due to sedimentation resulting in an increased flooding in the nearby floodplain regions. In addition, the flood modelling results described in detail in Section 4.4.3 were used to identify the operational and failure conditions (HHWLs, return periods and future climate change years) for the various adaptation alternatives identified for this study. Similar analysis was performed on all the selected alternatives and determined functionality threshold and related vulnerability scoring, which are discussed in detail in the alternatives selection report. The three groups, along with projected cost, benefits, and drawbacks of each group, are also presented in Table 13. Based on the review of these benefits and drawbacks, including comparative analysis of these groups, alternatives within Group A are identified as the preferred adaptation measures; therefore, ERM proposes Group A alternatives to advance to the pre-engineering design stage.

Table 13: Alternative Groups

Group	Alternative ID	Alternative	Alternative Description	Projected Cost	Total Group Cost	Benefits	Drawbacks
Group A	1	Alt 2	New flood protection wall from Knuffelsgracht Street to SMS Pier	$5.11 M	$7.80 M	• Strong measure for coastal flood protection • Adaptive to future	• May obstruct view • Inland flood control requires operation of
	2	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	$2.33 M			

Group	Alternative ID	Alternative	Alternative Description	Projected Cost	Total Group Cost	Benefits	Drawbacks
	3	Alt 11	Create buffer with enhanced mangrove plantings	$0.36 M		by increasing wall height • Addresses critical flood area • Address both coastal and inland flooding	pump and gates • Flood wall overlaps with existing water tax business • Management of potentially impacted sediment
Group B	1	Alt 3	Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal	$2.19 M	$7.21 M	• Minimal constructio n disturbanc e to rehabilitate existing wall • Added functionalit y along canal for walkways • Address both costal flood and limited (reduced segment of canal improveme nt)	• Critical flood area not addressed • Only portion of canal is rehabilitated • Inland flood control requires pump and gates operation • Management of potentially impacted sediment
	2	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	$2.33 M			
	3	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)	$2.33 M			
	4	Alt 11	Create buffer with enhanced mangrove plantings	$0.36 M			
Group C	1	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	$2.33 M	$7.57 M	• No view obstruction • Added functionalit y along canal for walkways • Address both coastal flood and limited (reduced segment of canal improveme nt)	• Critical flood area partially addressed by new pump station (PS) – Alt 5 • Construction disturbance at new PS – Alt 5 • Inland flood control requires pump and gates operation
	2	Alt 5	Rehabilitate sluice gate and pumping station at Knuffelsgracht Street	$2.55 M			
	3	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)	$2.33 M			
	4	Alt 11	Create buffer with enhanced mangrove	$0.36 M			

4.4.5.2 Description of Group A Alternatives

1. ***New Flood Protection Wall:*** The historic flood wall on the south side of Waterfront Street will be replaced with a modern sheet pile wall extending approximately 250 meters from Knuffelsgracht Street to the SMS Pier. The steel sheet pile wall will be reinforced along the river side with locally available riprap/stone and finished with a concrete/brick cap. A two- to four-meter wide walkway will be installed on the street side with tree/shrub plantings. A schematic of the proposed flood wall is presented in Figure 42. Additionally, street side drainage improvements will be implemented, including storm drain rehabilitation. The existing historic landing for small boats and a steel jetty within the limits of the proposed flood protection wall will be rehabilitated during the wall construction.

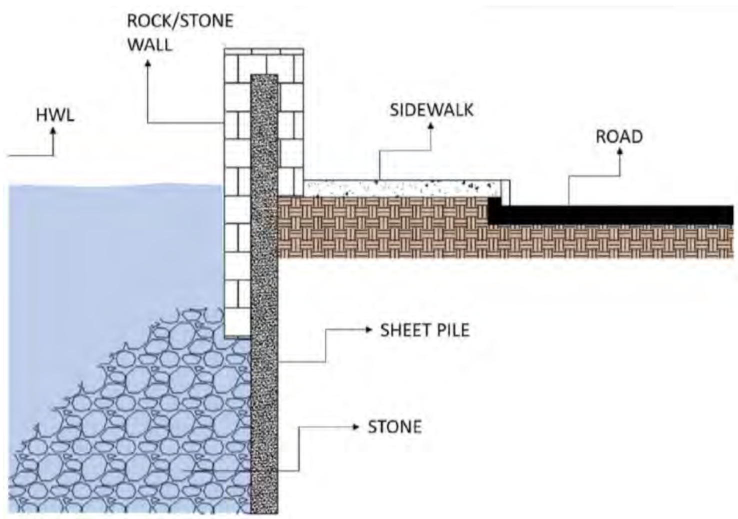


Figure 42: Flood Protection Sea Wall Detail

2. ***Rehabilitate Van Sommelsdijckse Pumping Station and Sluice Gates:*** Currently, two of three pumps at the Van Sommelsdijckse Canal pump station are operational. This alternative includes adding a new pump or refurbishing the third pump to restore the original capacity of the pump station. Other improvements include upgrading the outdated mechanical and electrical systems, rehabilitating the sluice gate structures, and increasing the capacity of the water storage area in front of the sluice gates by dredging accumulated sediment.

3. ***Enhance Mangrove Plantings:*** The existing mangrove plantings at the Van Sommelsdijckse Canal pump station outlet will be enhanced and expanded to provide additional erosion protection. The enhancements will include constructing wooden cribbing to facilitate sediment entrapment and natural vegetation growth. Additional mangrove plantings will be made in this area as well.

The existing flood model of the Study Area was rerun for the baseline and the climate change 2020, 2050 and 2080 scenarios at 10-, 25-, 50- and 100-year return periods by adding alternative option 1 from Group A (referred in this report as Alternative 2 for all modelling purposes) and option 1 from Group B (referred in this report as Alternative 3 for all modelling purposes) as levees in the model domain with top elevation set at 3.25 m NSP. We identified specific adaption options and performed flooding hazard analysis using FLO-2D and HEC-RAS models. The flood hazard analysis for the rest of the adaptation options were derived from the existing flood modelling results. For example, the impact of the implementation of mangrove fields (option 3 in Group A) as an adaption alternative in the Fort Zeelandia area was derived from existing results by reducing the flood inundation depths in the mangrove fields proportional to the increase in the roughness and infiltration factors. Similar approach was developed for other adaption options.

The cost of residual flooding for various alternatives was determined using identified failure modes as described previously and then were included in the coast benefit analysis report (Benefit Cost Analysis of Mitigation Alternatives for Suriname) submitted to IDB.

4.4.6 Analysis of Coastal Flooding due to the Alternative 2 and 3 Flood Adaptation Options

4.4.6.1 Flooding Inundation – Baseline (Figure 43)

Under the baseline conditions, the general elevation of the Water Taxi Area (See Figure 35 for location identification) is above the 10-year flood level and consequently little, if any flooding occurs inland. This is also the case with proposed Alternatives 2 and 3 in place. For the baseline 25-, 50-, and 100-year return periods, flooding begins to occur from the Paramaribo Central Market to the Water Taxi area, expanding as the return period increased. With Alternatives 2 and 3 in place no flooding occurs for the 25-year return period and for the 50-year return period, only very minor flooding is seen directly along the bank of the Suriname River east of the Paramaribo Central Market. For the 100-year return period with Alternatives 2 and 3 in place, more significant flooding occurs. Minor flooding occurs along the bank of the Suriname River west of the Water Taxi Area and extends into the Paramaribo Central Market area. Flooding also occurs along Waterkant Street to the west of the proposed Alternative 2 and extends behind the flood wall along Waterkant Street to the intersection of Watermolen Street. Although flooding does occur in the western section of the Study Area with Alternatives 2 and 3 for the 100-year return period, the affected area is approximately less than half us the area affected under baseline condition.

In the western section of the Study Area near Fort Zeelandia (See Figure 35 for location identification), little, if any, flooding occurs under baseline conditions for the 10-, 25-, 50-, and 100-year return periods. As one would expect, with the construction of Alternatives 2 and 3, there was no flooding of this area under for the 10-, 25-, 50-, and 100-year return periods.

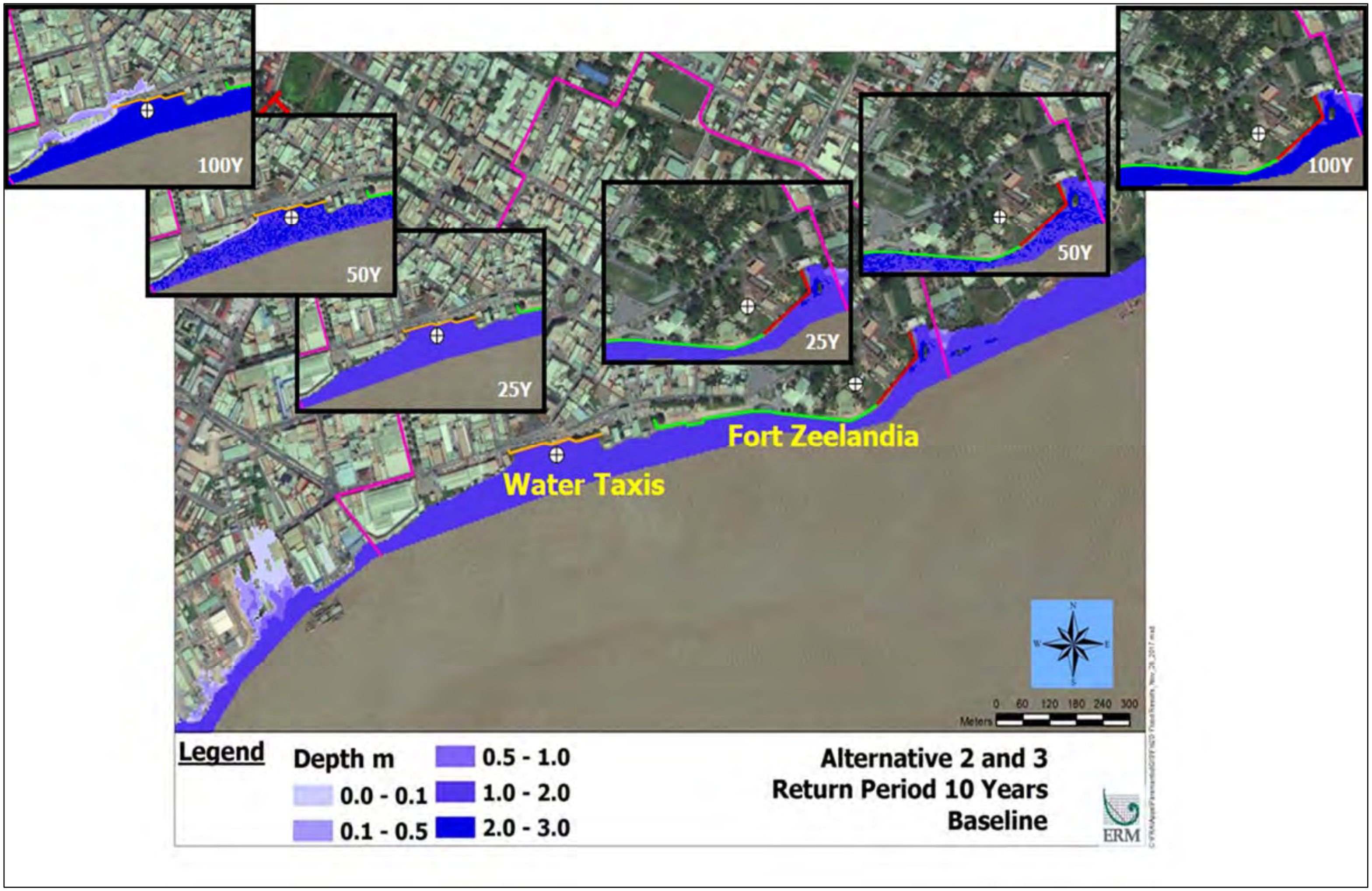


Figure 43: Comparison of Coastal flooding inundation at the Water Taxi and Fort Zeelandia regions for the baseline scenario at 10-, 25-, 50-, and 100-year return periods and with Alternatives 2 and 3 options

4.4.6.2 Flooding Inundation – Climate Change

Flood inundation impacts from climate change with Alternatives 2 and 3 are evaluated below for the years 2050, and 2080.

2050 Climate Change Scenario (Figure 44)

In the western portion of the Study Area near the Water Taxi Area (See Figure 35 for location identification), the elevation of Waterkant Street is below the 10-, 25-, 50-, and 100-year flood levels for the 2050 climate change scenario. Consequently, significant flooding occurs along this region of the Suriname River. The implementation of Alternatives 2 and 3 under the 2050 climate change scenario, results in a smaller area impacted by flooding for the 10-year return period. The area that benefits primarily under this specific scenario is the area immediately surrounding Bodega & Grill De Waag, which remains in unaffected. For the 25-, 50-, and 100-year return periods, however, Alternatives 2 and 3 have little or no impact on inundation in the western portion of the Study Area.

In the eastern portion of the Study Area, near Fort Zeelandia (See Figure 35 for location identification), the baseline 2050 climate change scenario leads to flooding along the western side of the Sommeldijckse Canal for the 10-year return period. Flooding expands to the area around Fort Zeelandia for the 25-year return period and continues to move inlands for the 50- and 100-year return periods. With the implementation of Alternatives 2 and 3, flooding is significantly reduced for the 25- and 50-year return periods. In both of these scenarios, flooding is limited to the area immediately adjacent to the Sommeldijckse Canal. For the 100-year return period, however, Alternatives 2 and 3 are ineffective and the areal extent and depth profile of the flooding are essentially the same at the baseline case for the 100-year return period.

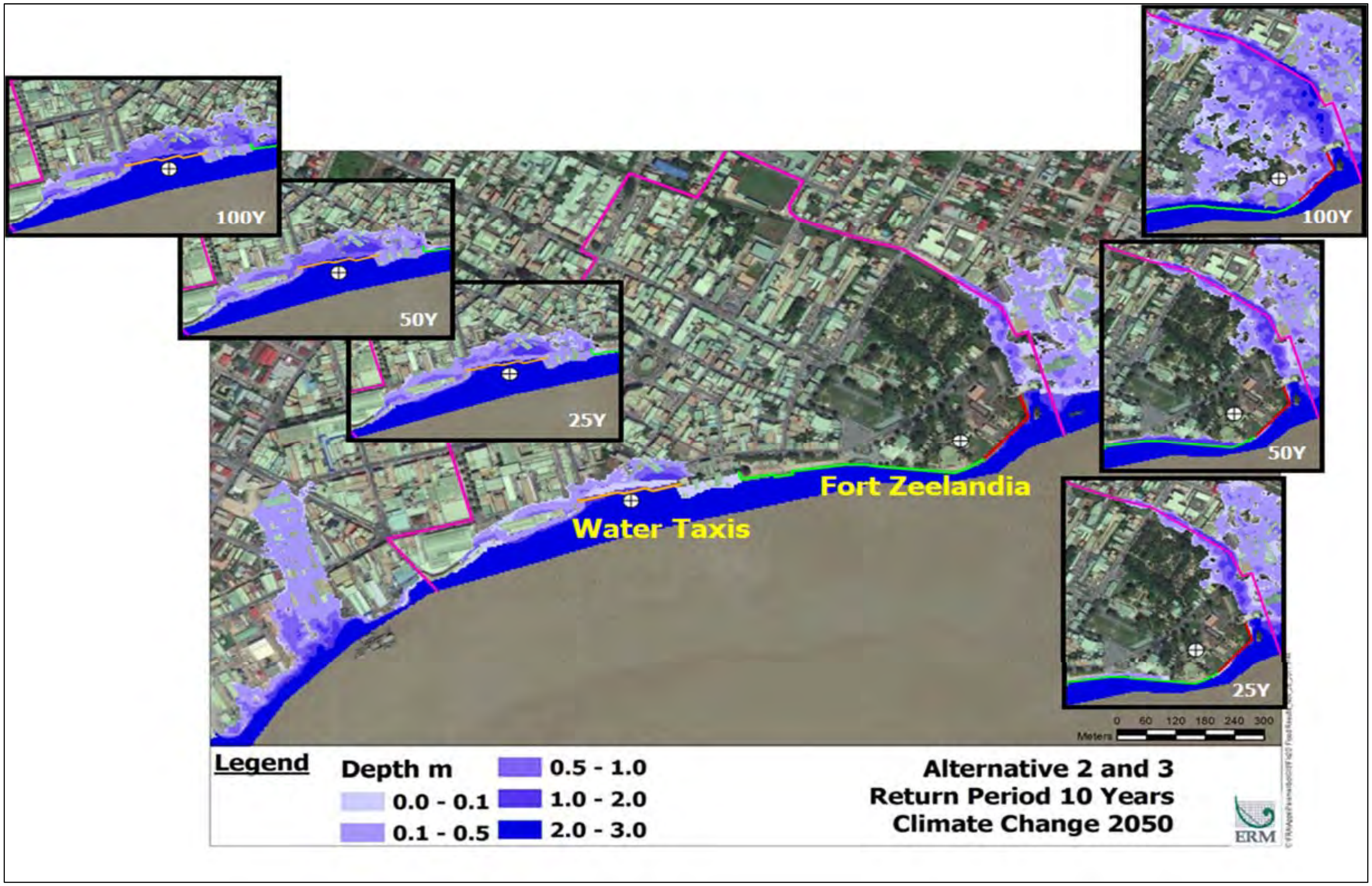


Figure 44: Comparison of coastal flooding inundation at the Water Taxi and Fort Zeelandia regions for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods and with Alternatives 2 and 3 options

2080 Climate Change Scenario (Figure 45)

As noted previously, the areas along the bank of the Suriname River in the western portion of the Study Area near the Water Taxi Area (See Figure 35 for location identification) are particularly impacted for the 2080 climate change scenario and the 10-, 25-, 50-, and 100-year return periods. The implementation of Alternatives 2 and 3 under the 2080 climate change scenario, results in flooding patterns similar to the baseline for all return periods. There appears to be only a marginal decrease in areal extent of flooding.

In the eastern portion of the Study Area, near Fort Zeelandia (See Figure 35 for location identification), extreme flooding impacts above baseline occur under the 2080 climate change scenario for all return periods. With the implementation of Alternatives 2 and 3 under the 2080 climate change scenario and 10-year return period, flooding is significantly reduced north and northwest of Fort Zeelandia. The area around the Walter Amo Sporthal on Koninginne Street, which was inundated under the baseline 2080 climate change scenario, is not impacted. In general, for the 25-, 50-, and 100-year return periods, the implementation of Alternatives 2 and 3 results in a somewhat smaller area of inundation, mostly confined to small pockets north of Fort Zeelandia.

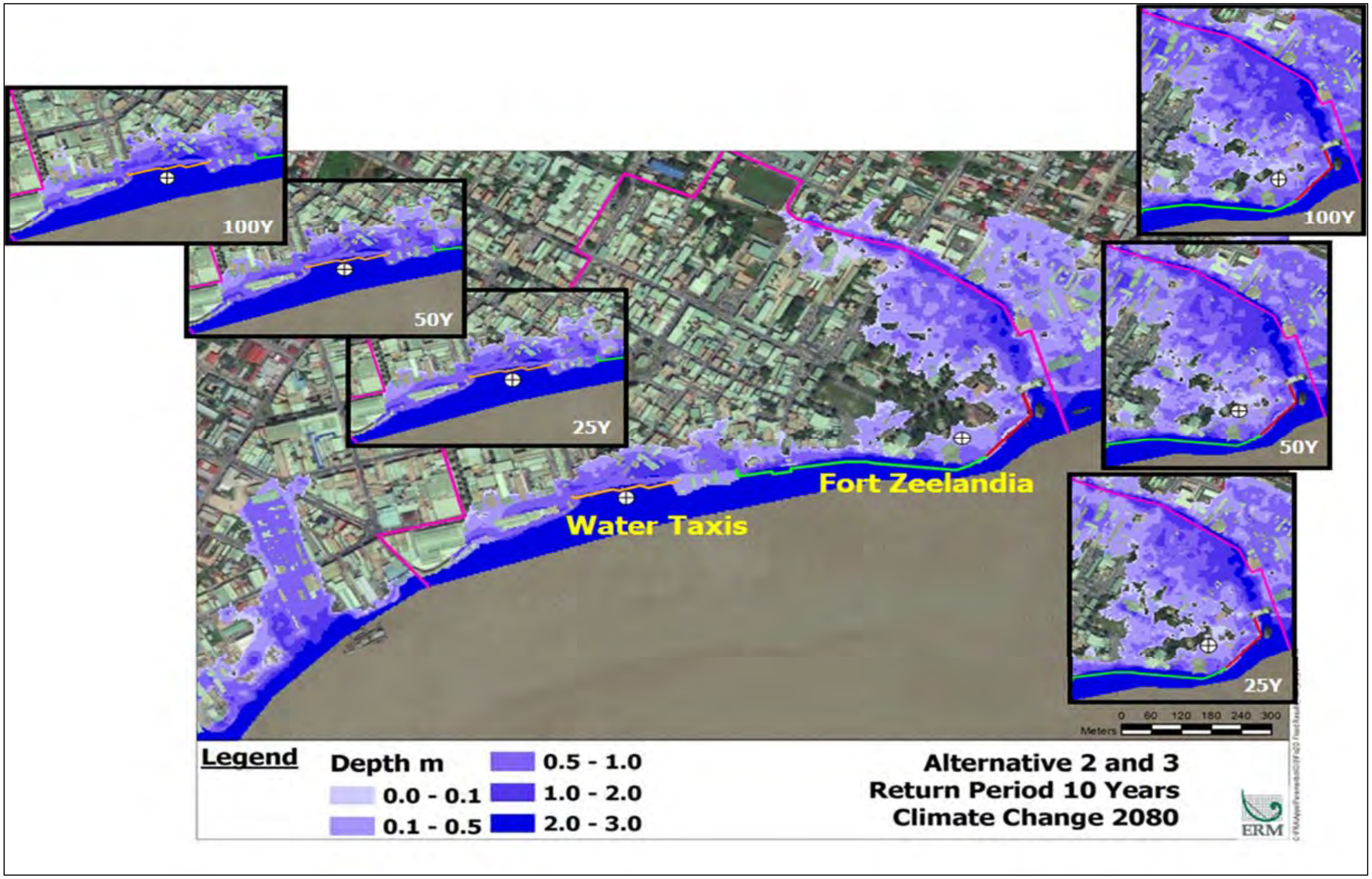


Figure 45: Comparison of Coastal flooding inundation at the Water Taxi and Fort Zeelandia regions for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods and with Alternatives 2 and 3 options

4.4.6.3 Flooding Hazard – Baseline (Figure 46)

As noted previously, the elevation of Waterkant Street in the Water Taxi Area (See Figure 35 for location identification) is above the baseline 10-year flood level and consequently little, if any flooding occurs inland. Flood hazards are high only along the bank of the Suriname River in the western portion of the Study Area. Small areas with a medium hazard level occur immediately to the west of the Water Taxi Area. For the baseline 25-, 50-, and 100-year return periods, hazard levels essentially mirror inundation levels in this region of the Study Area. With the implementation of Alternatives 2 and 3, flooding in this part of the Study Area is fairly small and is not considered a hazard under all return periods.

Around Fort Zeelandia (See Figure 35 for location identification) to the west of the Water Taxi Area, the elevation generally above the 10-year flood level; consequently little, if any flooding occurs inland. The only flooding occurs in a small wooded area near the mouth of the Sommeldijckse Canal. For the 25-, 50-, and 100-year return periods flooding in the area is essentially that same as the 10-year return period. As such, medium and high hazard levels are associated only with the bank of the Suriname River and the mouth of the Sommeldijckse Canal. With the implementation of Alternatives 2 and 3, medium and high hazard levels are also associated only with the bank of the Suriname River and the mouth of the Sommeldijckse Canal.

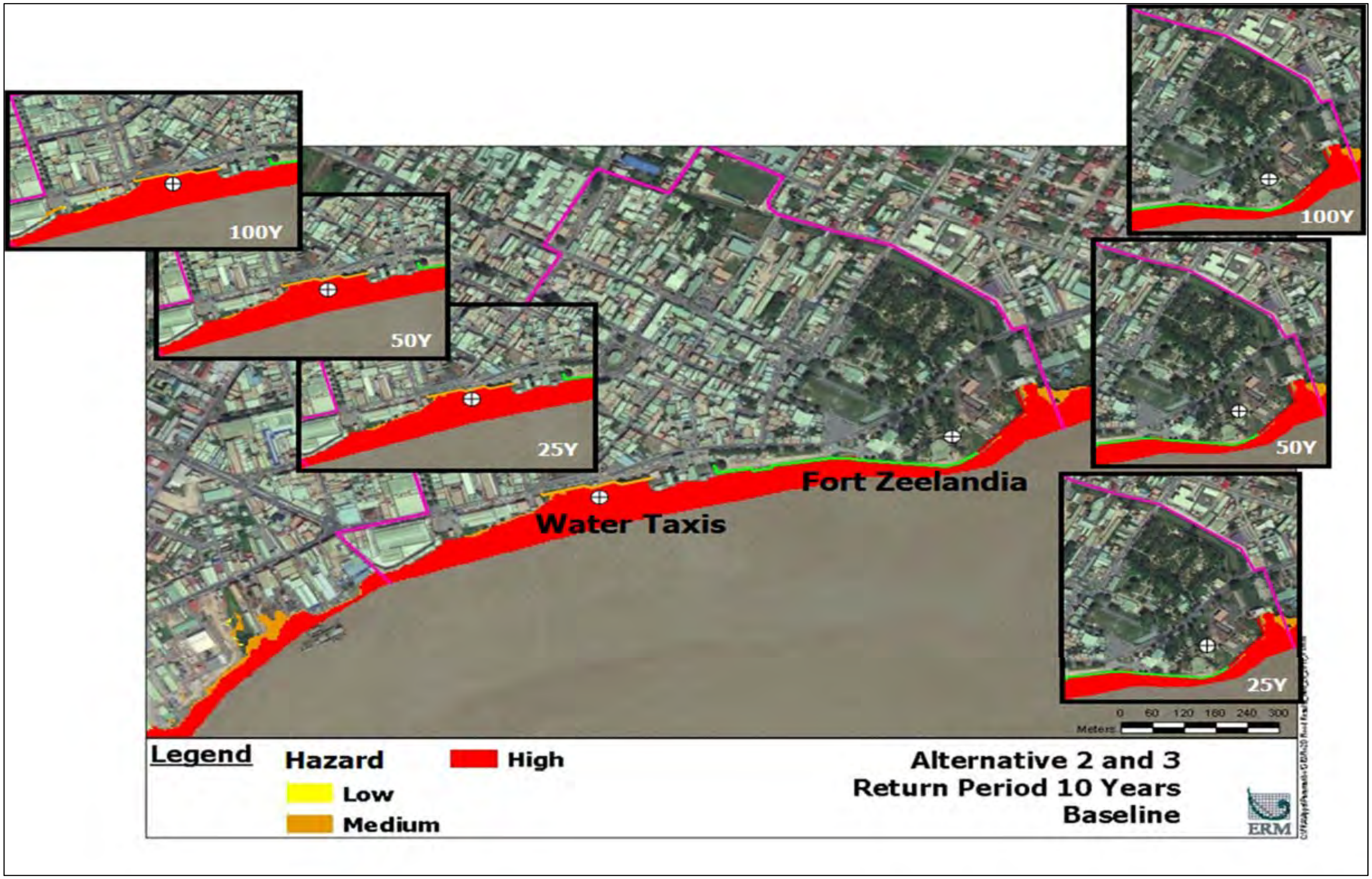


Figure 46: Comparison of coastal flooding hazard at the Water Taxi and Fort Zeelandia regions for the baseline scenario at 10-, 25-, 50-, and 100-year return periods and with Alternatives 2 and 3 options

4.4.6.4 Flooding Hazard – Climate Change

Flood hazard impacts from climate change with Alternatives 2 and 3 are evaluated below for the years 2050, and 2080.

2050 Climate Change Scenario (Figure 47)

As noted previously, in the western portion of the Study Area near the Water Taxi Area (See Figure 35 for location identification), the 2050 climate change scenario exacerbated flooding along Waterkant Street and the bank of the Suriname River above baseline. The implementation of Alternatives 2 and 3 results in a reduction in the area of low risk for the 25-year return period, particularly in the area on the land side of the Alternative 2 flood wall. Other than this, the implementation of these alternatives has little impact on the medium and high hazard areas for the 50- and 100-year return period in the part of the Study Area.

In the eastern portion of the Study Area, the implementation of Alternatives 2 and 3 has little impact on the flood hazards identified for the baseline for 10-, 25-, and 50-year return periods since there is only minor flooding in this area. For the 2050 climate change scenario with a 100-year return period, however, Alternatives 2 and 3 result in a significant decrease in the area exhibiting medium hazard, particularly to the west of the Sommeldijckse Canal. There is also a significant reduction in the high hazard area directly along the canal.

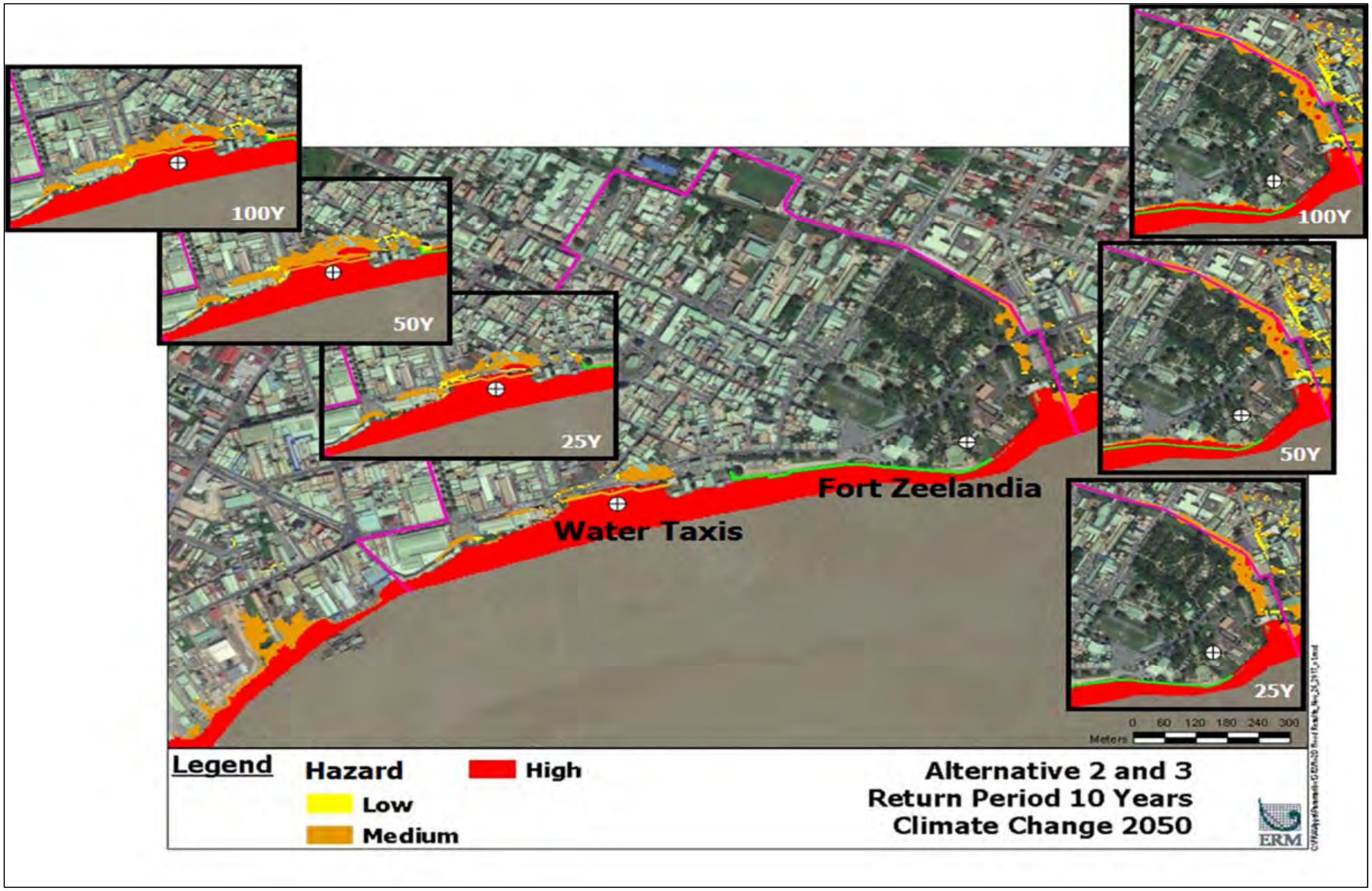


Figure 47: Comparison of coastal flooding hazard at the Water Taxi and Fort Zeelandia regions for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods and with Alternatives 2 and 3 options

2080 Climate Change Scenario (Figure 48)

2080 climate change scenario for all year return periods exacerbates flooding above the baseline. In the western portion of the Study Area near the Water Taxi Area (See Figure 35 for location identification), the areas along the bank of the Suriname River are particularly impacted. In general, medium hazard areas occur along Waterkant Street and immediately inland. One large area of high risk is located near the Magic Island Casino. Implementation of Alternatives 2 and 3 has some impact on medium hazard areas, but appears to have little impact on high hazard areas.

In the eastern portion of the Study Area, the implementation of Alternatives 2 and 3 results in a reduction in the area of medium hazard for all return periods. These areas are mostly associated with areas inland from the Suriname River and the Sommeldijckse Canal. Alternatives 2 and 3 also result in a reduction of some small areas of high hazard, but the most significant reduction is associated with medium hazard areas.

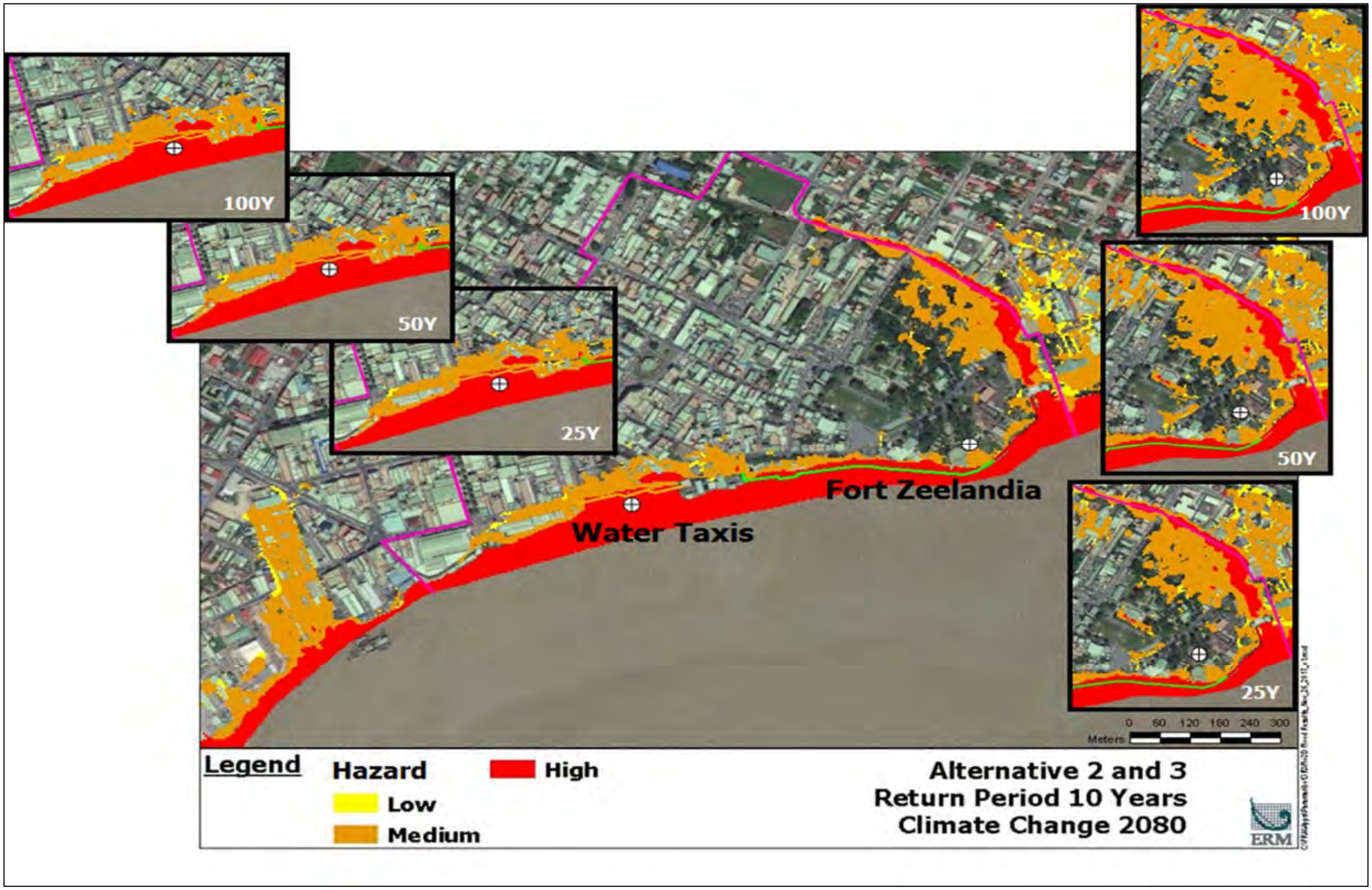


Figure 48: Comparison of Coastal flooding hazard at the Water Taxi and Fort Zeelandia regions for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods and with Alternatives 2 and 3 options

In summary, for the baseline conditions, the implementation of the alternatives 2 and 3 flood walls are successful in reducing the flooding inundation and hazard in the Water Taxi area for the 25-, 50-, and 100-year return periods. In the eastern portion of the Study area, alternatives 2 and 3 have minimal impact on flooding and hazard because the area is already mostly unaffected for all return periods under baseline conditions. For the 2050 climate change scenario, flooding still occurs in the Water Taxi area with the implementation of alternatives 2 and 3; however, the overall area of flooding inundation decreases as does the areas identified as low, medium and high hazard. In the eastern portion of the Study Area, near Fort Zeelandia, alternatives 2 and 3 reduce flooding inundation and hazard for low and medium return periods. While these alternatives have little impact on the area of flooding in this area for the 100-year return period, they are effective in reducing the flood hazard, however. For the 2080 climate change scenario, alternatives 2 and 3 have little impact on flooding inundation and hazard in the eastern portion of the Study Area along the Suriname River bank and the Sommeldijckse Canal. They also have minimal impact on flooding inundation in the western portion of the Study Area. There are only small localized reductions in flooding inundation and in areas identified as low hazard, Alternatives 2 and 3 have the most impact on flooding inundation and hazard to the north of Fort Zeelandia.

Consequently, although alternatives 2 and 3 significantly improve flooding conditions under the baseline scenario, their effectiveness is significantly reduced under climate change conditions and, particularly, for long return periods. The reduction in flood inundation and hazard is not sufficient to minimize the socioeconomic risk associated with it, since the baseline hazard itself is high for the years 2050 and 2080 due to climate change, especially for long return periods. The proposed flood walls are effective to some extent, but in longer time horizons with climate change flooding still happens but from other locations. This means that they are effective for the specific locations it aims to manage, but flooding from elsewhere happens and these would need to be addressed as part of a program of adaption works.

4.4.6.5 Results for Other Adaptation Options

The flood hazard analysis for the rest of the adaptation options were derived from the existing flood modeling results. For example, the impact of the implementation of mangrove fields as an adaption option in the Fort Zeelandia area was derived from existing results by reducing the flood inundation depths in the mangrove fields (Alternative 11) proportional to the increase in the roughness and infiltration factors. According to Spalding (2014), hundreds of meters of mangrove fields are needed to significantly reduce waves (wave height is reduced by 13-66% per 100m of mangroves). Sufficient mangrove forest width needs to be present to maintain sediment balance. This can help to prevent erosion and may encourage active soil build-up. Mangroves do not provide a secure defense (nor do many engineered defenses). Thousands of meters are needed to reduce flooding impacts (storm surge height is reduced 5 - 50 cm/km). However, developing a complex knitted root systems are effective wave energy dissipaters, storm surge blockers and sediment trappers. A sustained mangrove field needs a continuous supply of freshwater and sediments. The added value of having mangrove fields is that it provides a strong biodiversity. Similar approach was developed for other adaption options.

4.4.7 Assumptions and Limitations

For the coastal flooding analysis, ERM assumed that HHWL in the Suriname River was constant for the entire period of simulation in the Study Area FLO-2D model. In an actual event, however tides with maximum elevation of HWL appear only two times in a day.

The FLO-2D model does not have a method to implement the automatic operation of sluice gate and pump based on elevation difference between the upstream and downstream of a hydraulic unit. ERM assumed continuous operation of 2 pumps in the Sommeldijckse Canal for all the baseline and climate change scenarios in the Study Area FLO-2D model.

ERM assumed that HHWLs obtained for the Suriname River were based on many years of measured water levels that include the combined effect of tides, waves and storm surges. So, HHWLs for climate change were obtained by superimposing SLR on the baseline HHWLs.

The quality of the Study Area FLO-2D model results depends on the quality of data since this model needs many spatial datasets at a reasonable resolution. The ground truthing of digital elevation data is a very crucial process and is performed by a detailed site survey.

4.5 HYDROLOGICAL MODELLING OF VAN SOMMELDIJCKSE CANAL USING HEC-RAS

The FLO-2D model used for the Study Area cannot simulate the automatic operation of the sluice gate and pump used to manage the flow of wastewater (run off and other wastewater drains in to the Paramaribo canal system) in the Van Sommeldijckse Canal to control flooding around its watershed regions during normal and extreme climatic conditions. Because of this FLO-2D model limitation, the flooding hazard associated with the Van Sommeldijkse Canal was quantified by developing a hydrological/hydraulic/flood model for the Canal and its surroundings. The hydrological model development was consisted of a terrain analysis and hydrologic and hydraulic modelling. The Terrain analysis was carried out using ArcGIS and HEC-GeoRAS. Hydraulic modelling was carried out using the one-dimensional HEC-RAS unsteady state model and hydrologic modelling was performed using the rational methodology. In the terrain analysis, the 2 m flood plain digital elevation model and canal cross-sectional data obtained from published reports (MPW, 2008) were used to develop the geometrical data for the HEC- RAS model and for the demarcation of the catchment area. A detailed hydrologic analysis was conducted for the catchment area using rational methodology in order to develop the Canal design hydrograph associated with several return periods. Rational Equation is widely used for urban drainage studies in order to design the peak flow and associated hydrograph. Hydraulic analysis was performed with HEC-RAS software using the canal/flood plain geometry and flow hydrograph.

4.5.1 Model Setup

The high resolution 2 m flood plain digital elevation data provided by the client was used for the flood plain analysis. However, the flood plain DEM is not representative of the Canal bathymetry in detail. In order to overcome this limitation, Canal cross-sectional data available in the Sommeldijkse Creek measurement report by Ministry of Public works (MPW, 2008) was used. Four cross-sections were available along the Canal at an average spacing of 350 m. Cross-section profiles and spatial location along the model domain are shown in Figure 49 and Figure 50, respectively. These cross-sections were digitized in the ArcGIS environment and linearly interpolated to create a continuous channel digital elevation model. Later, channel DEM was combined with 2 m flood plain DEM in order to develop a coherent integrated canal terrain model comprised of the Canal and its adjacent floodplains. This integrated river terrain model serves as input to HEC-GeoRAS and shown in Figure 51.

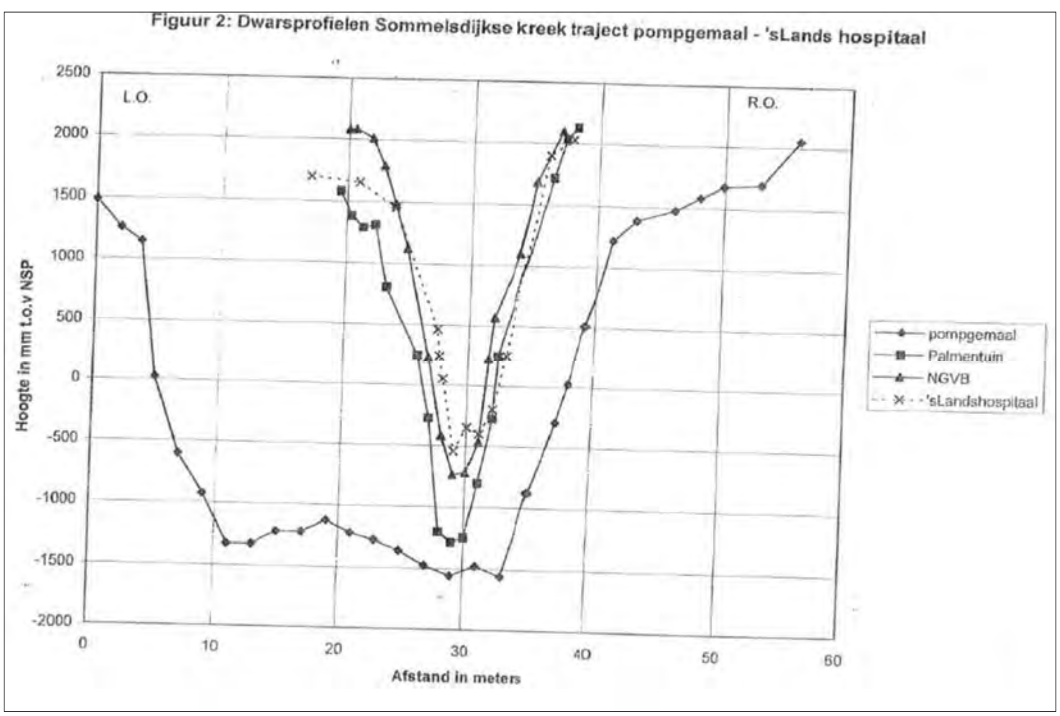


Figure 49: Available surveyed cross-sections for the Canal (MPW, 2008)

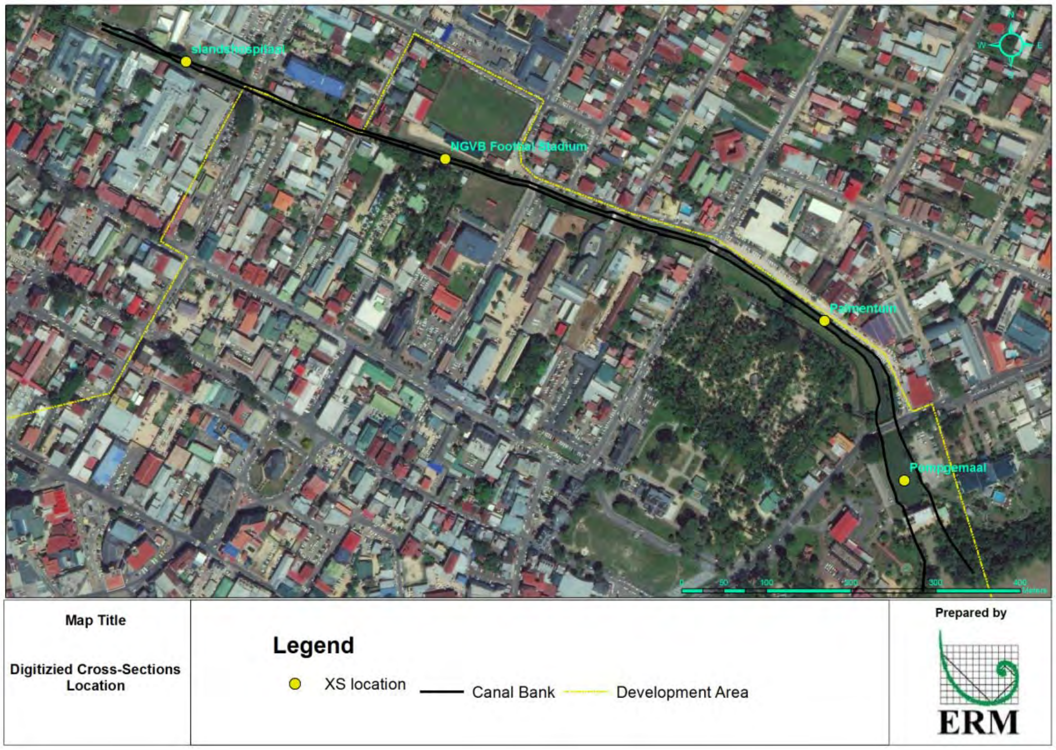


Figure 50: Available surveyed cross-section locations along the Canal

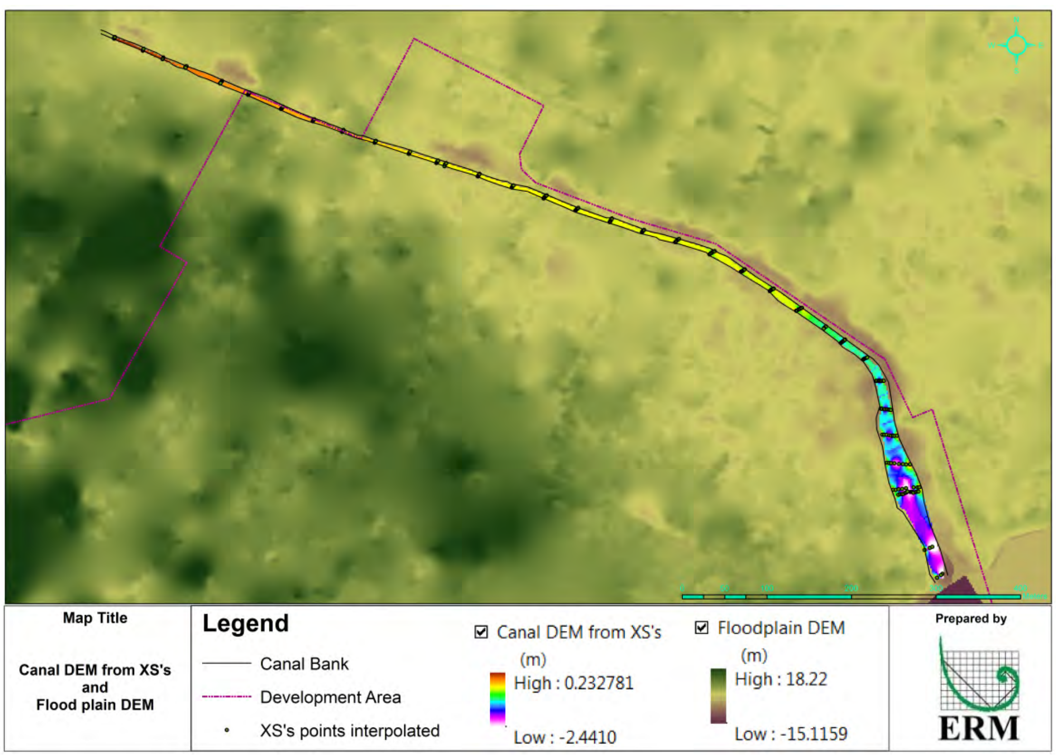


Figure 51: Integrated Canal terrain model to process geometrical input in HEC-GeoRAS

HEC-GeoRAS is a geographic river analysis system developed using ArcGIS by the U.S Army corps of engineers (HEC, 2009) to function as a pre-processor for preparing the HEC-RAS geometric input data and a post-processor to delineate flood plain using water surface profile results exported from HEC-RAS. HEC-GeoRAS allowed the preparation of geometric data for import into HEC-RAS. HEC-GeoRAS requires a digital terrain model in grid format. Hence, the developed coherent integrated canal terrain model comprised of the main channel and its adjacent floodplain in grid format was used to extract geometrical description of canal. In HEC-GeoRAS, river geometry was developed by digitizing and populating attribute of the following RAS themes: stream centerline, bank lines, flow path centerlines and cross-sectional cut lines. HEC-GeoRAS canal setup is shown below in Figure 52. Geometric file for import into HEC-RAS contains river, reach and station identifiers; cross-sectional cut lines; cross-sectional bank stations; downstream reach lengths for the left overbank, main channel, the right overbank and cross-sectional roughness coefficient. These geometrical characteristics exported in HEC-RAS are represented below in Figure 53 and Figure 54.

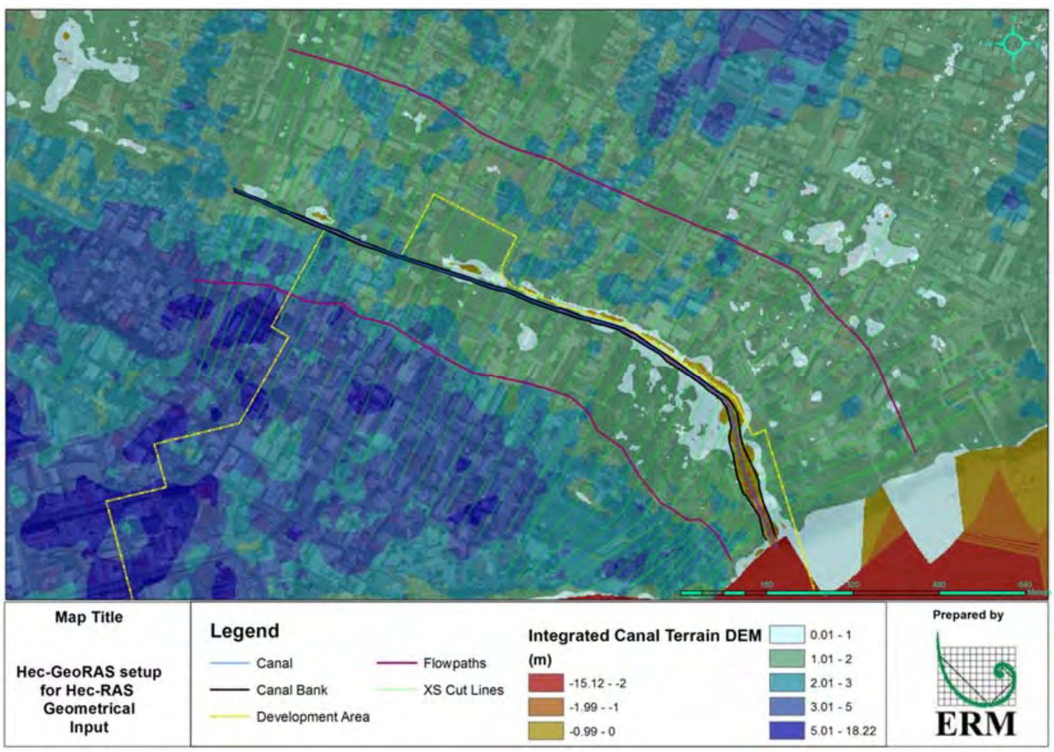


Figure 52: Canal model setup in HEC-GeoRAS

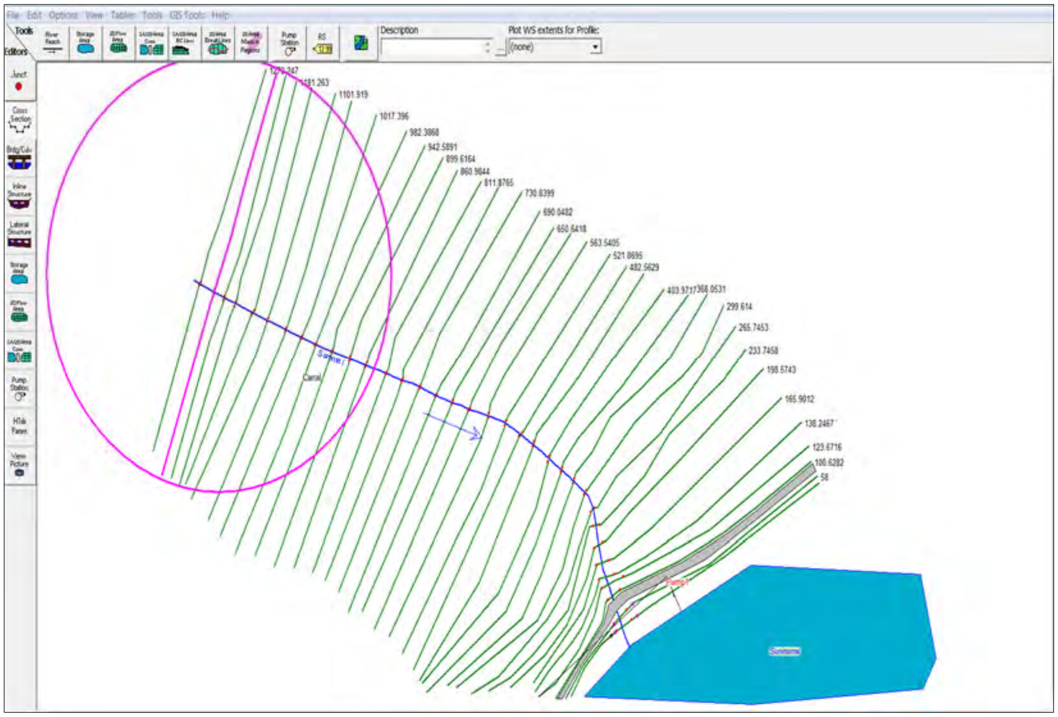


Figure 53: Schematic of Canal cross-sections layout in HEC-RAS

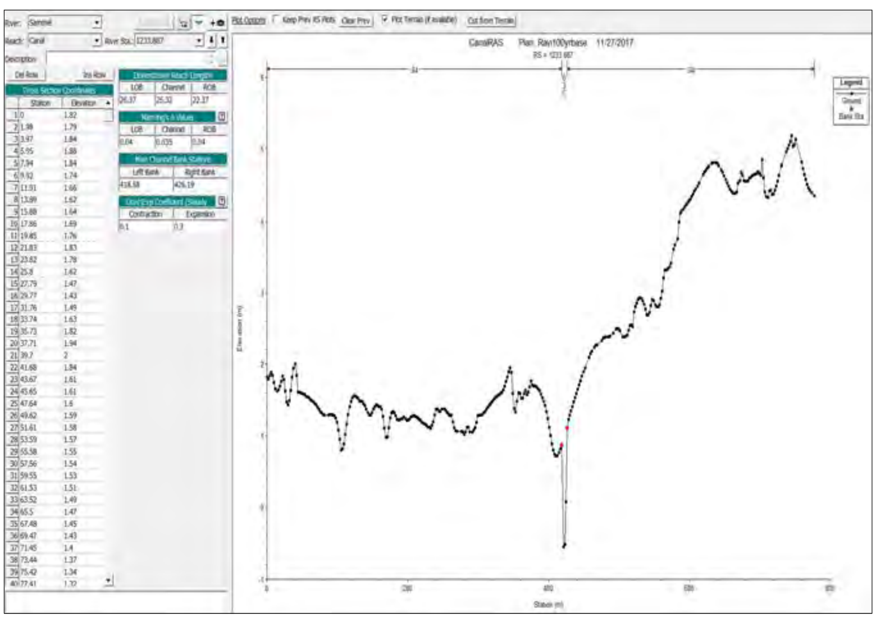


Figure 54: Schematic of canal cross-section in HEC-RAS

After the cross-sections were exported into HEC-RAS, existing pump (2 pumps are currently in operation with individual capacity of 4.5 m^3/sec) and sluice gate structure (2 gates are current in operation) were added to HEC-RAS geometrical setup. The schematic of setting up pump operation in HEC-RAS model is shown in Figure 55. Sluice gate setup schematic is shown below in Figure 56. The sluice gate characteristics are obtained from the Ministry of Public Works reports (MPW, 2017) and field observations during the site visit.

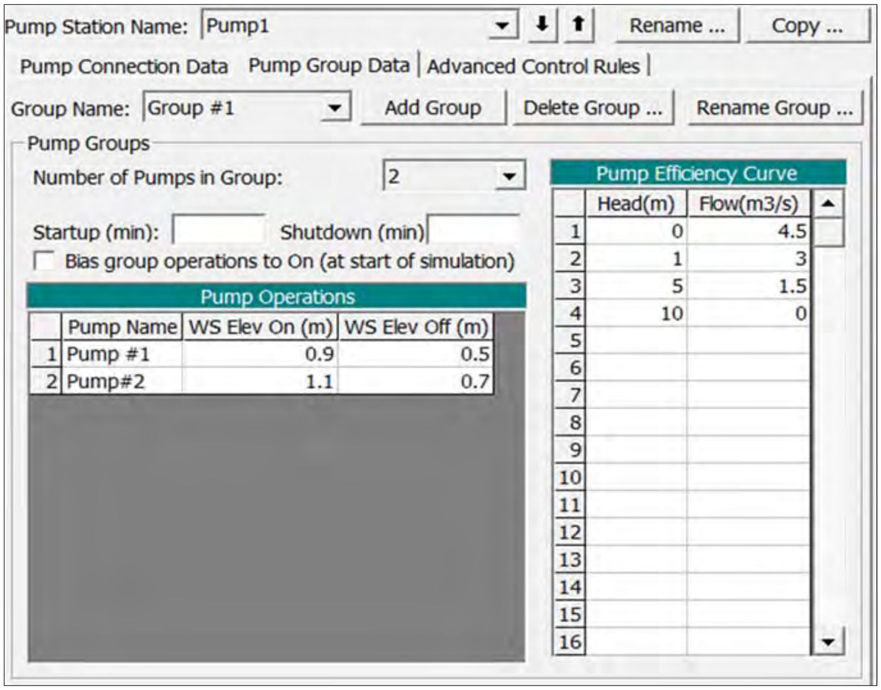


Figure 55: Setting up Canal pump operation in HEC-RAS. Two pumps are currently in operation with a total capacity of 9.0 m³/sec

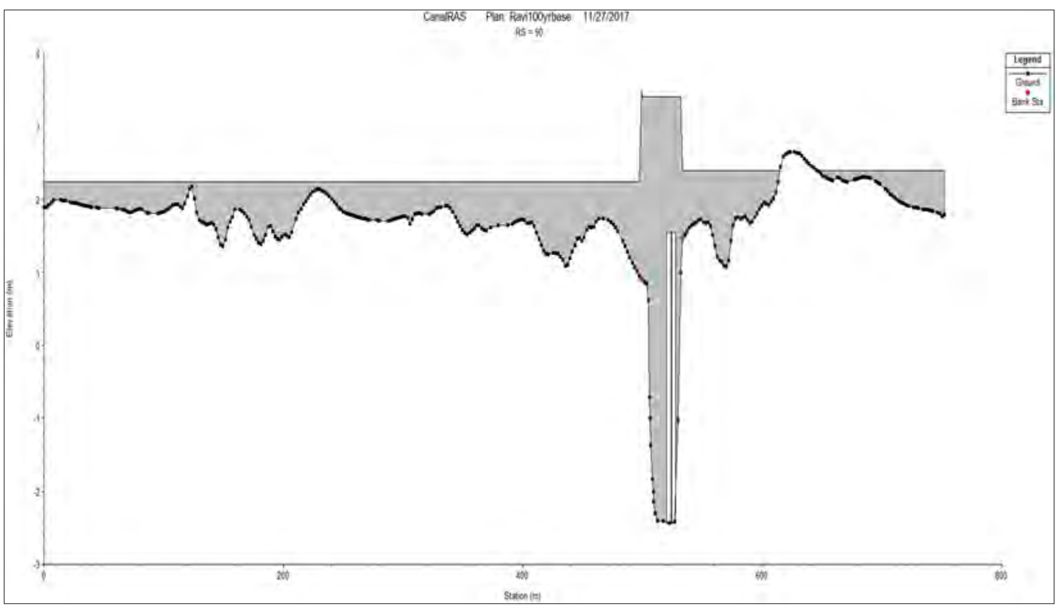


Figure 56: Setting up Canal sluice gate operation in HEC-RAS. Two sluice gates are currently in operation.

Hydrologic analysis was carried out using the rational method in order to develop Canal runoff hydrographs for 25-, 50-, and 100-year return periods. The runoff hydrograph is another primary input for HEC-RAS in addition to the geometrical cross-sectional data. Design hydrograph was derived for all the baseline climate change 2050 and 2080 scenarios at 25-, 50-, and 100-year return periods. Peak Flow was estimated using below rational equation:

$$Q_p = CIA$$

Where Q_p is peak runoff rate (m^3/s); C is runoff coefficient; I is the intensity of rainfall (m/s); and A is area of catchment (m^2)

Catchment area of the Van Sommeldijckse canal was delineated using hydrological spatial analyst tool of ArcGIS. In addition, the natural drainage canal network was also delineated using the same tool. A digital elevation model of 2 m resolution was used to delineate the catchment and associated natural drainage network shown in Figure 57. With this approach, the catchment area was determined based on the hydrological borders.

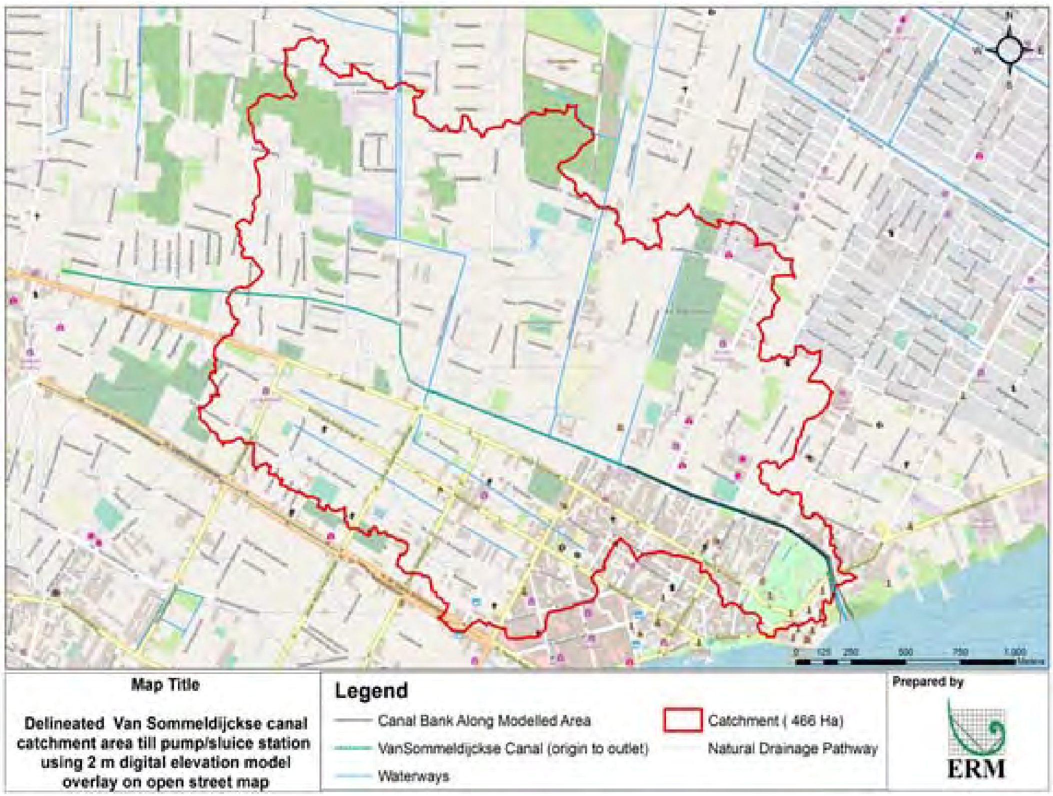


Figure 57: Delineated catchment region of the Van Sommeldijckse Canal

It is important to mention that the delineated catchment area (466 Hectare) was not draining completely along the length of the Van Sommeldijckse canal. This is due to the highly developed urban area where manmade drainage network covering the topography does not allow the natural gravity drainage. In addition, discussion with the local Suriname based sub-contractor revealed that the catchment area of the Van Sommeldijckse Canal/Pump/Gate is about 700 hectare. This number looks reasonable to accommodate the manmade neighboring canals draining into the Van Sommeldijckse Canal, which does not fall within the GIS based delineated catchment. Hence, the catchment area of 700 Ha (conservative value) was used for peak storm flow calculation using the rational approach.

Rainfall intensity was obtained by Intensity-Duration-Frequency (IDF) curves for the baseline and the climate change return periods. The hydrological modelling (rainfall-runoff) of canal includes storm water from buildings as the area associated with buildings falls within the catchment area. Rational approach (CIA) uses the catchment area to calculate the peak storm flow in the Canal. Wastewater discharge data was not available for the canal catchment and so, this flow was not taken into consideration for runoff calculation. Runoff coefficient of 0.5 was used in the HEC-RAS model. It is the weighted runoff coefficient for the entire canal catchment obtained by considering the building, street, garden, and undeveloped area. In addition, discussion with Suriname based sub-contractor reveals that the average paved /impervious percent (%) in the flood plains of the Canal is nearly 50%. Hence, the specified runoff coefficient which includes the effects of building structures aligns with field observation.

Once peak runoff was calculated, the design hydrograph was obtained by assuming the design rainfall duration was equal to time of concentration as shown in Figure 58. Time of concentration is defined as the time needed for water to flow from the most remote point in a watershed to the watershed outlet. Hence, Time of concentration is a fundamental watershed parameter for the computation of the peak discharge of a watershed. Time of concentration is derived from the Kirpich Equation (Soliman, 2010)

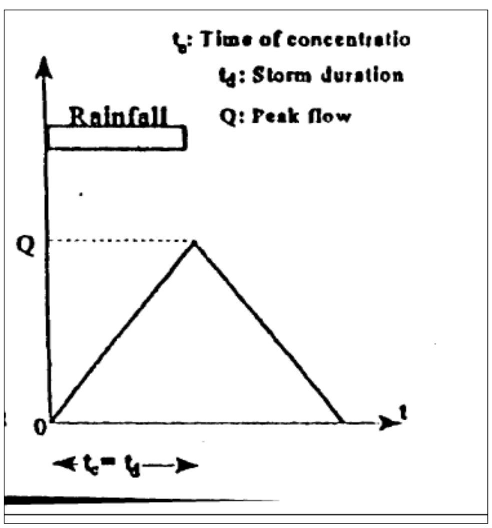


Figure 58: Design Hydrograph Development Methodology

Design storm hydrograph for the 100-year baseline return period is shown in Figure 59. This hydrograph was added to the Canal HEC-RAS model as the upstream boundary condition. A 12-hour tidal hydrograph was given as downstream boundary condition, which is shown n Figure 60.

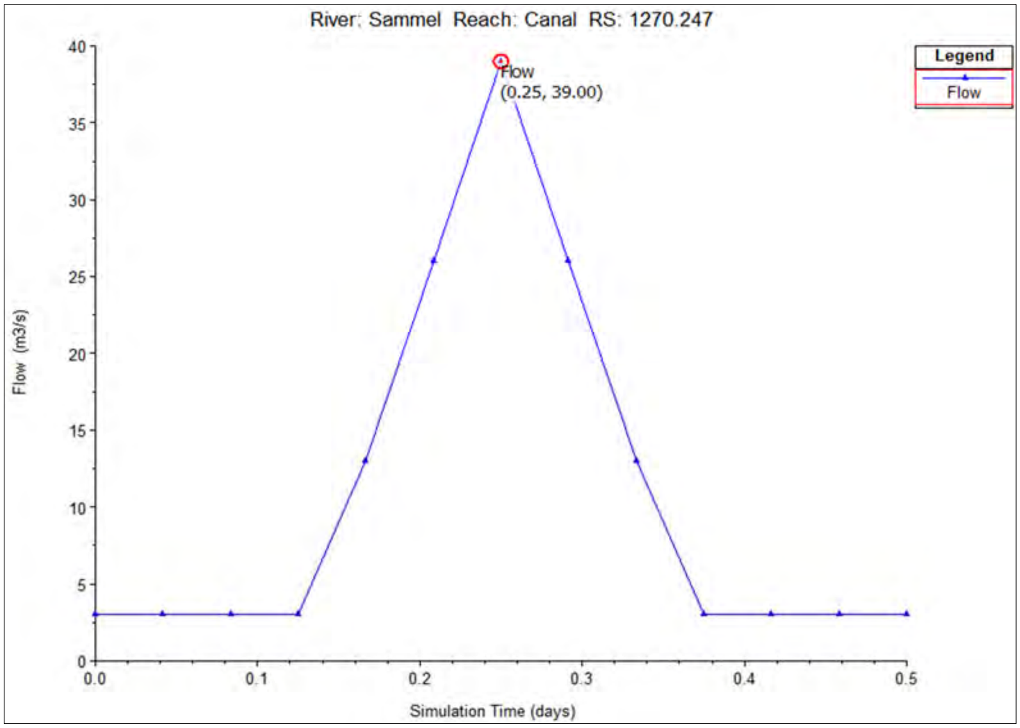


Figure 59: 100-year baseline return period design hydrograph

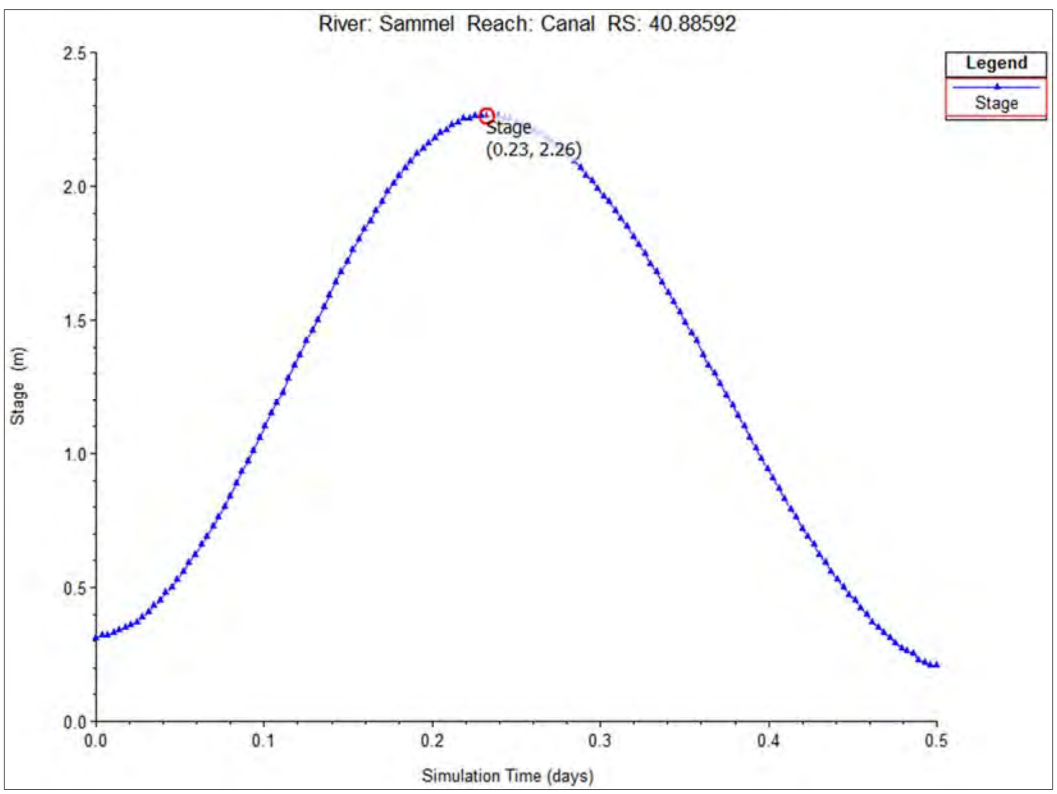


Figure 60: 100-year baseline return period tidal hydrograph

For all canal scenarios, 12-hr duration was used as model simulation time period. The design storm hydrograph was developed in such a way that the peak catchment runoff in canal happens simultaneously with high tide in Suriname River and so, depicts the worst case flooding scenario.

4.5.2 Analysis of HEC-RAS Modelling Results of the Van Sommeldijckse Canal

A detailed analysis of HEC-RAS modelling of the Van Sommeldijckse Canal for the existing configuration is provided in the Appendix C1. The analysis of all flooding inundation maps of the Canal and its surroundings clearly shows that the maximum inundation occurs near the entrance to the canal at Prinsessestraat, in the vicinity of Jessurunstraat and Koninginne Straat and on either side of the Canal near the discharge point to the Surinam River with more intense flooding in the Palmtree Garden region. During the Canal gate/pump operation, the maximum flooding inundation does not happen at all times. The maximum flooding occurs only during the high tide conditions in the Suriname River. At other times, the flooded regions are controlled by the stage of the tide conditions in the Suriname River. Most of the flooded regions in the Canal surroundings are in the medium to low hazard levels for all the baseline scenarios. The flooded regions become exacerbated with the climate change resulting in more high hazard regions on either side of the canal with more intense flooding in the Palmtree Garden and the Kleine Waterstraat regions.

Appendix C1 shows the Canal flooding results corresponds to 12-hr simulation duration. The 100-yr baseline flood inundation Figure C1- 3 depicts the maximum inundation (worst case) that occurs during the simulation that corresponds to peak catchment flow in the Canal and simultaneous high tide in the Suriname River. However, the flooding inundation in the Canal and its surroundings changes with time during the time period of simulation due to the time varying flow and tide hydrographs in the upstream and downstream side of the Canal, respectively. Figure C1- 11 shows 100-yr baseline flood inundation map at discrete hours during the simulation time.

ERM developed a series of 12-hr flood animations for 100-yr baseline scenario to understand the flooding and draining of the flood plains. It showed that the flood wave propagates slowly along the Study Area for the first 6-hour duration. After that, peak flood occurs for the duration of around 6 to 8 hour and then the flood wave drains rapidly for the remaining duration of around 8 to 12 hr. Based on this analysis, It can be concluded that around 2-hr of peak flooding will have most adverse effects on humans and infrastructure. This argument is typically holds good for all baseline scenarios.

Canal climate change scenarios also follow relatively the same trend of flood wave in terms of propagation and recession whereas the flood peak occurs comparatively a larger duration of around 3 hour.

One of the flood adaptation measures identified in section 4.4.5.1 is to improve the Van Sommeldijckse Canal infrastructure (referred in this report as Alternative 4). The existing HEC-RAS model for the Canal was rerun by adding one more pump to increase its pumping capacity from 9.0 m^3/sec to 13.5 m^3/sec. The model was run only for the baseline scenario at various return periods to evaluate its effectiveness in controlling the floods around the Canal. A detailed analysis of the HEC-RAS modeling of the Canal with the Alternative 4 option and the baseline scenario is provided in the Appendix C2. The results show that the medium hazard regions on either side of the Canal at its confluence with the Suriname River reduces considerably with the addition of one more pump to the Canal infrastructure. However, with climate change, the change in the impact of flooding around the Canal will be minimal as compared to the baseline conditions similar to the arguments provided in the coastal flooding section 2.4.1.2 of this report.

4.5.3 Assumptions and Limitations

The following assumptions were made during the application of HEC-RAS model for the Van Sommeldijckse Canal flood study.

- HEC-RAS one-dimensional hydraulic analysis with unsteady flow regime was assumed to simulate flooding in the Van Sommeldijckse Canal and its surroundings. This assumption typically holds true for the Canal because the sluice gate and pump operation downstream of the Canal makes the flow transient in nature. Transient flow represents the sudden change in flow characteristics like depth, discharge, velocity and pressure.
- Tidal cycle of 12-hour duration was assumed to simulate the Canal hydraulics. This duration includes two-high and two-low tide stages in the Suriname River.
- Sluice gate was assumed to be fully opened in the starting of simulation time period. During other times of simulation, it was assumed a water level difference of 10 cm between the Suriname River and the Canal controls the opening and closing operations of the Canal sluice gates. Similar control mechanism was implemented for the operation of two pumps in the Canal.
- Standard Manning's coefficient (n) values for the Canal and its adjacent flood plain were assumed to be 0.04 and 0.035, respectively. These values were obtained from the HEC-RAS manual.
- Detailed geometrical characteristics of drainage networks were not available for the canal catchment; therefore, the widely used rational methodology was used to calculate the runoff associated with the catchment and the associated Canal hydrograph.

- The HEC-RAS model domain for the Canal extended from its discharge to the Suriname River to 1.5 km upstream of the discharge location (at Prinsessestraat).

The following limitations were identified during the application of HEC-RAS model for the Van Sommeldijckse Canal flood study.

- HEC-RAS does not perform the higher level of hydrodynamic calculations in the canal flood plain region and provides only reasonable estimation of flood inundation depth in the Canal's surroundings. This limitation can be addressed by linking the HEC-RAS Canal model to another 2D hydraulic model for the Canal flood plain region.
- Only four surveyed cross-sections were available from the Canal 2008 survey report (MPW, 2008) along the study domain. These measurements were taken in 2008, and so, there may be some bathymetry changes in the Canal since that time.
- Due to data limitations, the HEC-RAS Canal model was not calibrated with any observed flood event. In addition, the current catchment runoff calculations did not consider waste water discharges that could enter into the Canal.

5.0 RISK ASSESSMENT

Risk is defined as the combination of the probability of an event and its negative consequences (UN, 2014). The components of risks for the Study Area, people and environment are:

- Exposure (probability and intensity of natural disasters and the number of people exposed or threatened by these disasters); and
- Vulnerability (considering susceptibility, coping capacity, and adaptive capacity).

In the Study Area, baseline physical configuration and hydrological and meteorological conditions provided the information to establish baseline hazard and associated risks. Relevant climate change projections, which alter the existing dynamic system, were used to predict future changes that could lead to changes in the baseline hazard and risk profiles. By using all the data collected, generated and analyzed in previous sections, ERM evaluated the damages to assets associated to floods within the Study Area using the following methodology:

- Development of flooding hazard maps (water depth and velocity);
- Assessment of vulnerability (exposed building characteristics and population) using land use/cover, spatial economic and population databases;

- Estimates of economic and population risk and development of associated maps;

Land costs were used to create the economic-based risk maps based on existing land used data and costs obtained from the Suriname real estate websites while population-based risk maps were created by using population density for Paramaribo from 2012 demography data. The analytical methods used to calculate economic- and population-related risks using computed flooding hazard and socio-economic databases are described in detail in Appendix A2 of the Hazard and Risk Study report (ERM, 2017) developed for the city of Paramaribo in Suriname and selected by the Inter-American Development Bank (IDB) to be part of its Emerging and Sustainable Cities (ESC) program.

When risks were estimated, we looked at the maximum elevation and momentum in the study region due to the impact of maximum flooding at various return periods for baseline and future scenarios for the combined impact of storm surge and inland flooding due to rainfall. This was done by summing the maximum impact at each grid cell from all the simulations described in the previous sections and appendices. Though combined flood inundation maps were not included in the report, they were created as interim results to develop economic and population risk maps.

5.1 CALCULATION OF ECONOMIC RISK

A detailed discussion on land costs were included in Appendix A2 of the Paramaribo Hazard & Risk Study final report submitted to IDB as part of Emerging and Sustainable Cities program. A brief description of land costs used to create the economic-based risk maps is discussed in this section. The inventory of exposed assets involves understanding the distribution of people, buildings, and infrastructure that may be affected by floods. Exposed assets are buildings and infrastructure that are susceptible to damage given some hazard. Assets can be residential, commercial, and industrial buildings, institutions such as hospitals and schools, or infrastructure such as roads and bridges, electrical systems, and telecommunication systems. Other potential exposed assets include:

- Urban buildings
- Urban infrastructure (e.g., roads, bridges)
- Rural infrastructure
- Natural and regional infrastructure
- Human exposure

In Paramaribo Metropolitan, there was insufficient detailed information to carry out a site-specific assessment of all buildings; therefore, the assessment starts with estimated property values compiled through conversations with local real estate experts (See Table 14), ERM developed a two-step calibration or scaling approach to use the information. First, the reported asset values per m2 are too high, and second, using only asset values will underestimate avoided costs because it excludes lost income and indirect effects. The calibration approach adjusts for both of these effects.

The total value of the entire metropolitan area using these values is $172 billion. The estimated GDP of the study region is $4.98 billion (World Bank Statistics 2018), which implies an asset to GDP ratio of 39.7. A recent study of global wealth estimated that the value of physical assets are about 3.2 times larger than annual GDP (Arcadis 2015). The study conducted an analysis of 32 countries ranging in size from Ghana to China and included Brazil and Chile in South America. The study found a fairly stable relationship for the asset/GDP ratio. Based on these calculations, ERM decided that the values could be useful for relative asset values by type of land use, but should be scaled to reflect the magnitude of values from the Arcadis (2015) study (see Figure 61: Land use property values in US dollars estimated for the Paramaribo Metropolitan. Therefore, the initial asset values were multiplied by 0.081 = 3.2/39.7. The costs were obtained from Suriname Real Estate Websites.

Table 14: Summary of Land/Asset Values

Land Use	Mean Value (USD$/m^2)
Low Density Residential	$450
Medium Density Residential	$350
High Density Residential	$220
High Density Housing – Informal or Government	$220
Agriculture and Livestock	$35
Medium/Low Density Farmstead Residential	$55
Commercial	$550
Institutional (schools, government, etc.)	$950
Industrial	$550
Park/Reserve/Roundabout	$400
Cultural Heritage	$1500
Cemetery	$85
Open Field (Some Vegetation)	$32
Field where Development is Prevalent	$85
Dense Vegetation and Forest	$100
Water/Canals	$55

For the second step, the damages to assets needed to be calibrated to reflect losses in income and other indirect effects. This calibration requires a Total Damage/Asset Damage ratio. ERM reviewed numerous studies, which are suitable for this purpose (ELEAC 2009). Despite employing different methodologies and metrics and evaluating different types of climate events, the studies show that the Total Damage/Asset Damage ratio ranges between 1.05 and 1.71. No individual estimate is a perfect match for flooding in urban areas in Suriname, therefore ERM used an average of all the estimates, 1.37, to reflect the long-run ratio. This ratio is multiplied by the first calibration step, 0.081, for a combined scaling factor of 0.11.

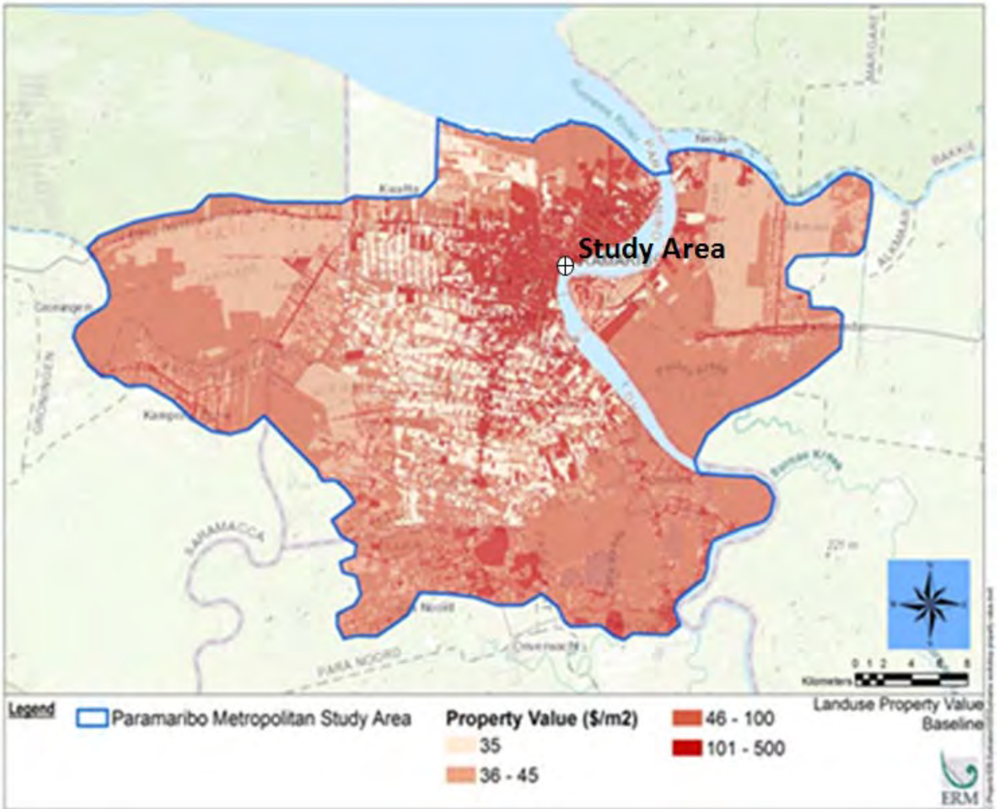


Figure 61: Land use property values in US dollars estimated for the Paramaribo Metropolitan Area

The Economic Risk Factor, ERF was calculated from the adjusted land costs using Equation 1.

Equation 1:

$$Economic\ Risk\ Factor = EVI * Land\ Asset\ Economic\ Value\ per\ m^2$$

Where EVI refers to Economic Vulnerability Index. EVI was estimated based on five grouped land use type and hazard. EVI measures the percentage of total value that would be lost from flooding levels with different hazard levels. It is based on South America global damage functions reported in Huizinga (2007) and calibrated with data from ECLAC Damage Assessment Reports. Similar studies in the neighboring countries indicated that the percentage of damage to asset value ranged from 15 to 32 percent. This information was used to scale the normalized damage functions from Huizinga resulting in the EVI values that varies between 0% and 32%. Table 15: Economic Vulnerability Index by land use and hazardTable 15 shows the EVI assigned to each of the five grouped land use categories and hazard levels (See Table 11).

Table 15: Economic Vulnerability Index by land use and hazard

Grouped Land use	Land Uses	Hazard

		none	low	medium	high
Residential	Informal, High Density Residential (HDR), Medium Density Residential (MDR), Luxury (L), Beach or Waterfront Park, Low Density Residential (LDR)	0%	3.75%	8.25%	32%
Commerce	Commerce (C), Cultural Heritage, Institutional, Recreation, Golf, Tourism (T)	0%	2.25%	6.75%	32%
Industry	Industrial	0%	2.5%	6.0%	32%
Infrastructure	Airport	0%	3.75%	8.25%	32%
Agriculture	Agriculture, unprotected forest, Mixed Dwelling Agriculture, Protected Forest, Protected Wetland, Unprotected Wetland, Vacant Vegetation.	0%	4.5%	9.75%	32%

Source: Adopted from Paramaribo Metropolitan from Huizinga, 2007

As an example, economic vulnerability index map for existing wall and climate change 2050 scenario is shown in Figure 62 and the corresponding economic risk map is shown in Figure 63.

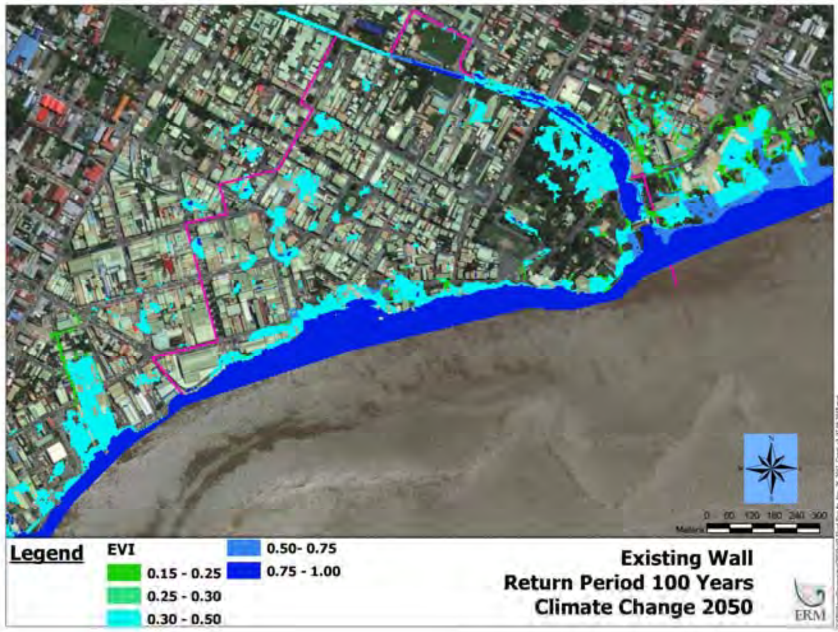


Figure 62: Economic-based vulnerability index map of the Study Area for the climate change 2050 scenario at 100-year return period

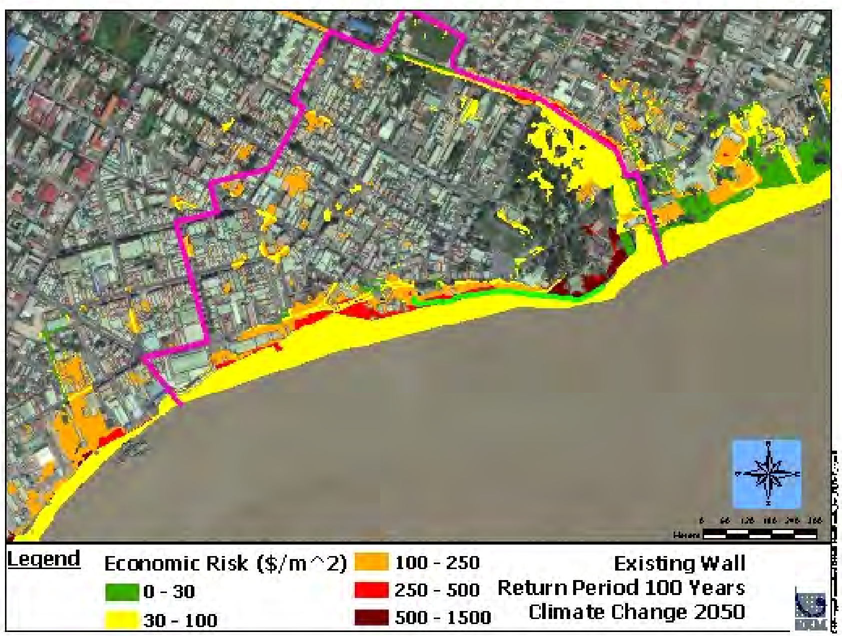


Figure 63: Economic-based risk map of the Study Area for the climate change 2050 scenario at 100-year return period

Figure 62 shows clearly that economic vulnerability index maps looks similar to the economic risk map shown in Figure 63 and hence only the economic-based risk maps were developed using the approach described above for the baseline and climate change scenarios for all selected return periods and are described in Sections 5.3, 5.4 and 5.5. However, the economic and population vulnerability indices are very useful in justifying the alternatives selected which are precisely oriented to protect the most vulnerable areas of downtown or where important economic assets exist.

5.2 CALCULATION OF POPULTION RISK

Population based risk refers to impact on human health which is quantified using the spatial distribution of population density in the Study Area. Estimated probable losses were determined from the exposed assets and flood hazards. Estimations were made for either the economic losses from property damage or for the risks posed to human health. Exposed assets are based on the distribution of properties and populations, as described in earlier sections. Information on the geographical distribution of population density was analyzed with geographic information systems (GIS). A map of the population density by resort is presented in Figure 64. Population density data was obtained from Paramaribo 2012 demography data. Paramaribo Metropolitan comprises a range of population densities, from low in the agricultural sectors to high within the city.

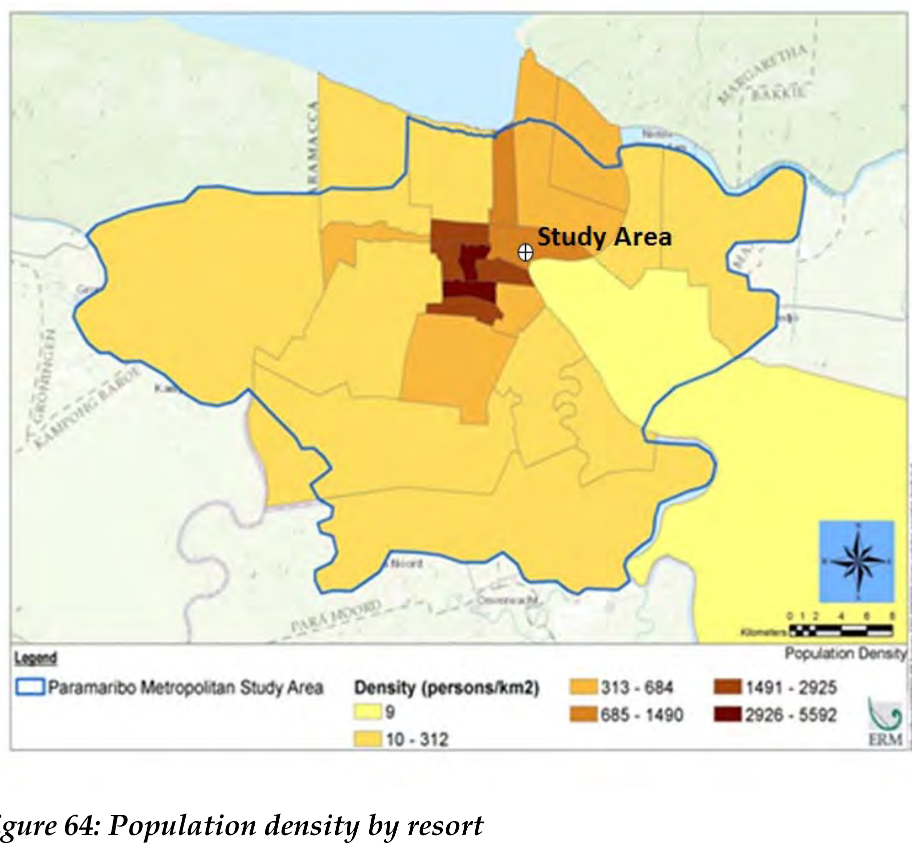


Figure 64: Population density by resort

The large value of population density in the Study Area along the riverbank of the Suriname River indicates that the 2012 census data takes into account the population related to waterfront recreation area and neighboring businesses. Population Risk Factor (PRF) was calculated using Equation 2.

Equation 2:

$$Population\ Risk = PVI * Population\ Density\ (\#\ people/m^2)$$

Where PVI refers to Population Vulnerability Index (PVI) and population density was obtained from 2012 demography data shown in Figure 64. PVI was assigned based on hazard ratings. The index ranges from 0 to 1 where 0 indicates that danger to persons is very low or non-existent, and 1 indicates a high or very high danger to persons, as provided in Table 16. A scale of the population risk was assigned ranging from very low to very high. The scale, provided in Table 17, is based on a Gaussian distribution where each category is above or below the mean risk by a number of standard deviations. Moderate risk is between -0.5 to +0.5 standard deviations of the mean risk for a 100-year event; high risk is +1.5 to +2.5 standard deviations above the mean; very high risk is +2.5 to +3.5 standard deviations above the mean; low risk is -1.5 to -2.5 standard deviations below the mean; and very low risk is -2.5 to -3.5 standard deviations below the mean. Areas with a very low risk are least affected by inland and coastal flooding, moderate areas are average (i.e. what most people will encounter), and very high risk areas are heavily impacted.

Table 16: Population vulnerability index (PVI) by hazard

Hazard	PVI
None	0
Low	0.25
Medium	0.50
High	1.0

Table 17: Population risk ratings for risk maps

Population risk (persons in danger per km^2)	Risk
0 - 350	Very Low
351 - 1050	Low
1051 - 1760	Moderate
1761 - 2461	High
2461 - 5505	Very High

km2 = square kilometers

As an example, population vulnerability index map for existing wall and climate change 2050 scenario is shown in Figure 65 and the corresponding economic risk map is shown in Figure 66.

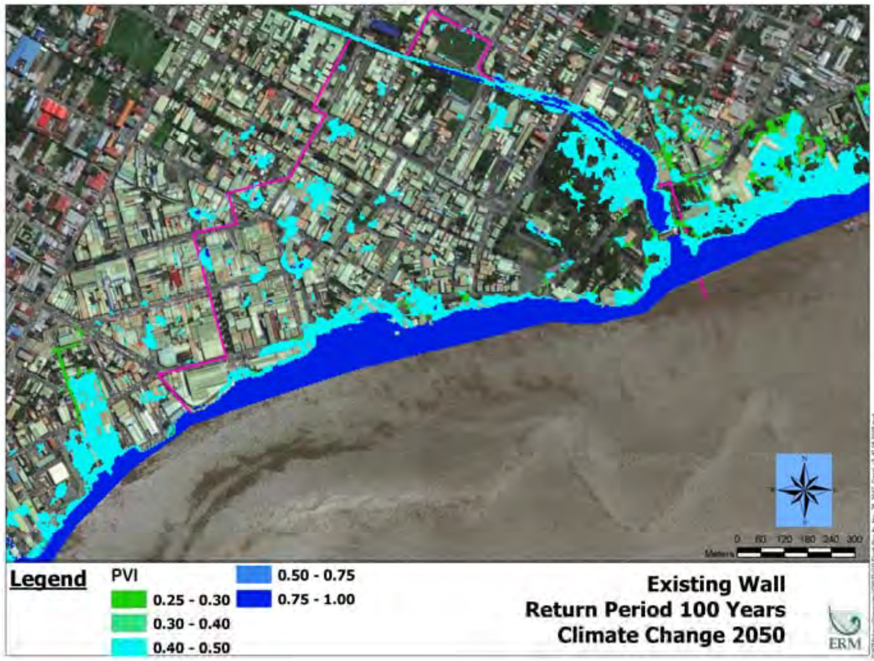


Figure 65: Population-based vulnerability index map of the Study Area for the climate change 2050 scenario at 100-year return period

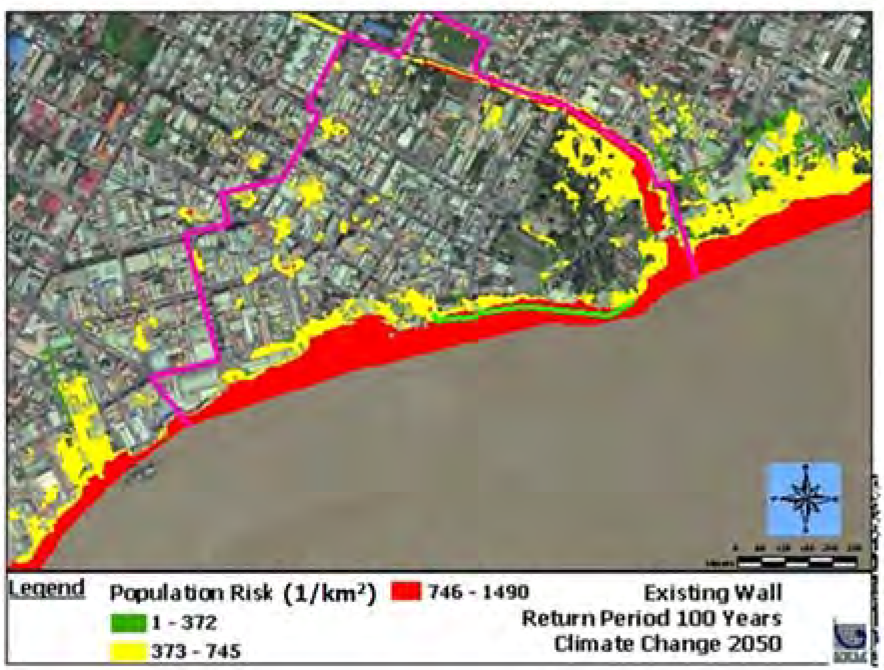


Figure 66: Population-based risk map of the Study Area for the climate change 2050 scenario at 100-year return period

Figure 65 shows clearly that population vulnerability index map looks similar to the population risk map shown in Figure 66 and hence only the population-based risk maps were developed using the approach described above for the baseline and climate change scenarios for all selected return periods and are described in Sections 5.3, 5.4 and 5.5.

The approach used for this study presented the following limitations:

- Damage to properties was assessed based on the flood depth and velocity, and the type of land use. Damages were applied uniformly within each land use, without considering building age or construction. Improved construction methods, such as a raised foundation, can reduce damages to a building.
- Population risks have been evaluated on an average resort-wide basis. The population distribution within a resort varies considerably, with some areas of high population density, and other areas where there is no population.
- Risks do not indicate fatality or the type of injury that may occur. It does not consider people moving to higher ground or avoiding flooded areas. Therefore, estimates of the population risk are considered a conservative estimate of danger to persons, and are most useful in indicating the relative danger that can occur across different areas of Paramaribo.
- In the estimation of population risk factor, length of time that people will be exposed to flooding is not included in the risk analysis. We used a conservative approach of using a value in the range 0 to 1 to define that if a person is in the low hazard region, we apply PVI value of 0.25. This approach includes only the intensity of exposure and not the length of exposure. Though national standards recommends flooding threshold as the maximum occurrence of water logging in the streets of 60 minutes, and the minimum of 12 hours of discharge of rainfall, we kept the impact evaluation as most conservative possible by looking at the maximum inundation depth and the maximum momentum (product of velocity x depth). This will provide most stringent information for the development of any hard or soft adaptation measures. In addition, similar method was implemented for the hazardous and risk assessment study of the district of Paramaribo (ERM, 2017).

In conclusion, areas of very high risk occur due to the most severe flooding and are concentrated in where there is low lying ground, many buildings, and a high population density. Much of the inland and agricultural areas are a low or very low population risk due to the low population density. Because population density is assigned for each resort, the population risk within a neighborhood of the resort can be greater than the average risk across the resort. A resort may have an overall low density, but a neighborhood within it with a higher density. In addition, economic losses will be largely impacted (an increase of 8-13%) by climate change. Land use changes, either increases or decreases in urbanization, can affect the flood losses, although to a lesser extent than climate change.

5.3 *ECONOMIC- AND POPULATION- RISK BASED MAPS OF THE STUDY AREA WITH THE EXISTING FLOOD WALL*

The economic-based risk maps for the Study Area are shown in Figure 67 to Figure 70 for the baseline scenario at 10-, 25-, 50-, and 100-year return periods; Figure 71 to Figure 74 for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods; Figure 75 to Figure 78 for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods; and Figure 79 to Figure 82 for the climate change scenario 2080 at 10-, 25-, 50-, and 100-year return periods.

Under baseline conditions, flooding in the western portion of the Study Area near the Water Taxi area leads to moderate to high economic risk along the bank of the Suriname River for all return periods (see Figure 67 to Figure 70). The economic risk, however, drops off quickly as flood waters lessen directly inland. For longer return periods, flood waters lead to localized areas of moderate economic risk in interior sections of the Study Area. In the eastern portion of the Study Area baseline conditions generally lead to low economic risk along the Sommeldijckse Canal from the Suriname River inland to beyond the Walter Amo Sporthal on Koninginne Street (see Figure 67 to Figure 70). The area of low economic risk expands inland as the return period increases. For the 100-year return period, high economic risk is seen along the bank of the Suriname River to the east of Fort Zeelandia, with small pockets of high economic risk located slightly inland.

Economic risks for the 2020 climate change scenario do not change noticeably from baseline conditions for the same return periods (see Figure 71 to Figure 74). For the 2050 climate change scenario, levels of economic risk mirror those seen in the baseline scenario for all return periods; however, these areas expand in area (see Figure 75 to Figure 78).

The situation changes considerably under the 2080 climate change scenario. There is a general increase in the intensity of economic risk as well as the areal extent of each risk category. The eastern portion of the Study Area near Fort Zeelandia is particularly impacted economically (see Figure 79 to Figure 82). Even for the 10-year return period (Figure 79), there are noticeable increases in damages along the bank both east and west of the Study Area, compared to either Figure 67 (Baseline, 10-year return) or Figure 71 (Baseline, 100-year return). There are also significant increases in damages along the northern border of the Study Area. Overall, it appears that the damages in the immediate area of the Existing Wall damages do not change noticeably over the different climate scenarios or return periods.

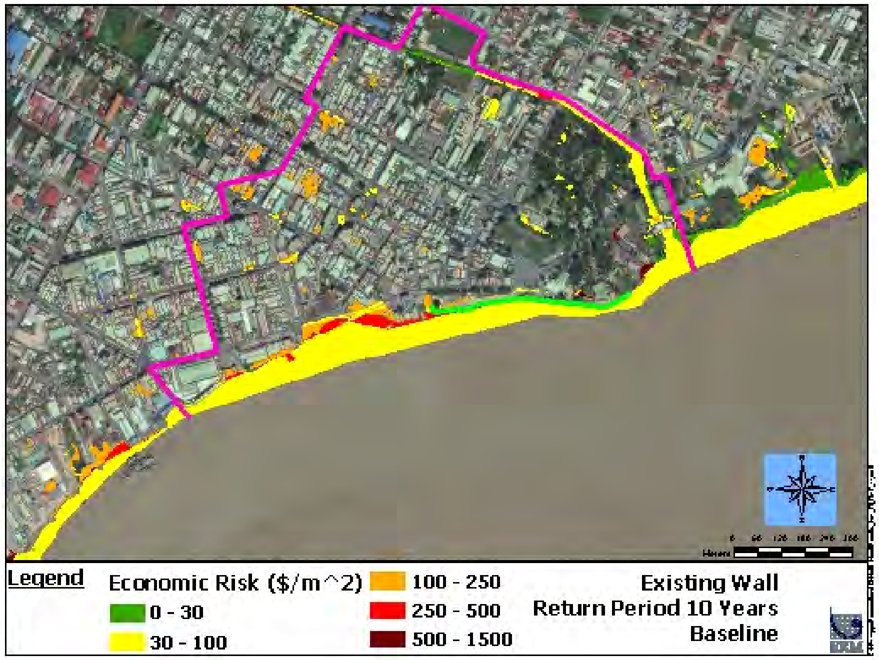


Figure 67: Economic-based risk map of the Study Area for the baseline scenario at 10-year return period

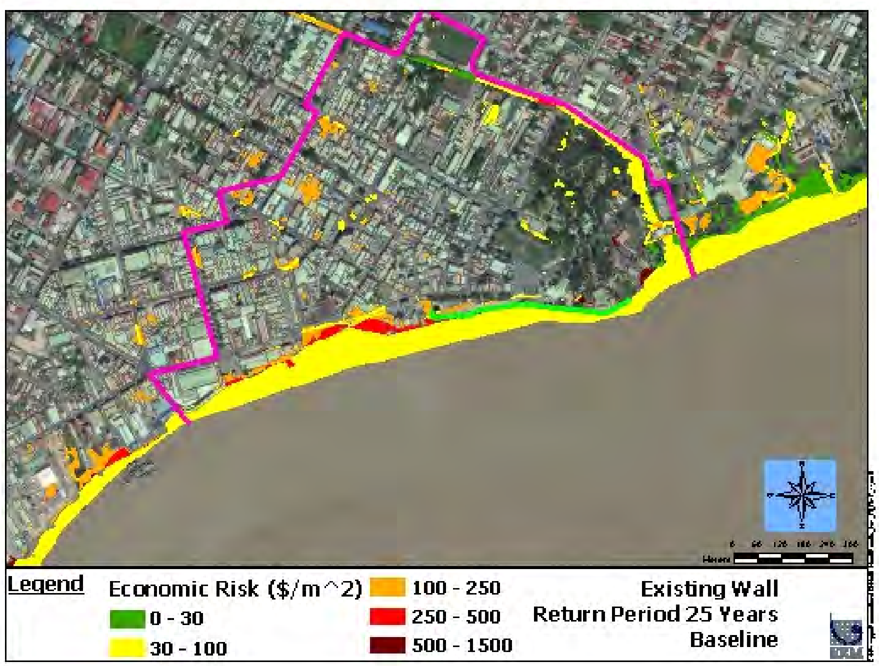


Figure 68: Economic-based risk map of the Study Area for the baseline scenario at 25-year return period

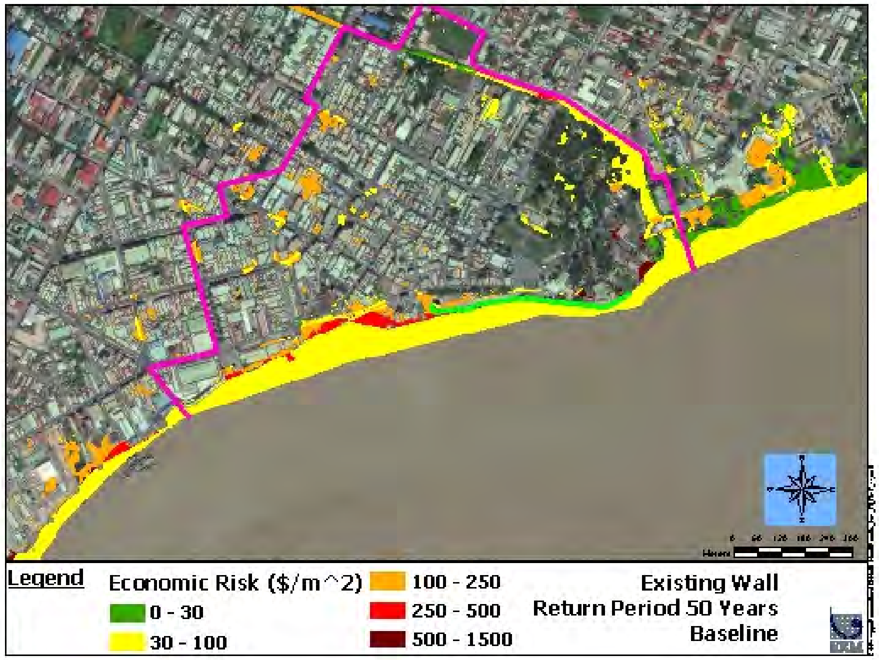


Figure 69: Economic-based risk map of the Study Area for the baseline scenario at 50-year return period

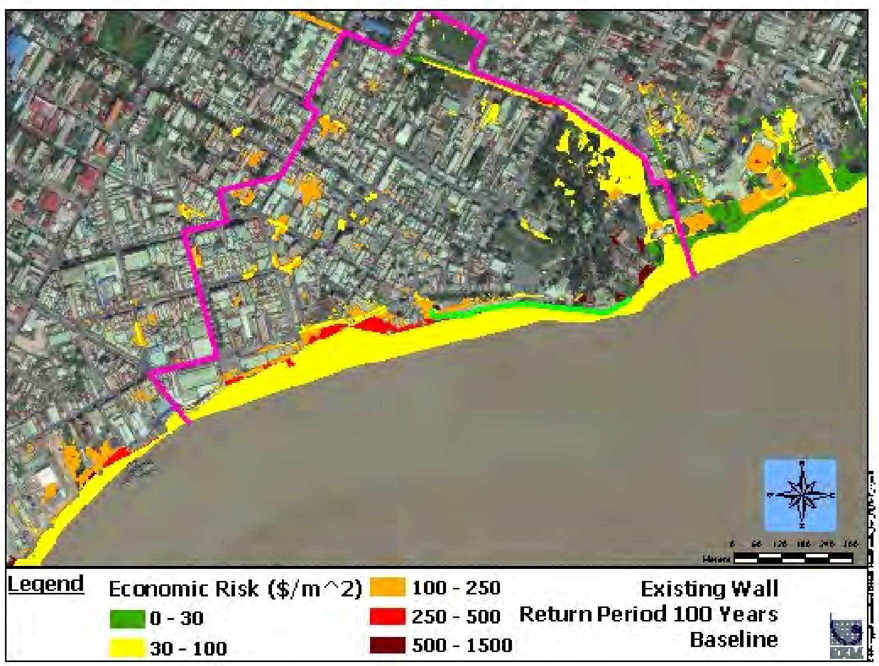


Figure 70: Economic-based risk map of the Study Area for the baseline scenario at 100-year return period

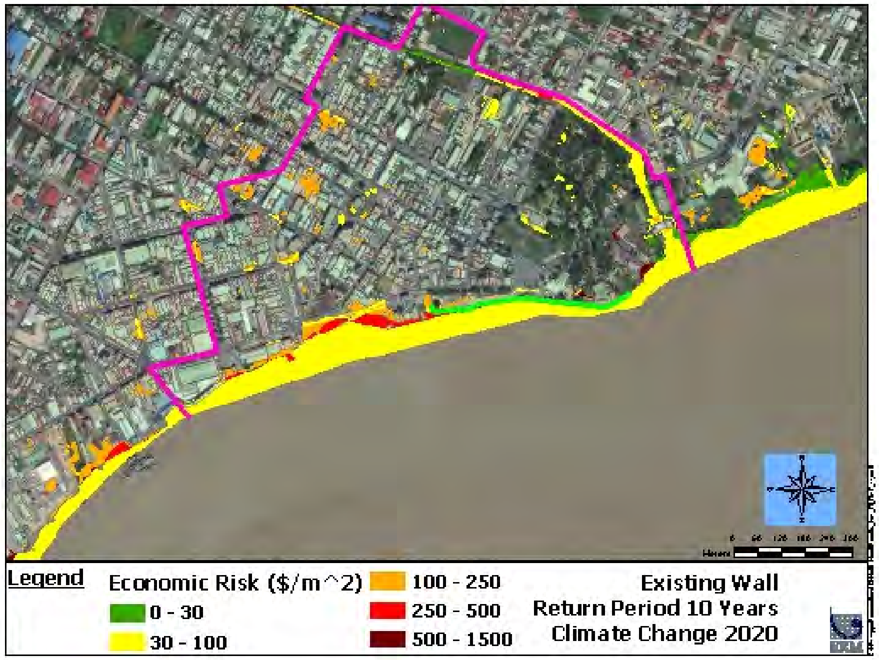


Figure 71: Economic-based risk map of the Study Area for the climate change 2020 scenario at 10-year return period

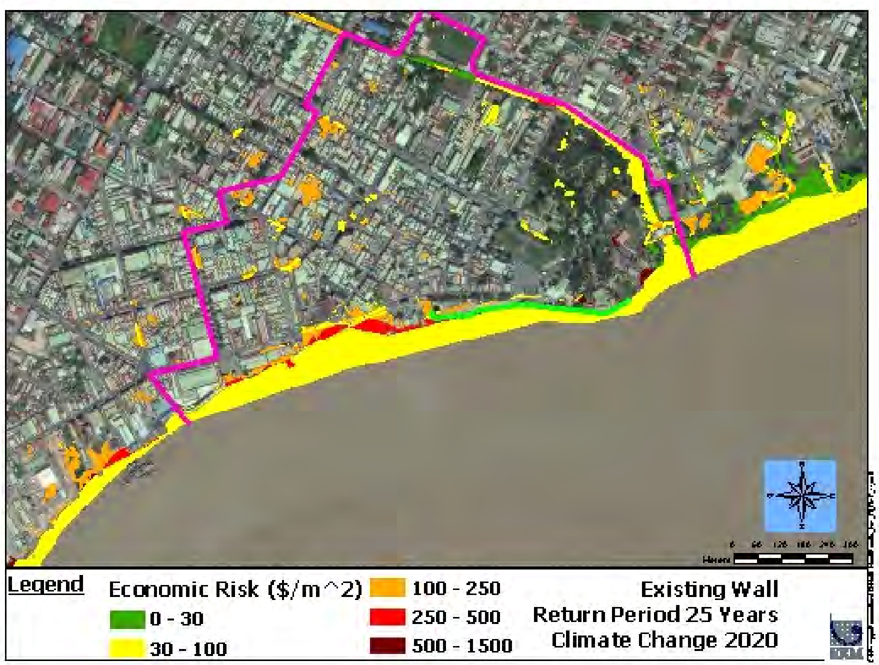


Figure 72: Economic-based risk map of the Study Area for the climate change 2020 scenario at 25-year return period

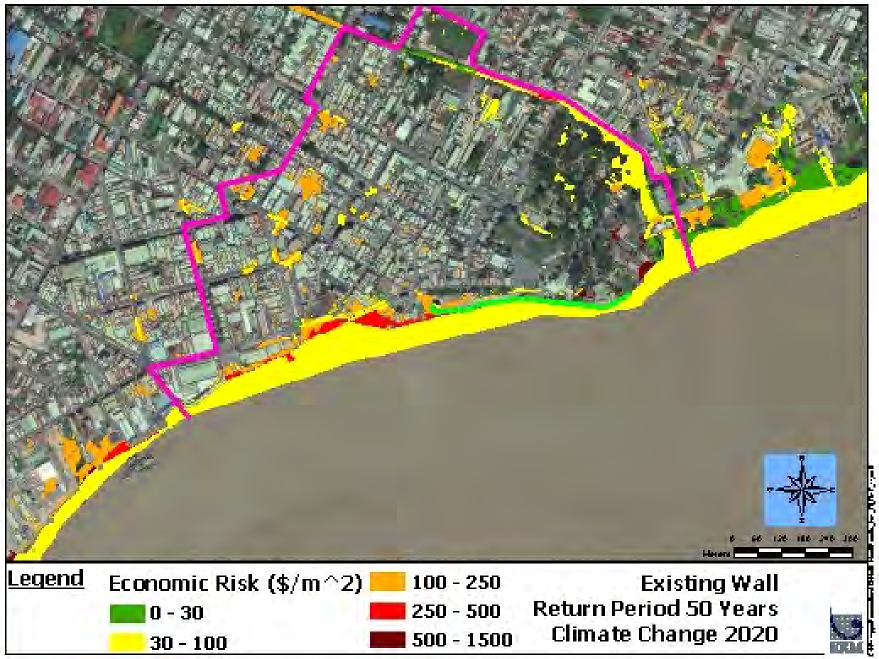


Figure 73: Economic-based risk map of the Study Area for the climate change 2020 scenario at 50-year return period

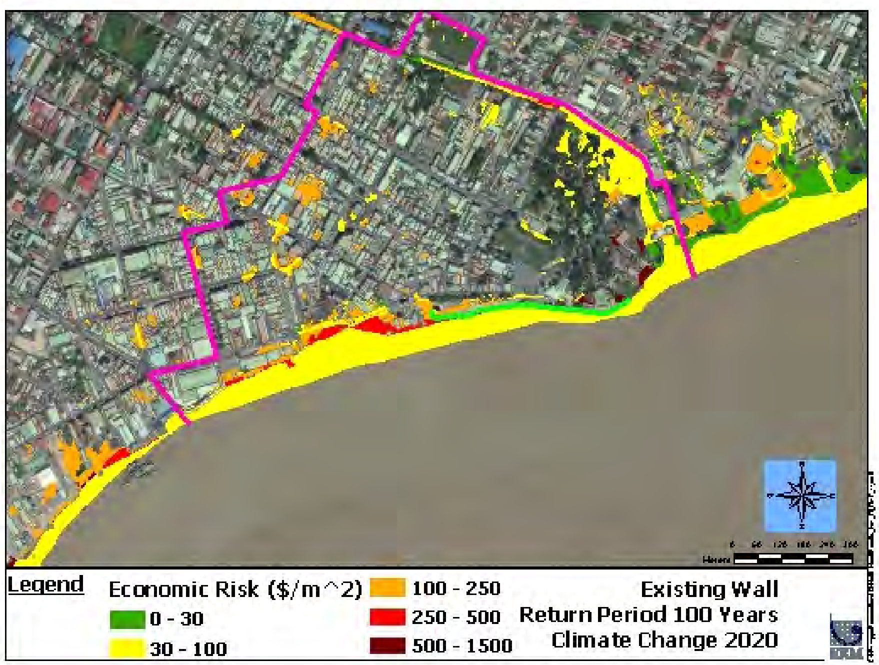


Figure 74: Economic-based risk map of the Study Area for the climate change 2020 scenario at 100-year return period

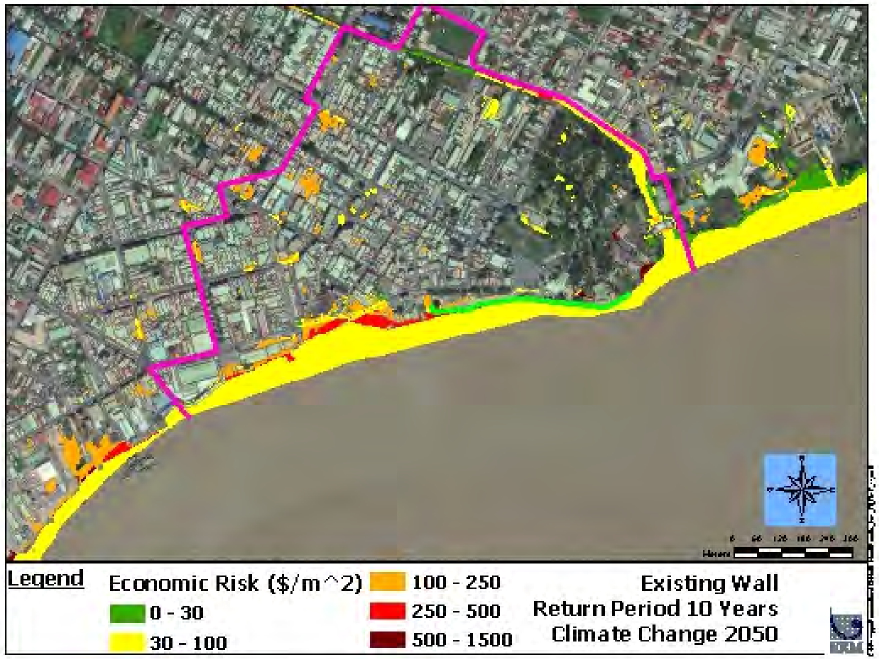


Figure 75: Economic-based risk map of the Study Area for the climate change 2050 scenario at 10-year return period

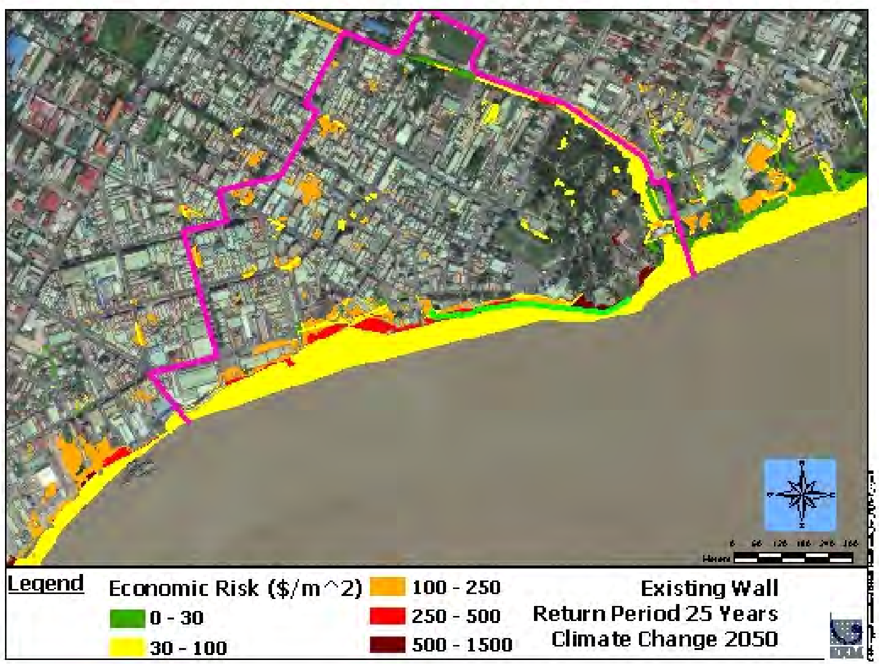


Figure 76: Economic-based risk map of the Study Area for the climate change 2050 scenario at 25-year return period

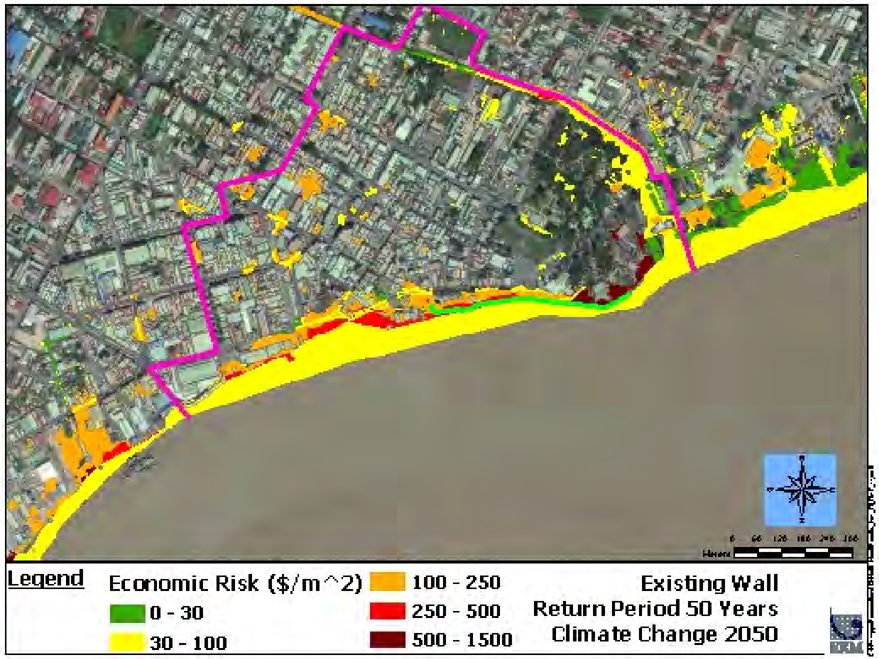


Figure 77: Economic-based risk map of the Study Area for the climate change 2050 scenario at 50-year return period

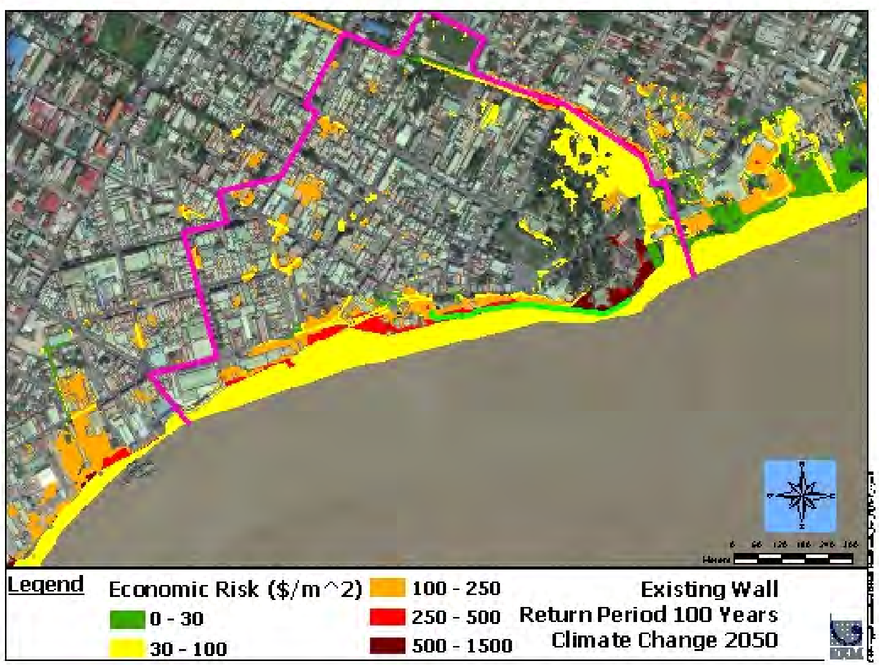


Figure 78: Economic-based risk map of the Study Area with the climate change 2050 scenario at 100-year return period

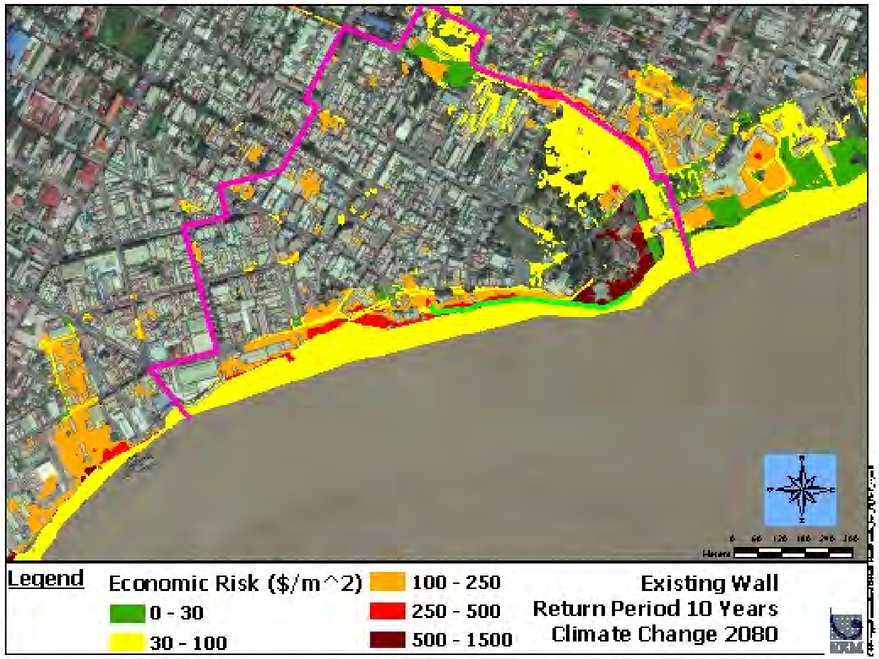


Figure 79: Economic-based risk map of the Study Area for the climate change 2080 scenario at 10-year return period

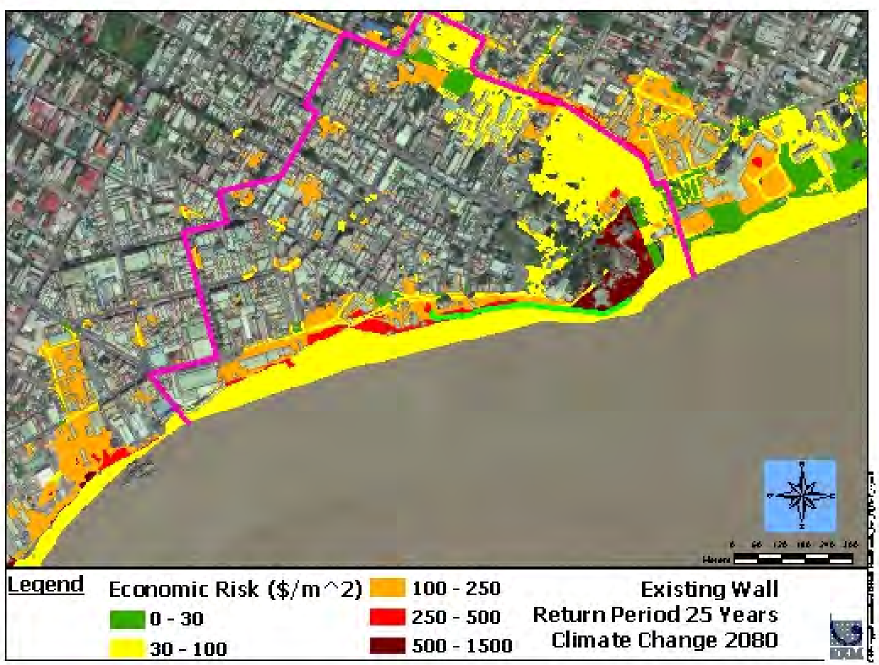


Figure 80: Economic-based risk map of the Study Area for the climate change 2080 scenario at 25-year return period

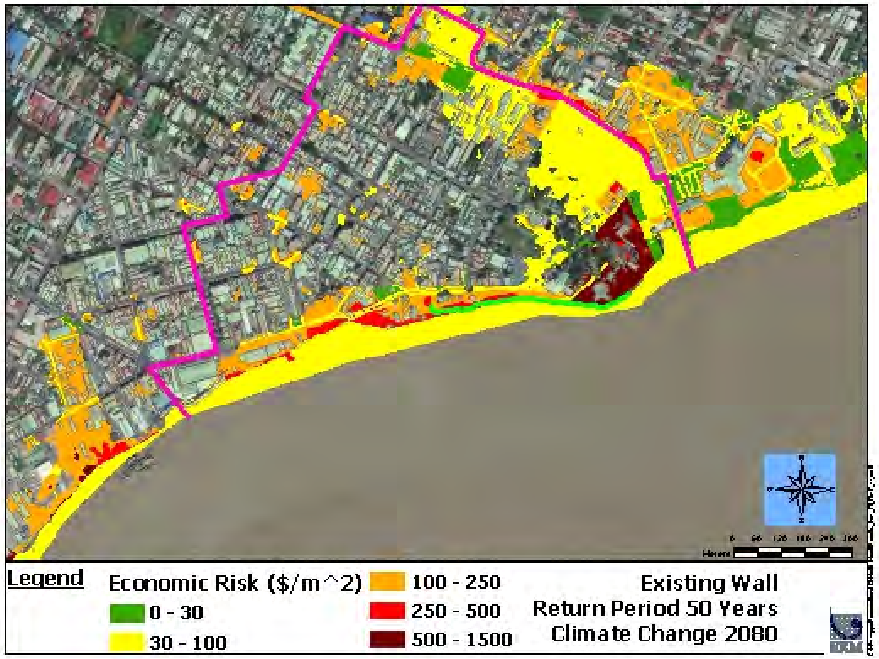


Figure 81: Economic-based risk map of the Study Area for the climate change 2080 scenario at 50-year return period

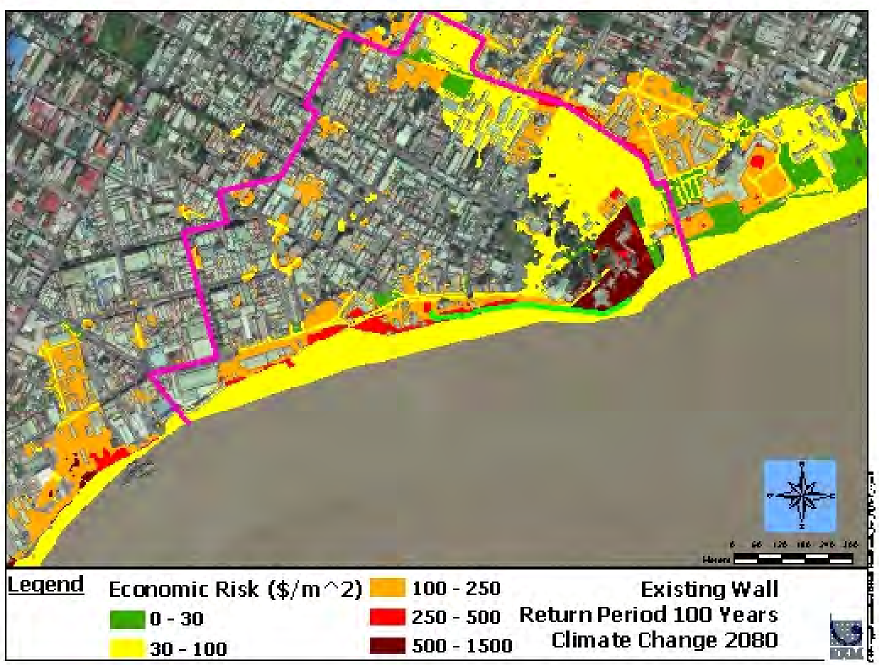


Figure 82: Economic-based risk map of the Study Area for the climate change 2080 scenario at 100-year return period

The population-based risk maps for the Study Area are shown in Figure 83 to Figure 86 for the baseline scenario at 10-, 25-, 50-, and 100-year return periods, respectively; Figure 87 to Figure 90 for the climate change 2020 scenario; Figure

91 to Figure 94 for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods, respectively; Figure 95 to Figure 98 for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods, respectively.

The population-based risk maps show the same general relative pattern as the economic risk maps with respect to increasing return periods and climate change severity. Most of the population risk is located along the bank, especially just west of the existing flood wall. And as the return period increases or climate change severity increases, the population risk increases east and west of the Study Area, along the bank. Population risk increases along the northern border of the study area as well.

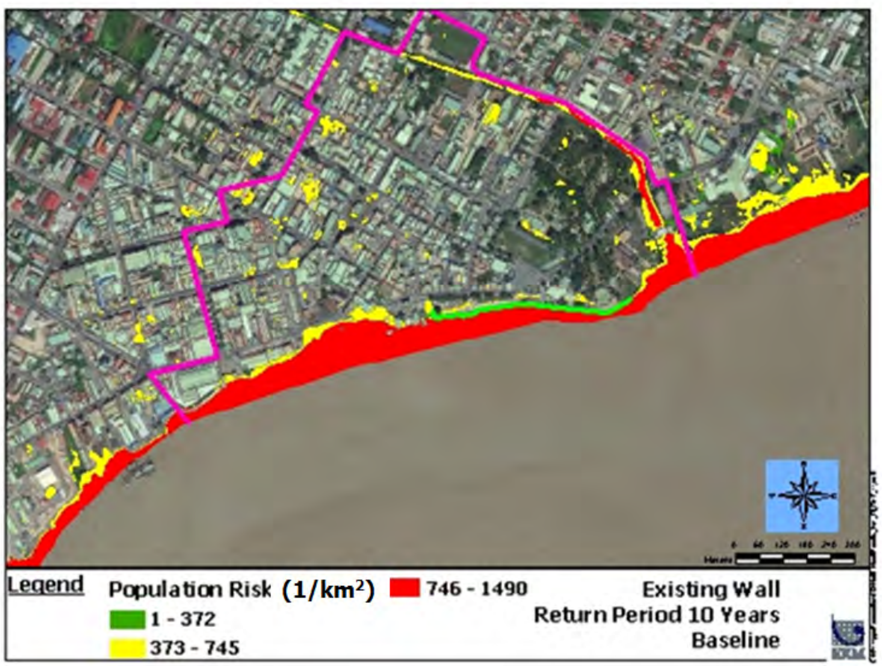


Figure 83: Population-based risk map of the Study Area for the baseline scenario at 10-year return period

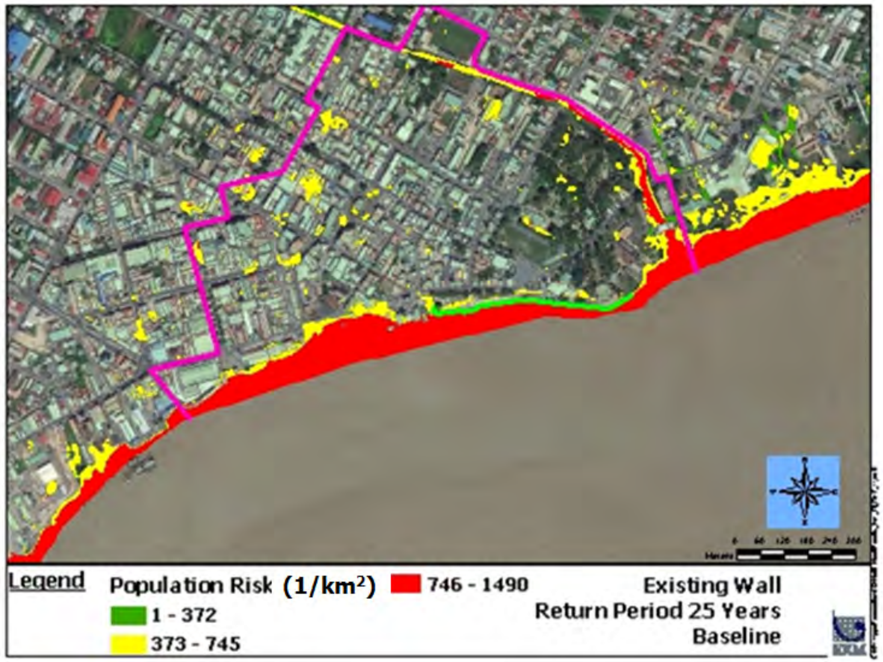


Figure 84: Population-based risk map of the Study Area for the baseline scenario at 25-year return period

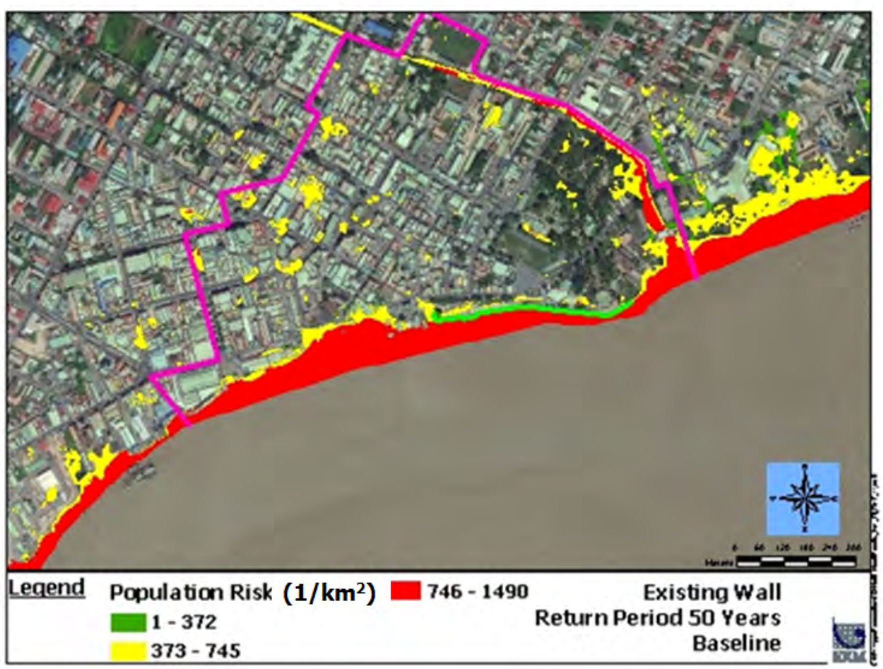


Figure 85: Population-based risk map of the Study Area for the baseline scenario at 50-year return period

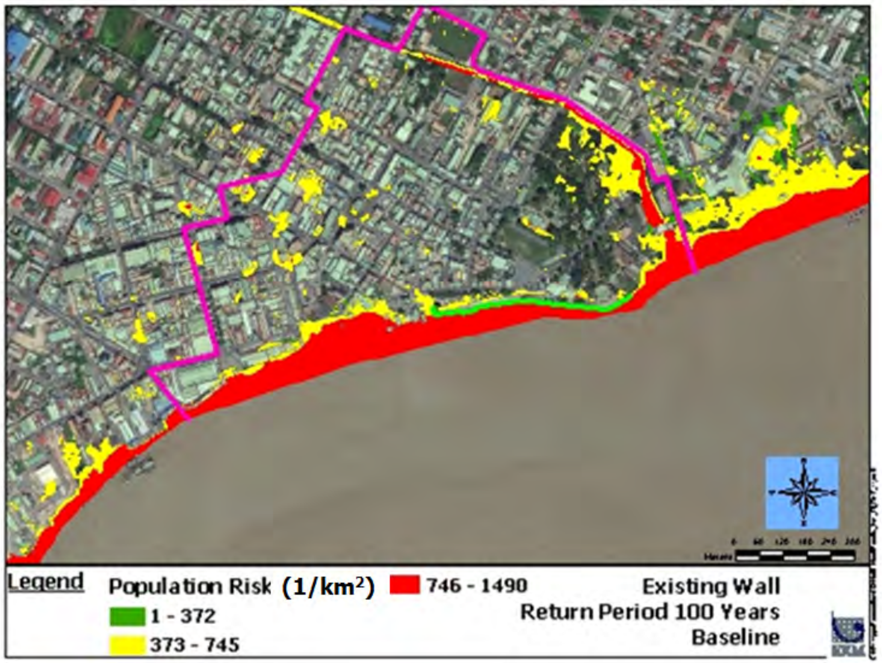


Figure 86: Population-based risk map of the Study Area for the baseline scenario at 100-year return period

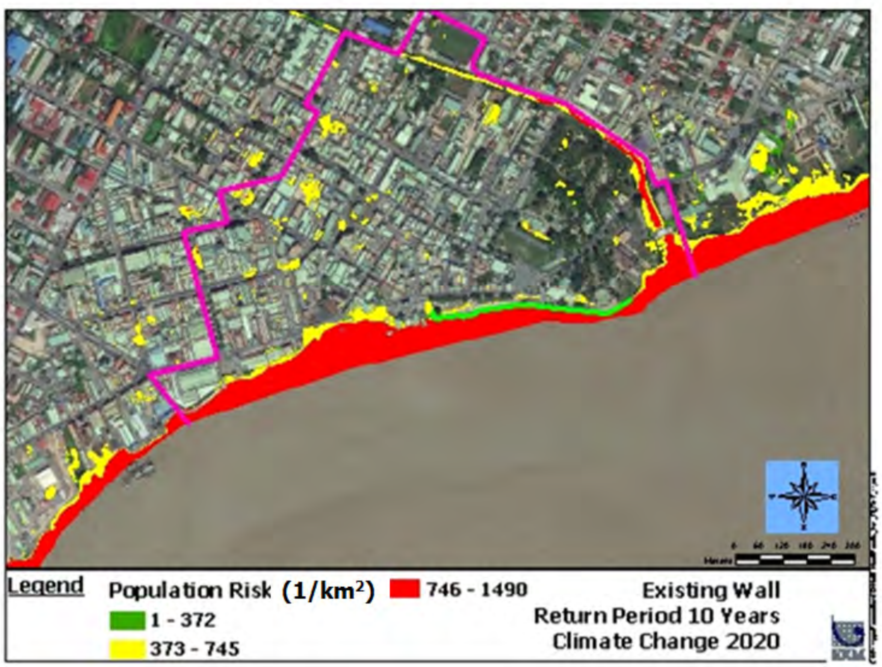


Figure 87: Population-based risk map of the Study Area for the climate change 2020 Scenario at 10-year return period

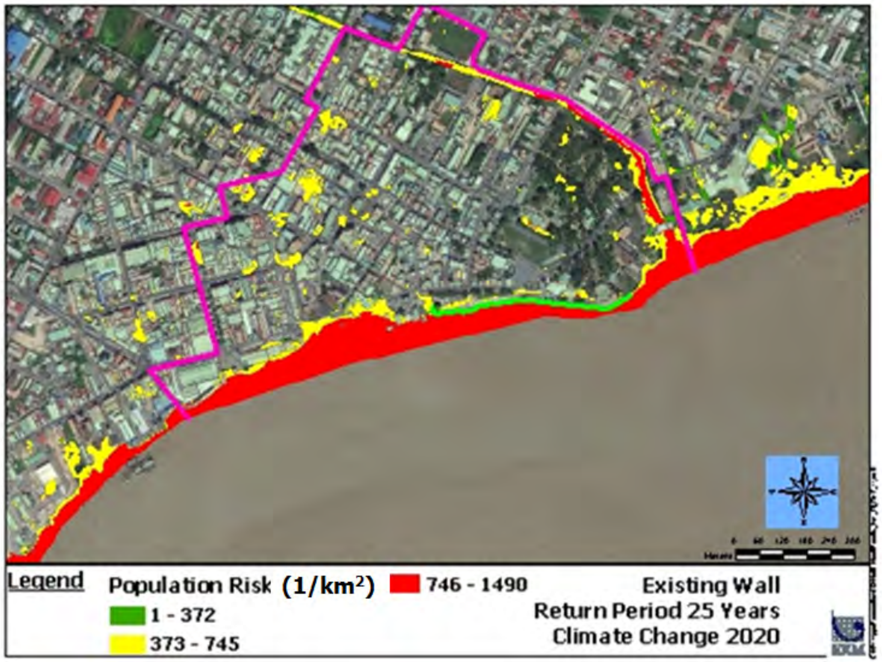


Figure 88: Population-based risk map of the Study Area for the climate change 2020 Scenario at 25-year return period

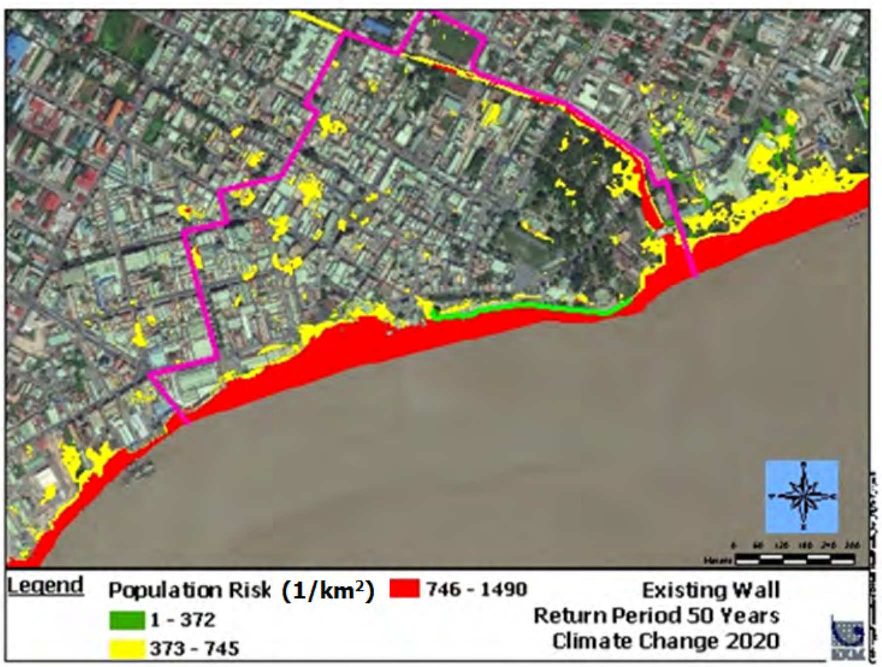


Figure 89: Population-based risk map of the Study Area for the climate change 2020 Scenario at 50-year return period

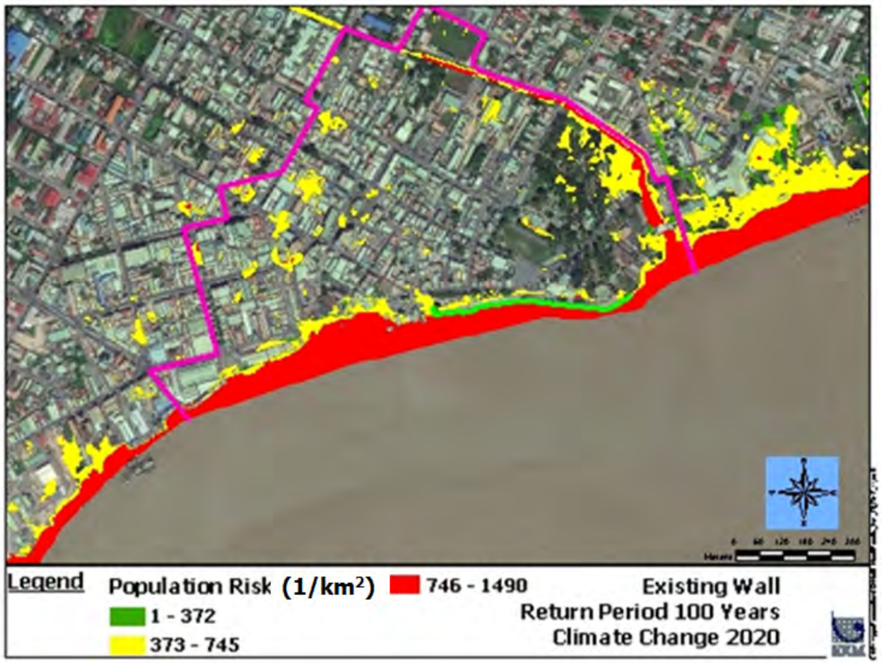


Figure 90: Population-based risk map of the Study Area for the climate change 2020 Scenario at 100-year return period

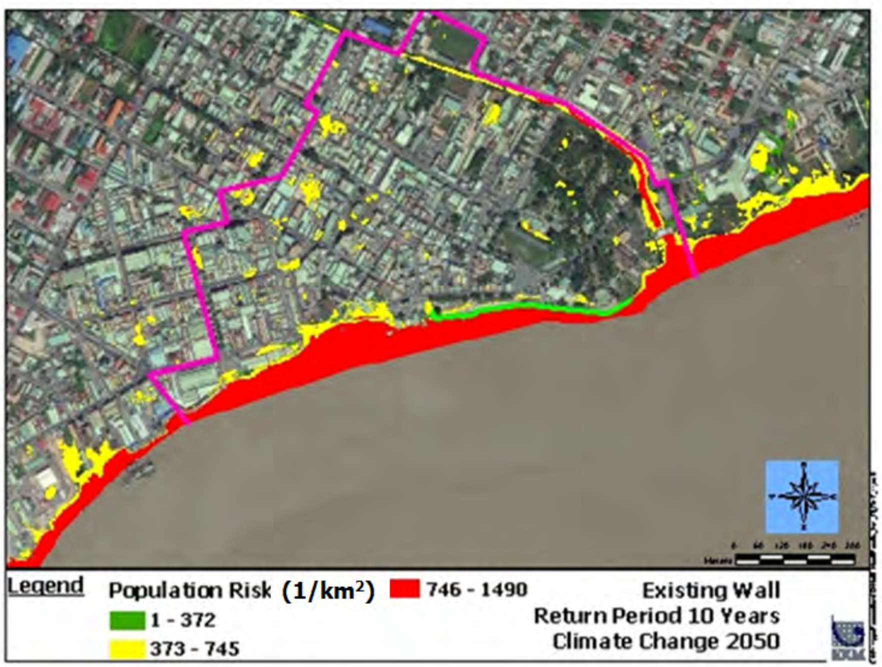


Figure 91: Population-based risk map of the Study Area for the climate change 2050 scenario at 10-year return period

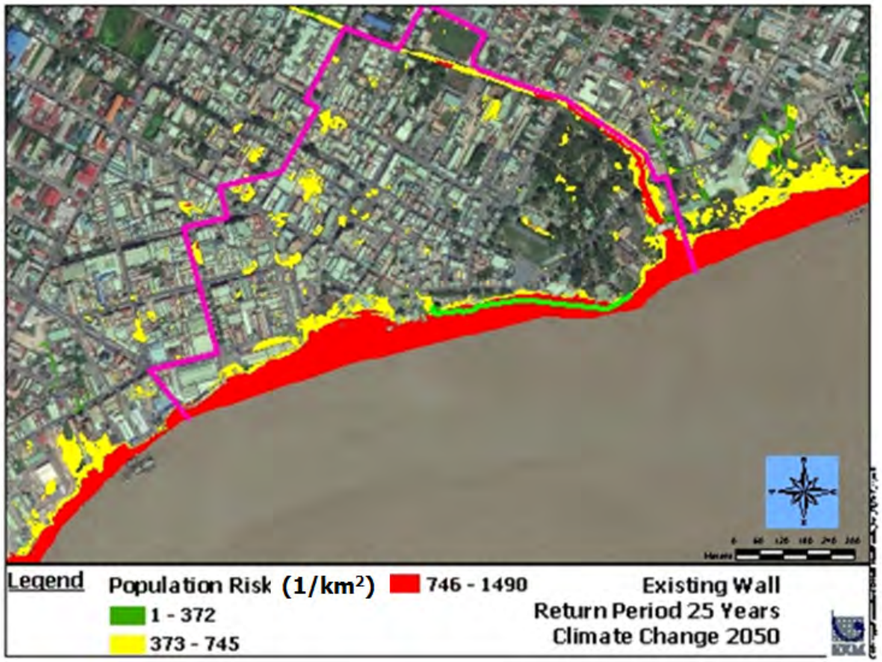


Figure 92: Population-based risk map of the Study Area for the climate change 2050 Scenario at 25-year return period

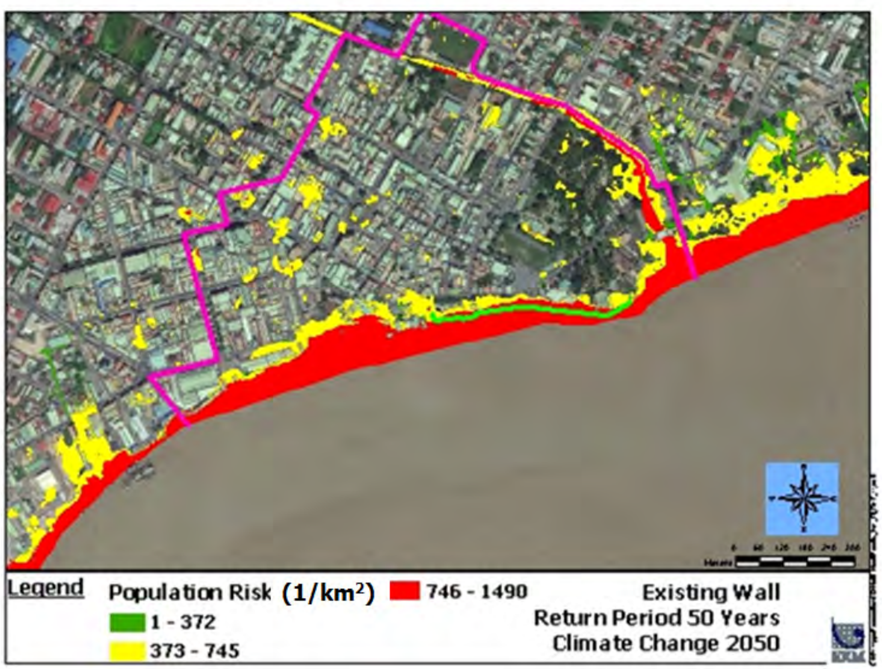


Figure 93: Population-based risk map of the Study Area for the Climate Change 2050 Scenario at 50-year return period

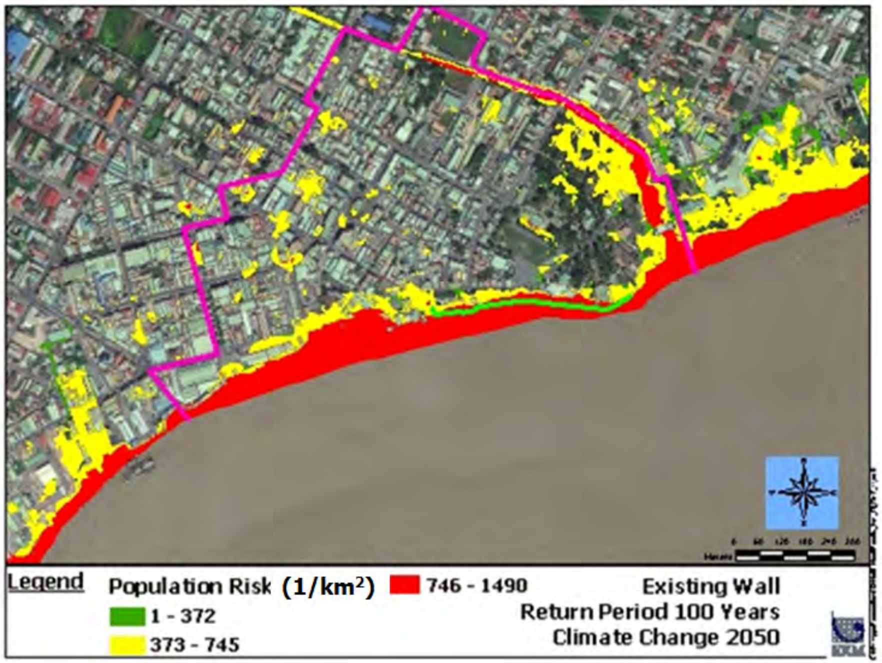


Figure 94: Population-based risk map of the Study Area for the Climate Change 2050 Scenario at 100-year return period

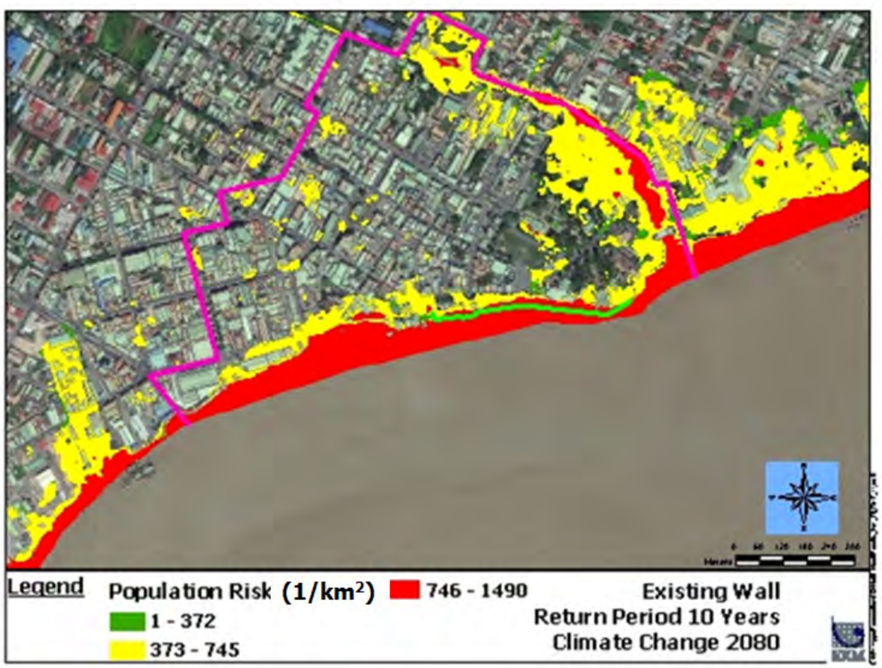


Figure 95: Population-based risk map of the Study Area for the Climate Change 2080 Scenario at 10-year return period

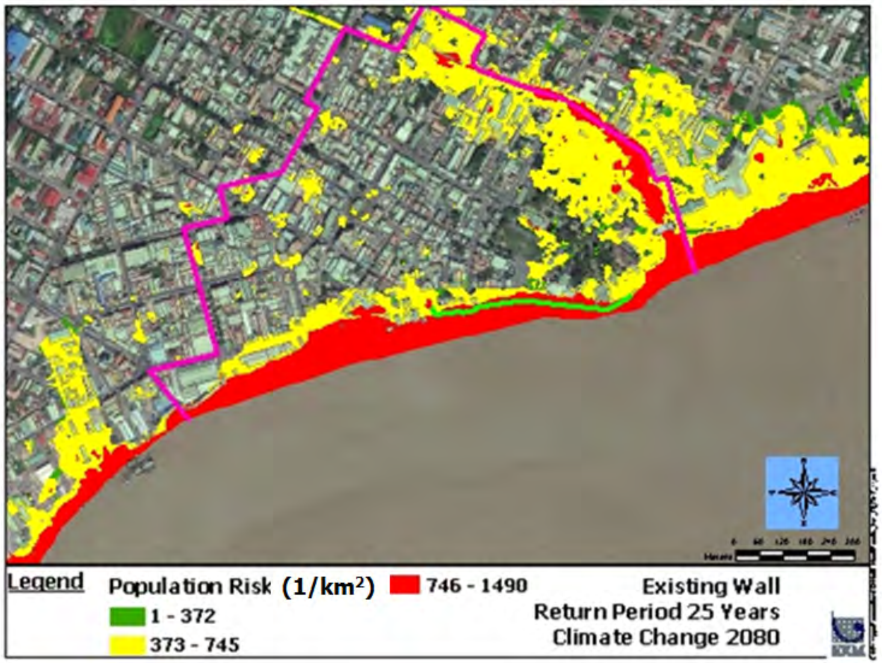


Figure 96: Population-based risk map of the Study Area for the Climate Change 2080 Scenario at 25-year return period

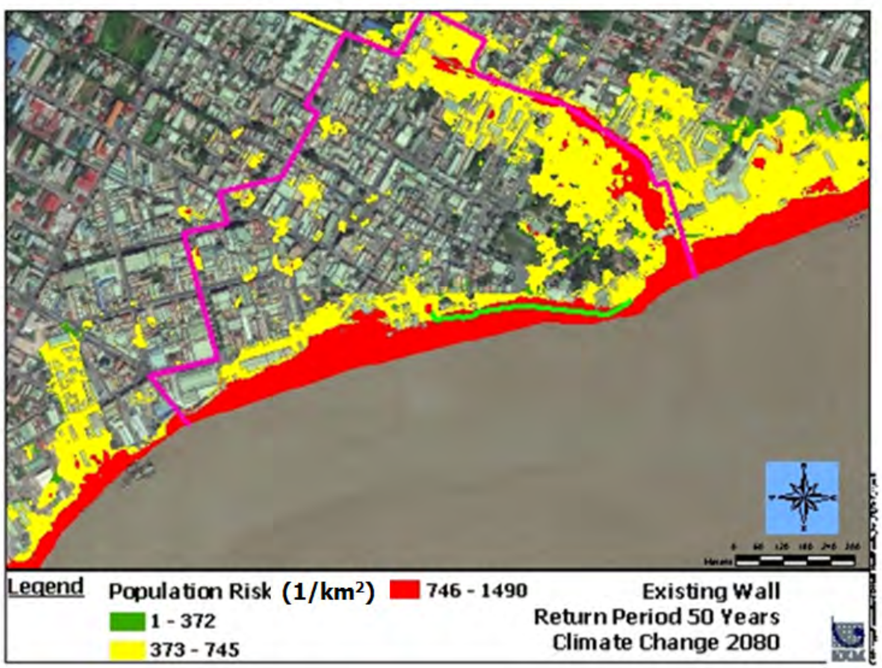


Figure 97: Population-based risk map of the Study Area for the Climate Change 2080 Scenario at 50-year return period

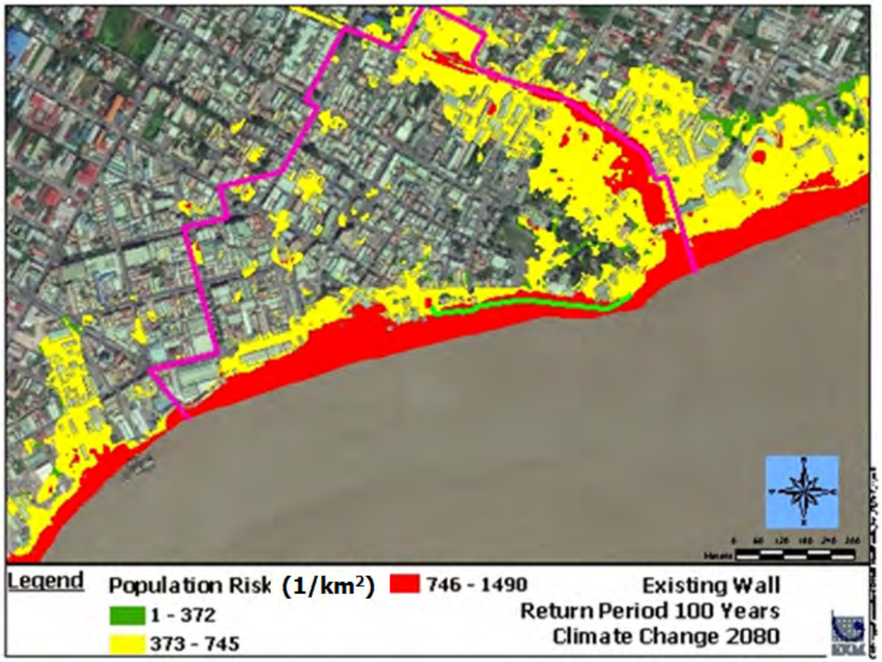


Figure 98: Population-based risk map of the Study Area for the Climate Change 2080 Scenario at 100-year return period

5.4 ECONOMIC- AND POPULATION- RISK BASED MAPS OF THE STUDY AREA WITH THE ALTERNATIVE 2 AND 3 CONCEPTUAL DESIGNS

The economic-based risk maps for the Study Area with the Alternative 2 and 3 conceptual designs are shown in Figure 99 to Figure 102 for the baseline scenario at 10-, 25-, 50-, and 100-year return periods; Figure 103 to Figure 106 for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods; Figure 107 to Figure 110 for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods; and Figure 111 to Figure 114 for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods.

The implementation of alternatives 2 and 3 under baseline conditions does not appear to result in a general lessening of economic risk throughout the Study Area for all return periods. In comparing Figure 70 (Baseline, 100-year return, with existing wall) and Figure 102 (Baseline, 100-year return, with existing wall and alternatives 2&3) there are no visual benefits from the alternatives.

For the 2050 climate change scenario, the implementation of alternatives 2 and 3 result in a slight reduction in economic risk in the western portion of the Study Area, near the Water Taxi area and on the inland side the existing flood wall, particularly for long return periods. For the eastern portion of the Study Area, alternatives 2 and 3 results in a reduction in the area of high economic risk near Fort Zeelandia, particularly for long return periods. The implementation of alternatives 2 and 3 also results in a reduction in the area of low economic risk north of Fort Zeelandia. In Figure 78 (2050 scenario, 100-year return, with alternatives 2 and 3), the reduction in economic risk becomes evident.

For the 2080 climate change scenario, alternatives 2 and 3 have minimal impact on economic risk in the western portion of the Study Area. There is no discernable decrease in neither the level of economic risk nor the areal extent of measurable economic risk. In the eastern portion of the Study Area, near Fort Zeelandia, however, alternatives 2 and 3 result in improvement in economic risk during all return periods. The most significant improvements in economic risk, however, occur with short return periods. For instance, there is a significant decrease in the areal extent of low economic risk just north of Fort Zeelandia for the 10- and 25-year return periods. For the 10-year return period, economic risk that exists near Walter Amo Sporthal to the north of Fort Zeelandia is mitigated with the implementation of alternatives 2 and 3. By comparing Figure 82 (2080, 100-year return, baseline) and Figure 114 (2080, 100-year return, with alternatives 2 &3), the value of the proposed flood walls will be felt most along about half of the northeast border of the Study Area starting with the Mangrove area.

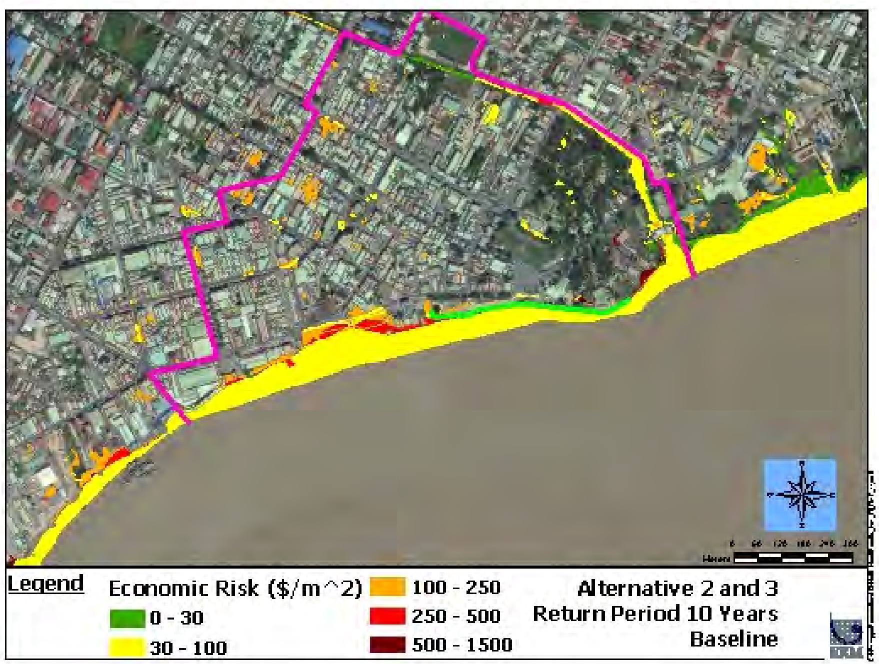


Figure 99: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 10-year return period

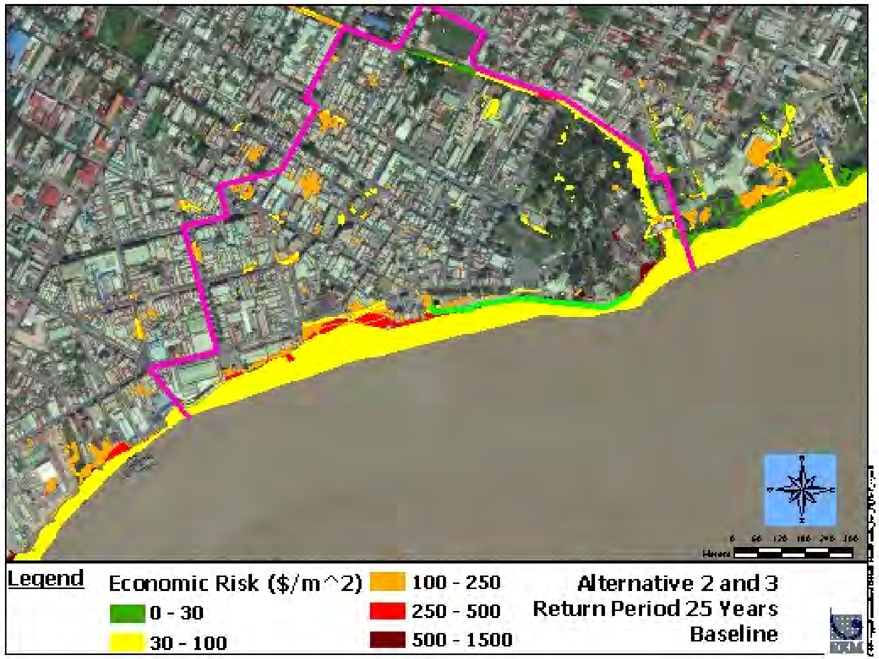


Figure 100: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 25-year return period

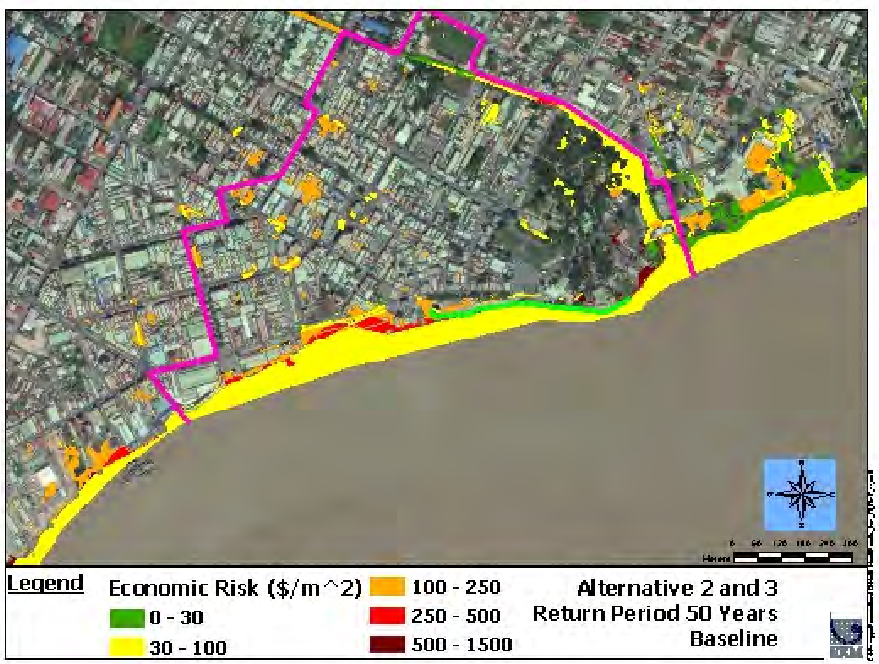


Figure 101: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 50-year return period

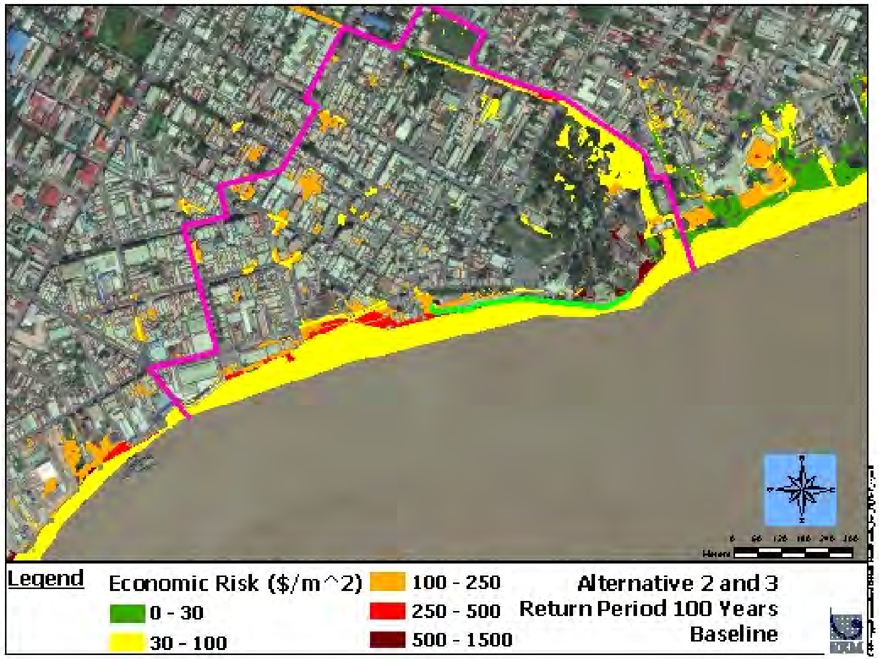


Figure 102: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 100-year return period

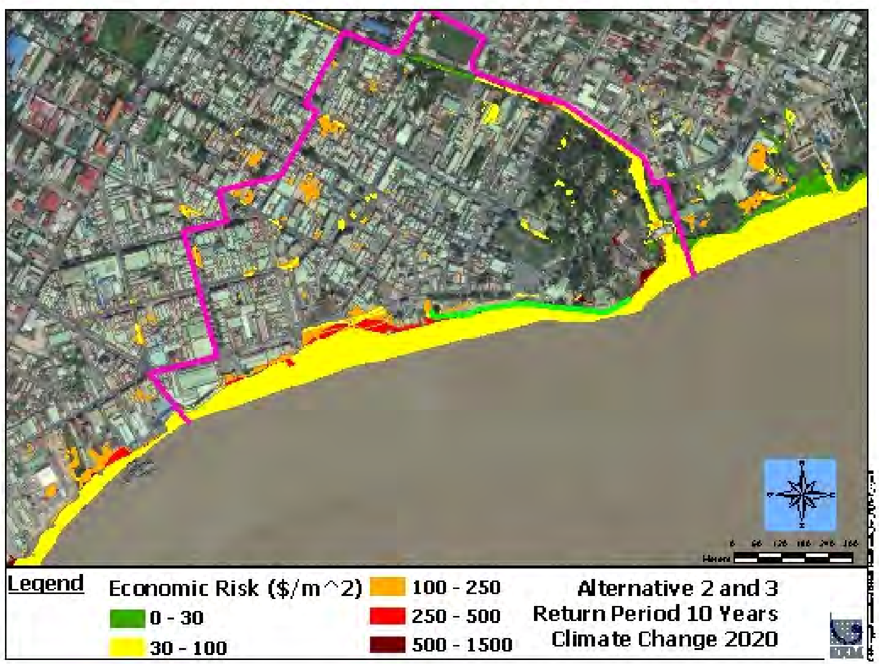


Figure 103: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 10-year return period

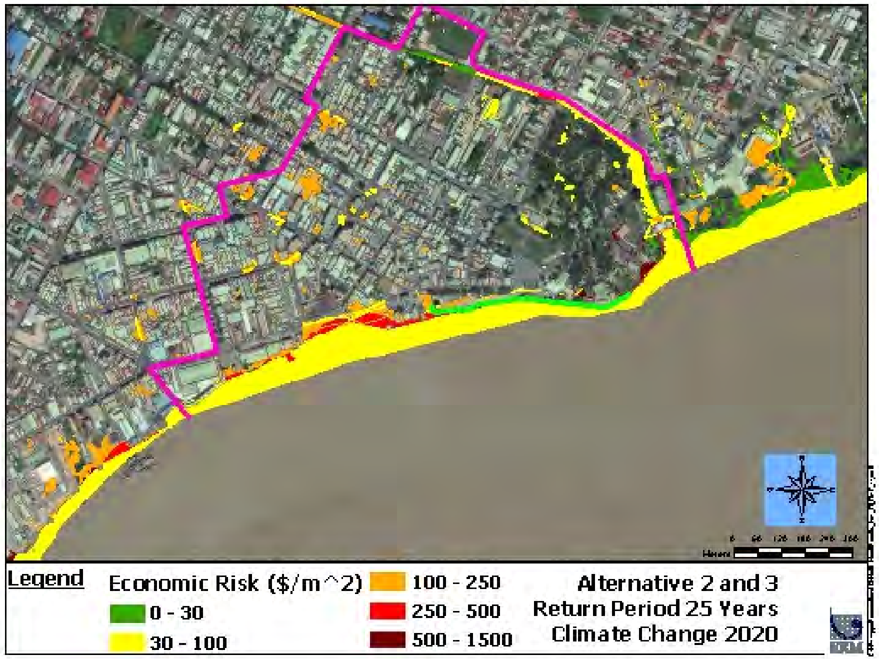


Figure 104: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 25-year return period

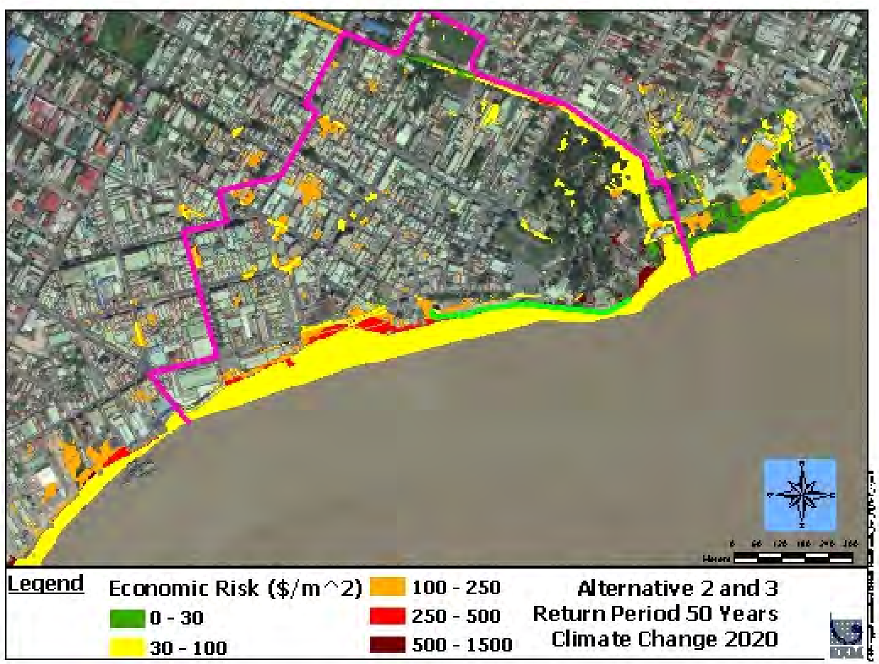


Figure 105: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 50-year return period

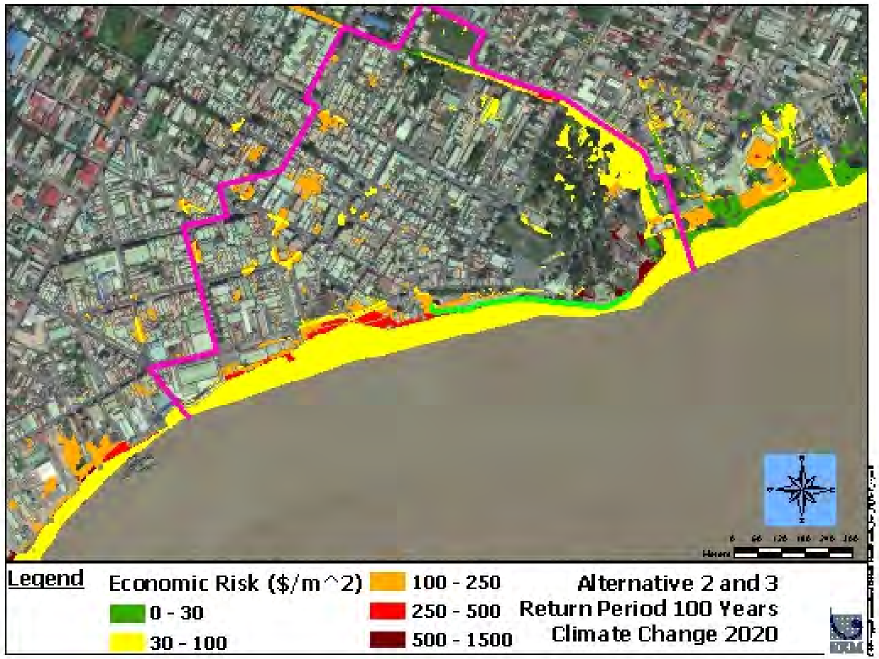


Figure 106: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 100-year return period

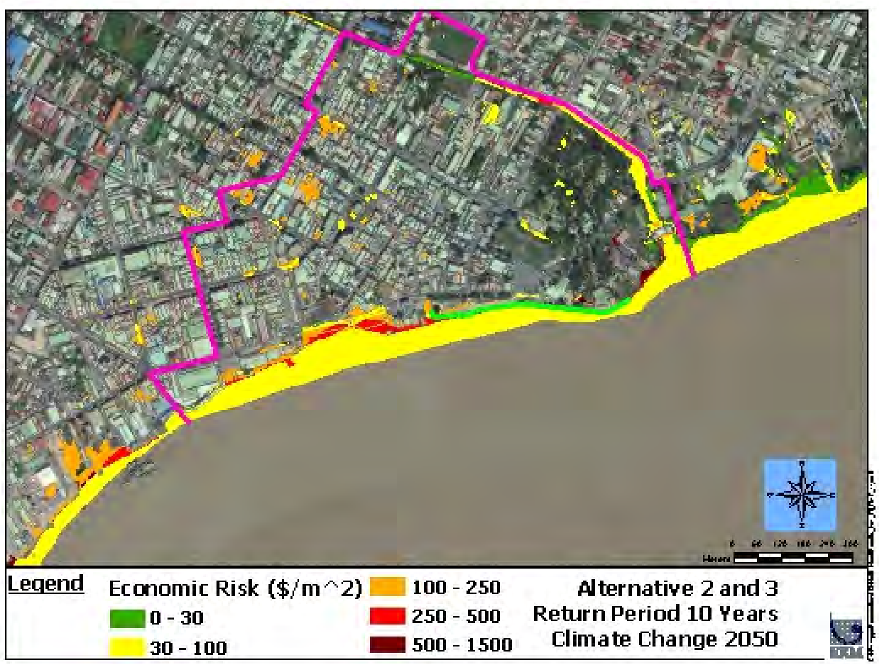


Figure 107: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 10-year return period

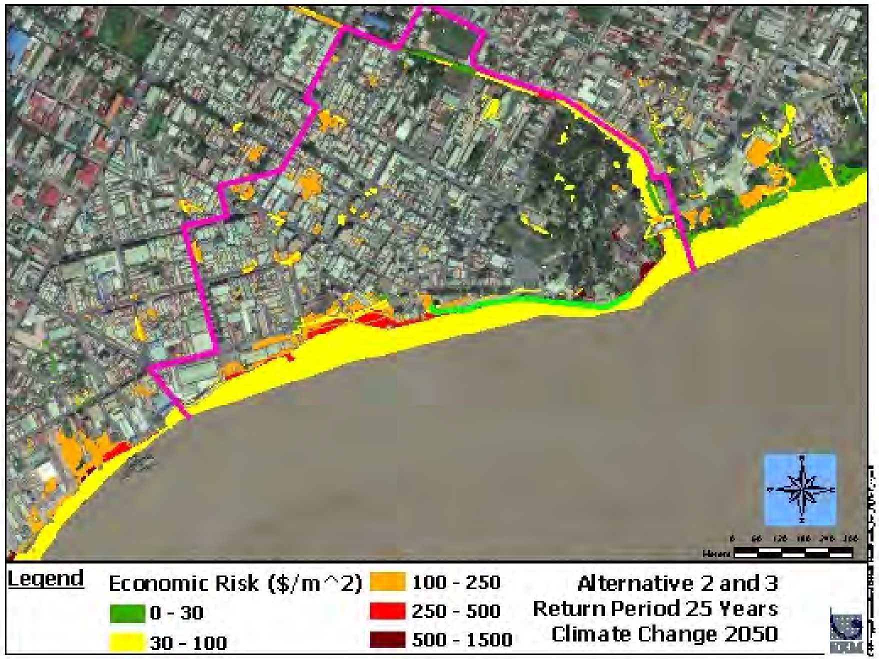


Figure 108: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 25-year return period

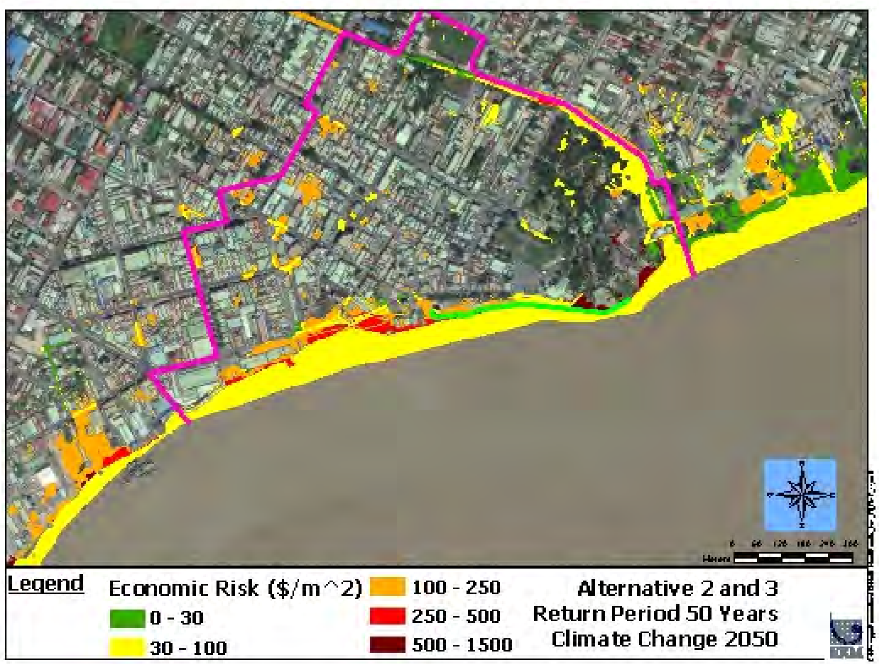


Figure 109: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 50-year return period

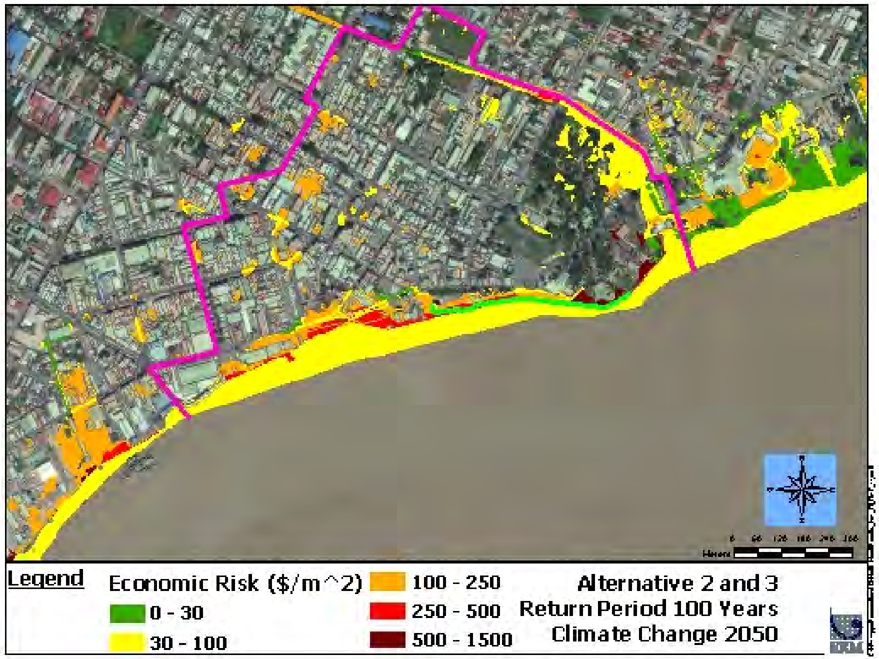


Figure 110: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 100-year return period

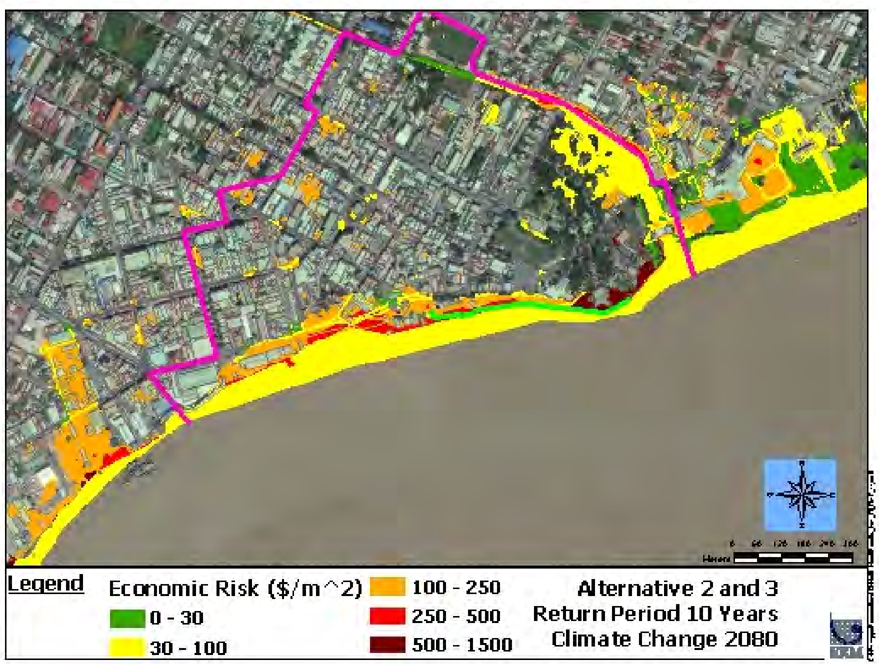


Figure 111: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 10-year return period

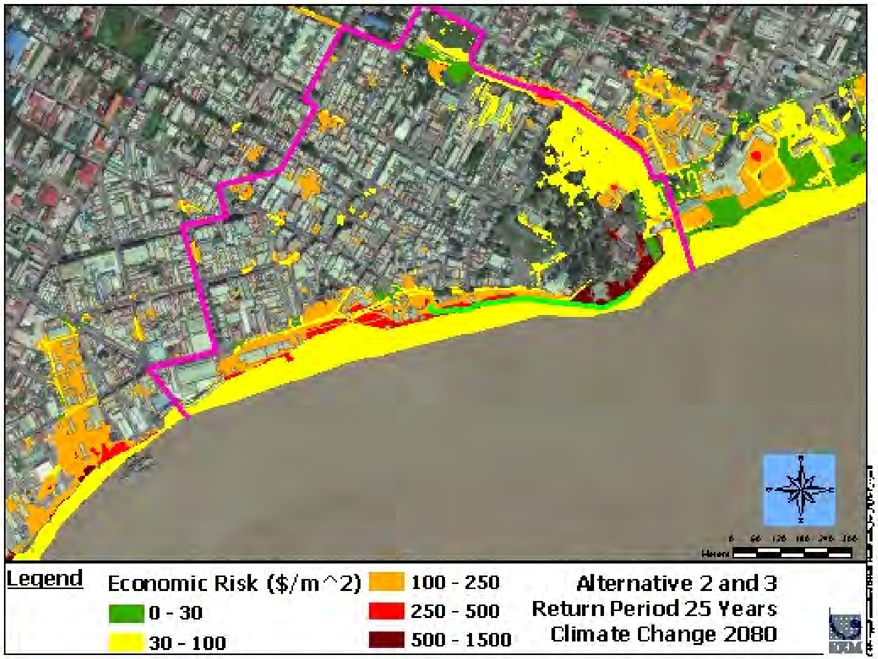


Figure 112: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 25-year return period

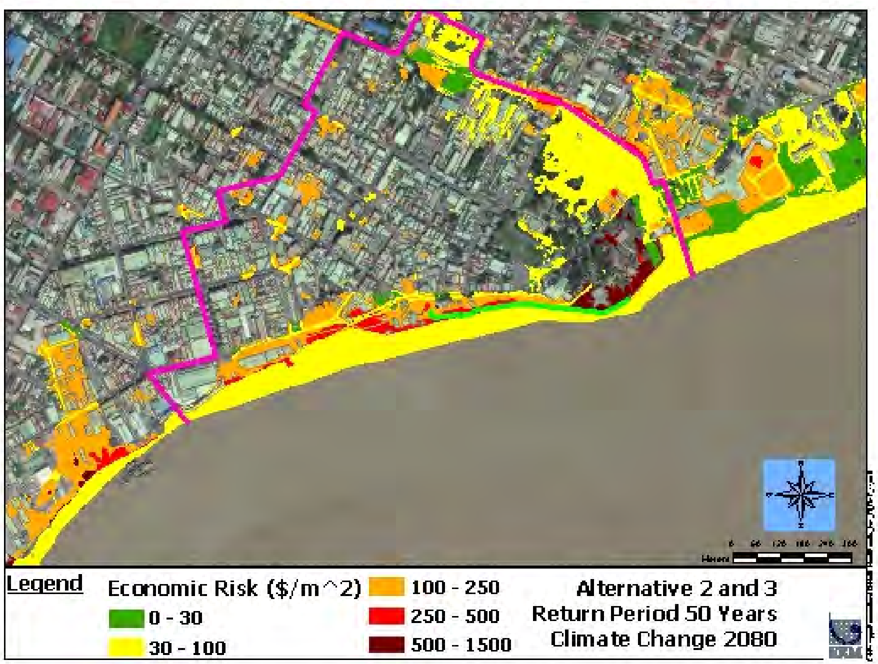


Figure 113: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 50-year return period

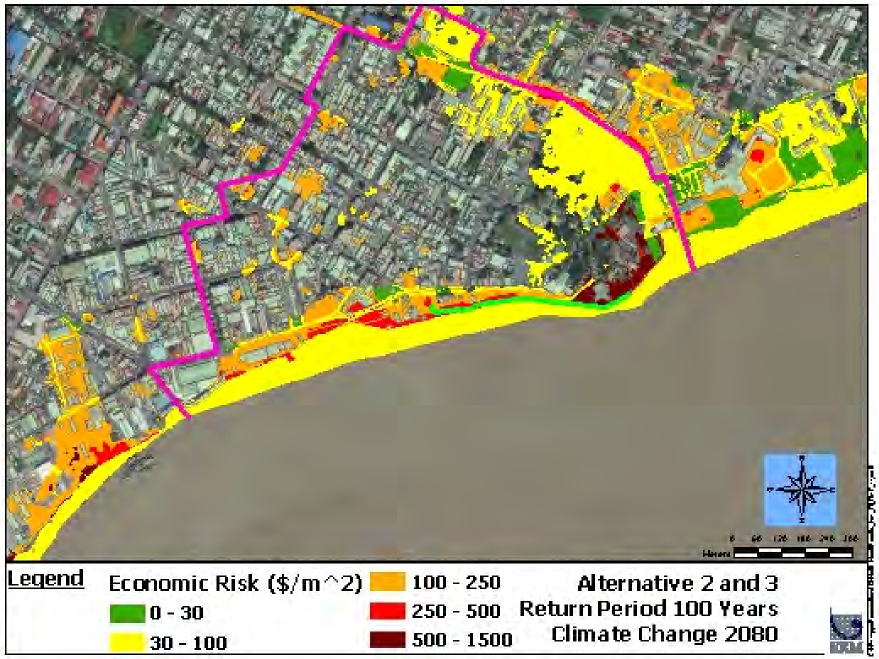


Figure 114: Economic-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 100-year return period

The economic-based risk maps for the Study Area with the Alternative 2 and 3 conceptual designs are shown in Figure 115 to Figure 118 for the baseline scenario at 10-, 25-, 50-, and 100-year return periods; Figure 119 to Figure 122 for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods; Figure 123 to Figure 126 for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods; and Figure 127 to Figure 130 for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods.

The population risk analysis shows a similar pattern found for the economic risk. The implementation of alternatives 2 and 3 under baseline conditions does not appear to result in a reduction of population risk levels throughout the Study Area, for all return periods.

For the 2050 climate change scenario, the implementation of alternatives 2 and 3 does not result in a reduction in population risk in the western portion of the Study Area for short return periods. For the 50- and 100-year return periods, however, there is a reduction in the areal extent of low population risk near the western portion of the existing flood wall. There is also a general reduction in population risk eastward along the existing flood wall. In the Fort Zeelandia area, the implementation of alternatives 2 and 3 also does not result in a reduction in population risk for short return periods. For the 50-year return period, however, alternatives 2 and 3 result in a reduction in population risk adjacent to Fort Zeelandia and westward along the existing flood wall. For the 100-year return period, there is a decrease in area of low population risk immediately landside of proposed alternative 3. There is also a significant decrease in the area of low population risk just north of proposed alternative 3.

For the 2080 climate change scenario, the implementation of alternatives 2 and 3 does not result in a reduction in population risk in the western portion of the Study Area for any return periods. In the eastern portion of the Study Area, alternatives 2 and 3 results in a decrease in the areal extent of low population risk for all return periods; however, the effectiveness of these alternatives decreases as the return period increases. The difference between Figure 130 (2080, 100-year return, existing wall with Alternatives 2 &3) and Figure 98 (2080, 100-year return, existing wall) indicates that the alternatives will protect areas with medium population risk.

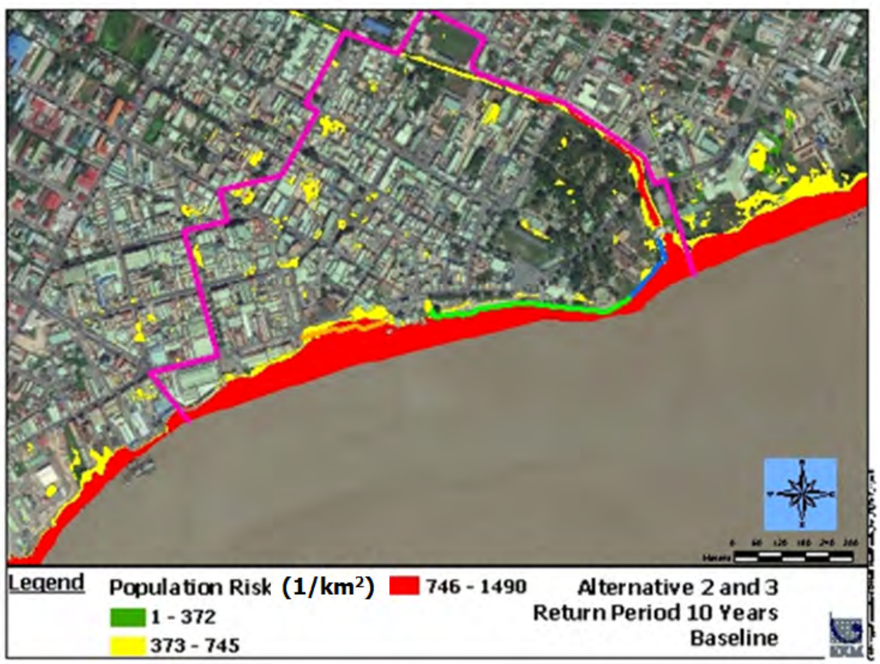


Figure 115: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline at 10-year return period

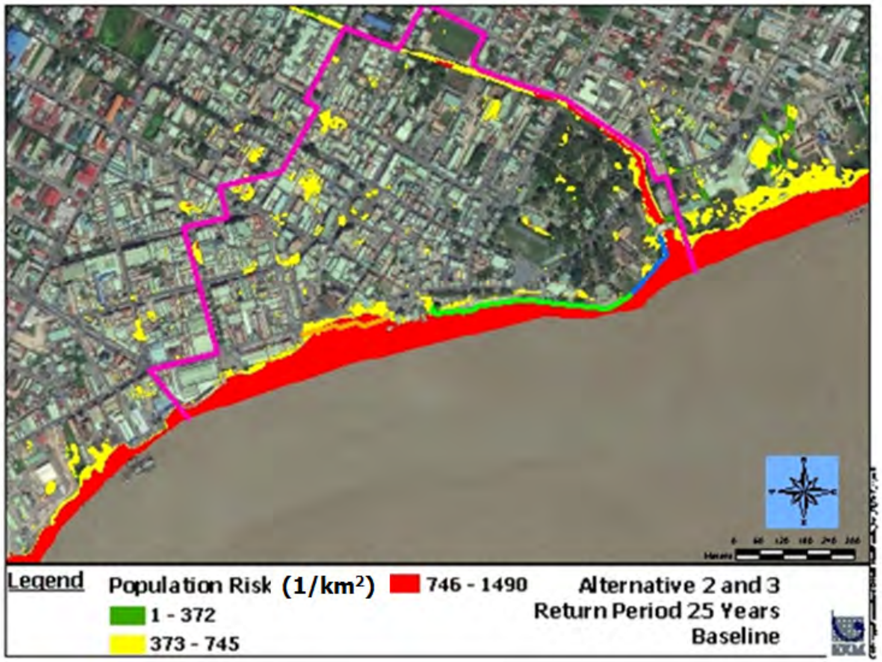


Figure 116: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline at 25-year return period

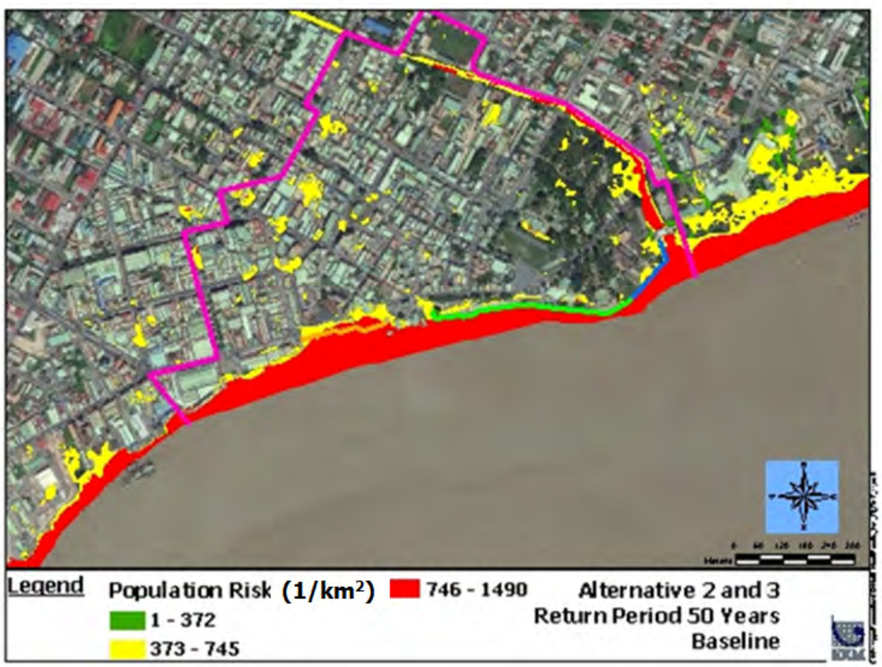


Figure 117: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline at 50-year return period

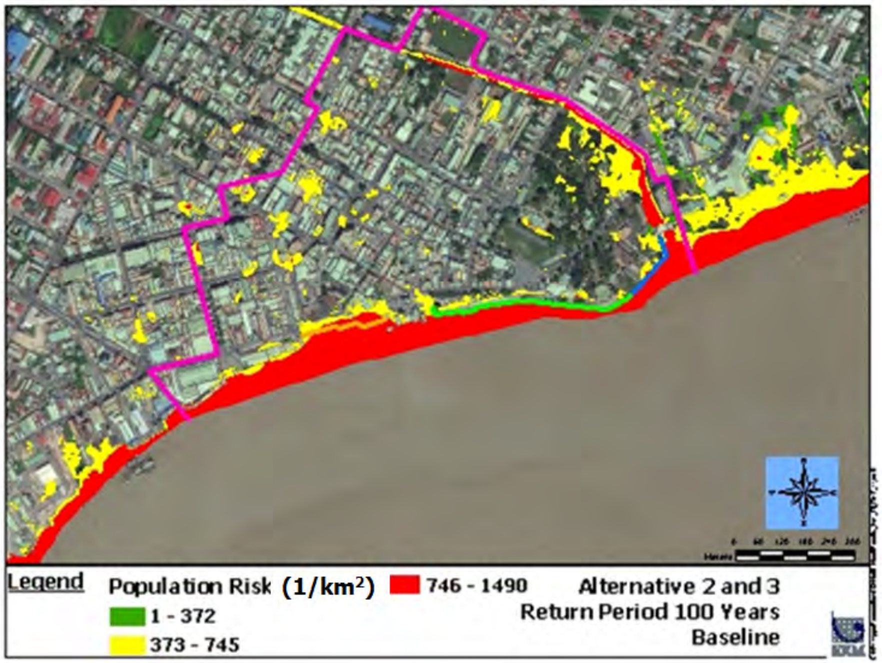


Figure 118: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline at 100-year return period

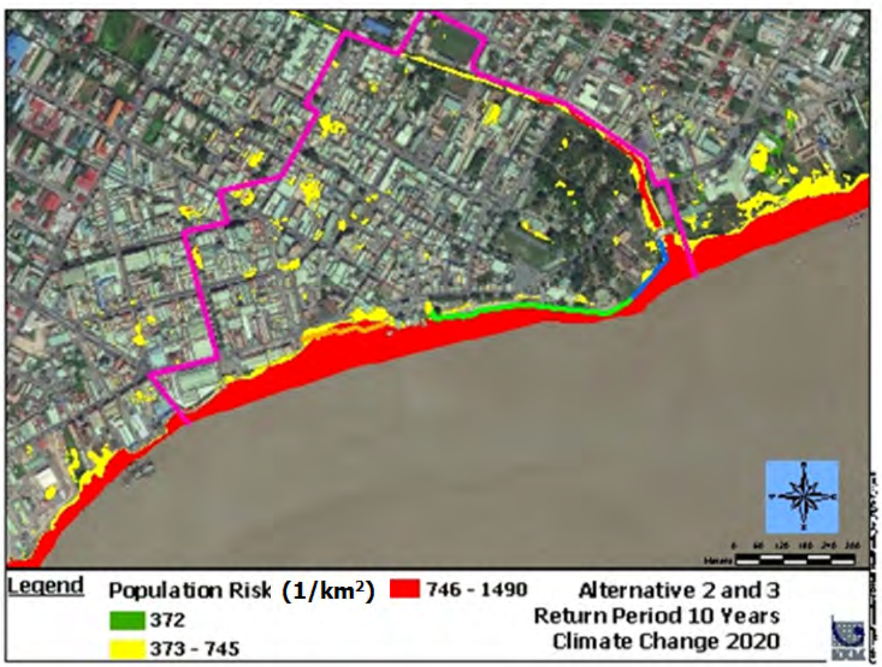


Figure 119: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 10-year return period

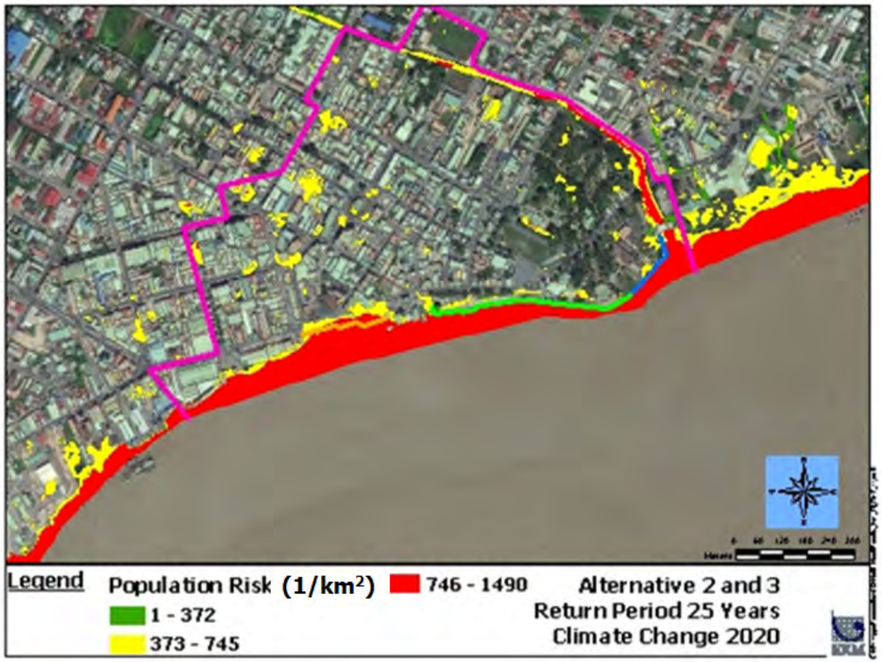


Figure 120: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 25-year return period

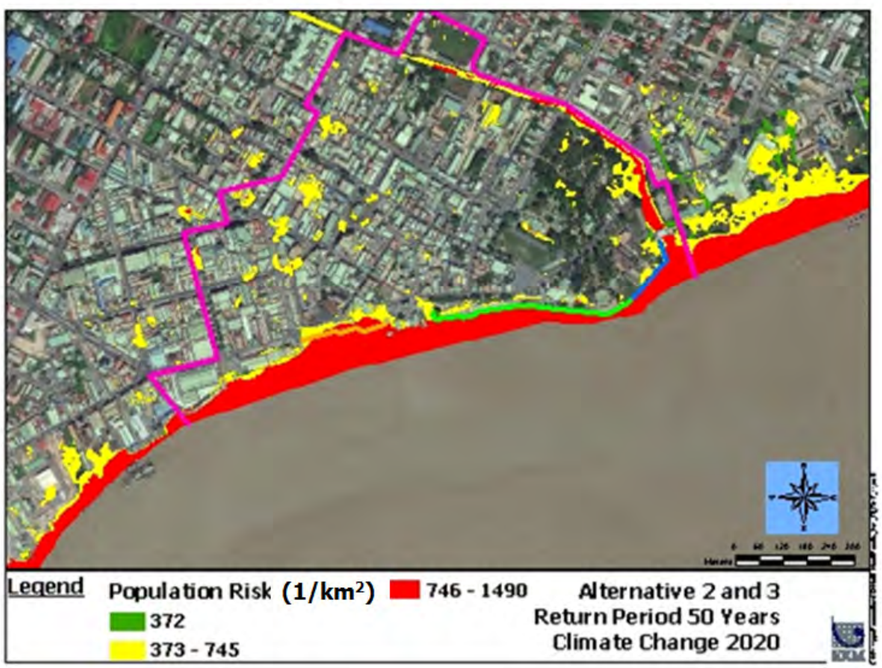


Figure 121: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 50-year return period

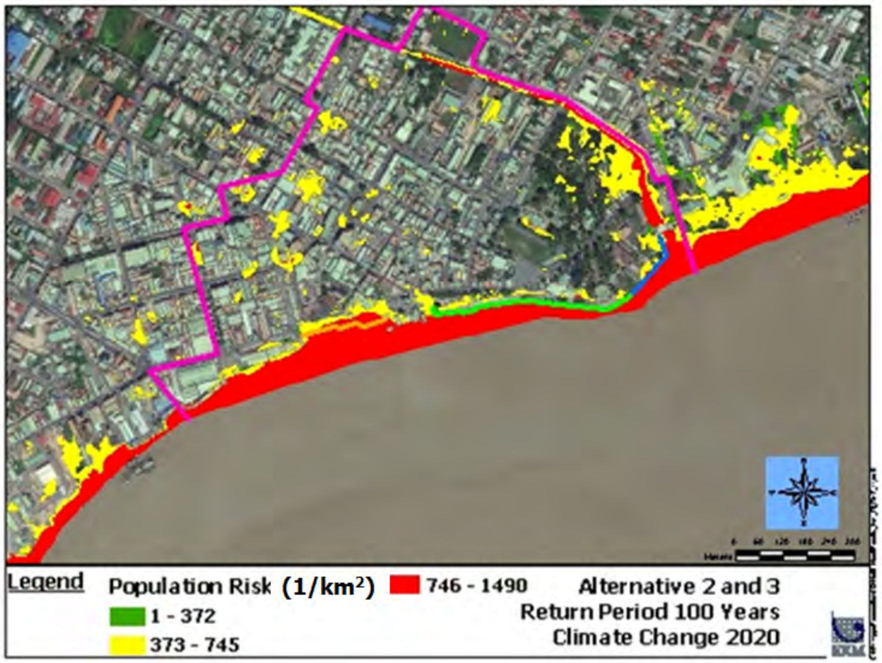


Figure 122: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 100-year return period

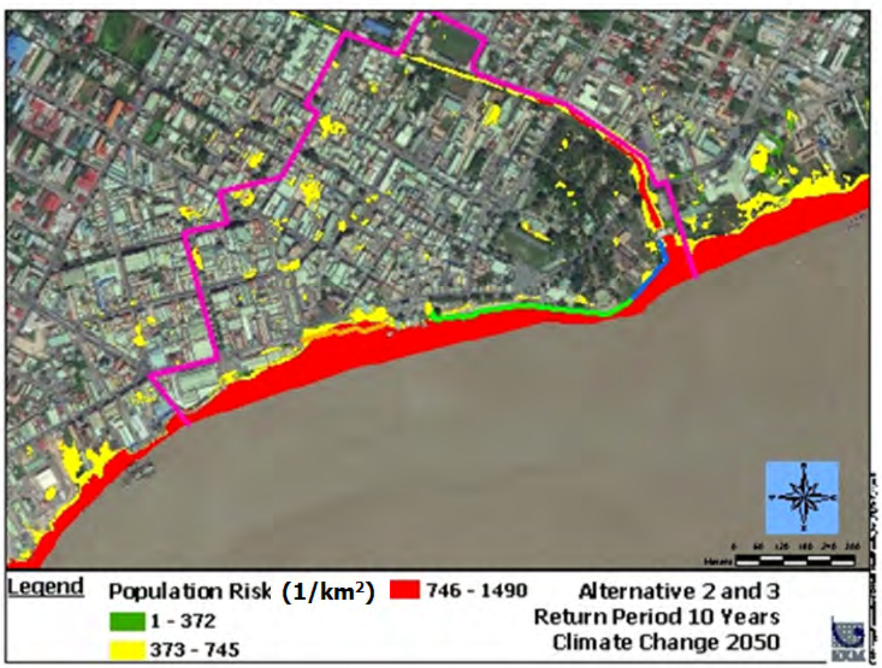


Figure 123: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 10-year return period

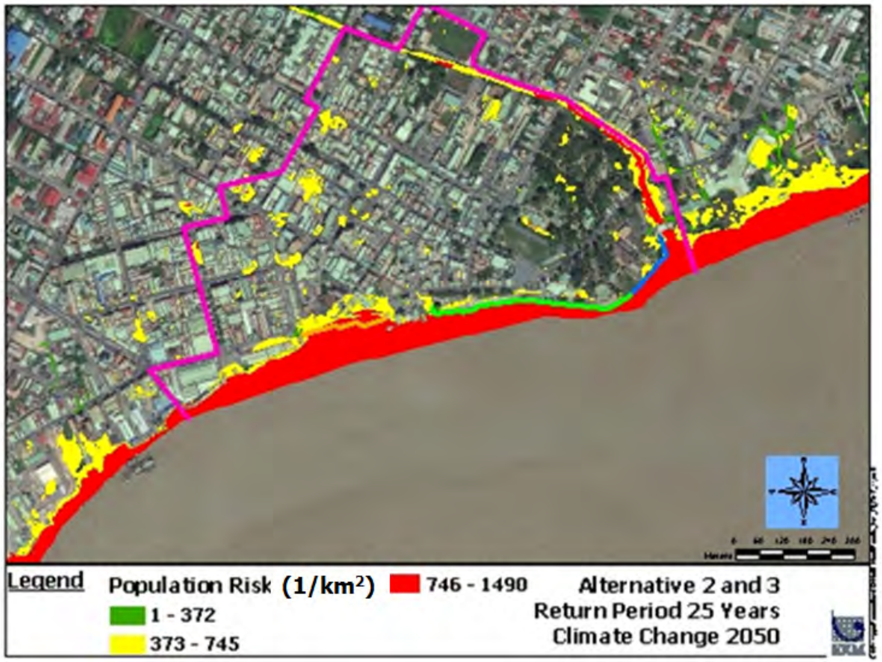


Figure 124: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 25-year return period

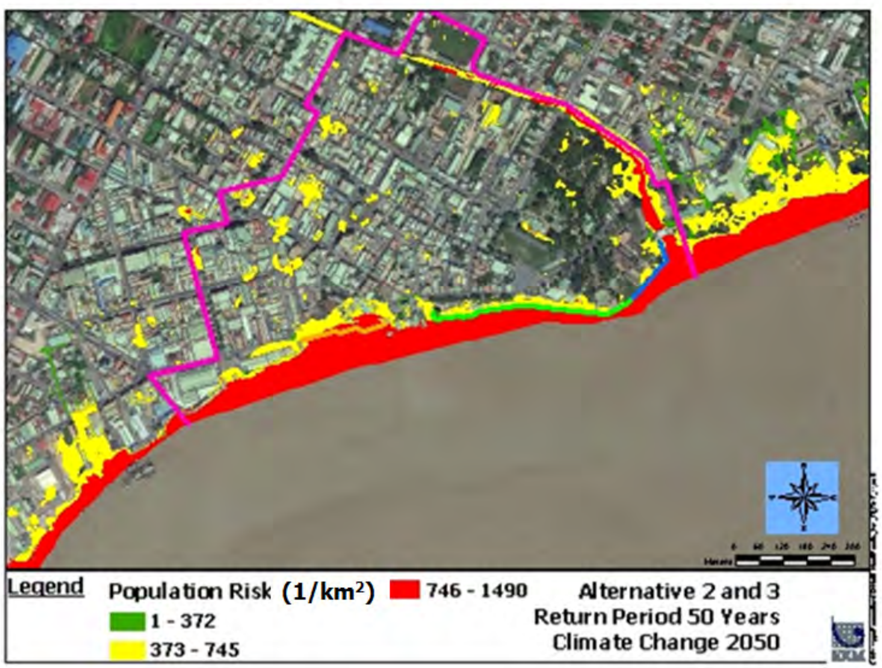


Figure 125: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 50-year return period

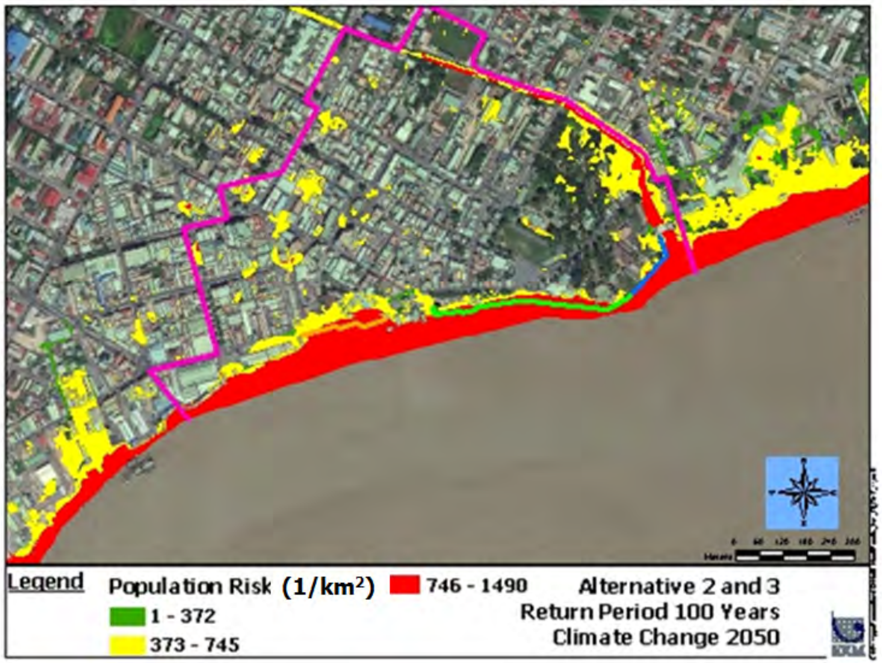


Figure 126: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 100-year return period

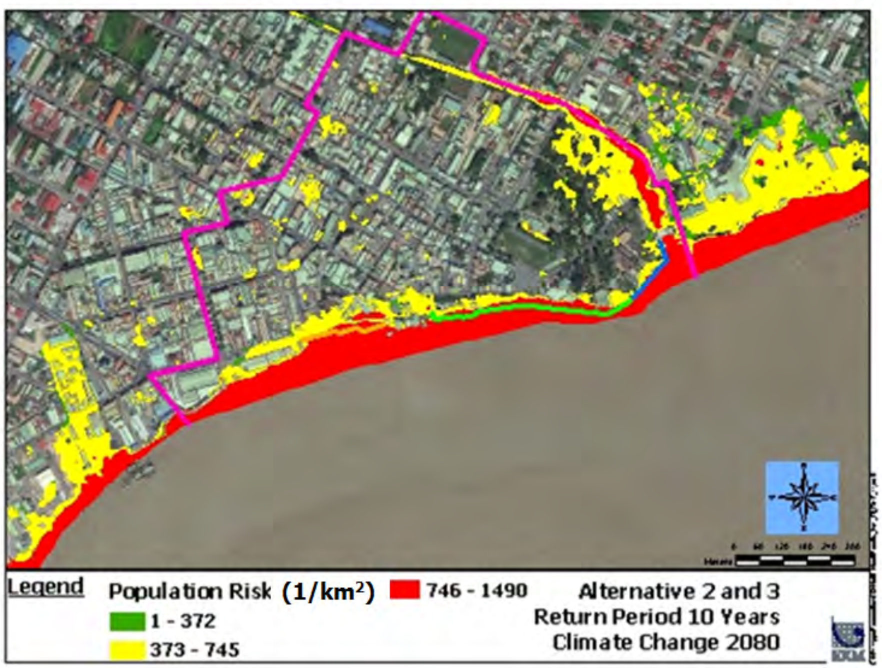


Figure 127: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 10-year return period

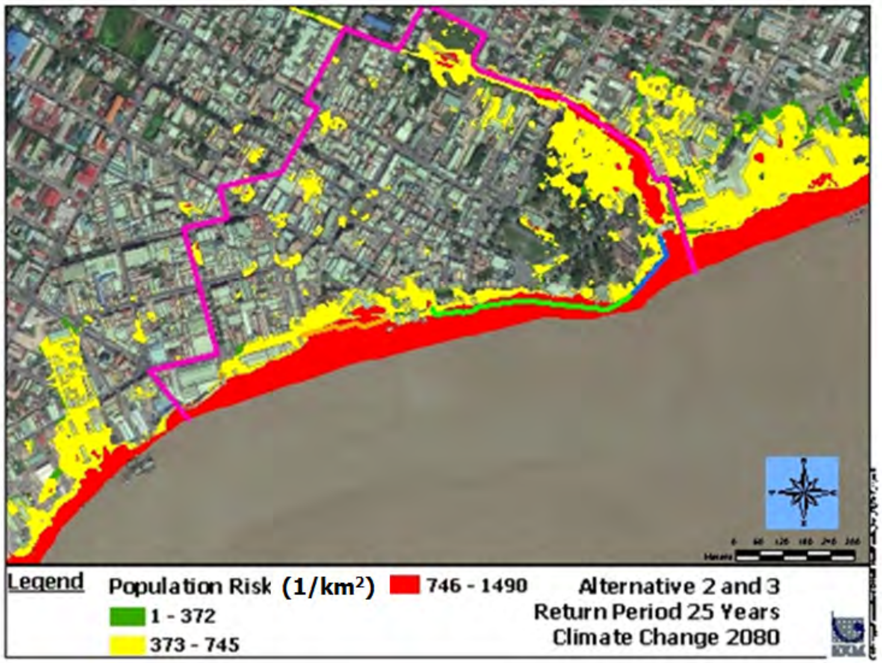


Figure 128: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 25-year return period

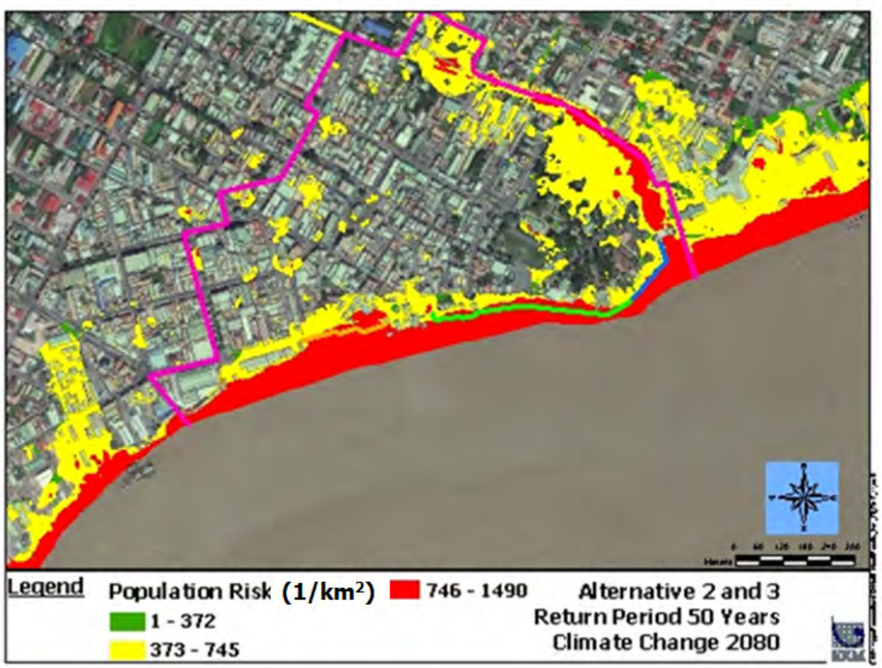


Figure 129: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 50-year return period

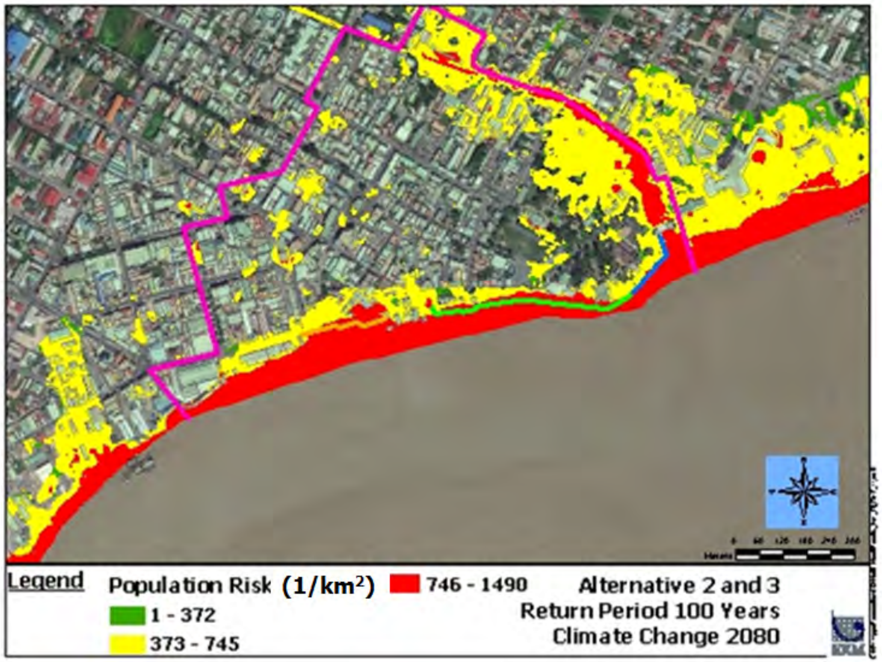


Figure 130: Population-based risk map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 100 year return period

In summary, the implementation of alternatives 2 and 3 under baseline conditions does not appear to result in a general lessening of population or economic risk throughout the Study Area. For the 2050 climate change scenario, alternatives 2 and 3 result in a slight reduction in population and economic risk in the Study Area, particularly for long return periods. For the 2080 climate change scenario, alternatives 2 and 3 have minimal impact on either population or economic risk in the western portion of the study area. In the eastern portion of the Study Area, alternatives 2 and 3 results in a decrease in population risk for all return periods; however, the effectiveness of these alternatives decreases as the return period increases. These alternatives also result in an improvement in economic risk during all return periods. The most significant improvements in economic risk, however, occur with short return periods, presumably because 2080 climate change condition swamp the effectiveness of these alternatives for long return periods.

5.5 ECONOMIC- AND POPULATION- RISK MAPS OF THE SOMMELDIJCKSE CANAL

The economic-based risk maps of the Sommeldijckse Canal are shown in Figure ***131*** to Figure 133 for the baseline scenario at 25-, 50-, and 100- year return periods; Figure 134 to Figure 136 for the climate change 2050 scenario at 25-, 50-, and 100- year return periods; and Figure 137 to Figure 139 for the climate change 2080 scenario at 25-, 50-, and 100- year return periods.

The population-based risk maps of the Sommeldijckse Canal are shown in Figure 140 to Figure 142 for the baseline scenario at 25-, 50-, and 100-year return periods; Figure 143 to Figure 144 for the climate change 2050 scenario at 25-, 50-, and 100-year return periods; and Figure 145 to Figure 148 for the climate change 2080 scenario at 25-, 50-, and 100-year return periods.

The economic risk is low for the existing Canal configuration with baseline conditions at all return periods. For the 2050 climate change scenario, flooding leads to medium risk downstream and on either side of the Canal (Palmentuin area, Van Sommelsdijckstraat area for low return periods and spreads upstream for long return periods. For the 2080 climate change scenario, flooding leads to high economic risk north of the Canal in the Van Sommelsdijckstraat area, Palmentuin area and in the vicinity of the Sports Complex area for long return periods.

The population risk maps for the existing Canal configuration shows similar trends like economic risk maps for the baseline and climate change scenarios.

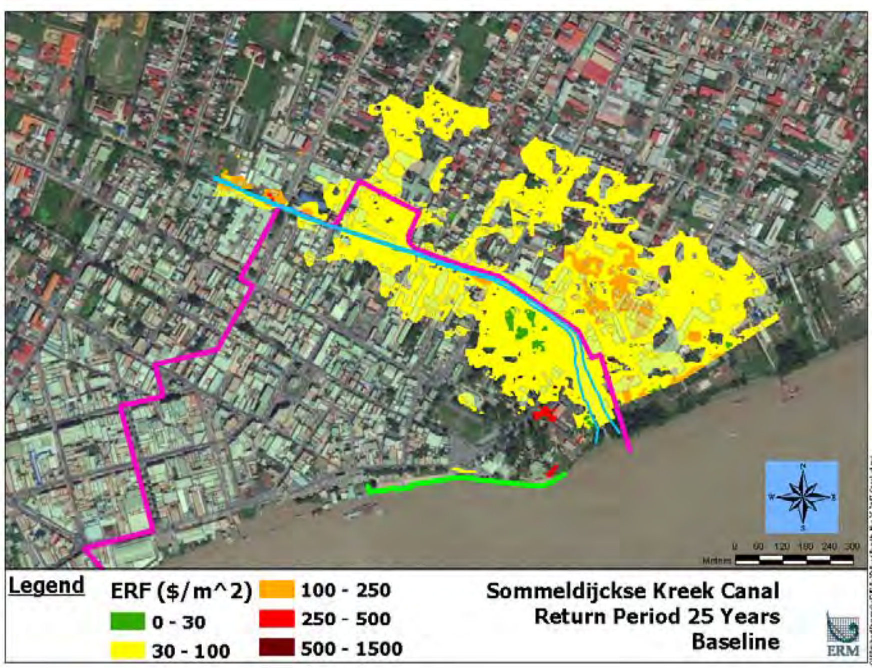


Figure 131*: **Economic-based risk map of the Sommeldijckse Canal for the baseline scenario at 25-year return period***

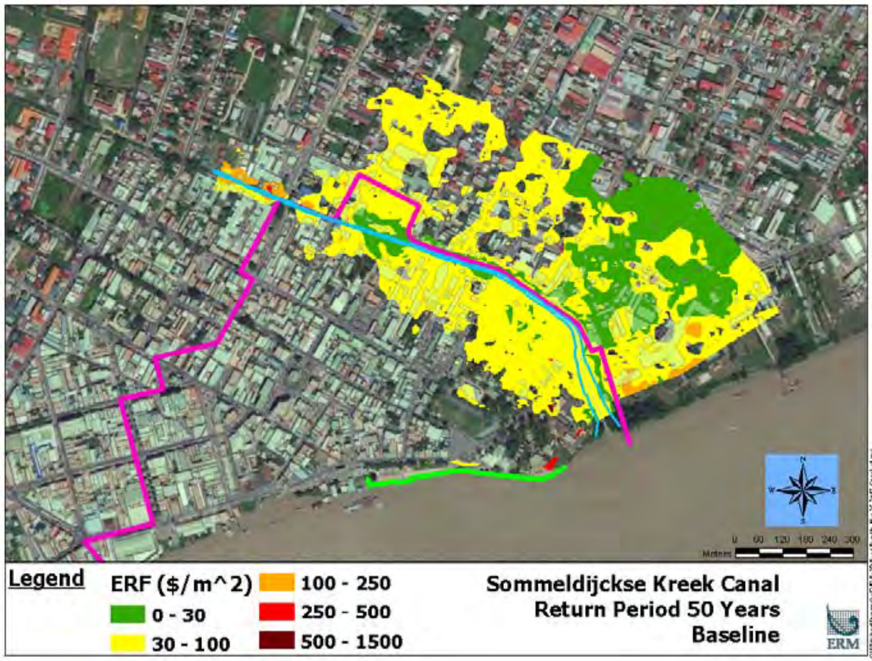


Figure 132: Economic-based risk map of the Sommeldijckse Canal for the baseline scenario at 50-year return period

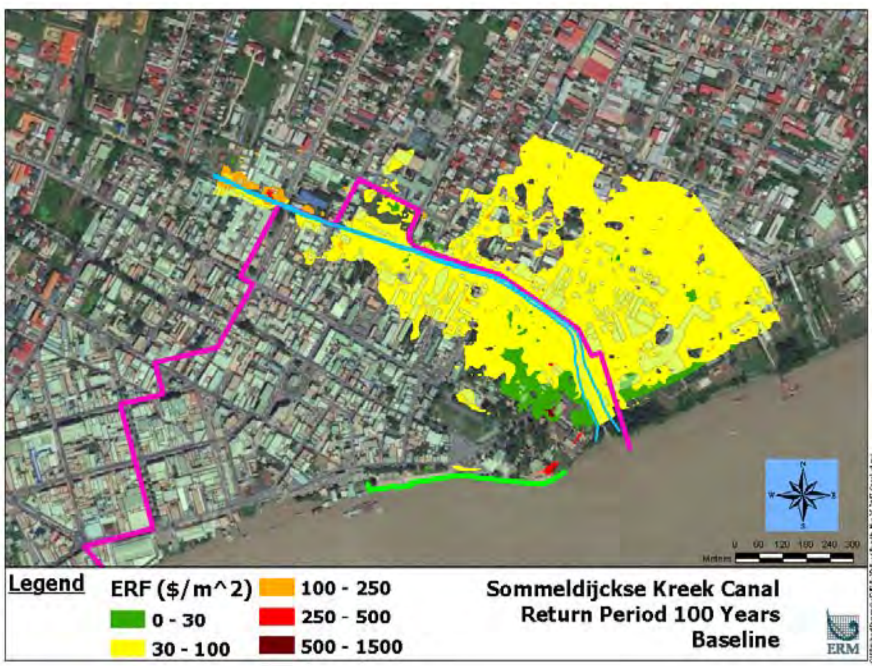


Figure 133: Economic-based risk map of the Sommeldijckse Canal for the baseline scenario at 100-year return period

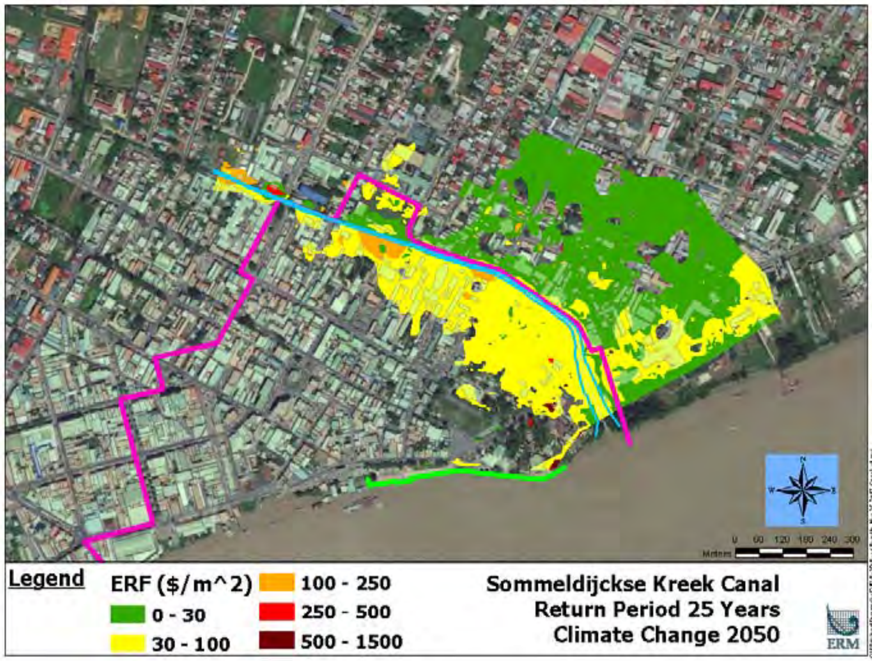


Figure 134: Economic-based risk map of the Sommeldijckse Canal for the climate change 2050 scenario at 25-year return period

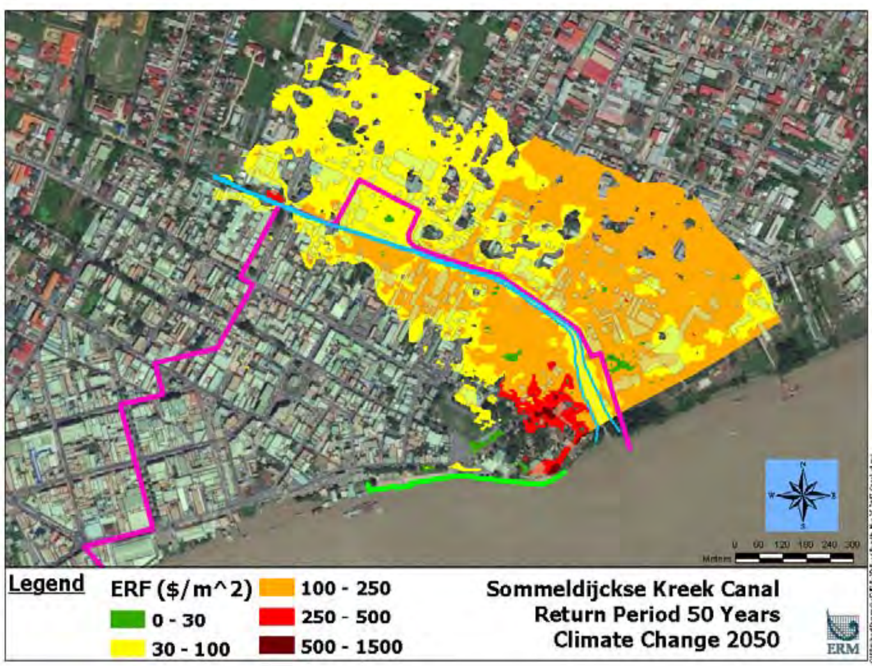


Figure 135: Economic-based risk map of the Sommeldijckse Canal for the climate change 2050 scenario at 50-year return period

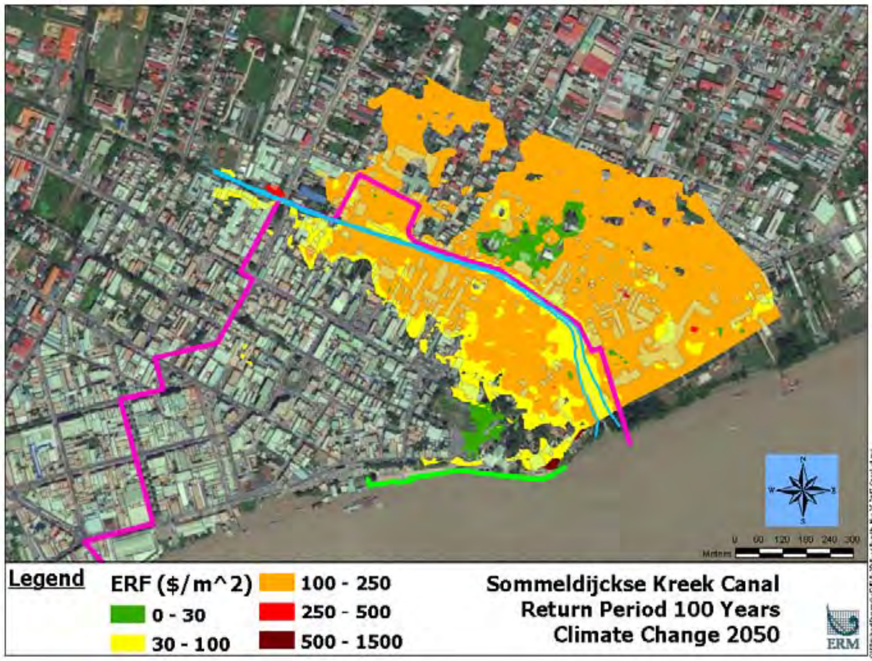


Figure 136: Economic-based risk map of the Sommeldijckse Canal for the climate change 2050 scenario at 100-year return period

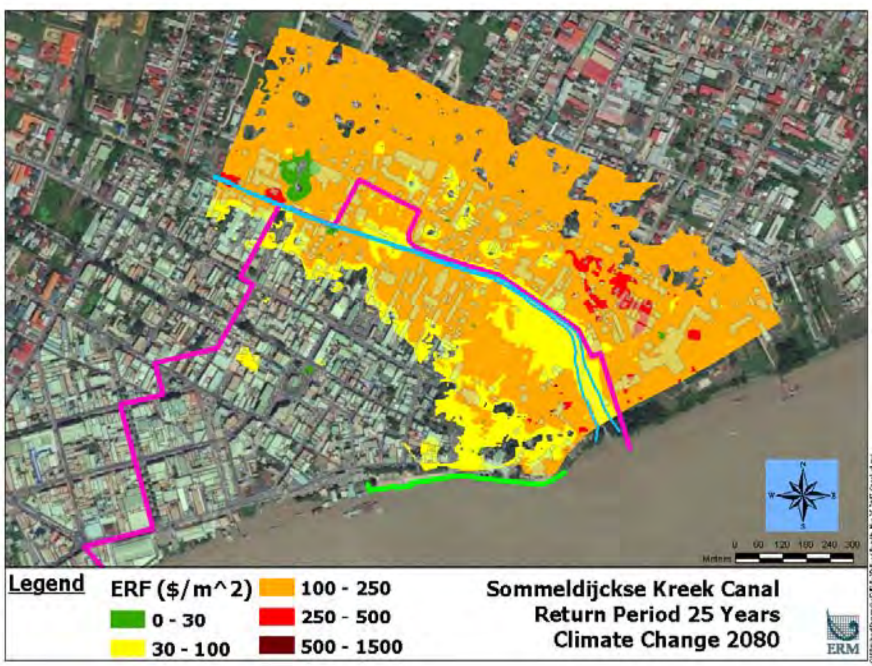


Figure 137: Economic-based risk map of the Sommeldijckse Canal for the climate change 2080 scenario at 25-year return period

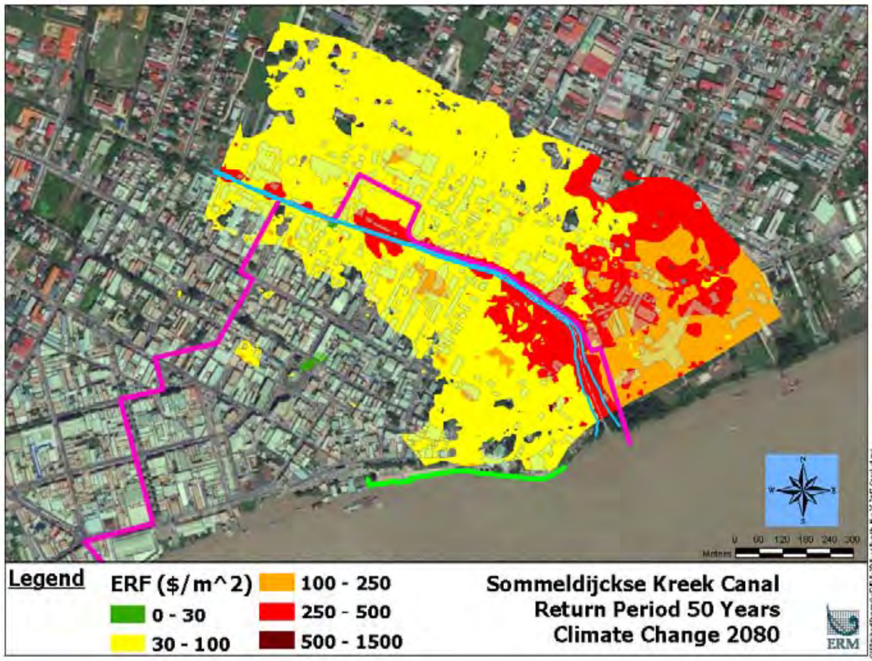


Figure 138: Economic-based risk map of the Sommeldijckse Canal for the climate change 2080 scenario at 50-year return period

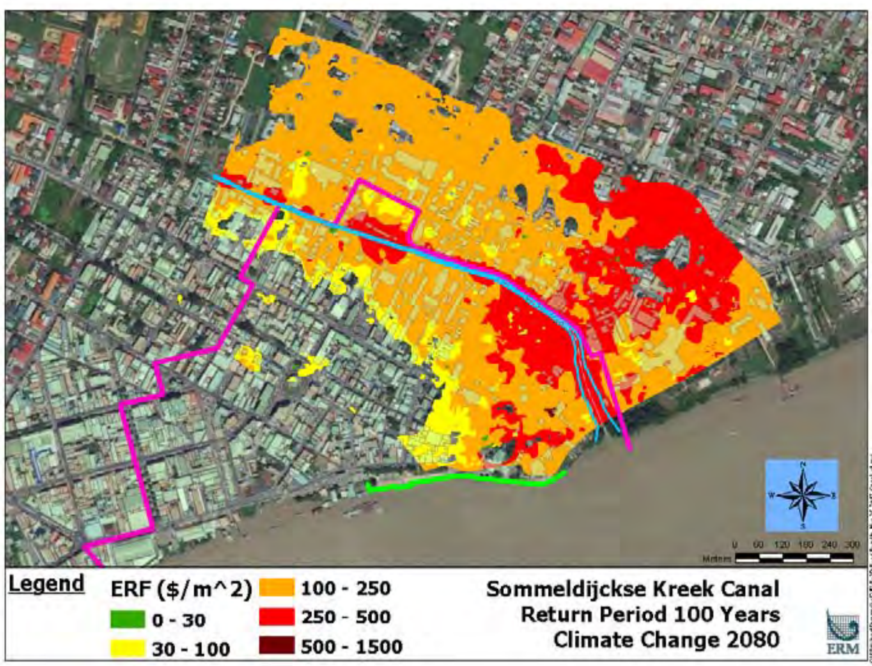


Figure 139: Economic-based risk map of the Sommeldijckse Canal for the climate change 2080 scenario at 100-year return period

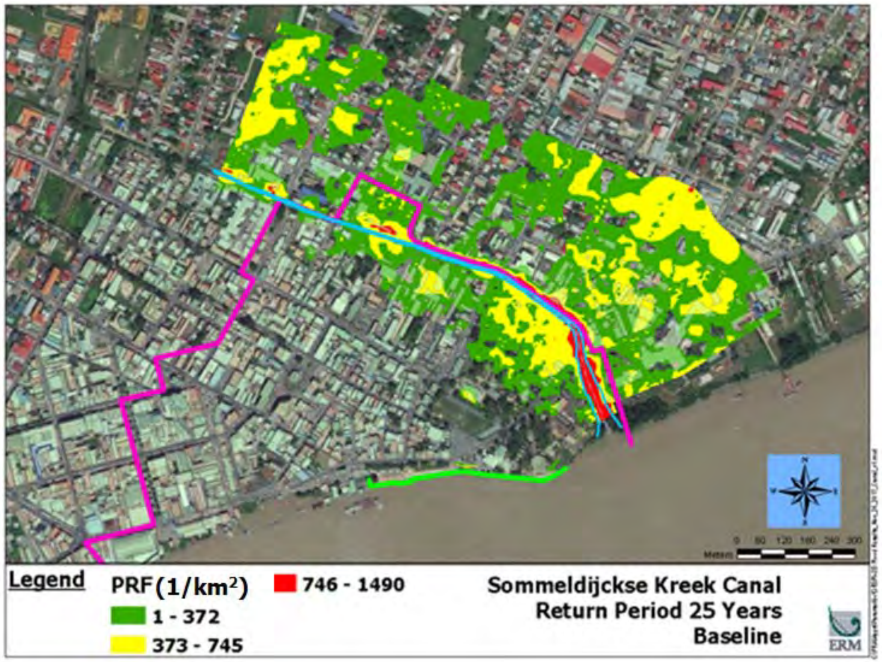


Figure 140: Population-based risk map of the Sommeldijckse Canal for the baseline scenario at 25-year return period

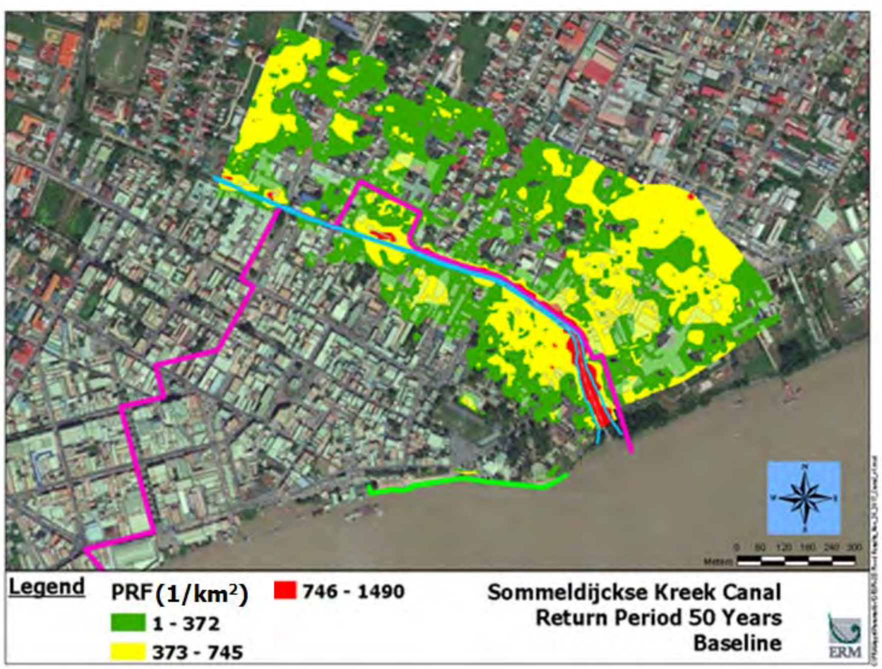


Figure 141: Population-based risk map of the Sommeldijckse Canal for the baseline scenario at 50-year return period

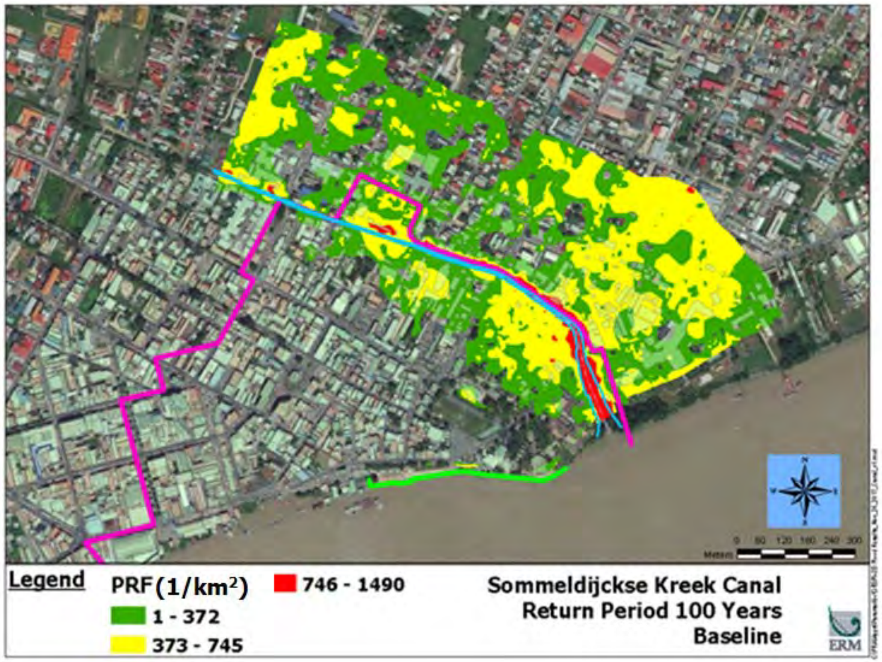


Figure 142: Population-based risk map of the Sommeldijckse Canal for the baseline scenario at 100-year return period

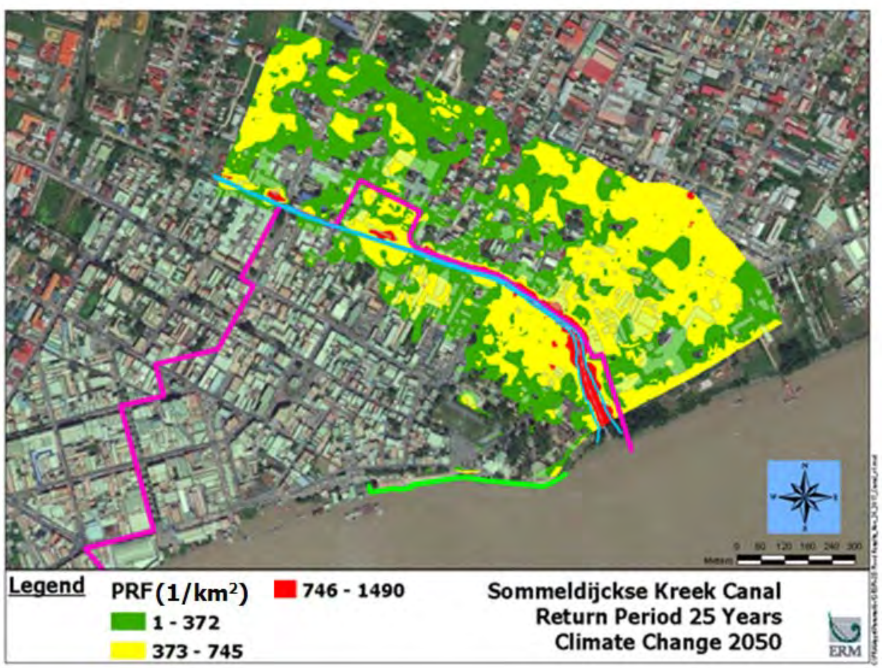


Figure 143: Population-based risk map of the Sommeldijckse Canal for the climate change 2050 scenario at 25-year return period

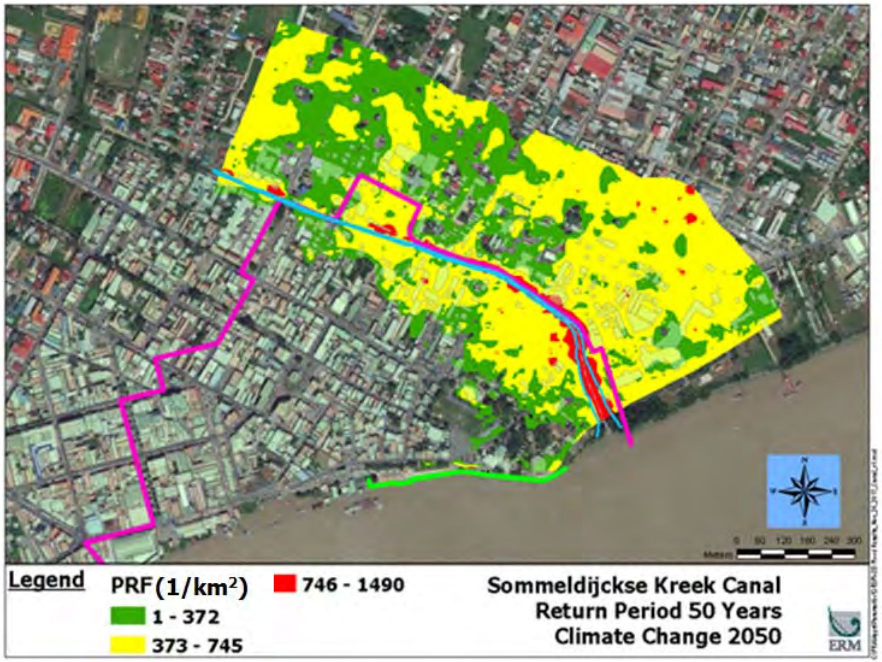


Figure 144: Population-based risk map of the Sommeldijckse Canal for the climate change 2050 scenario at 50-year return period

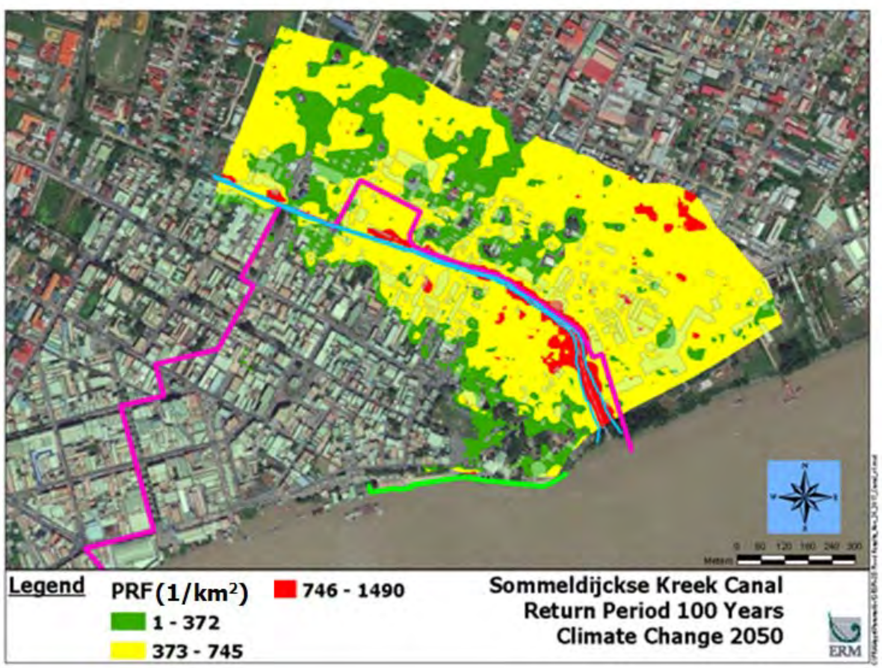


Figure 145: Population-based risk map of the Sommeldijckse Canal for the climate change 2050 scenario at 100-year return period

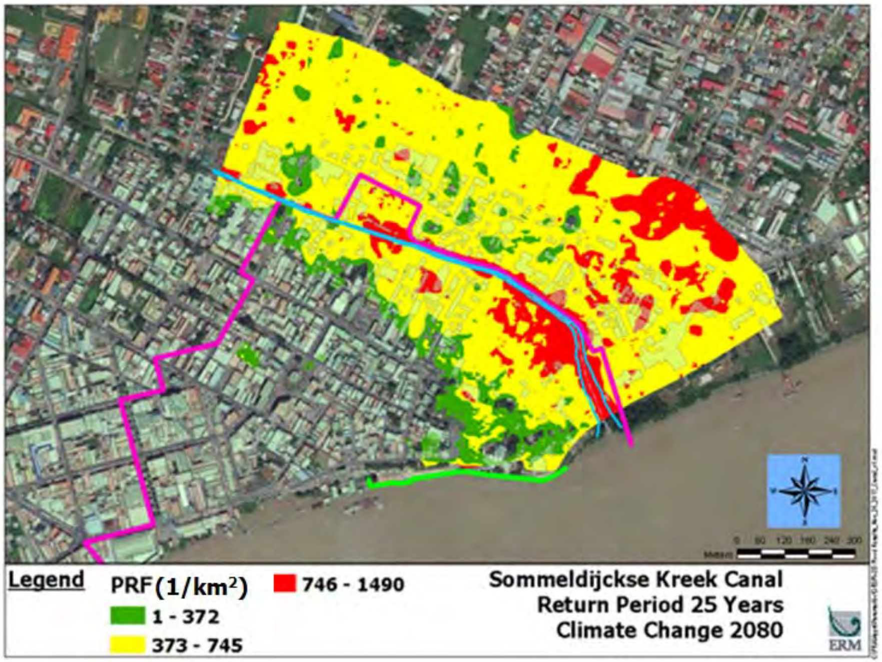


Figure 146: Population-based risk map of the Sommeldijckse Canal for the climate change 2080 scenario at 25-year return period

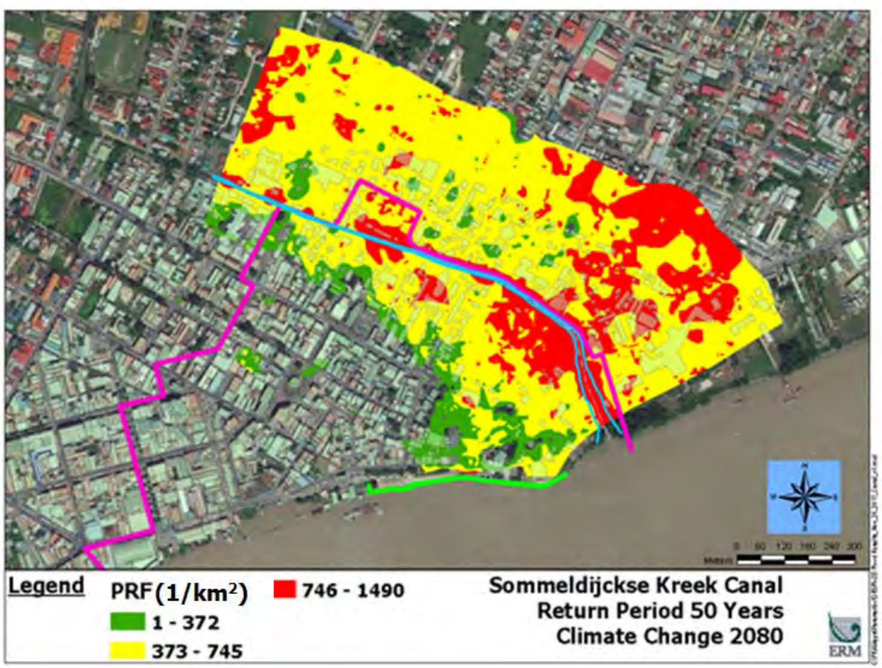


Figure 147: Population-based risk map of the Sommeldijckse Canal for the climate change 2080 scenario at 50-year return period

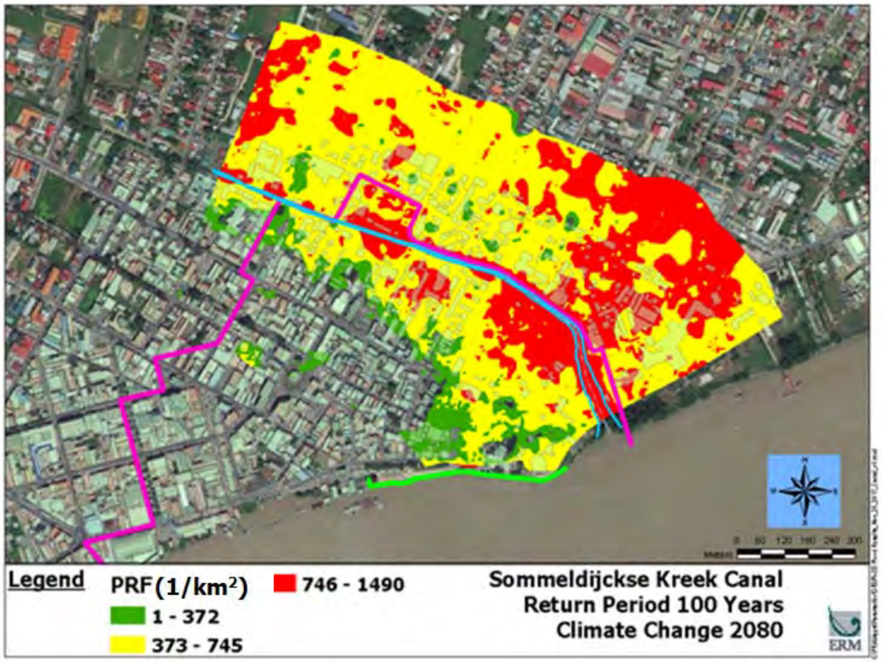


Figure 148: Population-based risk map of the Sommeldijckse Canal for the climate change 2050 scenario at 100-year return period

The economic-based risk maps of the Sommeldijckse Canal with the Alternative 4 option (addition of one more pump) is shown in Figure 149 to Figure 151 for the baseline scenario at 25-, 50-, and 100-year return periods.

The population-based risk maps of the Sommeldijckse Canal with the Alternative 4 option (addition of one more pump) is shown in Figure 152 to Figure 154 for the baseline scenario at 25-, 50-, and 100-year return periods.

The comparison of Figure ***131***(existing Canal configuration; baseline; 25-year return period) with Figure 149(existing Canal configuration with alternative 4 option; baseline; 25-year return period) clearly shows that Palmentuin and Van Sommelsdijckstraat regions downstream of the Canal shows low economic risk with the addition of alternative 4 pump option for the 25-year return period. For other return periods, the moderate risk area reduces considerably for long return periods in the downstream section of the Canal. Similar trend exists for population risk when alternative 4 pump option is added to the existing Canal configuration.

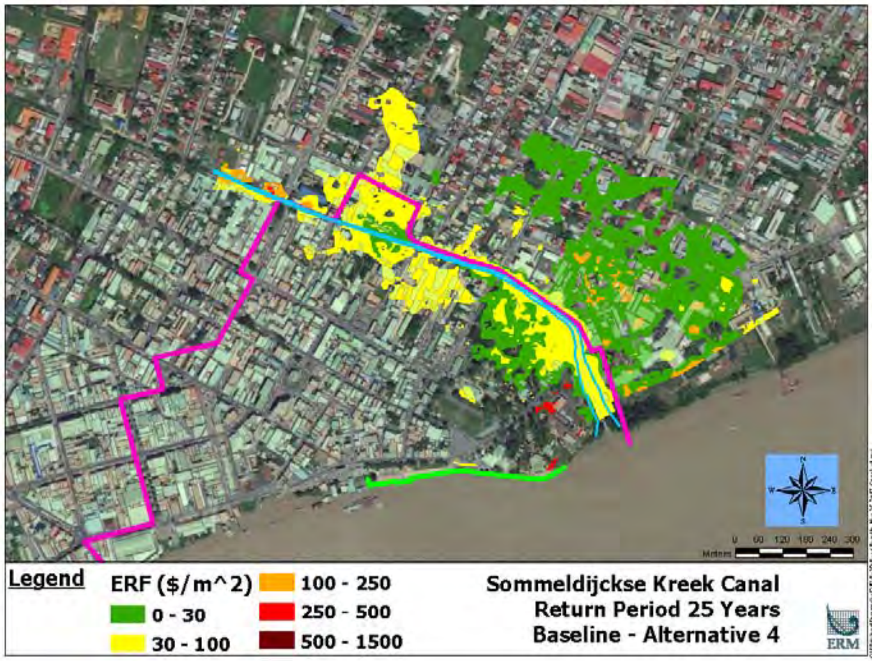


Figure 149: Economic-based risk map of the Sommeldijckse Canal with the Alternative 4 conceptual design for the baseline scenario at 25-year return period

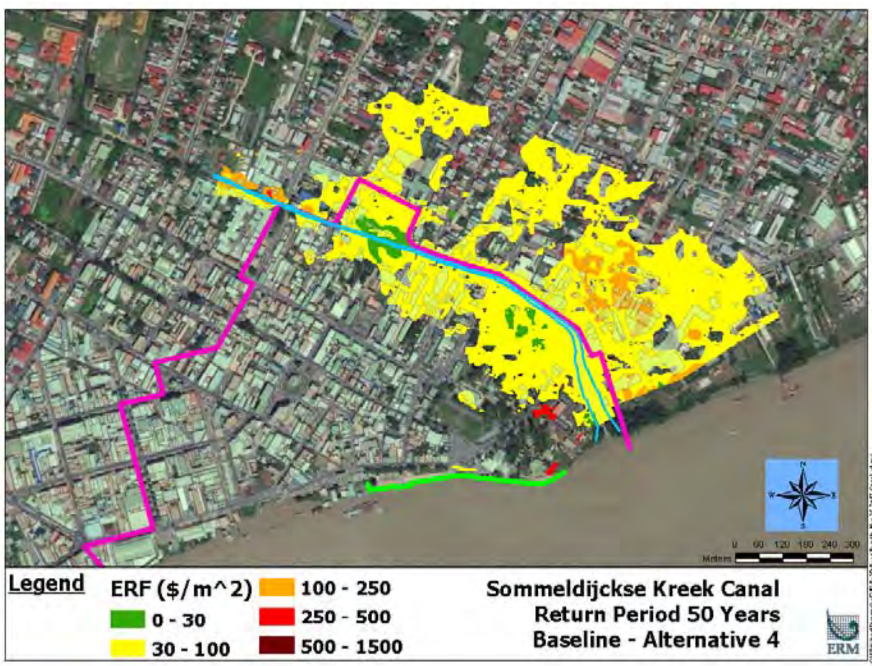


Figure 150: Economic-based risk map of the Sommeldijckse Canal with the Alternative 4 conceptual design for the baseline scenario at 50-year return period

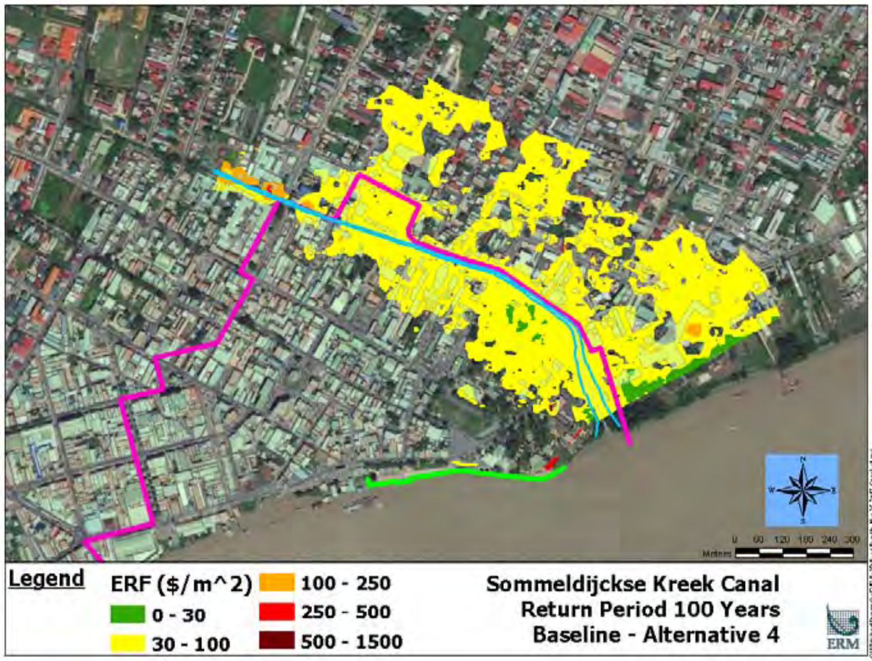


Figure 151: Economic-based risk map of the Sommeldijckse Canal with the Alternative 4 conceptual design for the baseline scenario at 100-year return period

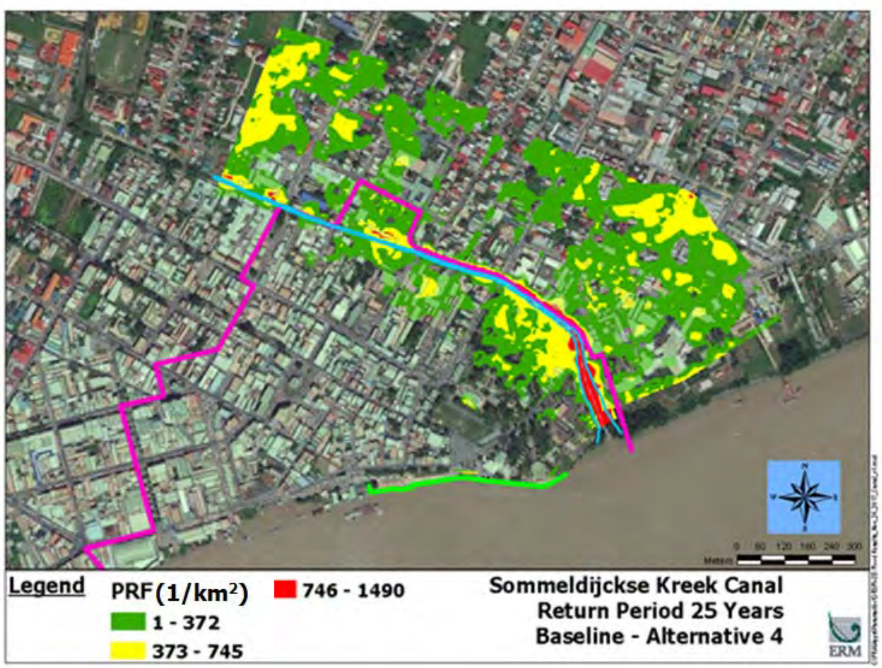


Figure 152: Population-based risk map of the Sommeldijckse Canal with the Alternative 4 conceptual design for the baseline scenario at 25-year return period

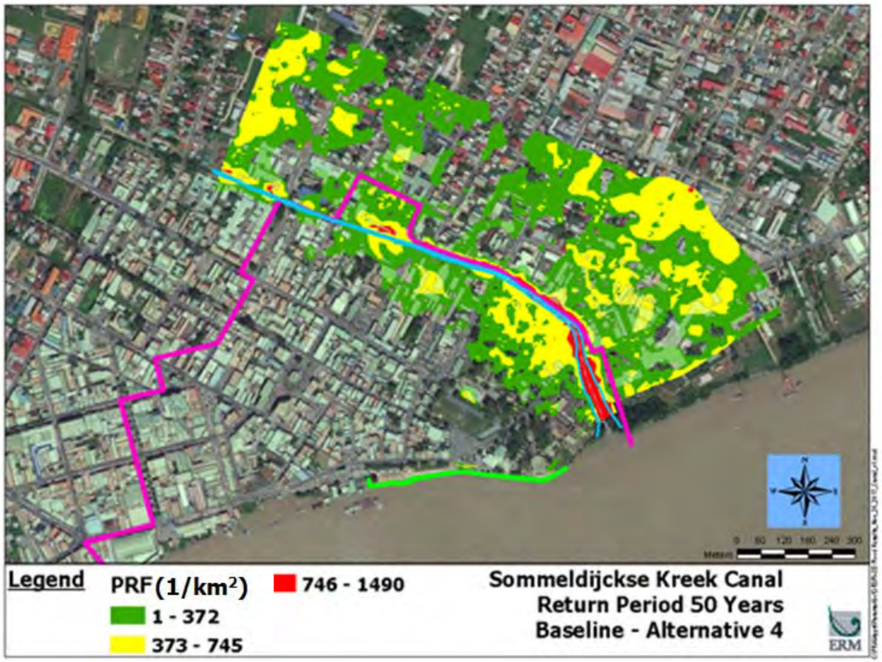


Figure 153: Population-based risk map of the Sommeldijckse Canal with the Alternative 4 conceptual design for the baseline scenario at 50-year return period

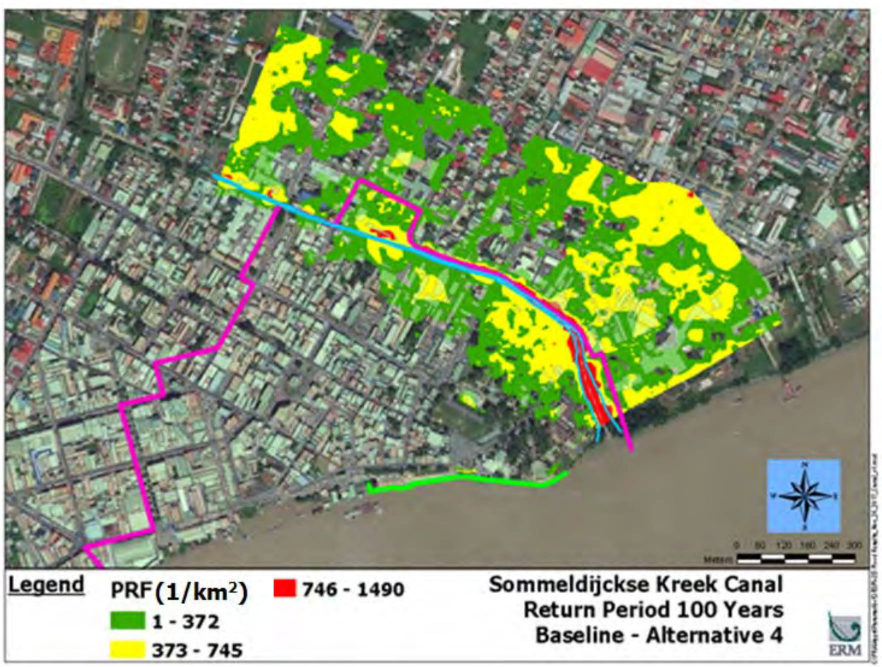


Figure 154: Population-based risk map of the Sommeldijckse Canal with the Alternative 4 conceptual design for the baseline scenario at 100-year return period

6.0 CONCLUSION

An extensive analysis of flooding hazard was performed for the Study Area (Historic center of Paramaribo) to support the development of a Full Proposal Document for submission to the Adaptation Fund for Urban Investments for the Resilience of Paramaribo. The analysis was performed using HEC-RAS and FLO-2D models, which are approved by the U.S. Federal Emergency Management Agency for delineating flood hazards, regulating floodplain zoning and designing flood mitigation in riverine as well as urban systems.

ERM estimated the likely occurrence of flooding hazards within the Study Area for 25-, 50-, and 100- year return periods using site-specific data collected from various Surinamese institutions, published reports and site visits. The probabilistic flood hazard analysis was performed using historic climate conditions (inland precipitation and Higher High Water Level in the Suriname River) and also for future years (2020, 2050 and 2080) using climate change projections for precipitation and sea level rise obtained from Regional Climate Models driven by HadAM3 and ECHAM4. A series of both inland and coastal flooding hazard maps of the Study Area and the Canal were created for the subsequent socio-economic risk analyses that resulted in the development economic and population risk maps that quantified damages in terms of financial loss and population affected in the Study Area.

The flood modelling study conducted for the current conditions was then applied to flood wall (Alternatives 2 and 3) and Van Sommeldijckse Canal infrastructure improvement (Alternative 4) alternatives identified as part of Paramaribo downtown adaptation measures for flood management program. The analysis of flood hazard maps from this study clearly shows that there is significant improvement in the reduction of flood risk related to Alternatives 2 and 3 along the river waterfront and for Alternative 4 in the vicinity of the Van Sommeldijckse Canal for small return periods. For future years of 2050 and 2080 with large return periods, effectiveness of flood control decreases due to the routing of flood water from neighboring regions of the riverfront. A similar analysis holds good for other alternatives (adaption measures) identified in the conceptual design and impact scoping report related to green infrastructure (absorption of flood wave energy) and drainage system (storm water removal rate larger than rainfall intensity). A recent flooding event in Houston, Texas showed that adding more flood walls, though they minimized flooding in specific regions, increased flooding in other regions due to flood wave deflection.

Further review of similar flood adaption measures used in other regions of the world shows that no single solutions can provide 100% flood control resulting from climate change. Multiple solutions along the river front will be needed to develop a sustainable solution for longer time horizons with climate change. The initial adaptation proposals that have been made are a starting point to build an adaptation and resilience strategy, but cannot succeed in isolation. Future investment will be needed on current nearby projects as this combination of solutions progresses; this is where the Paramaribo can build its sustainable adaptive ability. A multiphase approach to developing alternatives is essential so that investment on initial phases provides a solid foundation for additional phases of improvement using future monitoring of sensitive assets and climate change.

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APPENDIX A1: FLO-2D COASTAL FLOODING MODEL RESULTS

The FLO-2D model predicted coastal flooding inundation of the Study Area with the existing flood wall for the baseline scenario, which is shown in Figure A1- 1 to Figure A1- 4 for 10-, 25-, 50-, and 100- year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table A1- 1 and presented in Figure A1- 5. The corresponding flooding hazard maps are shown in Figure A1- 6 to Figure A1- 9 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flood hazard levels for the same scenario are listed in Table A1- 2 and presented in Figure A1- 10. The HHWLs applied along the Suriname River adjacent to the Study Area during FLO-2D model simulations were 2.02 m, 2.13 m, 2.21 m and 2.27 m for 10-, 25-, 50-, and 100-year return periods, respectively.

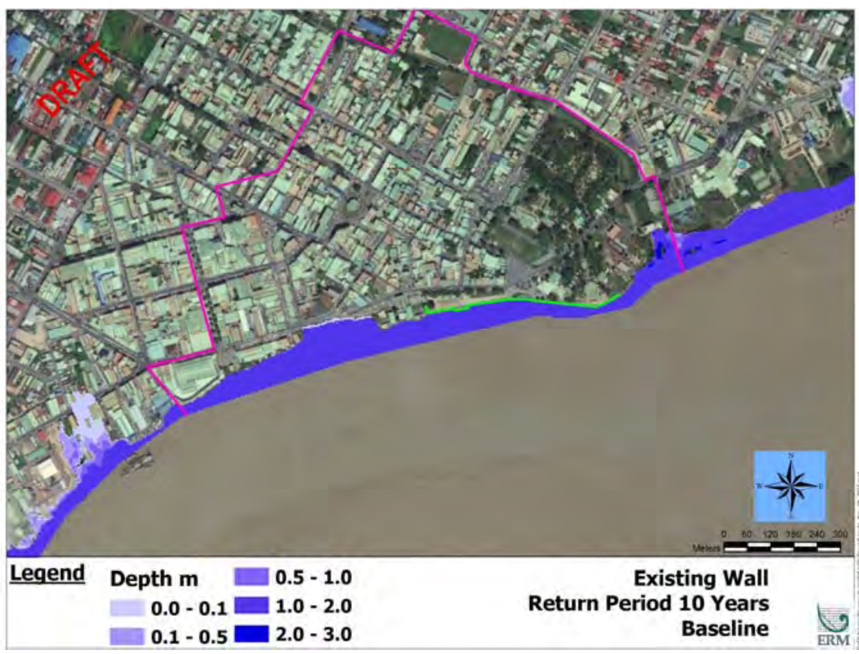


Figure A1- 1: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 10 year return period

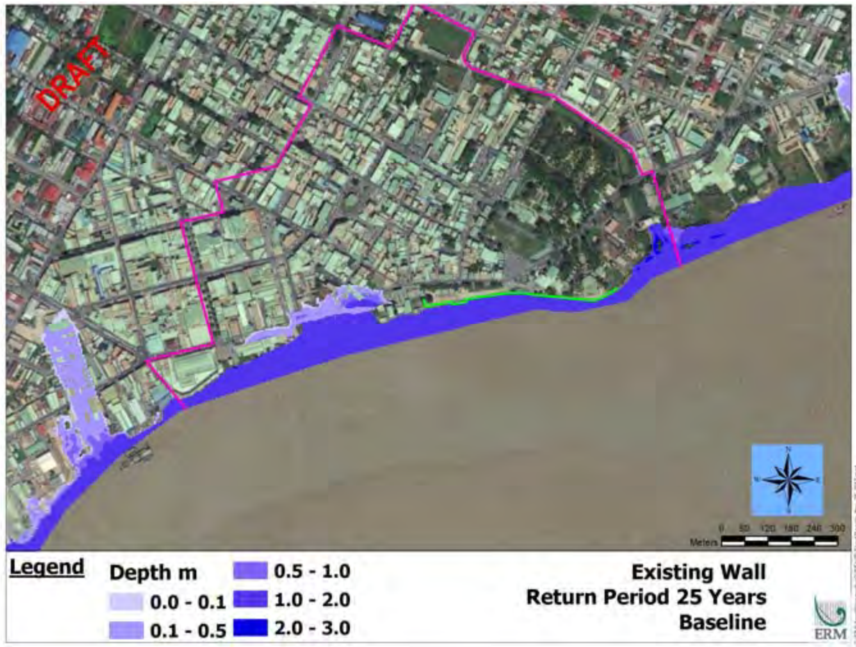


Figure A1- 2: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 25 year return period

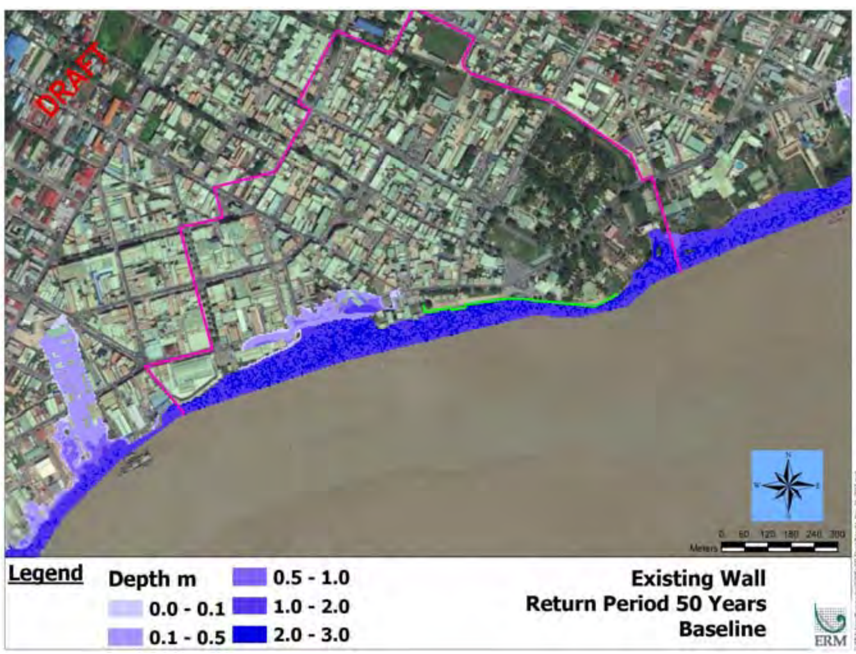


Figure A1- 3: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 50 year return period

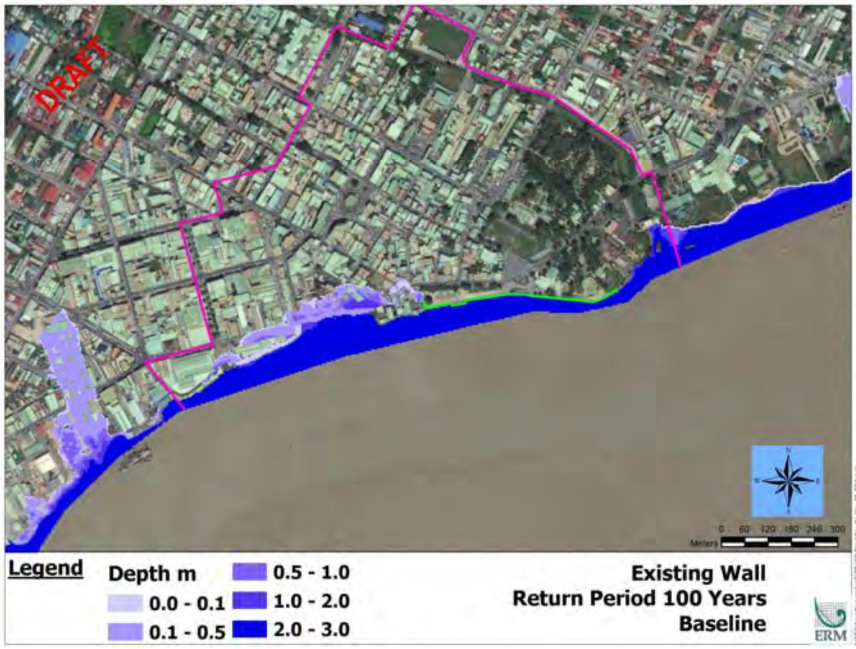


Figure A1- 4: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 100 year return period

Table A1- 1: Tabular comparison of coastal flooding inundation areas of impact of the Study Area with the existing flood wall for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Flooding Hazard Area, km^2			
	EW Base 10Y	**EW Base 25Y**	**EW Base 50Y**	**EW Base 100Y**
0.0 to 0.1	0.02762	0.02099	0.02232	0.02941
0.1 to 0.5	0.06896	0.06896	0.11755	0.12394
0.5 to 1.0	0.01552	0.01552	0.02880	0.03531
1.0 to 3.0	0.03545	0.03545	0.03914	0.04037

EW – Existing Flood Wall; Base - Baseline

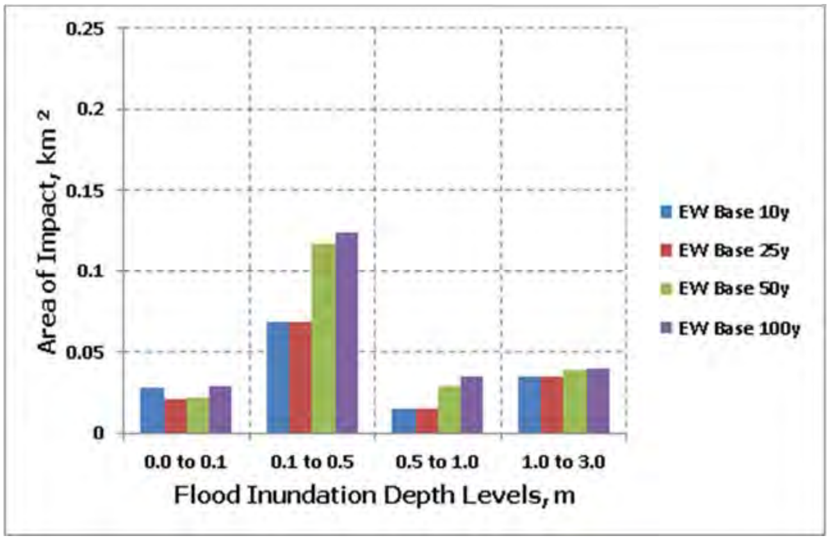


Figure A1- 5: Graphical comparison of coastal flooding inundation area of impact of the Study Area with the existing flood wall for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

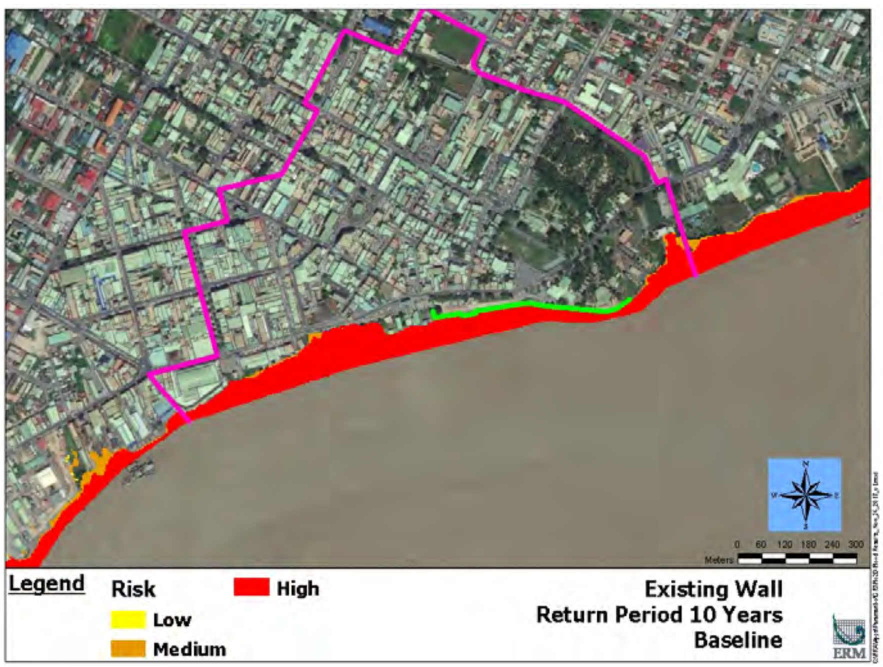


Figure A1- 6: Coastal flooding hazard map of the Study Area with the existing flood wall for the baseline scenario at 10-year return period

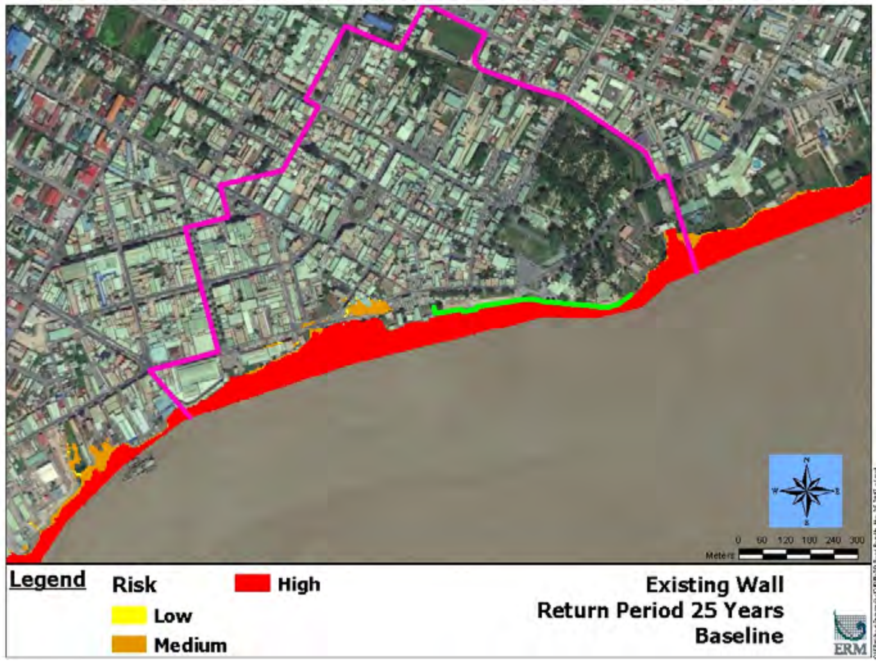


Figure A1- 7: Coastal flooding hazard map of the Study Area with the existing flood wall for the baseline scenario at 25-year return period

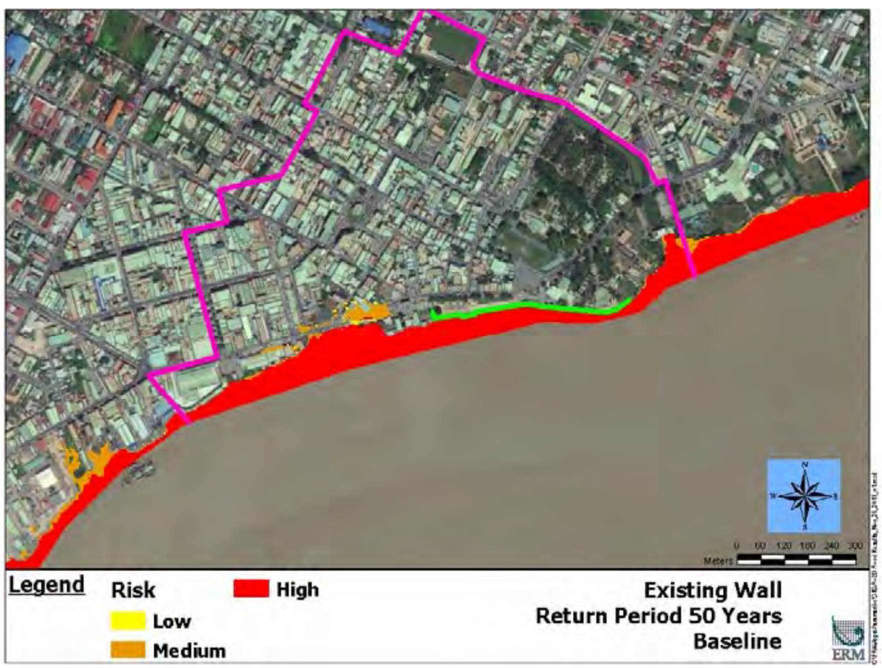


Figure A1- 8: Coastal flooding hazard map of the Study Area with the existing flood wall for the baseline scenario at 50-year return period

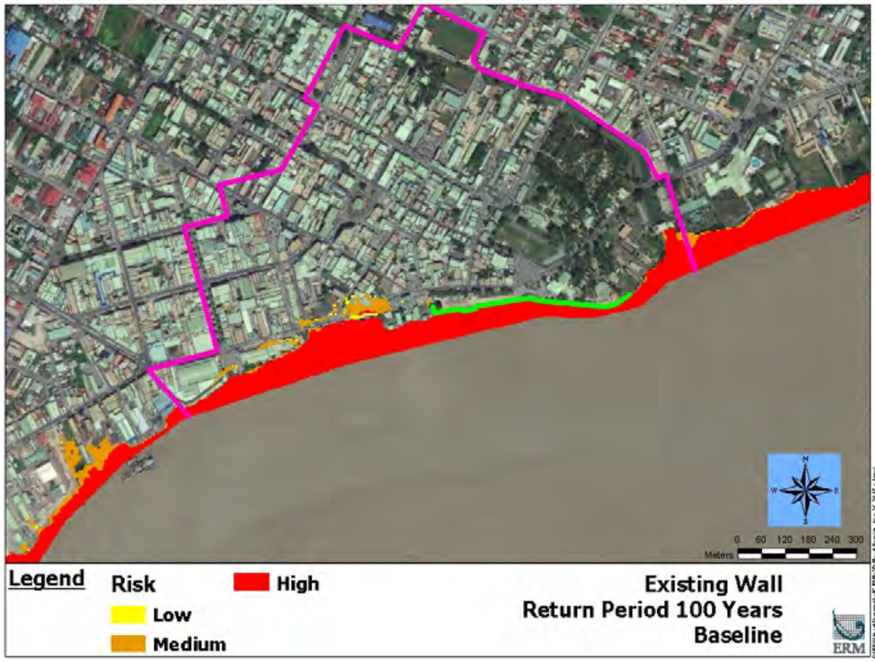


Figure A1- 9: Coastal flooding hazard map of the Study Area with the existing flood wall for the baseline scenario at 100 year return period

Table A1- 2: Tabular comparison of coastal flooding hazard area of impact of the Study Area with the existing flood wall for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

Risk Level	**Flooding Hazard Area, km²**			
	EW Base 10Y	**EW Base 25Y**	**EW Base 50Y**	**EW Base 100Y**
Low	0.00061	0.00126	0.00187	0.00230
Medium	0.02606	0.03406	0.03958	0.04569
High	0.02405	0.02638	0.02837	0.02995

EW – Existing Flood Wall; Base - Baseline

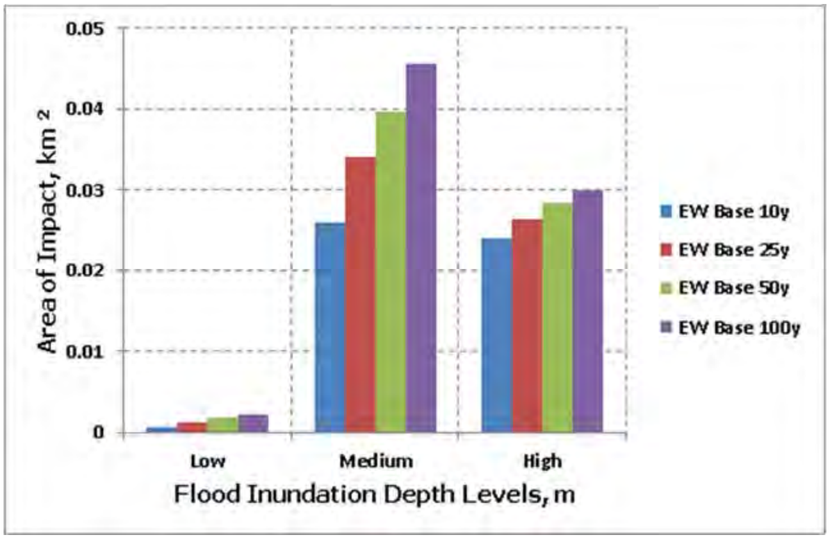


Figure A1- 10: Graphical comparison of coastal flooding hazard area of impact of the Study Area with the existing flood wall for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

The FLO-2D model predicted coastal flooding inundation of the Study Area with the existing flood wall for the climate change 2020 scenario is shown in Figure A1- 11 to Figure A1- 14 for 10-, 25-, 50-, and 100- year return periods. The area of impact at various flooding inundation depth levels for the same scenario is listed in Table A1- 3 and presented in Figure A1- 15. The corresponding flooding hazard maps are shown in Figure A1- 16 to Figure A1- 19 for 10-, 25-, 50-, and 100- year return periods. The area of impact at various flooding hazard levels for the same scenario is listed in Table A1- 4 and presented in Figure A1- 20. The HHWLs applied along the Suriname River adjacent to the Study Area for this set of FLO-2D model simulations were 2.11 m, 2.22 m, 2.30 m and 2.36 m for 10-, 25-, 50-, and 100-year return periods, respectively.

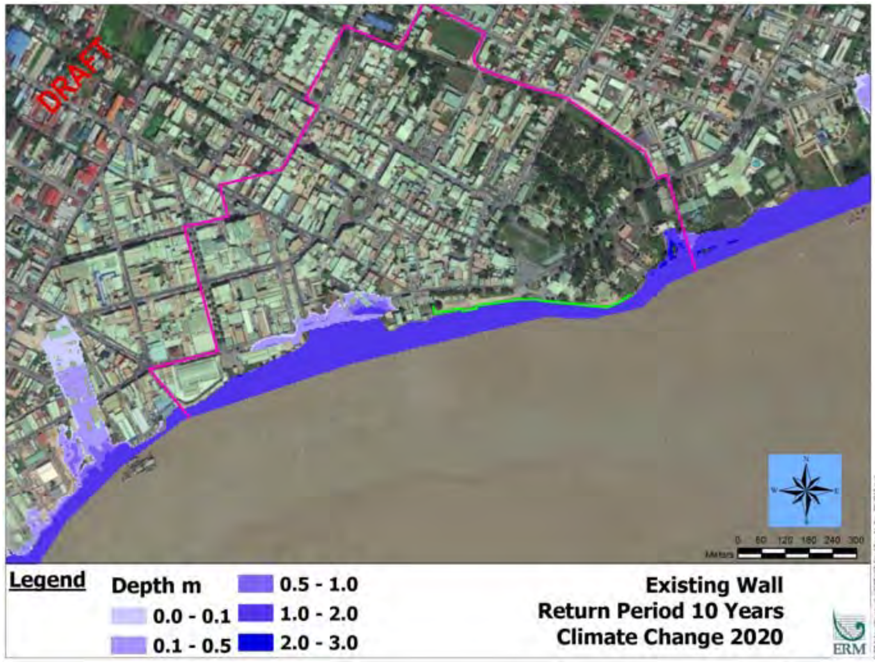


Figure A1- 11: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2020 scenario at 10-year return period

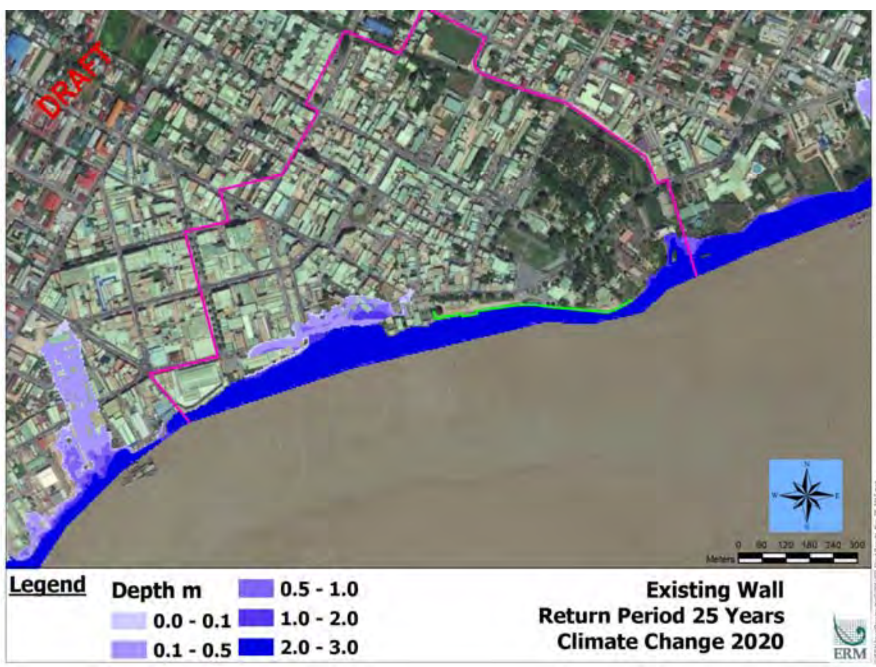


Figure A1- 12: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2020 scenario at 25-year return period

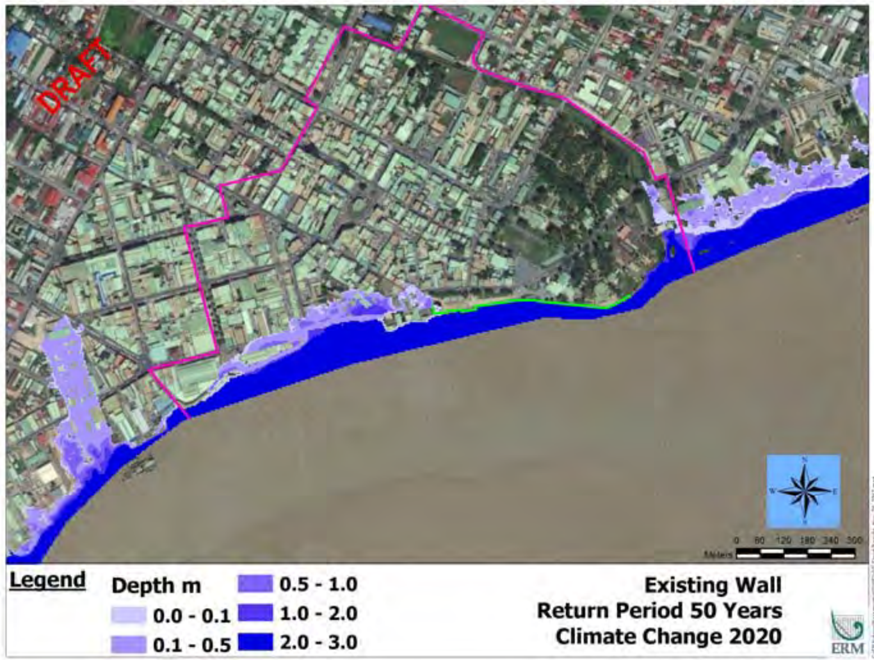


Figure A1- 13: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2020 scenario at 50-year return period

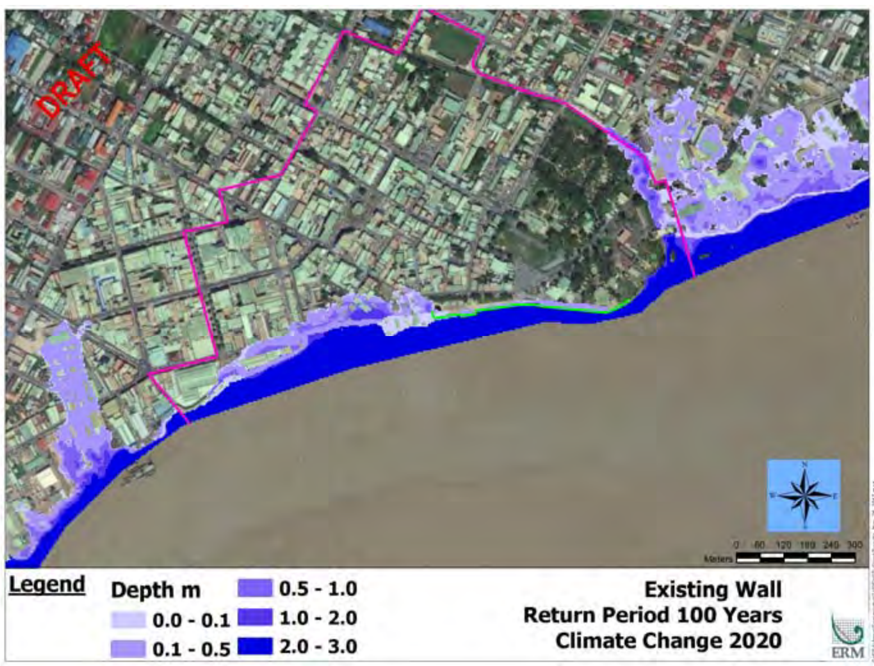


Figure A1- 14: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2020 scenario at 100-year return period

Table A1- 3: Tabular comparison of coastal flooding inundation areas of impact of the Study Area with the existing flood wall for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Flooding Inundation Area, km^2			
	EW CC2020 10Y	EW CC2020 25Y	EW CC2020 50Y	EW CC2020 100Y
0.0 to 0.1	0.02710	0.02242	0.04670	0.06195
0.1 to 0.5	0.10323	0.11837	0.15390	0.20309
0.5 to 1.0	0.02178	0.02966	0.04394	0.07187
1.0 to 3.0	0.03709	0.03928	0.04106	0.04432

EW – Existing Flood Wall; Base - Baseline

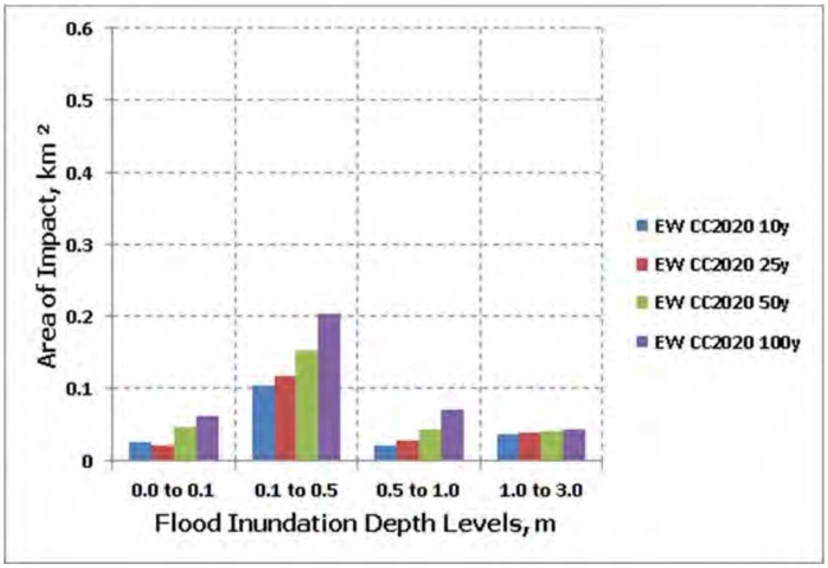


Figure A1- 15: Graphical comparison of coastal flooding inundation area of impact of the Study Area with the existing flood wall for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods

Figure A1- 16: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2020 scenario at 10-year return period

Figure A1- 17: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2020 scenario at 25-year return period

Figure A1- 18: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2020 scenario at 50-year return period

Figure A1- 19: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2020 scenario at 100-year return period

Table A1- 4: Tabular comparison of coastal flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods

Hazard Level	EW CC2020 10Y	EW CC2020 25Y	EW CC2020 50Y	EW CC2020 100Y
Low	0.00114	0.00187	0.00275	0.00789
Medium	0.03290	0.04024	0.05437	0.08382
High	0.02597	0.02874	0.03059	0.03227

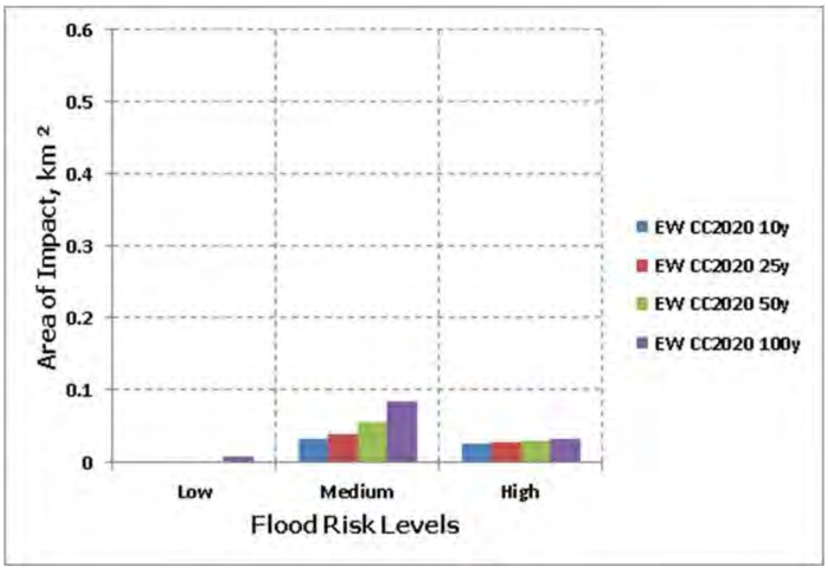


Figure A1- 20: Graphical comparison of coastal flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods

The FLO-2D model predicted coastal flooding inundation of the Study Area with the existing flood wall for the climate change 2050 scenario is shown Figure A1- 21 to Figure A1- 24 for 10-, 25-, 50-, and 100- year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table A1- 5 and presented in Figure A1- 25. The corresponding flooding hazard maps were shown in Figure A1- 26 to Figure A1- 29 for 10-, 25-, 50-, and 100- year return periods. The areas of impact at various flooding hazard levels for the same scenario is listed in Table A1- 6 and graphed in Figure A1- 30. The HHWLs applied along the Suriname River adjacent to the Study Area for this set of FLO-2D model simulations were 2.35 m, 2.46 m, 2.54 m and 2.60 m for 10-, 25-, 50-, and 100- year return periods, respectively.

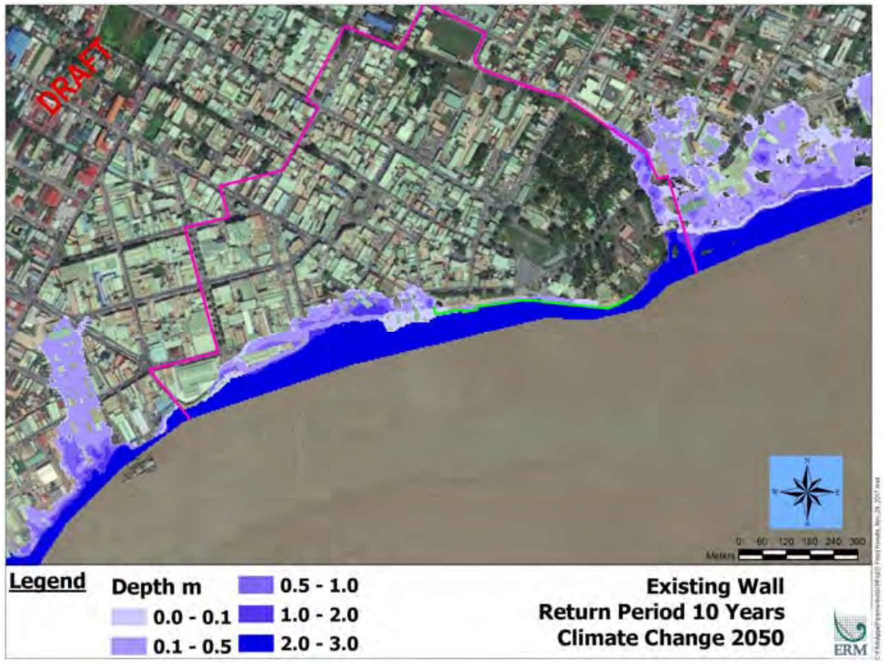


Figure A1- 21: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-year return period

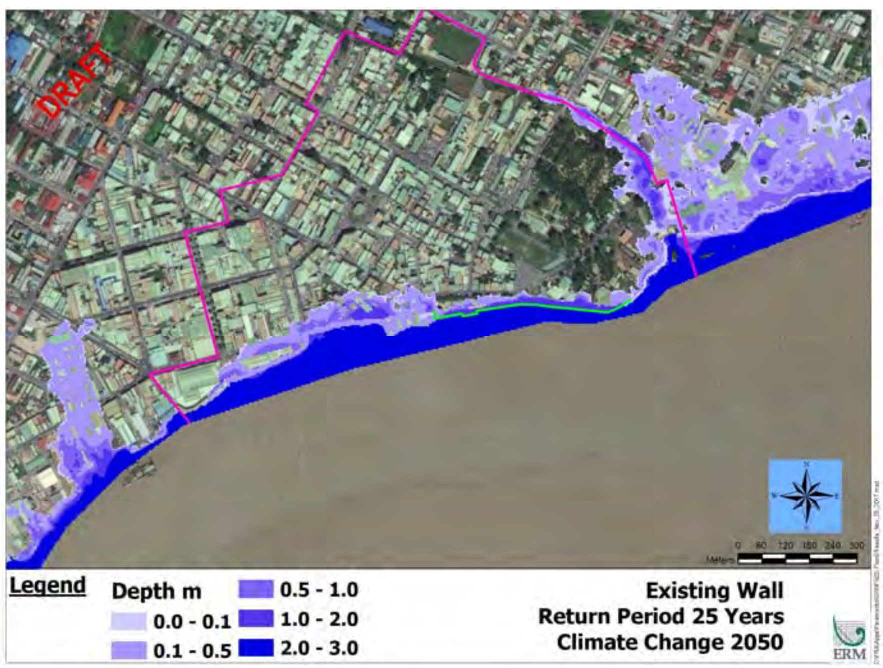


Figure A1- 22: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2050 scenario at 25-year return period

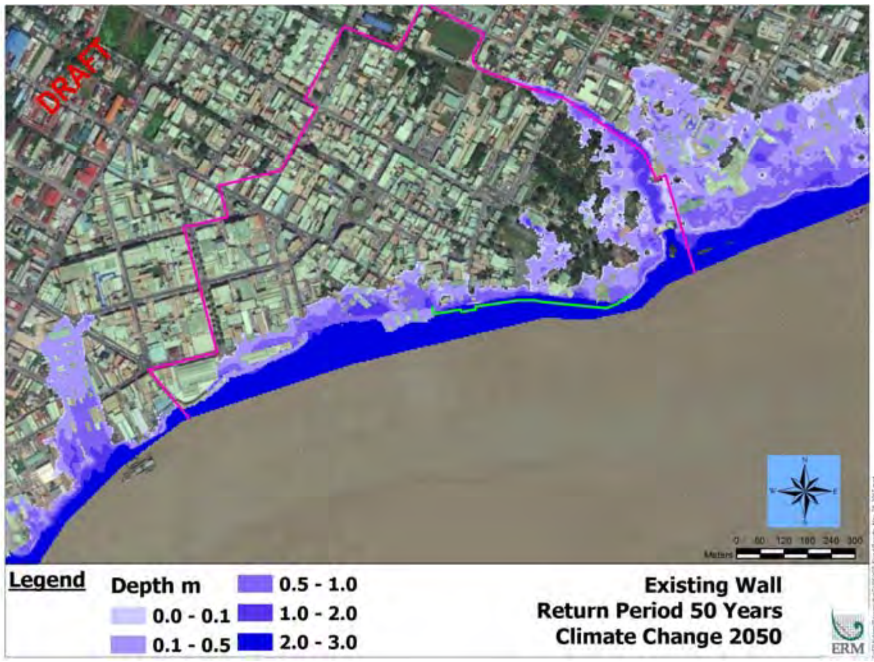


Figure A1- 23: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2050 scenario at 50-year return period

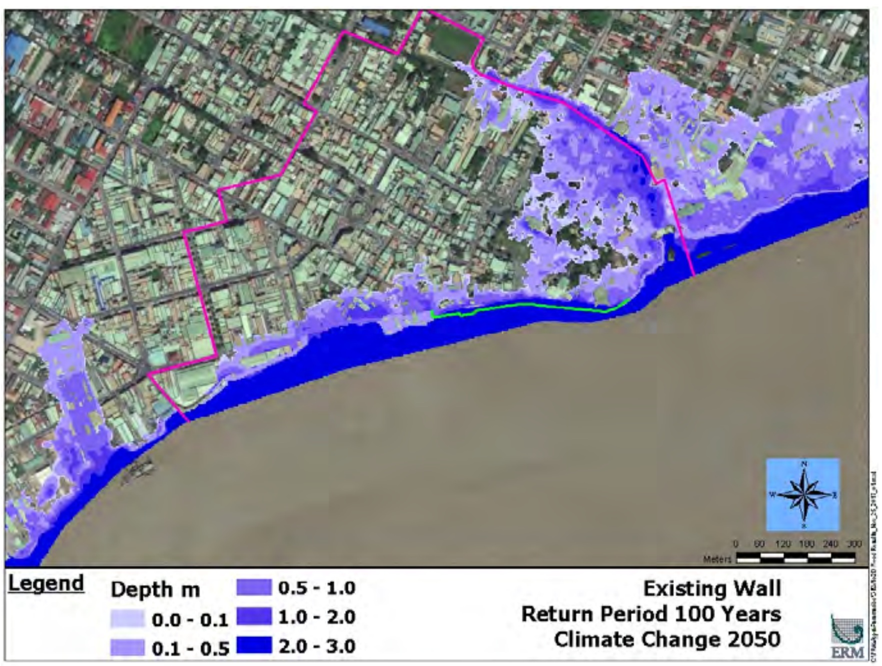


Figure A1- 24: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2050 scenario at 100-year return period

Table A1- 5: Tabular comparison of coastal flooding inundation areas of impact of the Study Area with the existing flood wall for the climate change scenario 2050 at 10-, 25-, 50-, and 100- year return periods

Flood Inundation Depth Level, m	EW CC2050 10Y	EW CC2050 25Y	EW CC2050 50Y	EW CC2050 100Y
0.0 to 0.1	0.06299	0.04894	0.04861	0.05352
0.1 to 0.5	0.19637	0.22480	0.22950	0.24547
0.5 to 1.0	0.06587	0.12266	0.17130	0.21835
1.0 to 3.0	0.04326	0.05946	0.07382	0.09659

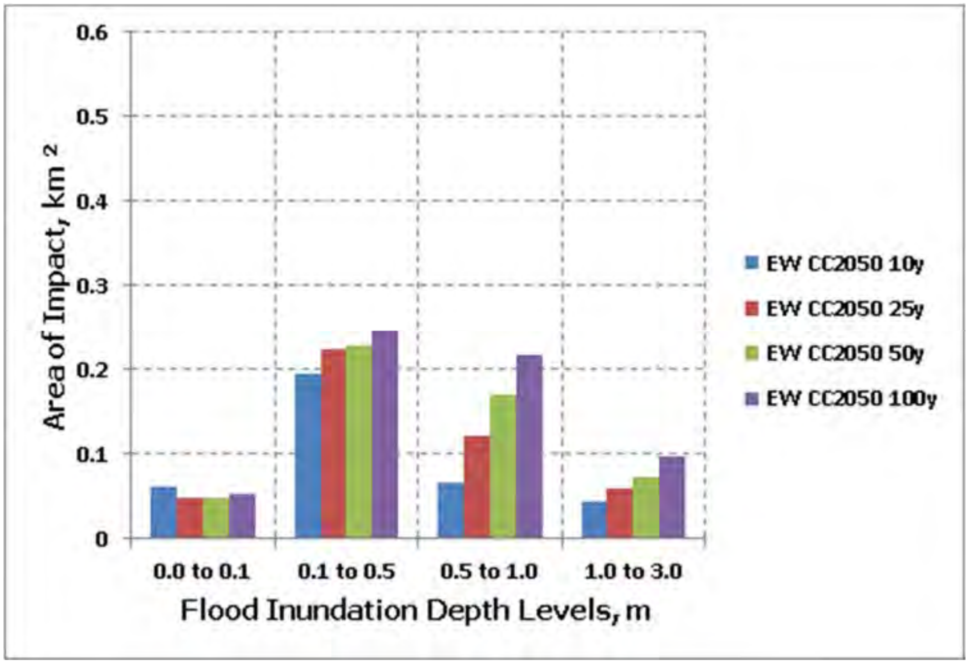


Figure A1- 25: Graphical comparison of coastal flooding inundation areas of impact of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-, 25, 50-, and 100-year return periods

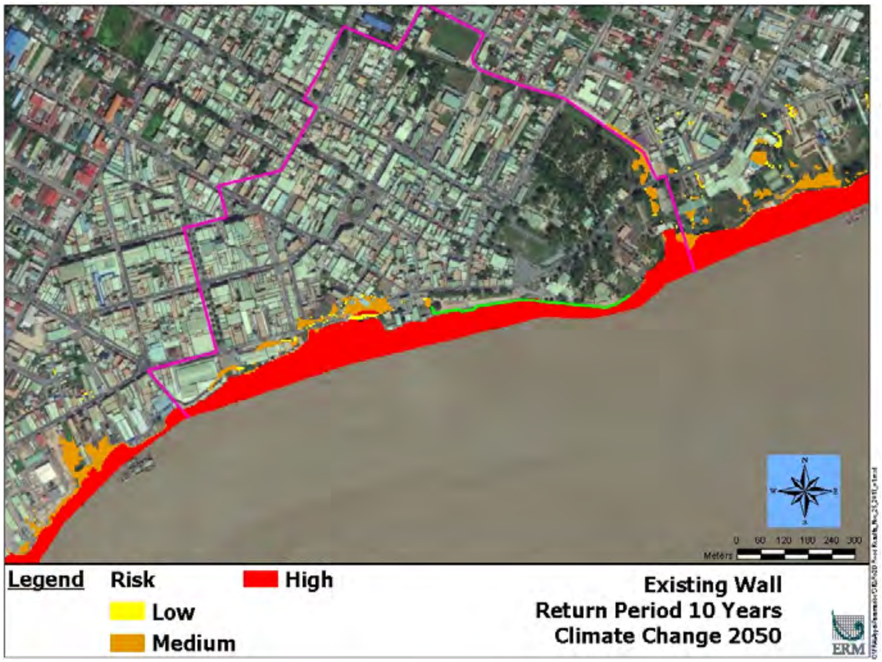


Figure A1- 26: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-year return period

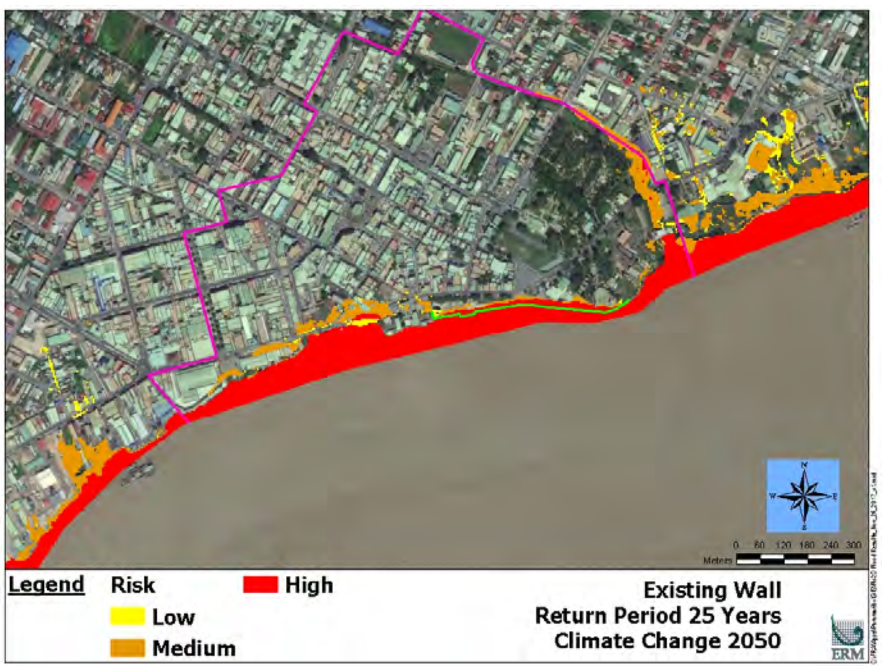


Figure A1- 27: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2050 scenario at 25-year return period

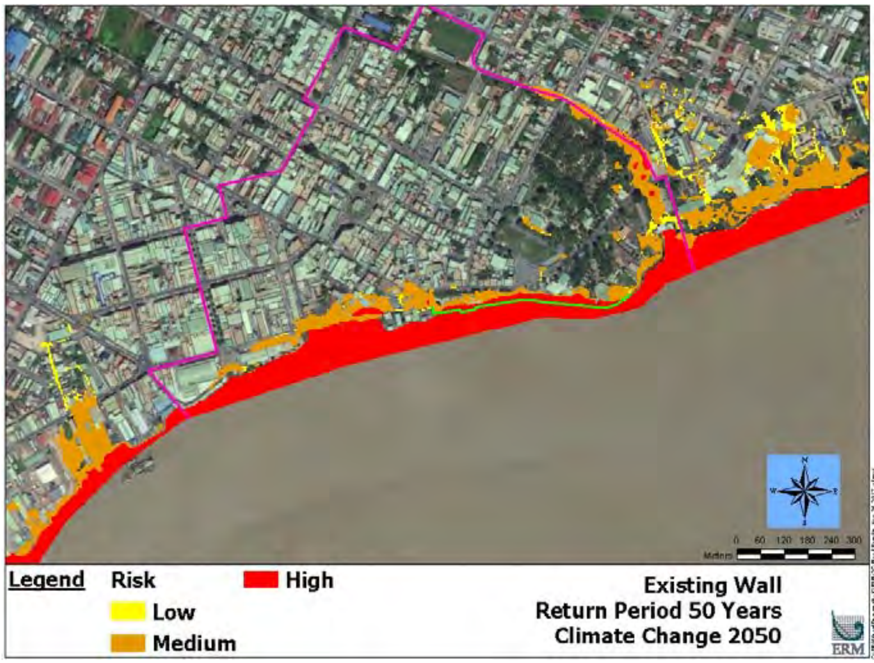


Figure A1- 28: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2050 scenario at 50-year return period

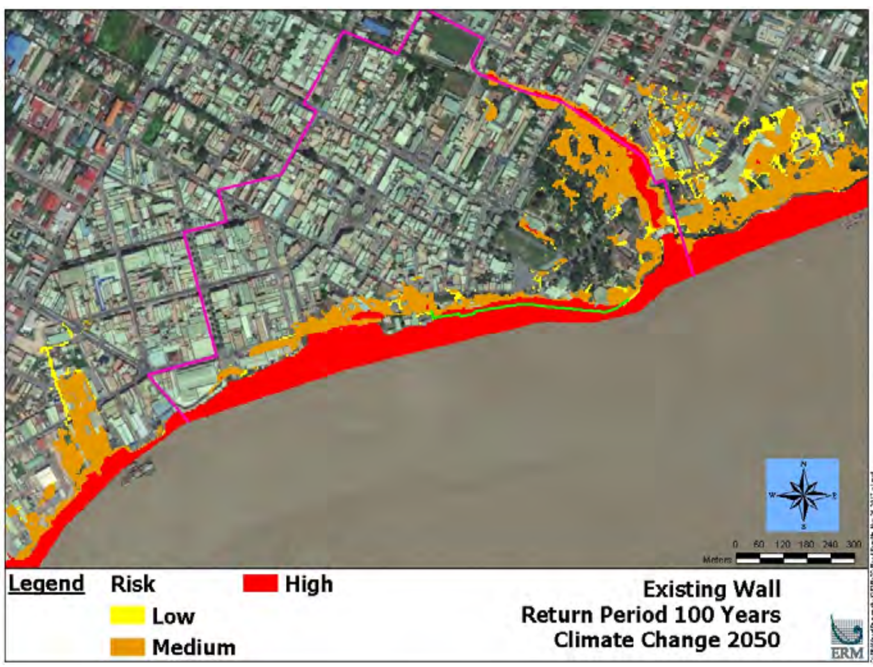


Figure A1- 29: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2050 scenario at 100-year return period

Table A1- 6: Tabular comparison of coastal flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-, 25-, 50-, and 100- year return periods

Hazard Level	**EW CC2050 10y**	**EW CC2050 25y**	**EW CC2050 50y**	**EW CC2050 100y**
Low	0.00664	0.01973	0.02557	0.03253

Medium	0.07701	0.14154	0.20002	0.25875
High	0.03203	0.04067	0.04523	0.05611

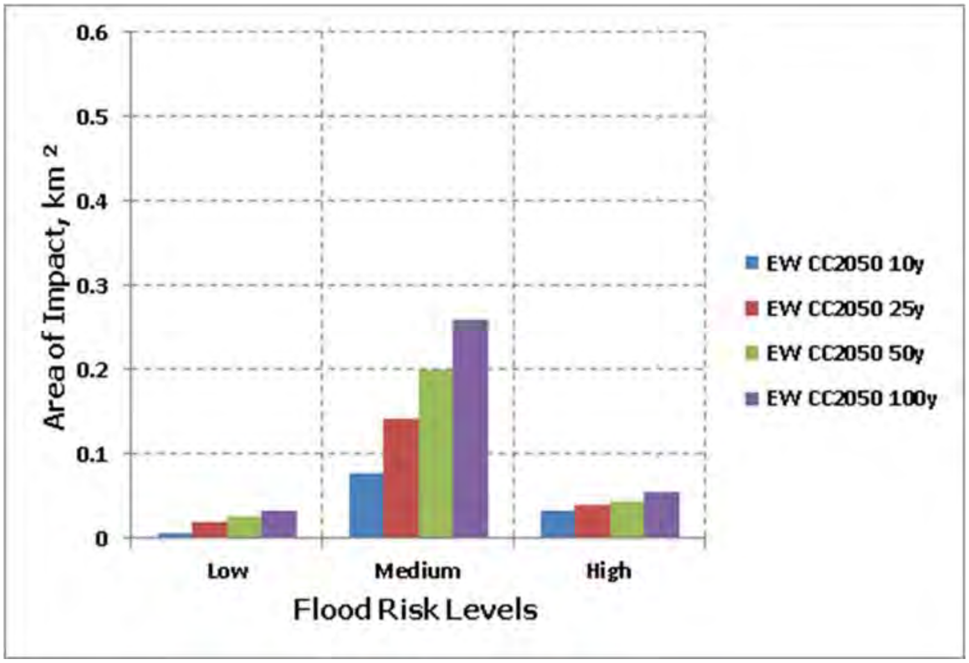


Figure A1- 30: Graphical comparison of coastal flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-, 25, 50-, and 100-year return periods

The FLO-2D model predicted coastal flooding inundation of the Study Area with the existing flood wall for the climate change 2080 scenario is shown in Figure A1- 31 to Figure A1- 34 for 10-, 25-, 50-, and 100- year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table A1- 7 and presented in Figure A1- 35. The corresponding flooding hazard maps were shown in Figure A1- 36 to Figure A1- 39 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding hazard levels for the same scenario are listed in Table A1- 8 and presented in Figure A1- 40. The HHWLs applied along the Suriname River adjacent to the Study Area for this set of FLO-2D model simulations were 2.72 m, 2.83 m, 2.91 m and 2.97 m for 10-, 25-, 50-, and 100- year return periods, respectively.

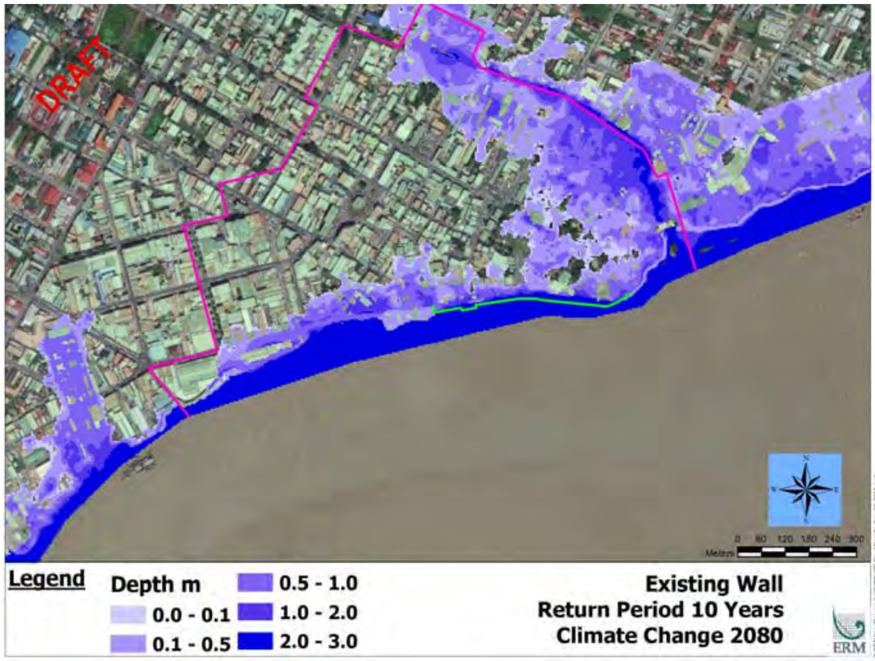


Figure A1- 31: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-year return period

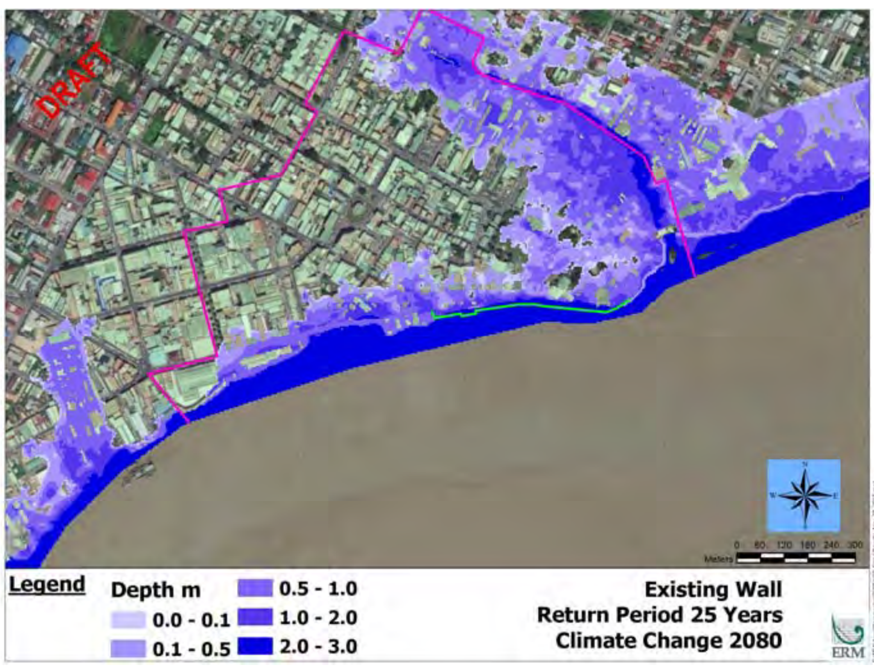


Figure A1- 32: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2080 scenario at 25-year return period

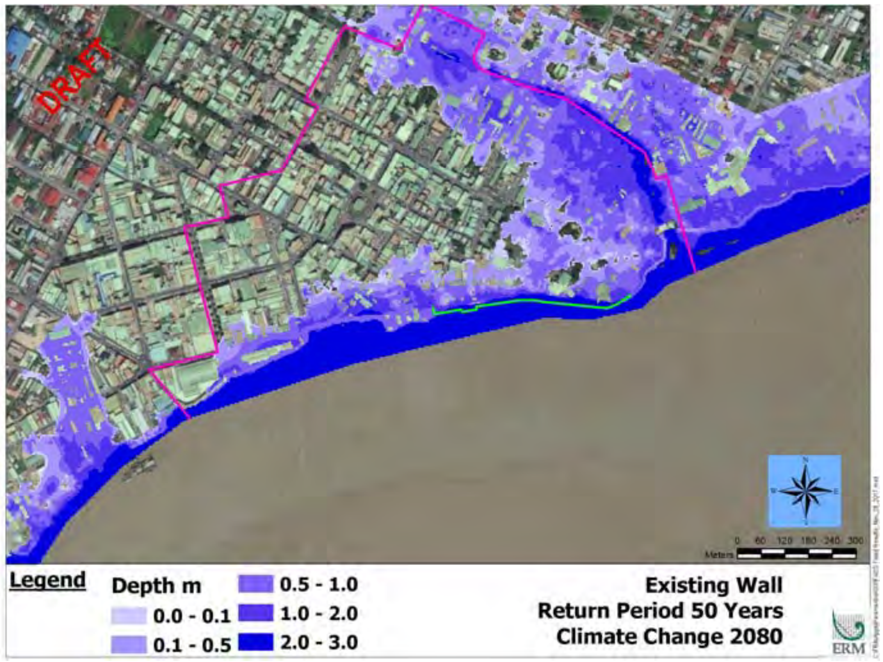


Figure A1- 33: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2080 scenario at 50-year return period

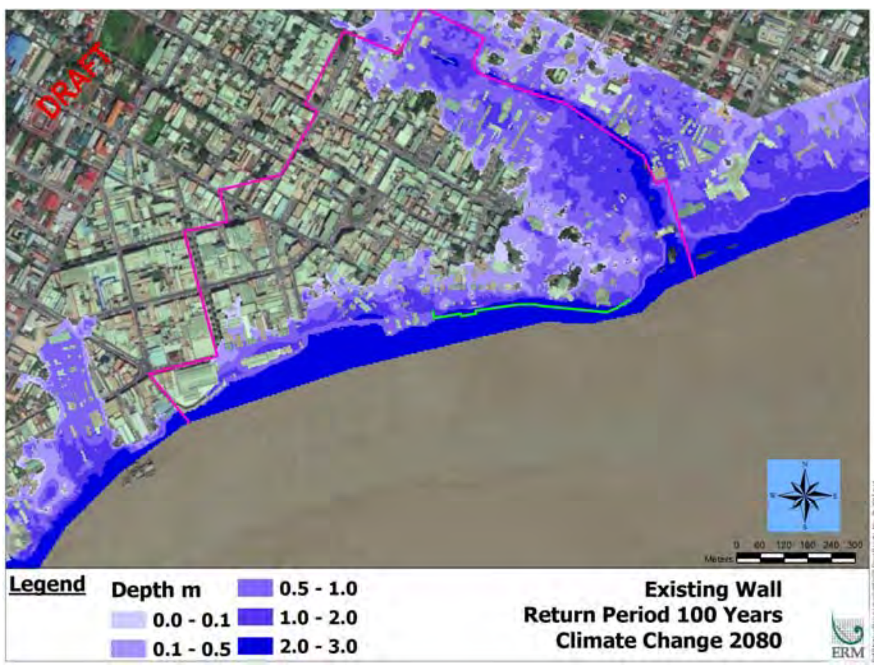


Figure A1- 34: Coastal flooding inundation map of the Study Area with the existing flood wall for the climate change 2080 scenario at 100-year return period

Table A1- 7: Tabular comparison of coastal flooding inundation areas of impact of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	EW CC2080 10Y	EW CC2080 25Y	EW CC2080 50Y	EW CC2080 100Y
0.0 to 0.1	0.05106	0.04731	0.04400	0.04190
0.1 to 0.5	0.25488	0.22293	0.20686	0.19752
0.5 to 1.0	0.29627	0.33640	0.33811	0.33051
1.0 to 3.0	0.14483	0.20272	0.24784	0.28419

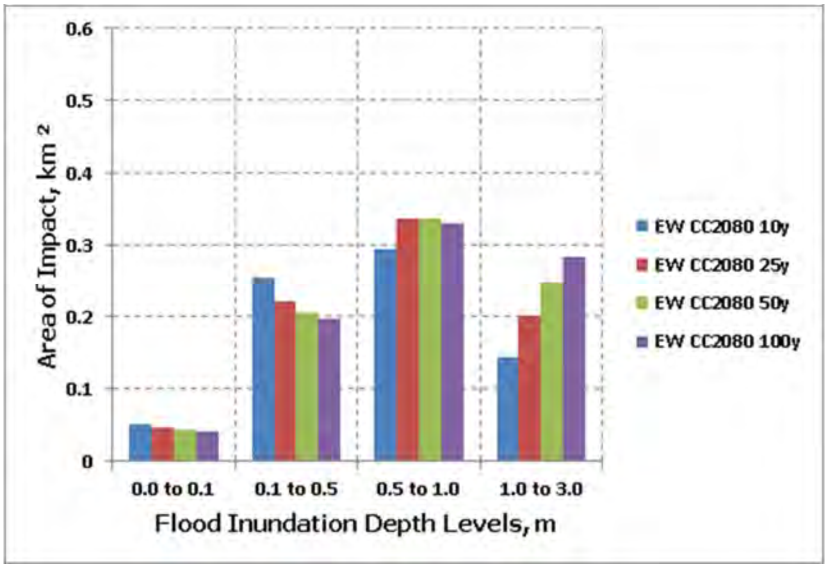


Figure A1- 35: Graphical comparison of coastal flooding inundation areas of impact of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

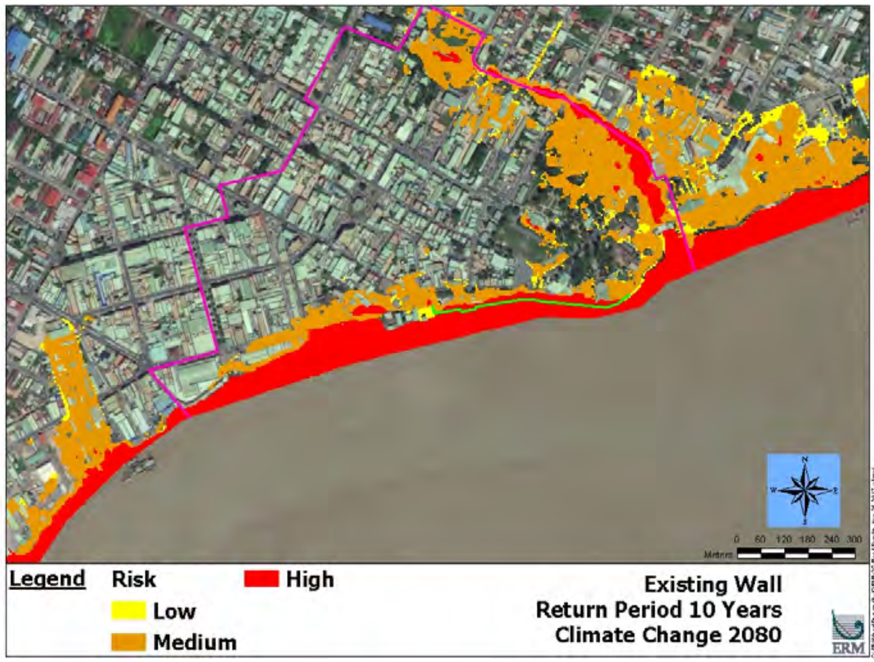


Figure A1- 36: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-year return period

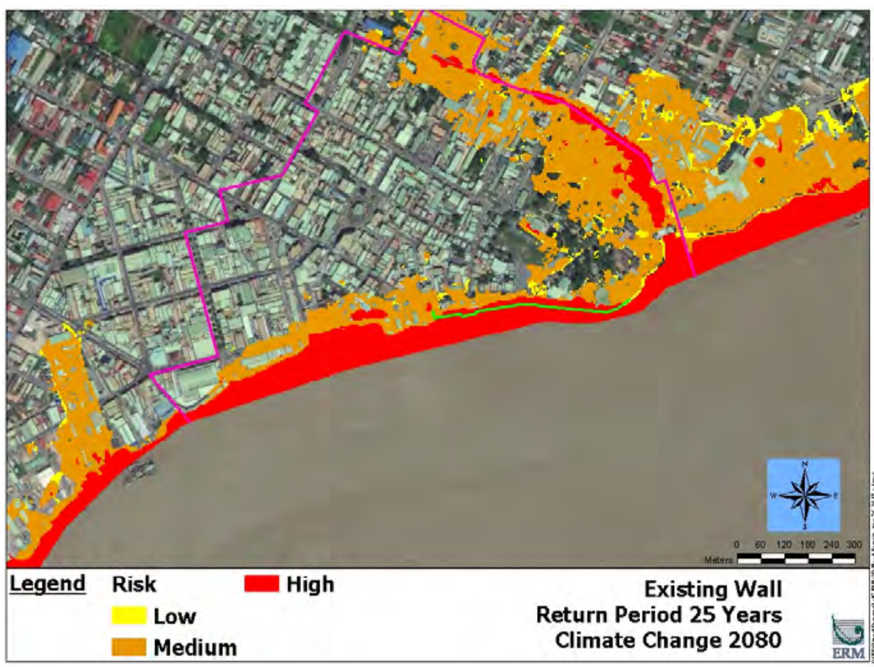


Figure A1- 37: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 25-year return period

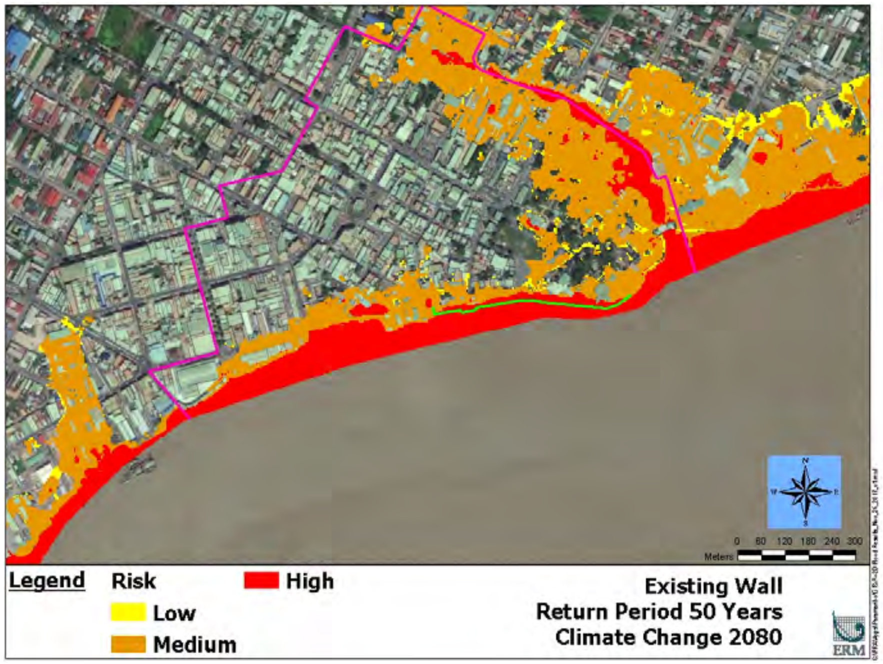


Figure A1- 38: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 50-year return period

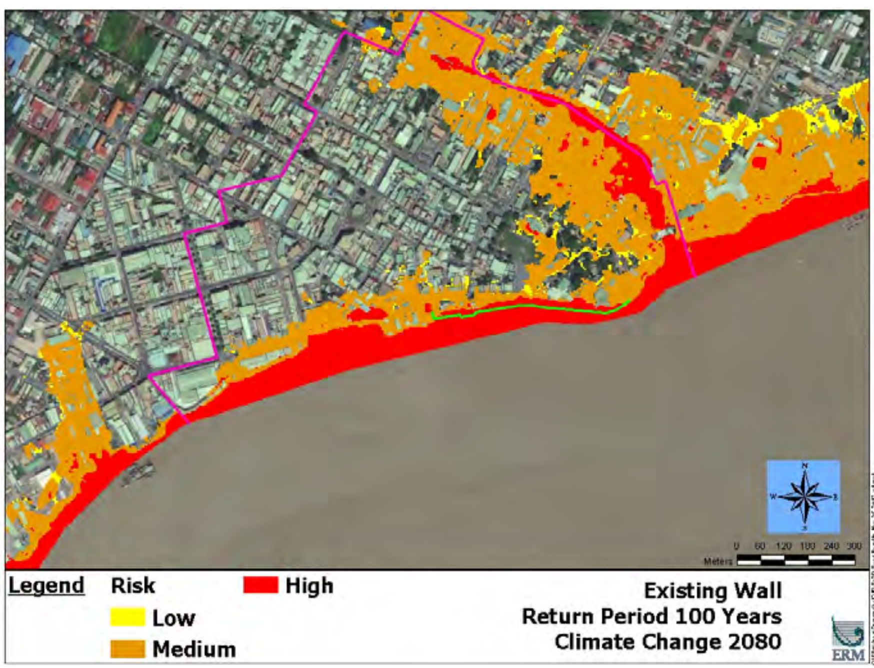


Figure A1- 39: Coastal flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 100-year return period

Table A1- 8: Tabular comparison of coastal flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-, 25-, 50-, and 100- year return periods

Risk Level	EW CC2080 10Y	EW CC2080 25Y	EW CC2080 50Y	EW CC2080 100Y
Low	0.04104	0.04264	0.04331	0.04435
Medium	0.37566	0.46410	0.50144	0.52139
High	0.06558	0.07552	0.08533	0.09440

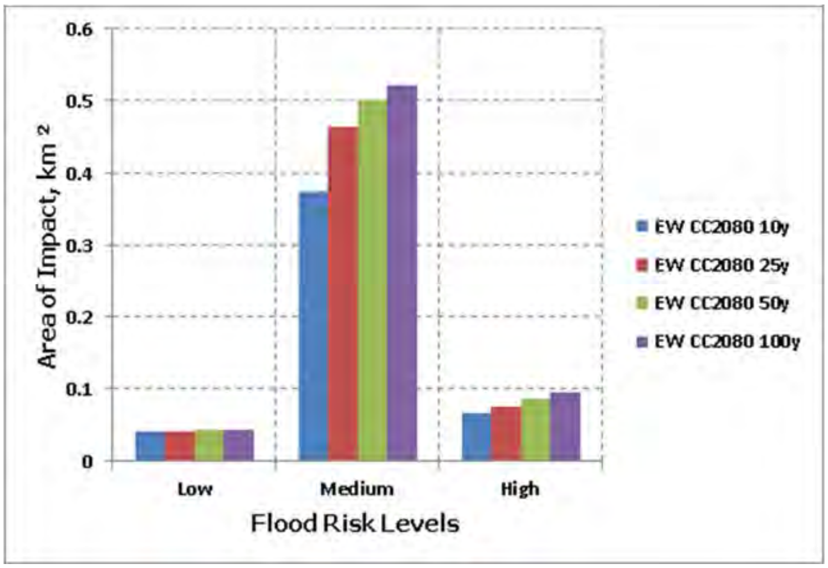


Figure A1- 40: Graphical comparison of coastal flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

APPENDIX A2: FLO-2D INLAND FLOODING MODEL RESULTS

The FLO-2D model predicted inland flooding inundation of the Study Area with the existing wall for the baseline scenario is shown in Figure A2- 1 to Figure A2- 4 for 10-, 25-, 50-, and 100- year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table A2- 1 and presented in Figure A2- 5. The corresponding flooding hazard maps were shown in Figure A2- 6 to Figure A2- 9 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding hazard levels for the same scenario are listed in Table A2- 2 and graphed in Figure A2- 10. The 24-hr maximum precipitation applied to the Study Area for this set of FLO-2D model simulations were 139 mm, 165 mm, 183 mm and 201 mm for 10-, 25-, 50-, and 100- year return periods, respectively.

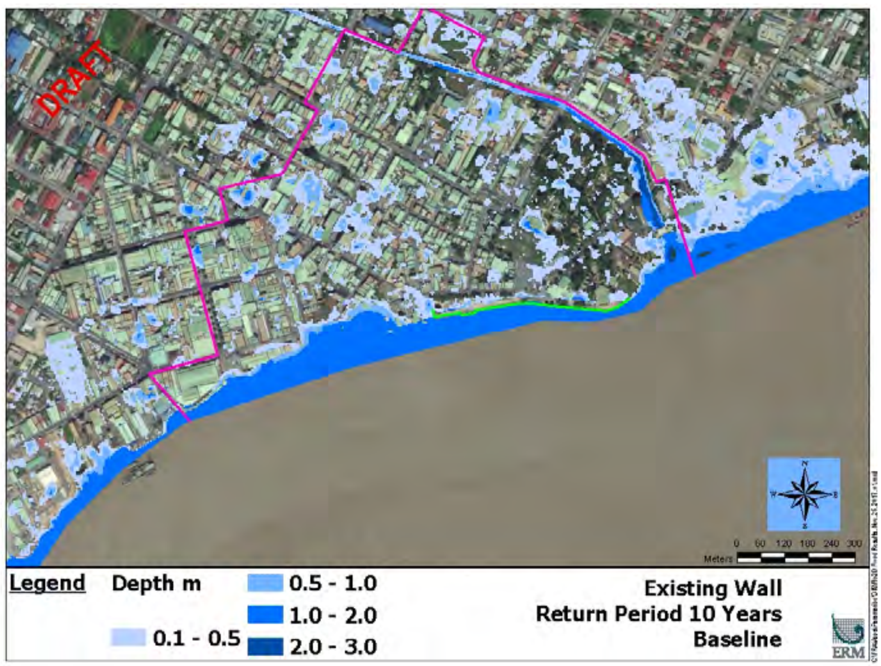


Figure A2- 1: Inland flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 10-year return period

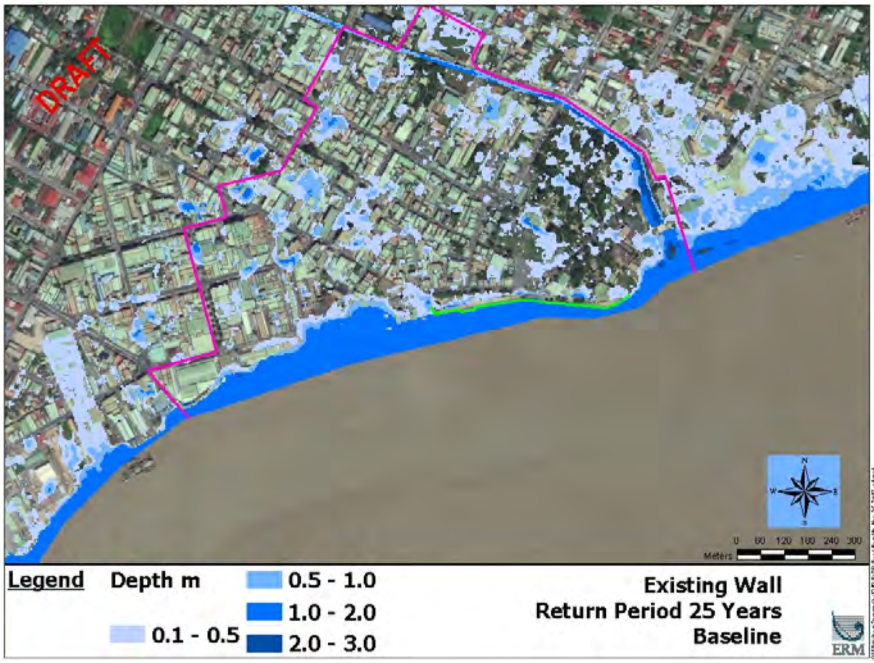


Figure A2- 2: Inland flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 25-year return period

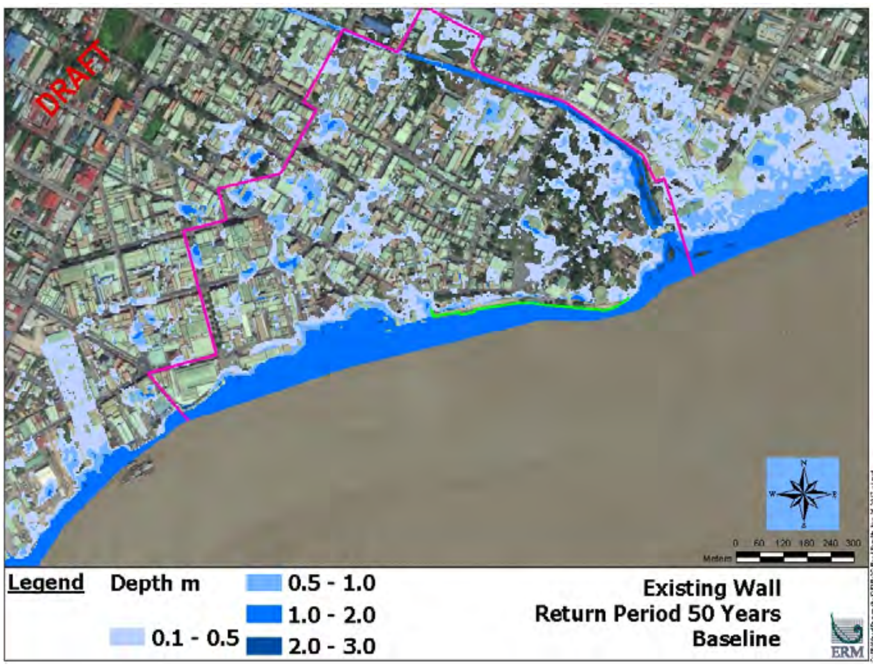


Figure A2- 3: Inland flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 50-year return period

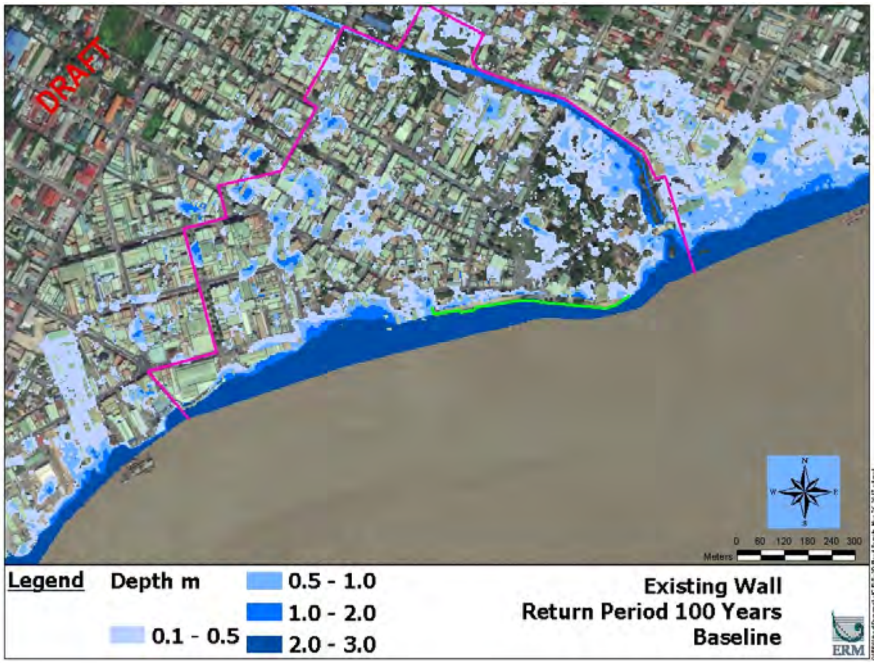


Figure A2- 4: Inland flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 100-year return period

Table A2- 1: Tabular comparison of inland flooding inundation areas of impact of the Study Area with the existing flood wall for the baseline scenario at 10-, 25-, 50-, and 100- year return periods

Flood Inundation Depth Level, m	EW Base 10Y	EW Base 25Y	EW Base 50Y	EW Base 100Y
0.0 to 0.1	0.84627	0.78477	0.74190	0.70085
0.1 to 0.5	0.34029	0.36272	0.36843	0.37136
0.5 to 1.0	0.09045	0.12045	0.14573	0.17504
1.0 to 3.0	0.05478	0.06386	0.07573	0.08454

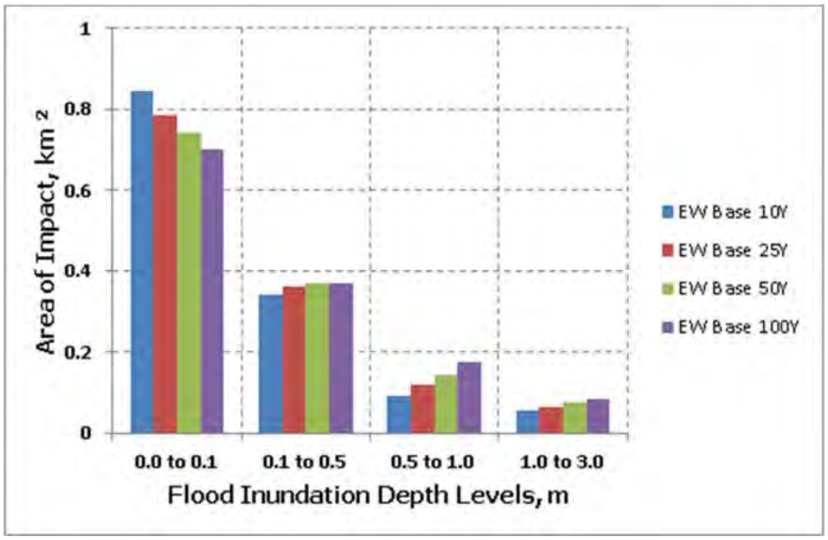


Figure A2- 5: Graphical comparison of flooding inundation area of impact of the Study Area with the existing flood wall for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

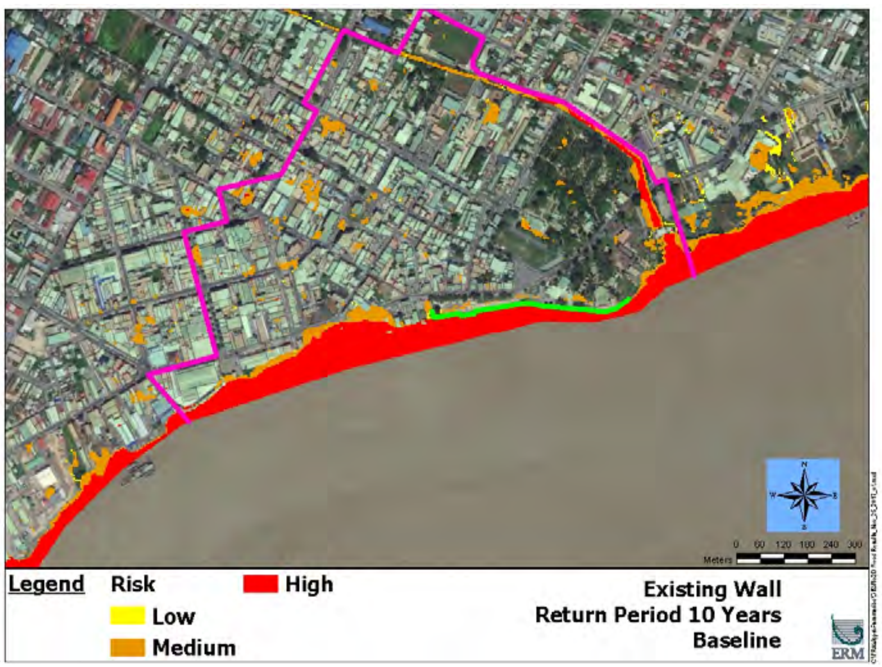


Figure A2- 6: Inland flooding hazard map of the Study Area with the existing flood wall for the baseline scenario at 10-year return period

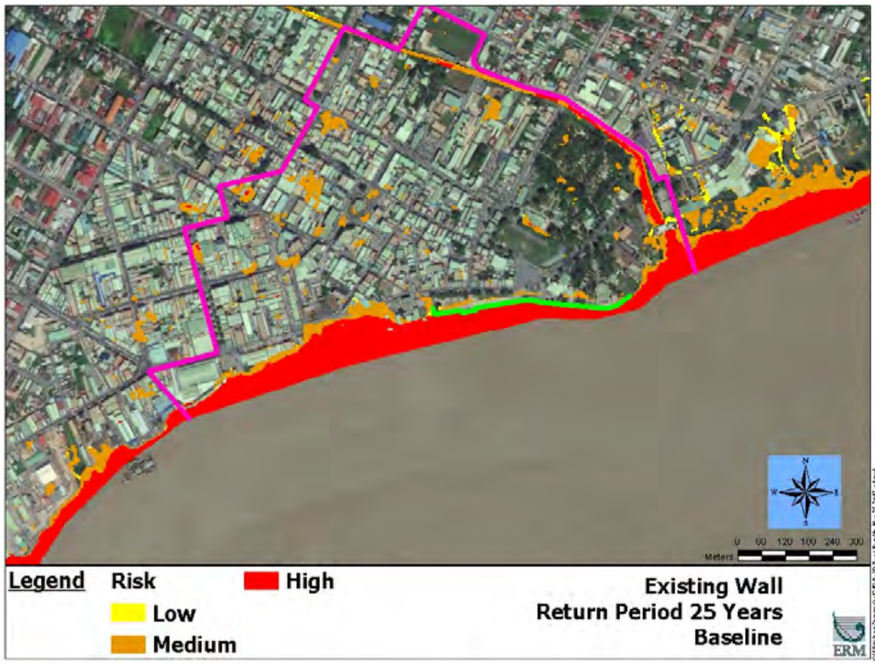


Figure A2- 7: Inland flooding hazard map of the Study Area with the existing flood wall for the baseline scenario at 25-year return period

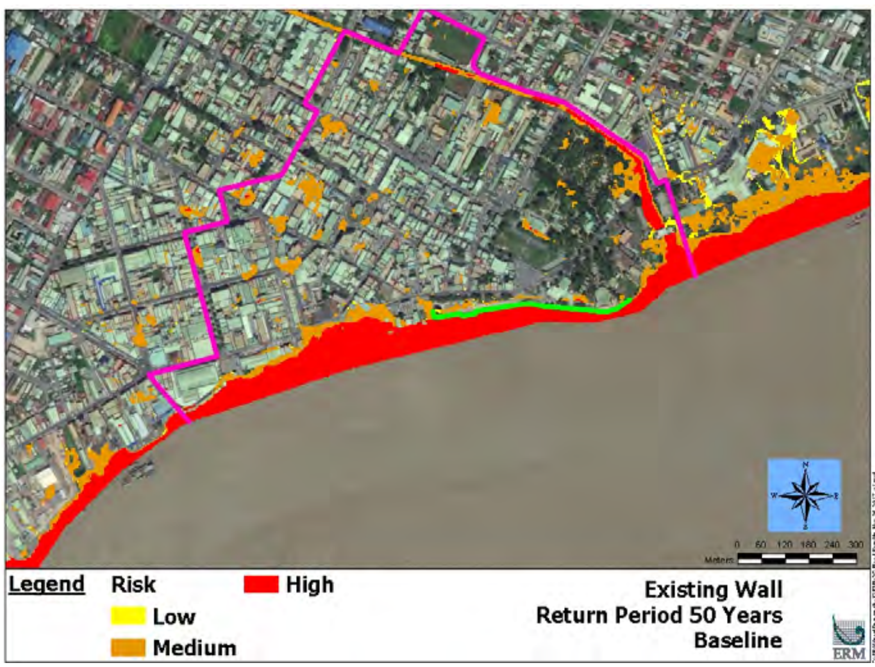


Figure A2- 8: Inland flooding hazard map of the Study Area with the existing flood wall for the baseline scenario at 50-year return period

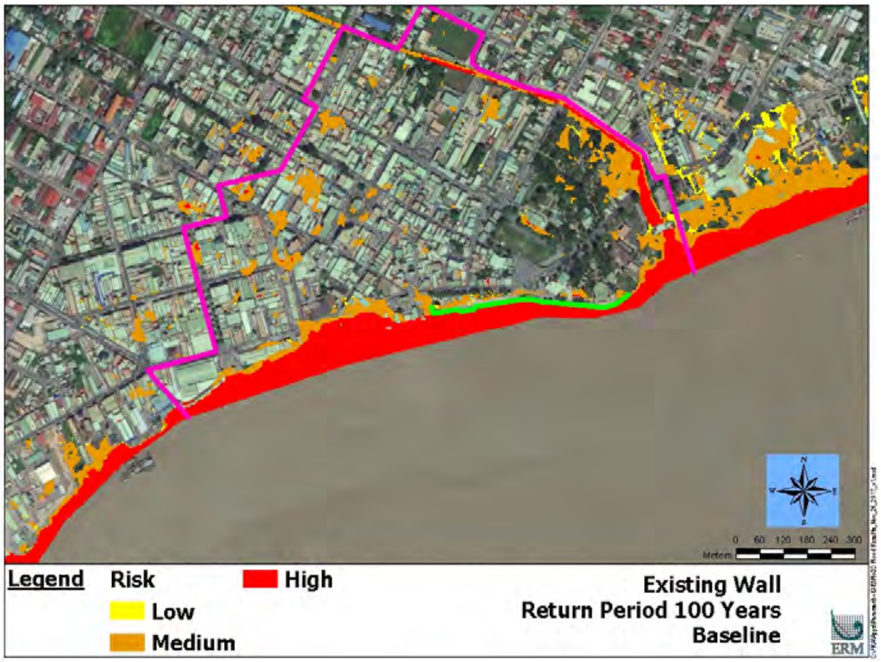


Figure A2- 9: Inland flooding hazard map of the Study Area with the existing flood wall for the baseline scenario at 100-year return period

Table A2- 2: Tabular comparison of inland flooding hazard areas of impact of the Study Area with the existing flood wall for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

Hazard Level	**EW Base 10Y**	**EW Base 25Y**	**EW Base 50Y**	**EW Base 100Y**
Low	0.00693	0.01133	0.01446	0.01660
Medium	0.11247	0.14755	0.18101	0.21523
High	0.21054	0.21472	0.21846	0.22218

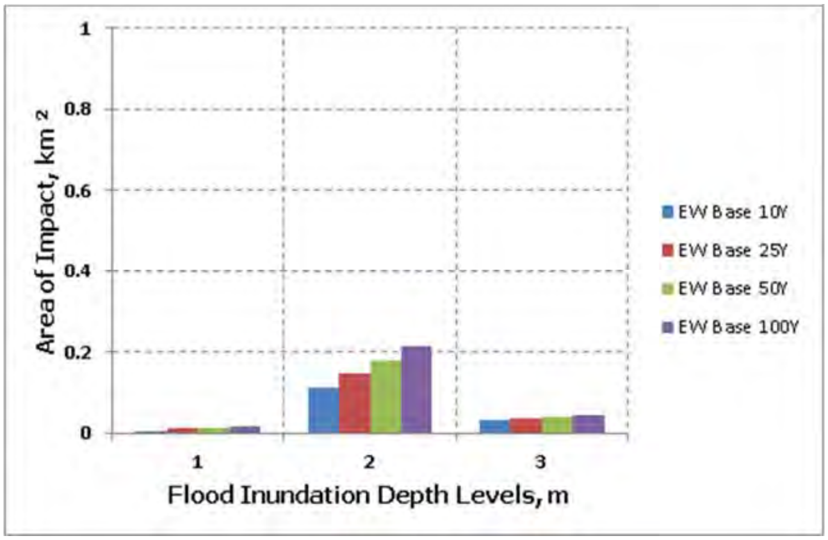


Figure A2- 10: Graphical comparison of inland flooding inundation areas of impact of the Study Area with the existing flood wall for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

The FLO-2D model predicted inland flooding inundation of the Study Area with the existing flood wall for the climate change 2050 scenario is shown in Figure A2- 11 to Figure A2- 14 for 10-, 25-, 50-, and 100- year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table A2- 3 and presented in Figure A2- 15. The corresponding flooding hazard maps are shown in Figure A2- 16 to Figure A2- 19 for 10-, 25-, 50-, and 100- year return periods. The areas of impact at various flooding hazard levels for the same are listed in Table A2- 4 and presented in Figure A2- 20. The 24-hr maximum precipitation applied to the Study Area for this set of FLO-2D model simulations were 153 mm, 180 mm, 200 mm and 220 mm for 10-, 25-, 50-, and 100-year return periods, respectively.

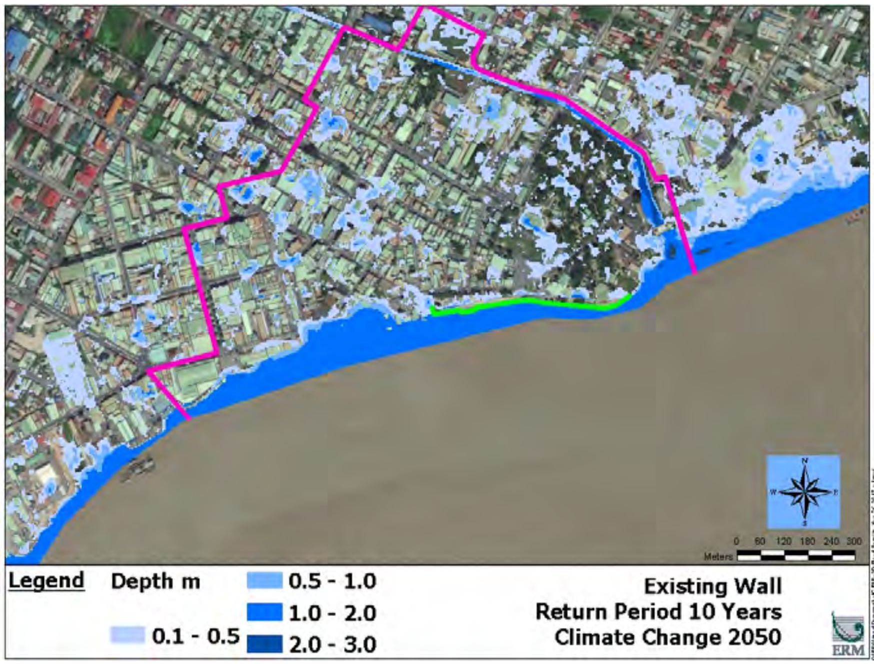


Figure A2- 11: Inland flooding inundation map of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-year return period

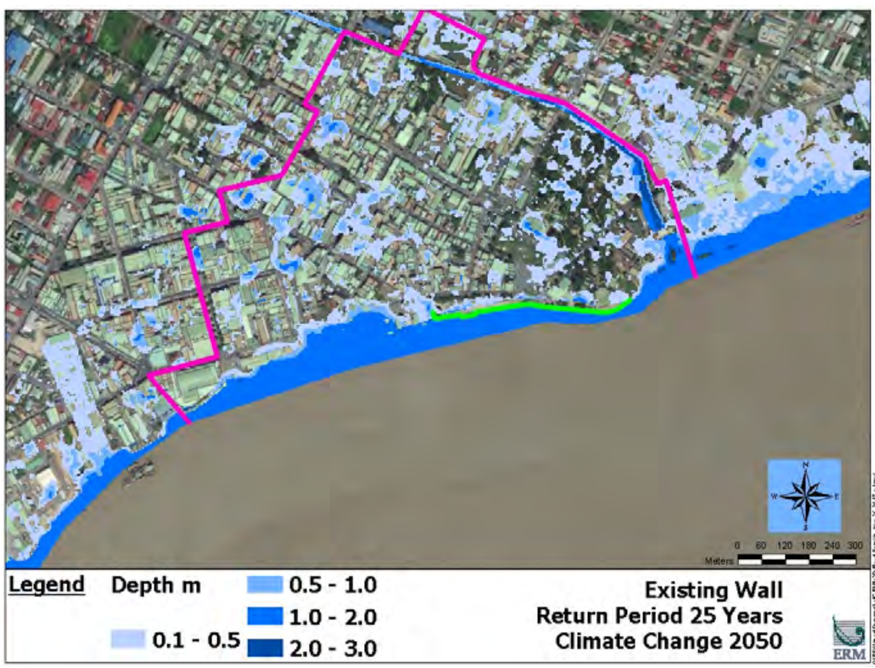


Figure A2- 12: Inland flooding inundation map of the Study Area with the existing flood wall for the climate change 2050 scenario at 25-year return period

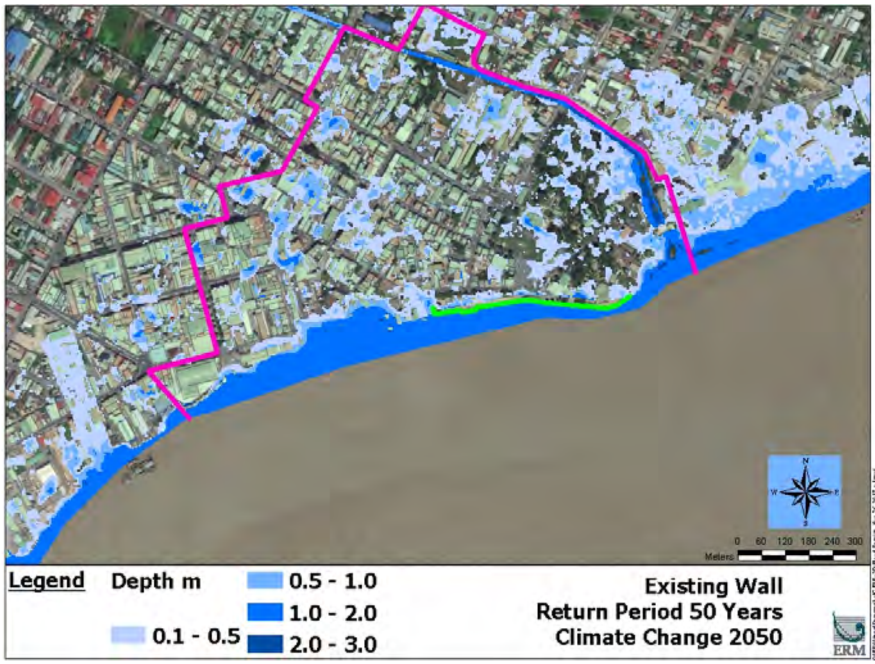


Figure A2- 13: Inland flooding inundation map of the Study Area with the existing flood wall for the climate change 2050 scenario at 50-year return period

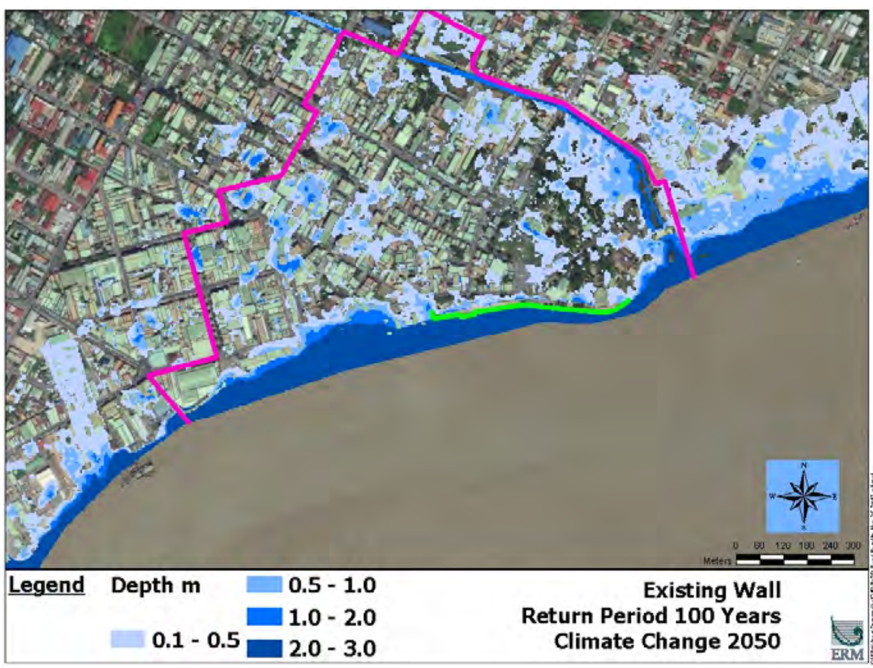


Figure A2- 14: Inland flooding inundation map of the Study Area with the existing flood wall for the climate change 2050 scenario at 100-year return period

Table A2- 3: Tabular comparison of inland flooding inundation areas of impact of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-, 25-, 50-, and 100- year return periods

Flood Inundation Depth Level, m	EW CC2050 10Y	EW CC2050 25Y	EW CC2050 50Y	EW CC2050 100Y
0.0 to 0.1	0.83482	0.77517	0.73293	0.69318
0.1 to 0.5	0.34830	0.36902	0.37381	0.37534
0.5 to 1.0	0.09286	0.12267	0.14824	0.17786
1.0 to 3.0	0.05581	0.06493	0.07682	0.08541

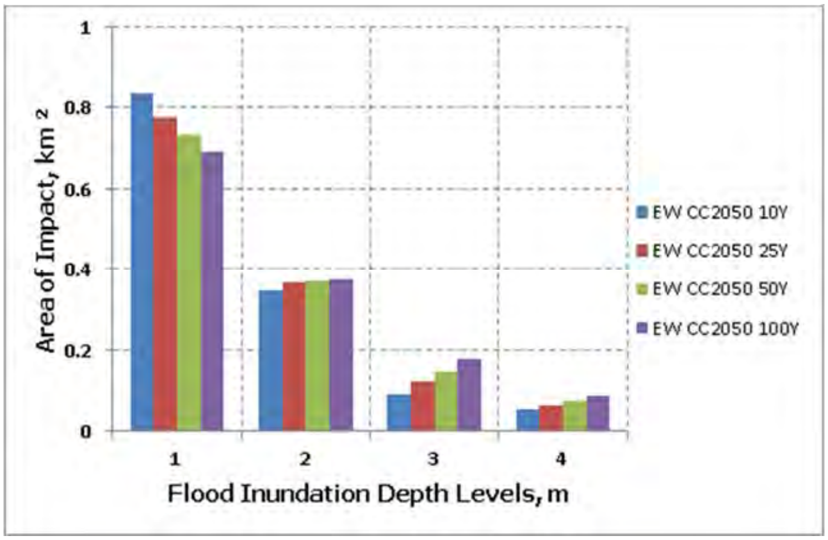


Figure A2- 15: Graphical comparison of inland flooding inundation areas of impact of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods

Figure A2- 16: Inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-year return period

Figure A2- 17: Inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2050 scenario at 25-year return period

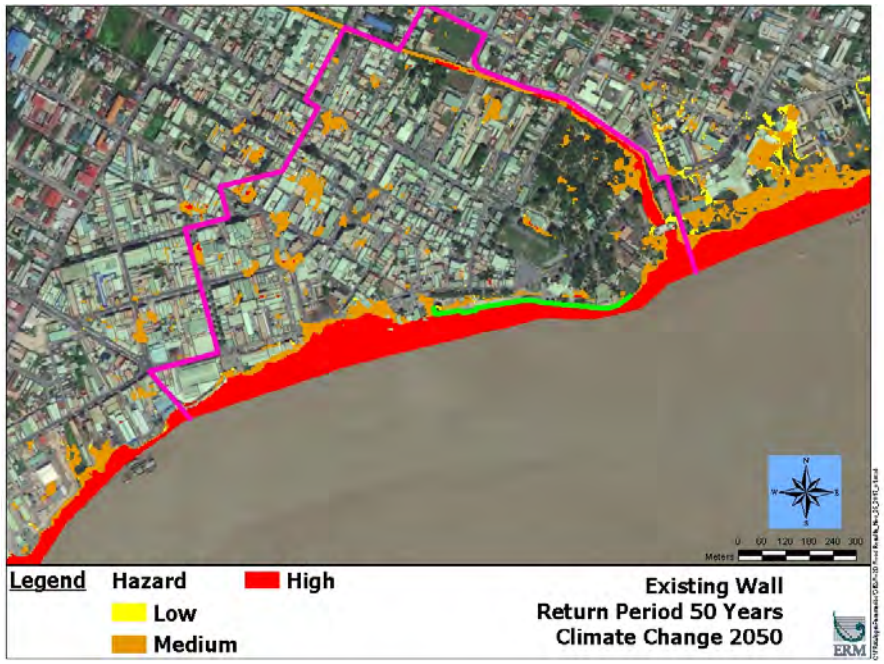


Figure A2- 18: Inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2050 scenario at 50-year return period

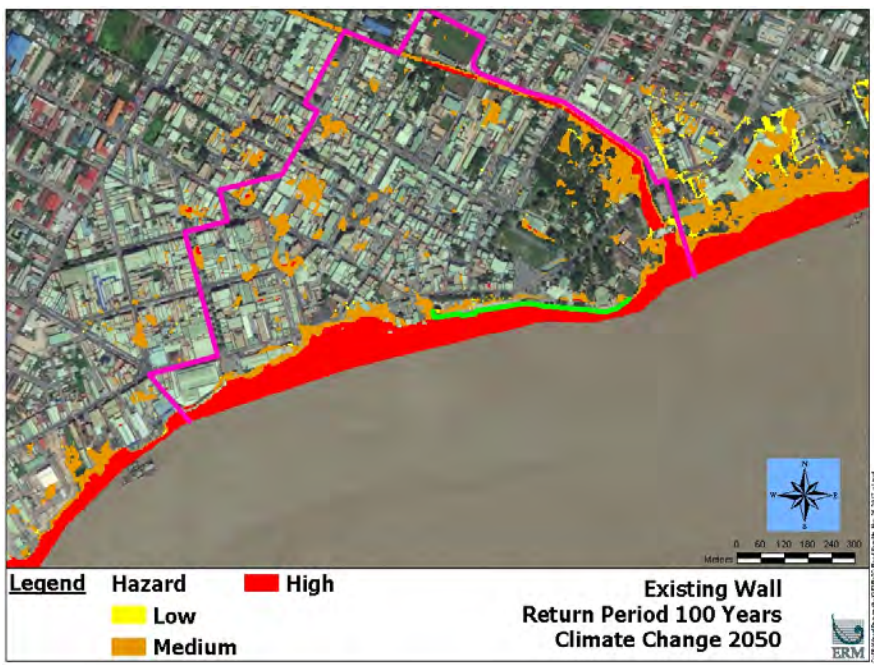


Figure A2- 19: Inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2050 scenario at 100-year return period

Table A2- 4: Tabular comparison of inland flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-, 25-, 50-, and 100- year return periods

Hazard Level	EW CC2050 10Y	EW CC2050 25Y	EW CC2050 50Y	EW CC2050 100Y
Low	0.00696	0.01122	0.01450	0.01659
Medium	0.11574	0.15075	0.18416	0.21861
High	0.03267	0.03688	0.04083	0.04445

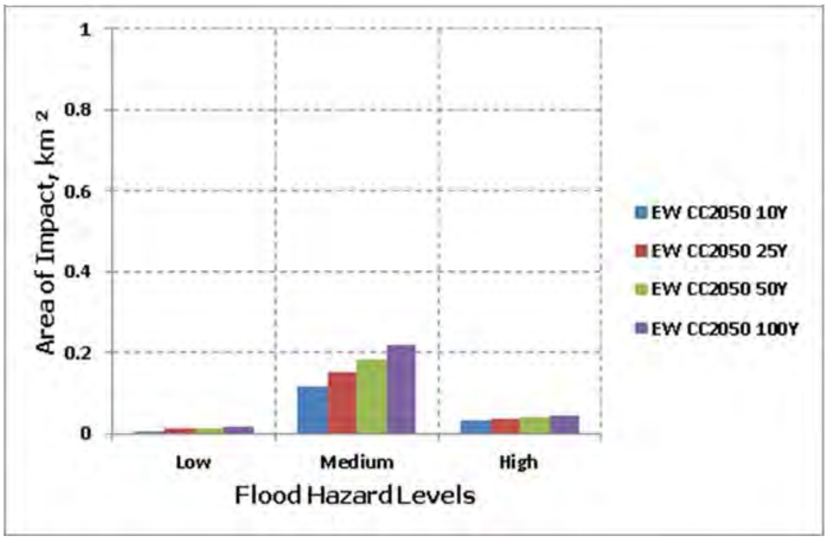


Figure A2- 20: Graphical comparison of inland flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods

The FLO-2D model predicted inland flooding inundation of the Study Area with the existing flood wall for the climate change 2080 scenario is shown in Figure A2- 21 to Figure A2- 24 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table A2- 5 and graphed in Figure A2- 25. The corresponding flooding hazard maps are shown in Figure A2- 26 to Figure A2- 29 for 10-, 25-, 50-, and 100- year return periods. The areas of impact at various flooding hazard levels for the same scenario are listed in Table A2- 6 and presented in Figure A2- 30. The 24-hour maximum precipitation applied in the Study Area for this set of FLO-2D model simulations were 155 mm, 182 mm and 222 mm for 10-, 25-, 50-, and 100-year return periods, respectively.

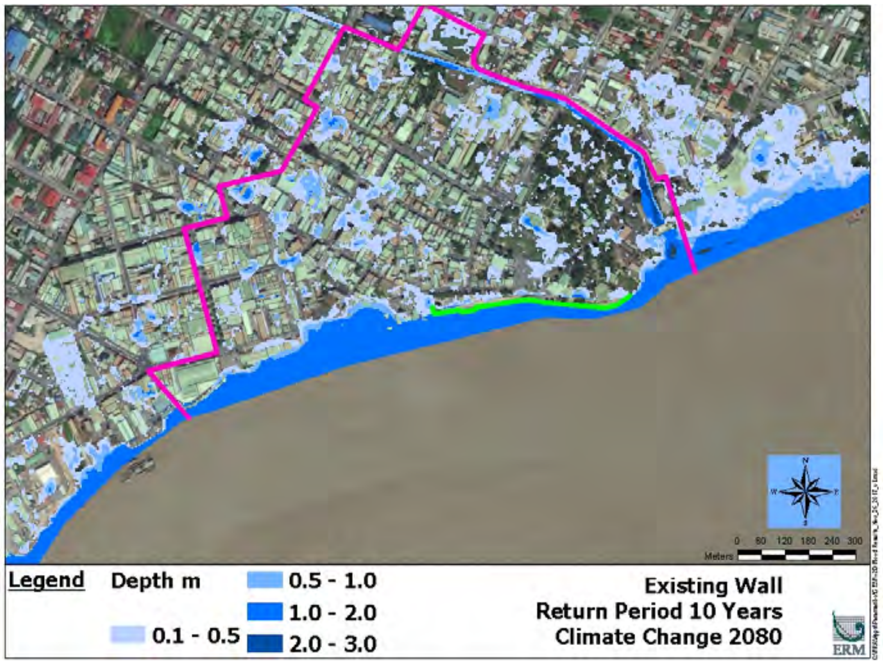


Figure A2- 21: Inland flooding inundation map of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-year return period

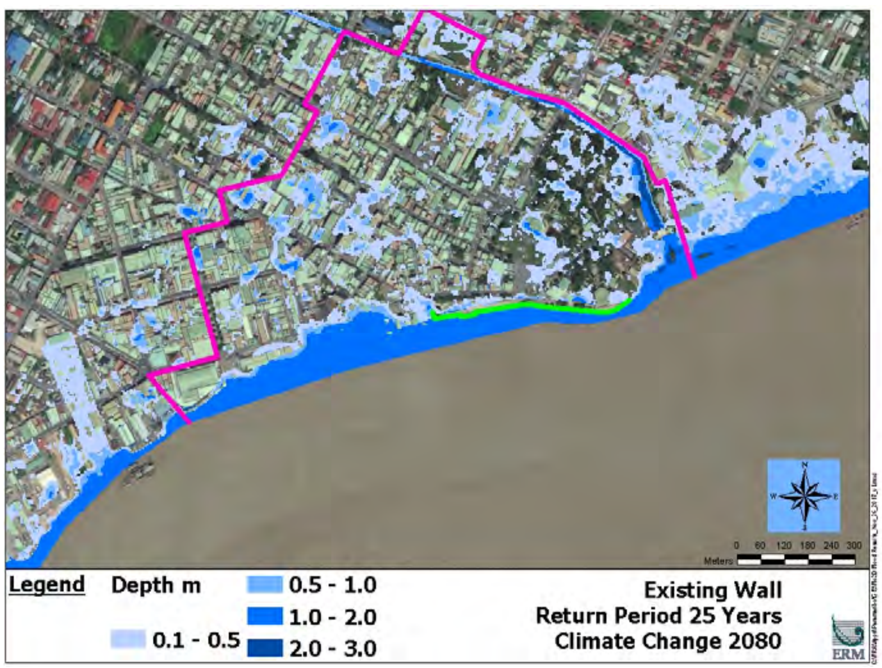


Figure A2- 22: Inland flooding inundation map of the Study Area with the existing flood wall for the climate change 2080 scenario at 25 year return period

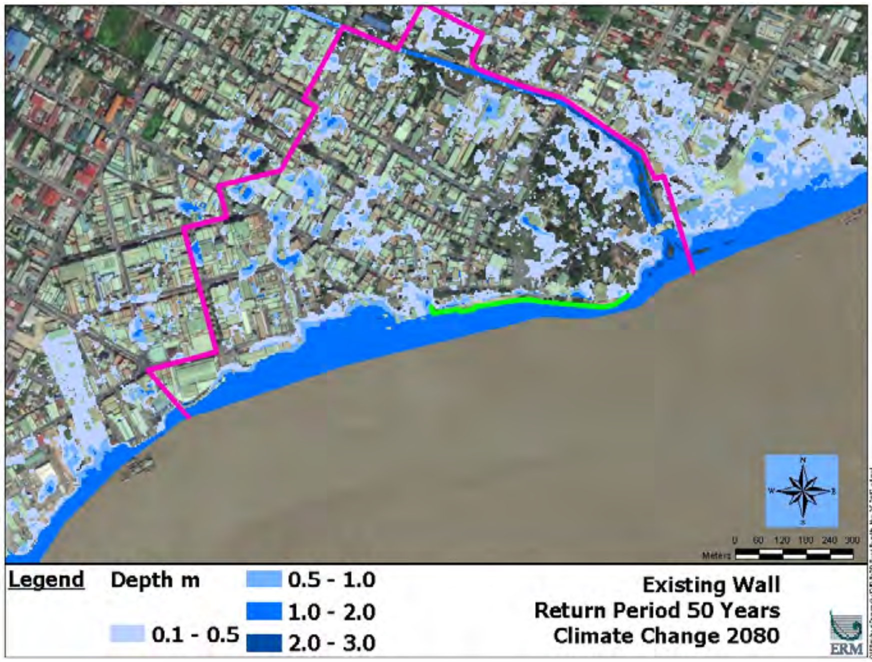


Figure A2- 23: Inland flooding inundation map of the Study Area with the existing flood wall for the climate change 2080 scenario at 50-year return period

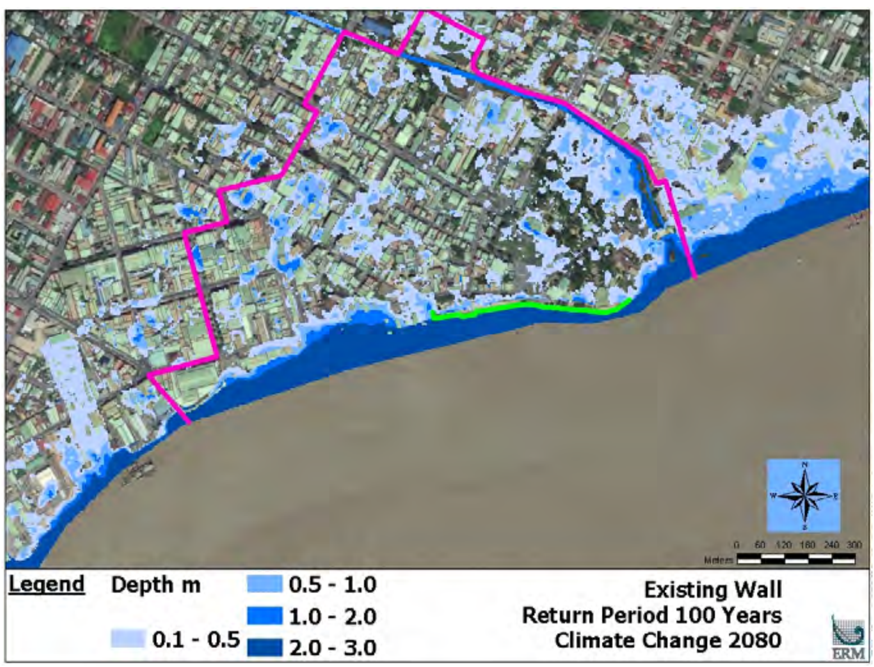


Figure A2- 24: Inland flooding inundation map of the Study Area with the existing flood wall for the climate change 2080 scenario at 100-year return period

Table A2- 5: Tabular comparison of inland flooding inundation area of impact of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	EW CC2080 10Y	EW CC2080 25Y	EW CC2080 50Y	EW CC2080 100Y
0.0 to 0.1	0.83269	0.77387	0.73181	0.69218
0.1 to 0.5	0.34904	0.36968	0.37446	0.37598
0.5 to 1.0	0.094016	0.12304	0.14840	0.17808
1.0 to 3.0	0.056048	0.06520	0.07712	0.08555

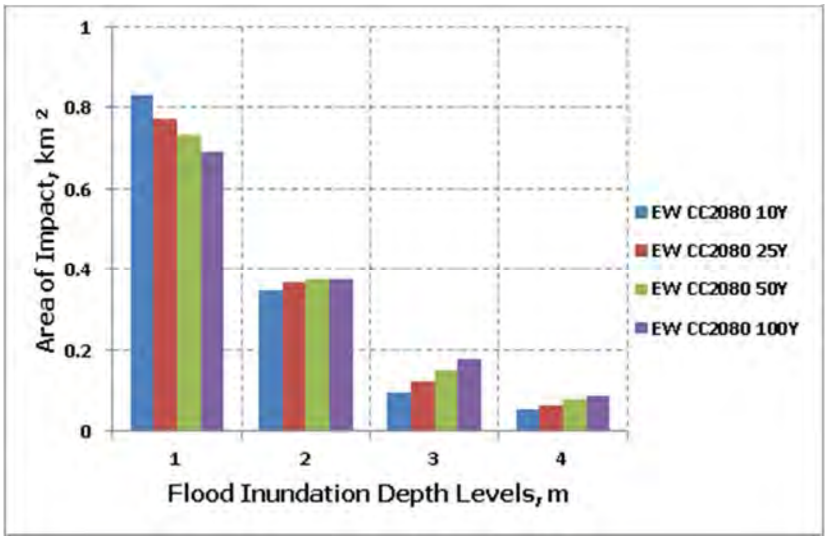


Figure A2- 25: Graphical comparison of inland flooding inundation areas of impact of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

Figure A2- 26: Inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-year return period

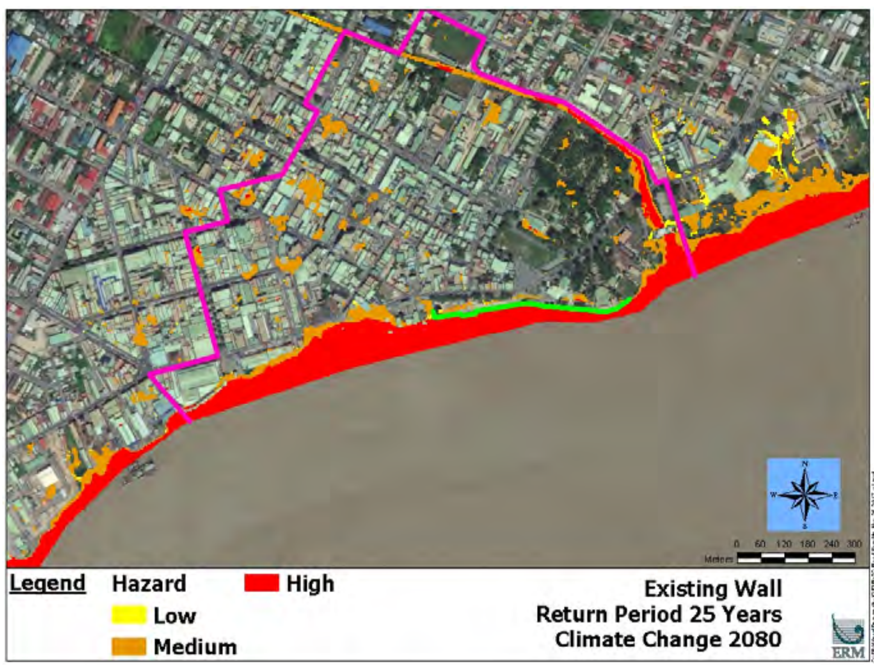


Figure A2- 27: Inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 25-year return period

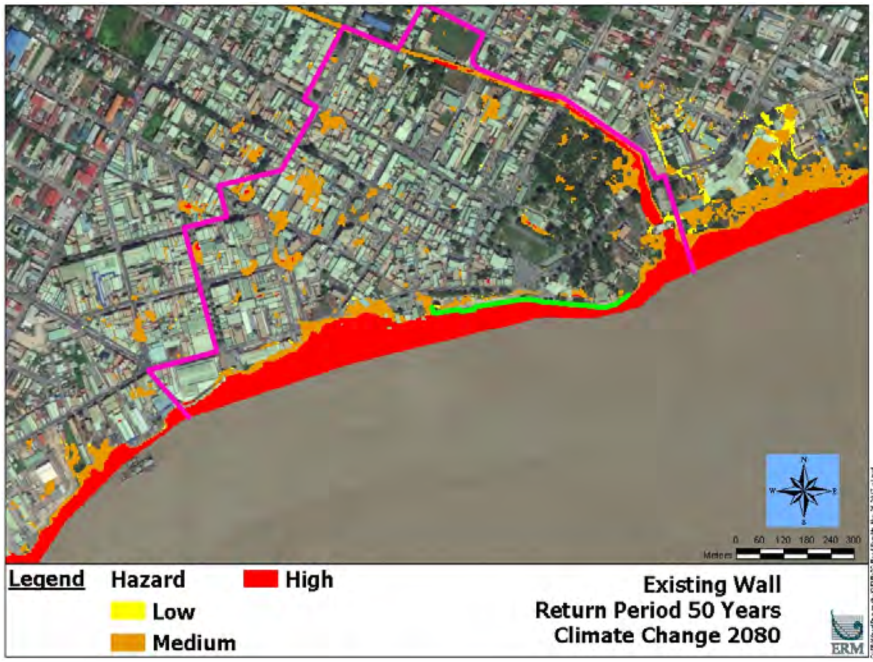


Figure A2- 28: Inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 50-year return period

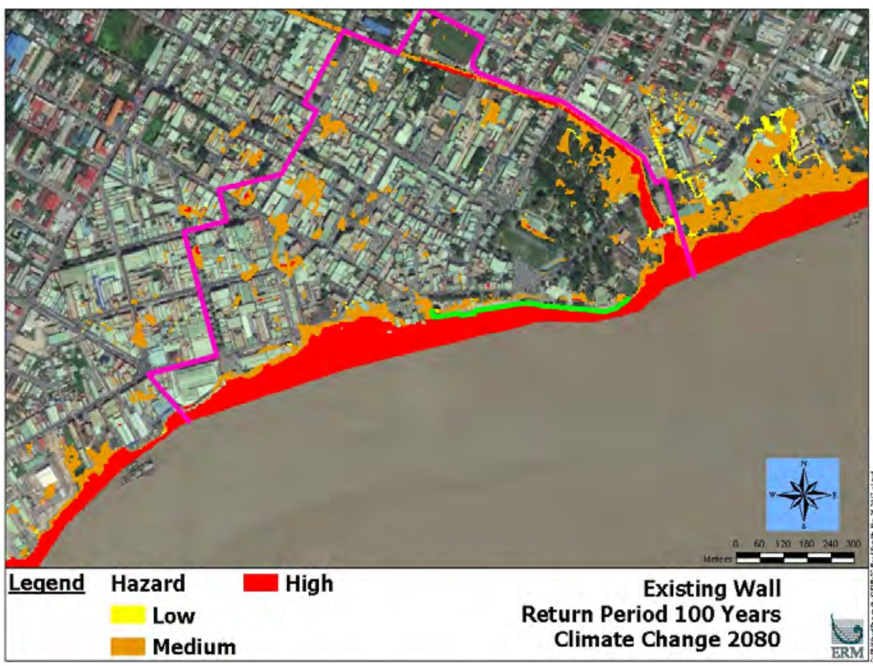


Figure A2- 29: Inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 100-year return period

Table A2- 6: Tabular comparison of inland flooding hazard area of impact of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

Hazard Level	**EW CC2080 10Y**	**EW CC2080 25Y**	**EW CC2080 50Y**	**EW CC2080 100Y**
Low	0.00694	0.01122	0.01453	0.01648
Medium	0.11723	0.15112	0.18446	0.21899
High	0.03269	0.03690	0.04090	0.04451

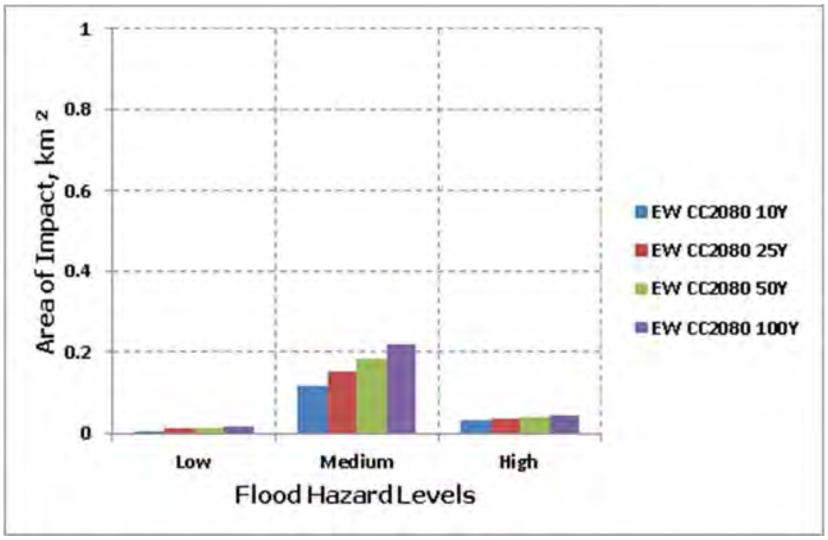


Figure A2- 30: Graphical comparison of inland flooding hazard areas of impact of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

APPENDIX B: FLO-2D COASTAL FLOODING MODEL RESULTS FOR THE PROPOSED FLOOD WALLS (ALTERNATIVE 2 AND 3)

A series of alternative conceptual designs were identified to control and minimize flooding in the Study Area and were discussed in detail in a report submitted to IDB on Paramaribo Phase 1 Alternative Selection. Alternative 2 and 3 described in the report were related to the flood wall conceptual design framework as identified in the proposal. These two alternatives were modeled as levees in the FLO-2D model along with the existing flood wall as shown in Figure B -1 **Error! Reference source not found.**. The same set of baseline and climate change scenarios were run for the 10-, 25-, 50- and 100-year return periods by including both the alternatives instead of running them as individual scenarios.

The FLO-2D model predicted coastal flooding inundation of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario is shown in Figure B- 1 to Figure B- 5 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table B- 1 and presented in Figure B- 6. The corresponding flooding hazard maps were shown in Figure B- 7 to Figure B- 10 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding hazard levels for the same scenario are listed in Table B- 2 and presented in Figure B- 11. The HHWLs applied along the Suriname River adjacent to the Study Area during FLO-2D model simulations were 2.02 m, 2.13 m, 2.21 m and 2.27 m for 10-, 25-, 50-, and 100-year return periods, respectively.

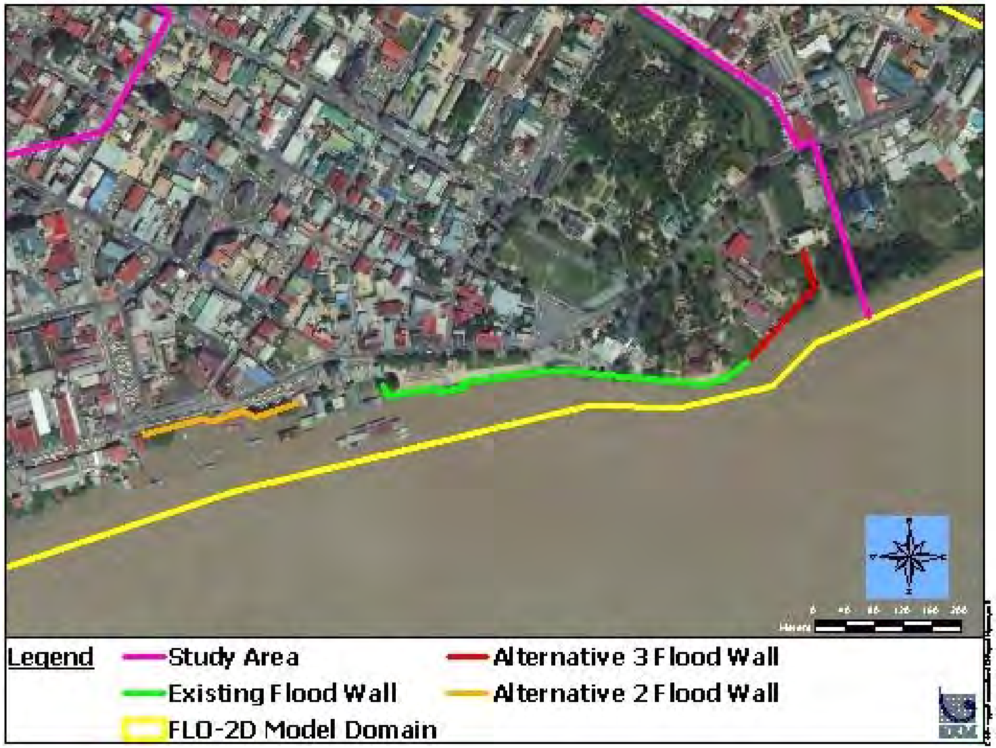


Figure B- 1: Alternative 2 and 3 conceptual design layouts on either side of the existing flood wall

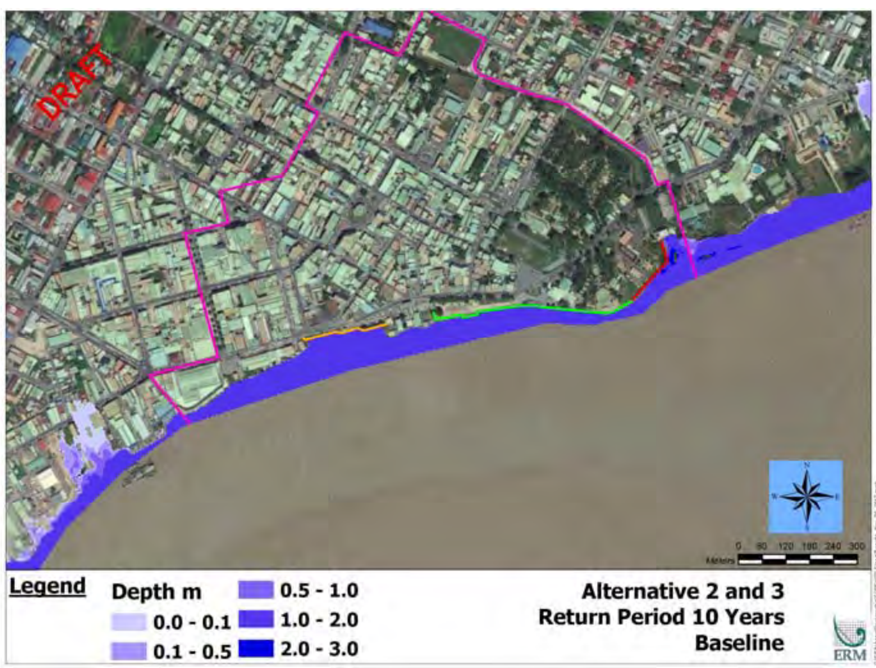


Figure B- 2: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for baseline scenario at 10-year return period

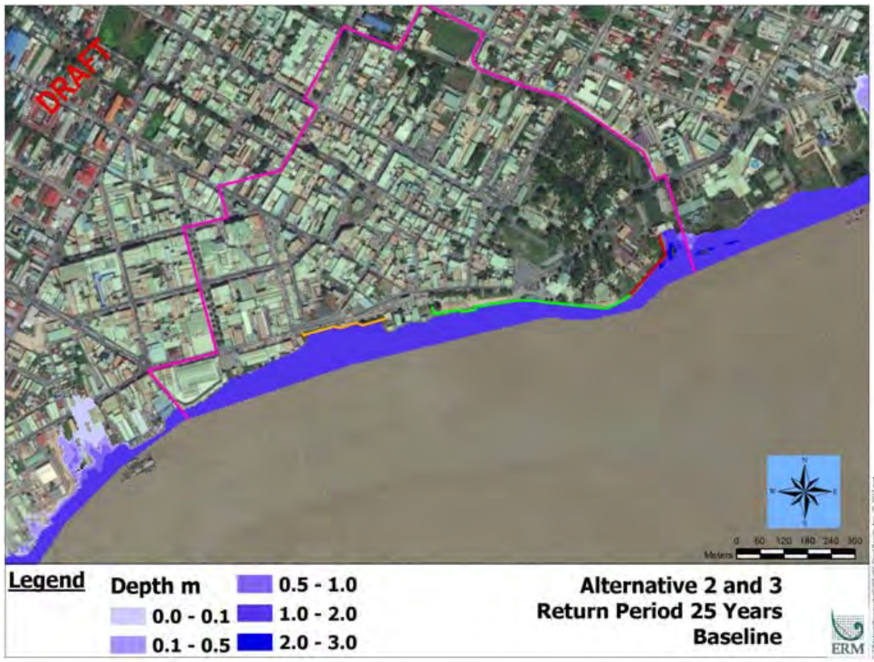


Figure B- 3: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 25-year return period

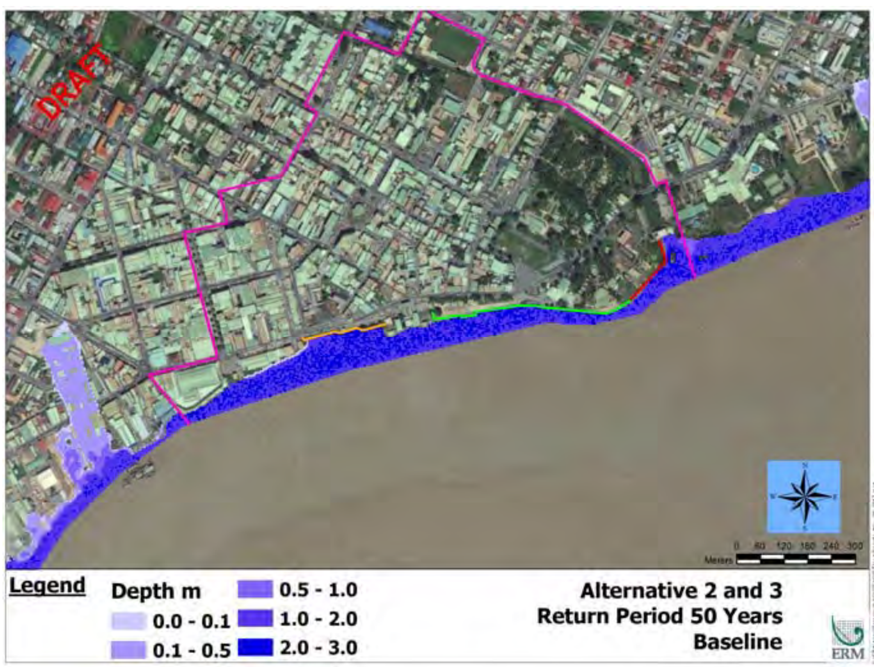


Figure B- 4: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 50-year return period

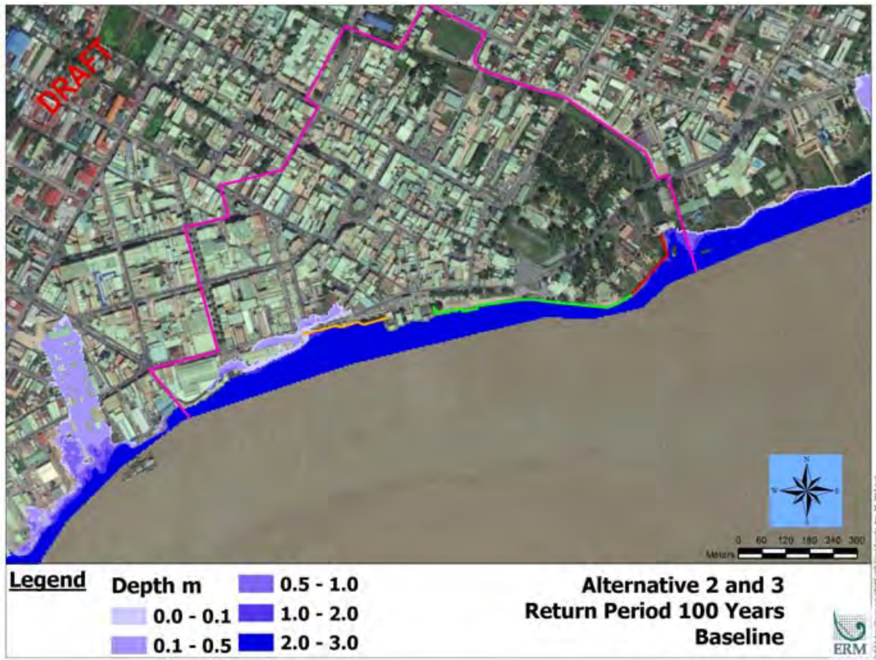


Figure B- 5: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 100-year return period

Table B- 1: Tabular comparison of coastal flooding inundation areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Alt 23 Base 10Y	Alt 23 Base 25Y	Alt 23 Base 50Y	Alt 23 Base 100Y
0.0 to 0.1	0.026512	0.026512	0.019824	0.02896
0.1 to 0.5	0.06888	0.06888	0.10688	0.115664
0.5 to 1.0	0.015488	0.015488	0.026048	0.032192
1.0 to 3.0	0.032688	0.032688	0.035632	0.036624

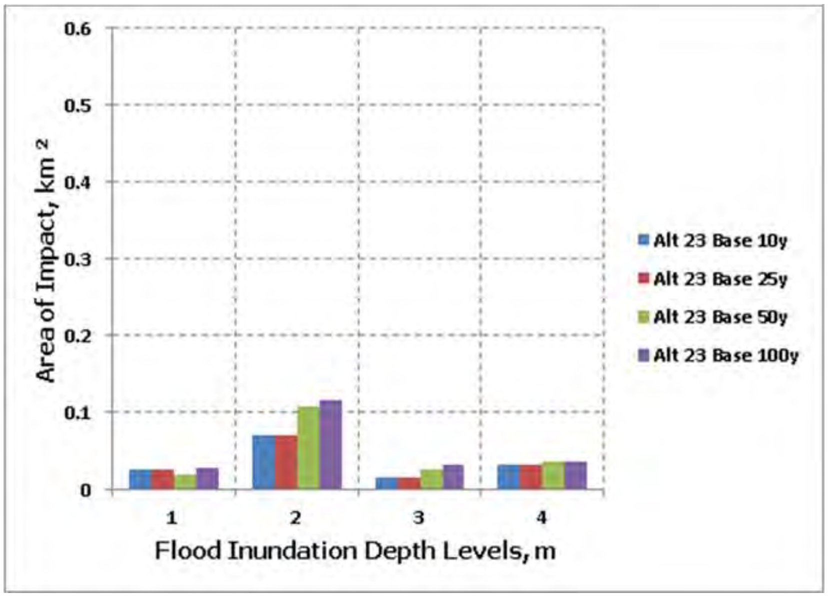


Figure B- 6: Graphical comparison of coastal flooding inundation areas of impact of the Study Area with Alternative 2 and 3 conceptual designs for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

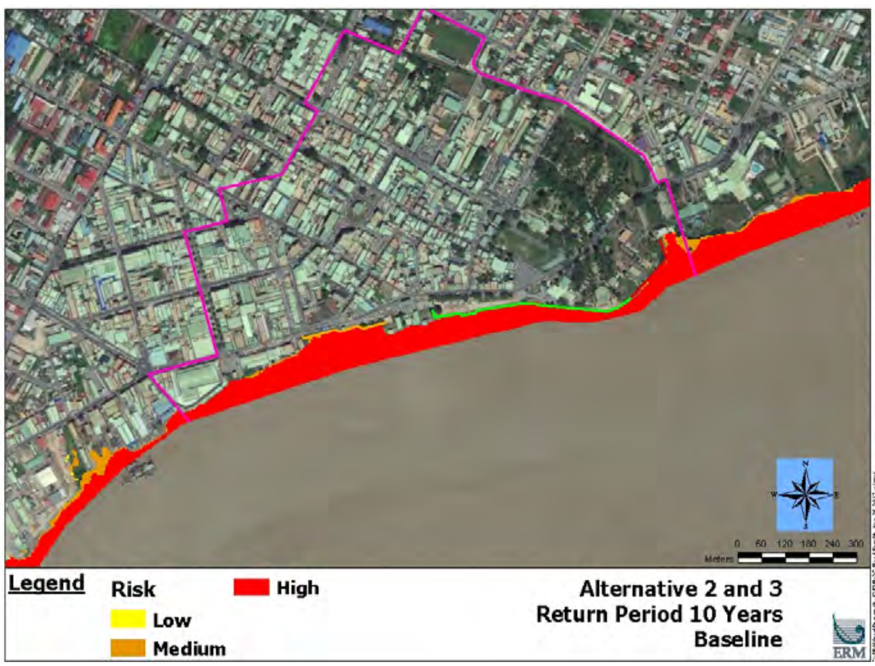


Figure B- 7: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 10-year return period

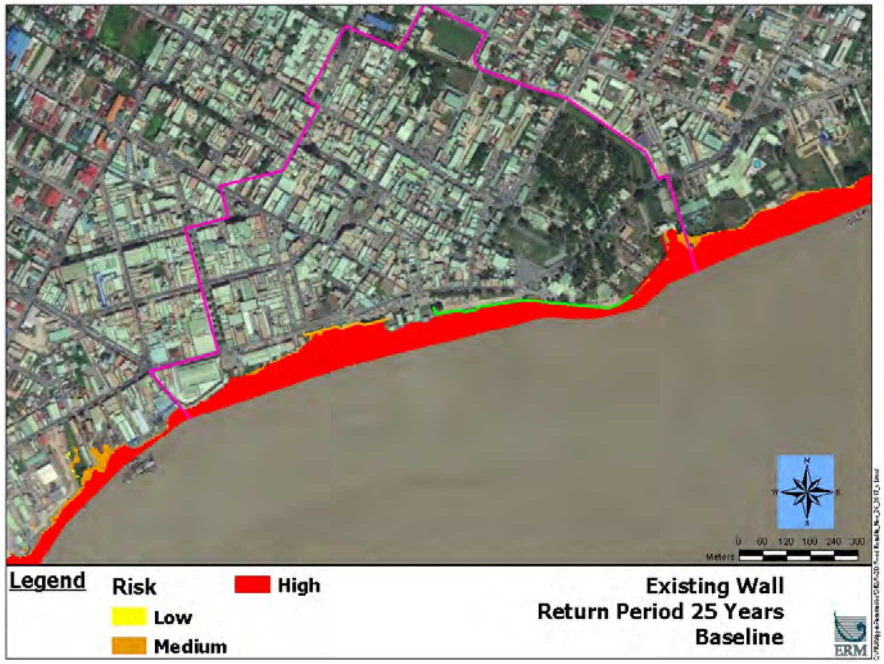


Figure B- 8: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 25-year return period

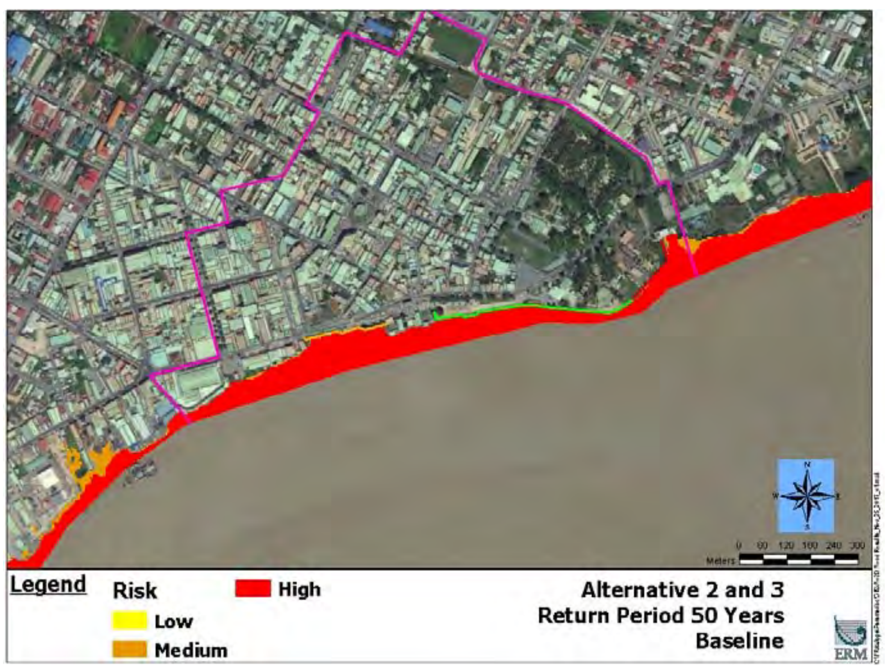


Figure B- 9: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 50-year return period

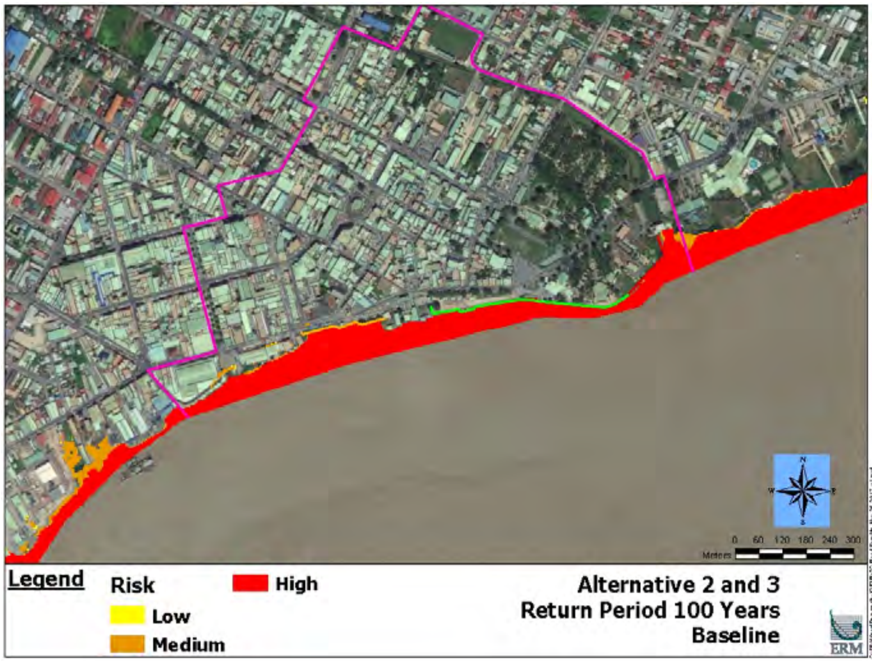


Figure B- 10: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 100-year return period

Table B- 2: Tabular comparison of coastal flooding hazard areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

Hazard Level	**Alt 23 Base 10Y**	**Alt 23 Base 25Y**	**Alt 23 Base 50Y**	**Alt 23 Base 100Y**
Low	0.00061	0.00061	0.00094	0.00117
Medium	0.02562	0.02562	0.03501	0.04075
High	0.02260	0.02260	0.02672	0.02802

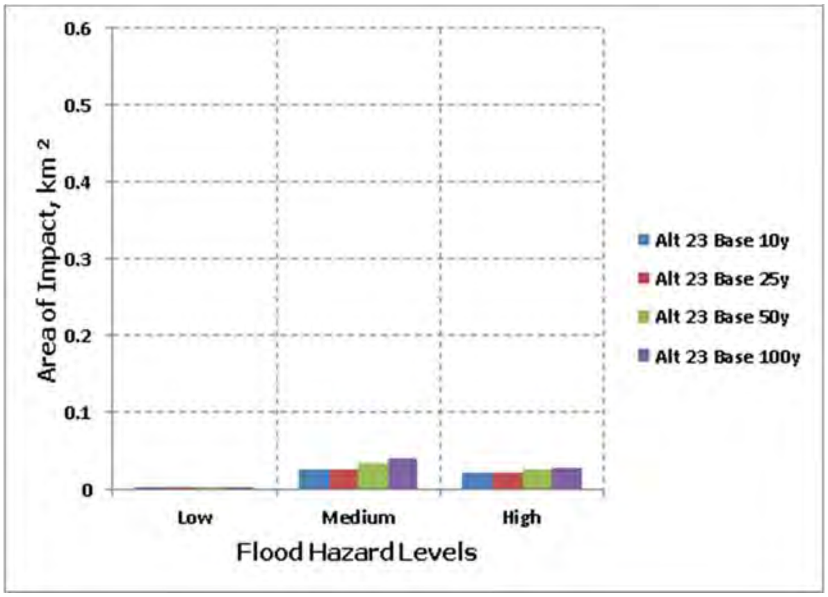


Figure B- 11: Graphical comparison of coastal flooding hazard areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

The coastal flooding inundation of the Study Area predicted by the model with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario is shown in Figure B- 12 to Figure B- 15 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table B- 3 and presented in Figure B- 16. The corresponding flooding hazard maps were shown in Figure B- 17 to Figure B- 20 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding hazard levels for the same scenario are listed in Table B- 4 and presented in Figure B- 21. The HHWLs applied along the Suriname River adjacent to the Study Area during FLO-2D model simulations were 2.11 m, 2.22 m, 2.30 m and 2.36 m for 10-, 25-, 50-, and 100-year return periods, respectively.

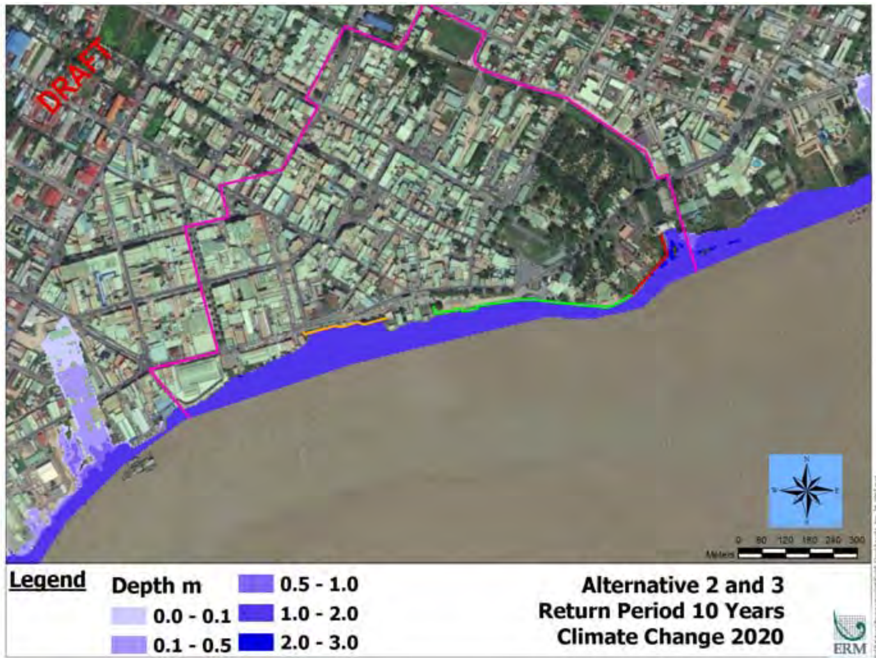


Figure B- 12: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 10-year return period

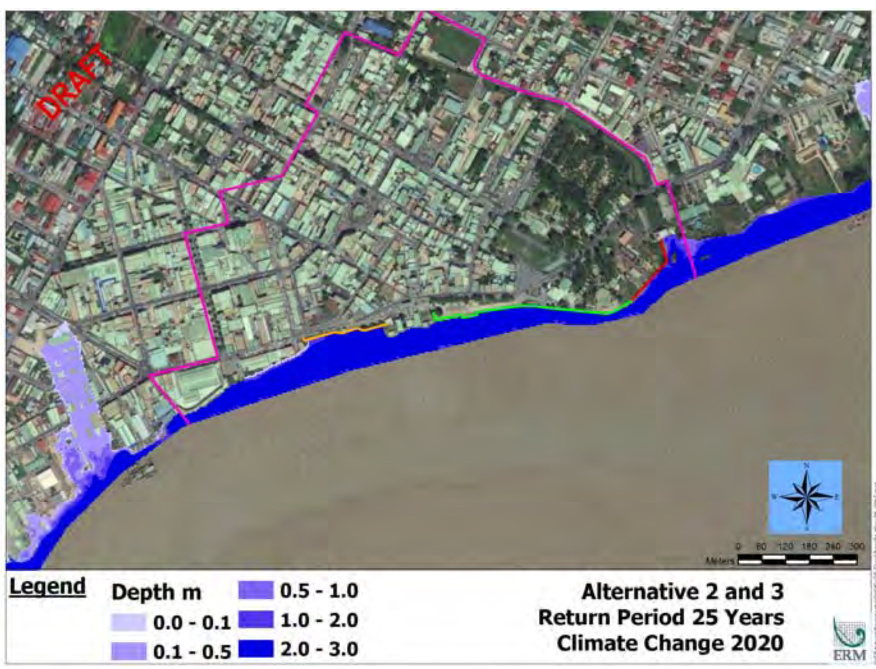


Figure B- 13: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 25-year return period

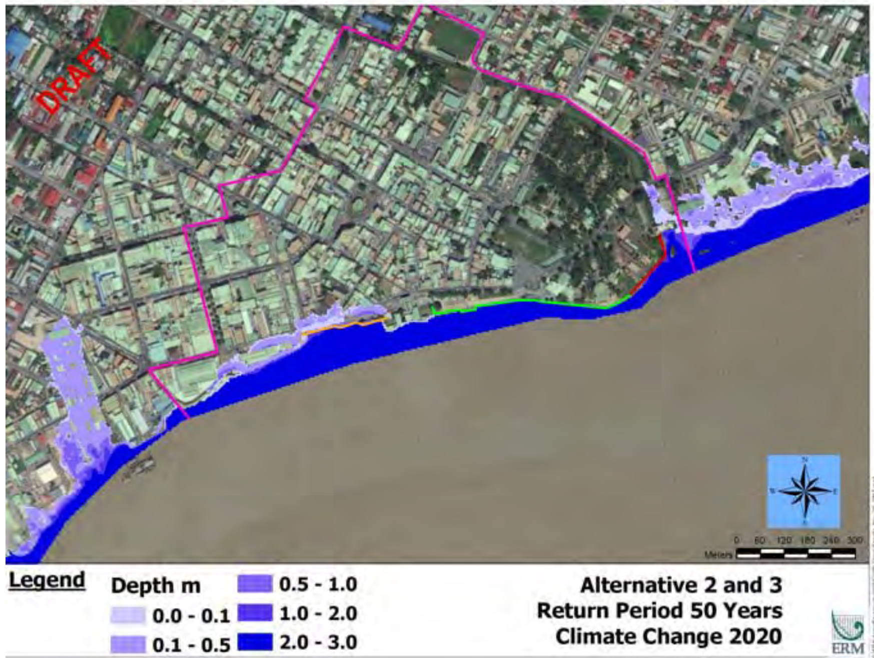


Figure B- 14: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 50-year return period

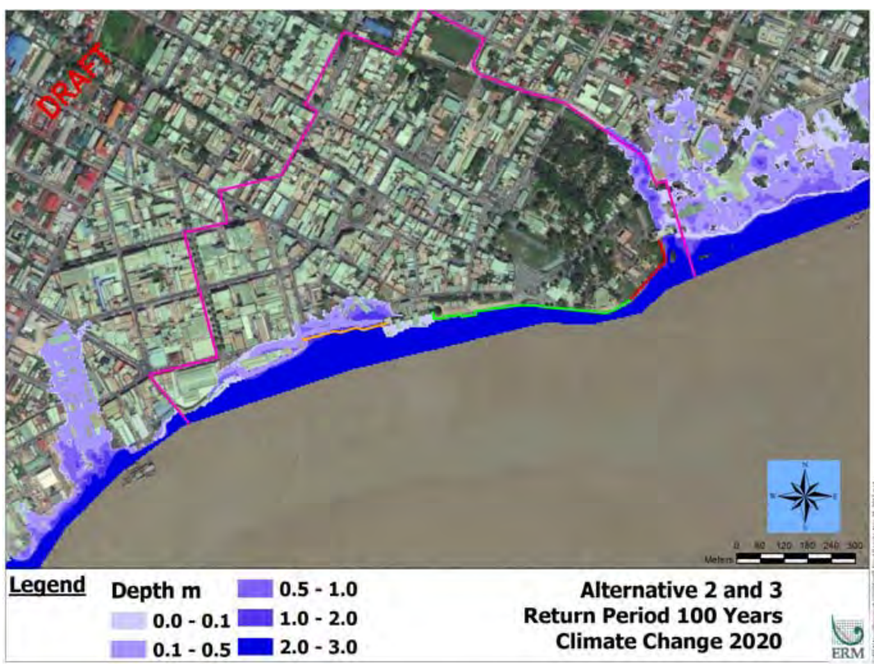


Figure B- 15: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 100-year return period

Table B- 3: Tabular comparison of coastal flooding inundation areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Alt23 CC2020 10Y	Alt23 CC2020 25Y	Alt23 CC2020 50Y	Alt23 CC2020 100Y
0.0 to 0.1	0.02501	0.01957	0.04661	0.05930
0.1 to 0.5	0.09400	0.10771	0.14674	0.19387
0.5 to 1.0	0.01978	0.02678	0.04208	0.06958
1.0 to 3.0	0.03390	0.03574	0.03733	0.04346

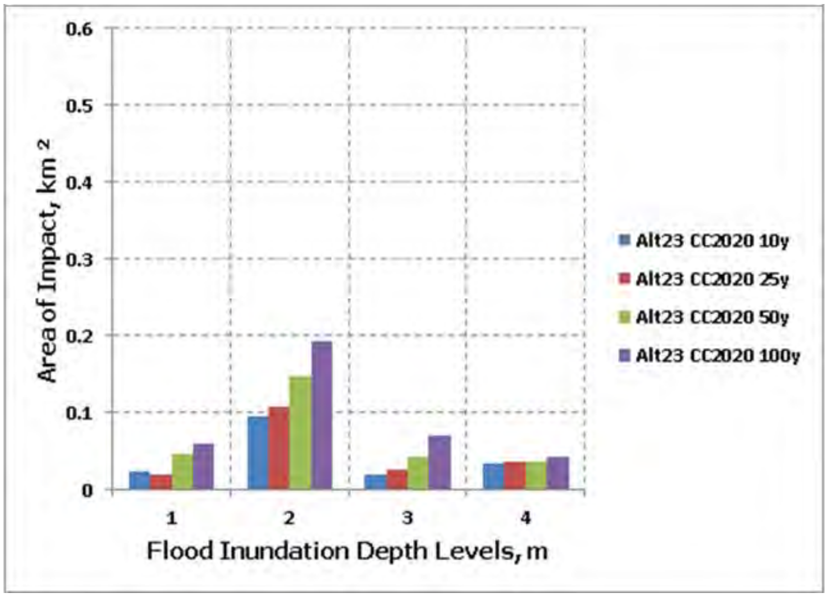


Figure B- 16: Graphical comparison of coastal flooding inundation areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change scenario 2020 at 10-, 25-, 50-, and 100-year return periods

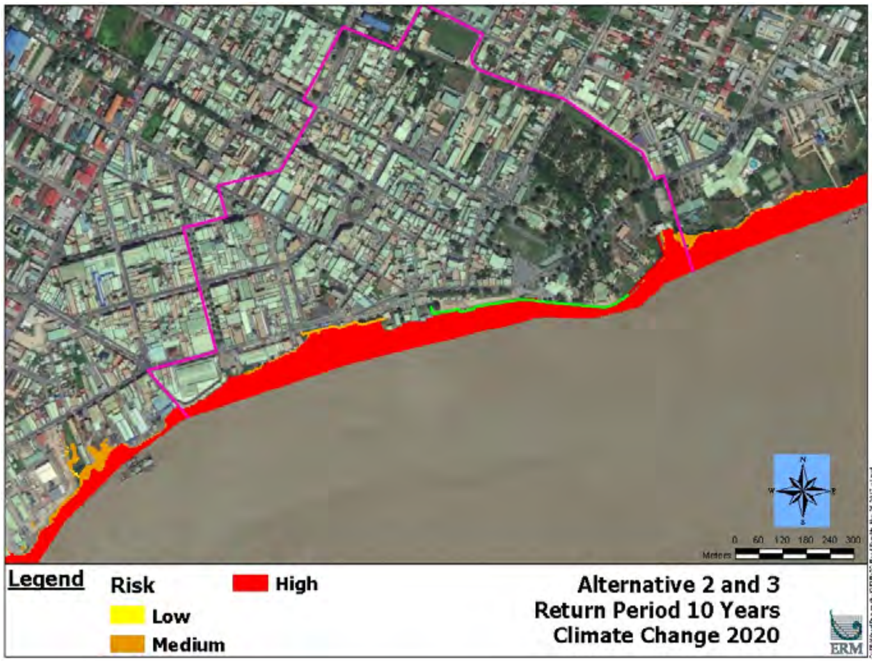


Figure B- 17: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 10-year return period

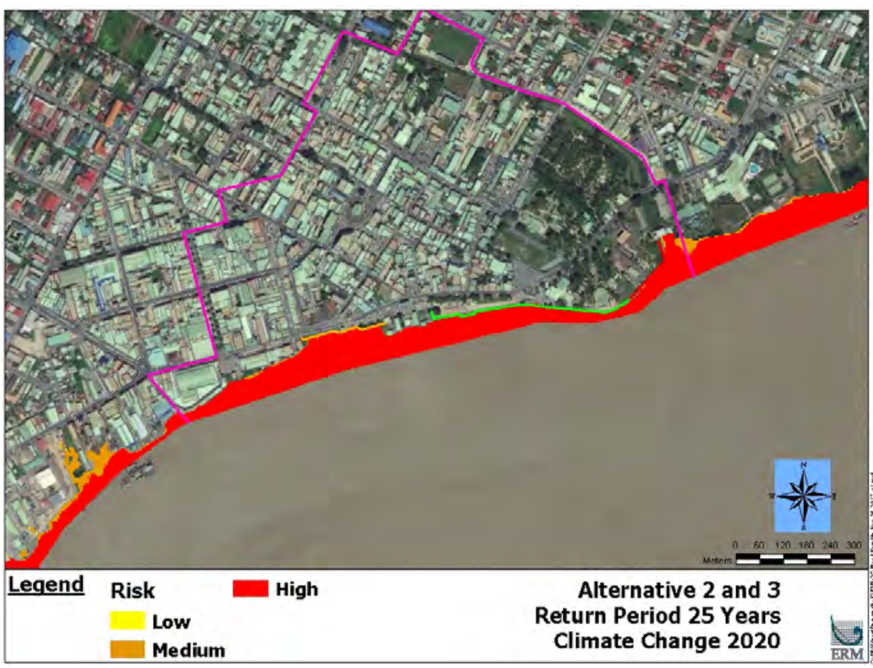


Figure B- 18: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 25-year return period

Figure B- 19: Coastal flooding hazard map for the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 50-year return period

Figure B- 20: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 100-year return period

Table B- 4: Tabular comparison of coastal flooding hazard areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods

Hazard Level	Alt23 CC2020 10Y	Alt23 CC2020 25Y	Alt23 CC2020 50Y	Alt23 CC2020 100Y
Low	0.00088	0.00097	0.00174	0.00682
Medium	0.02928	0.03558	0.05069	0.08142
High	0.02445	0.02699	0.02864	0.03155

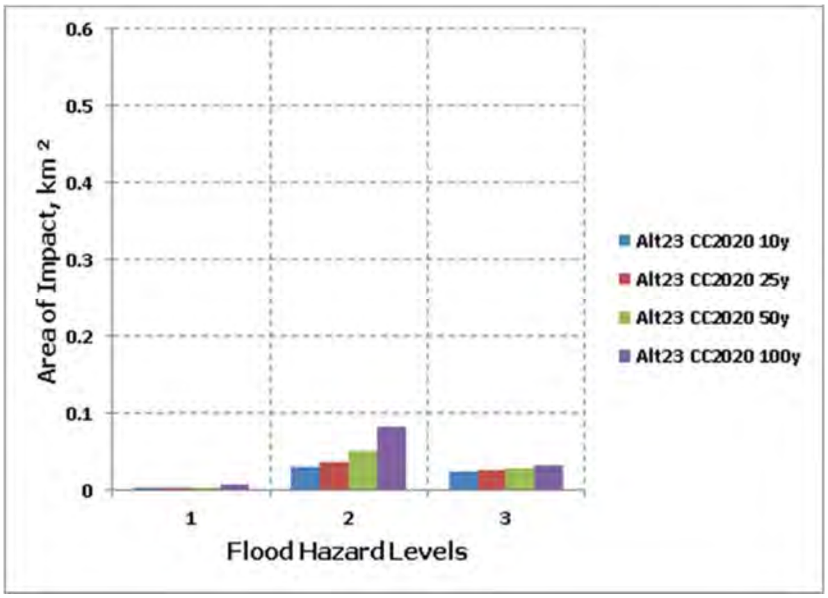


Figure B- 21: Graphical comparison of coastal flooding hazard areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2020 scenario at 10-, 25-, 50-, and 100-year return periods

The coastal flooding inundation of the Study Area predicted by the model with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario is shown in Figure B- 22 to Figure B- 25 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are listed in Table B- 5 and presented in Figure B- 26. The corresponding flooding hazard maps are shown in Figure B- 28 to Figure B- 30 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding hazard levels for the same scenario are listed in Table B- 6 and presented in Figure B- 31. The HHWLs applied along the Suriname River adjacent to the Study Area during FLO-2D model simulations were 2.35 m, 2.46 m, 2.54 m and 2.60 m for 10-, 25-, 50-, and 100-year return periods, respectively.

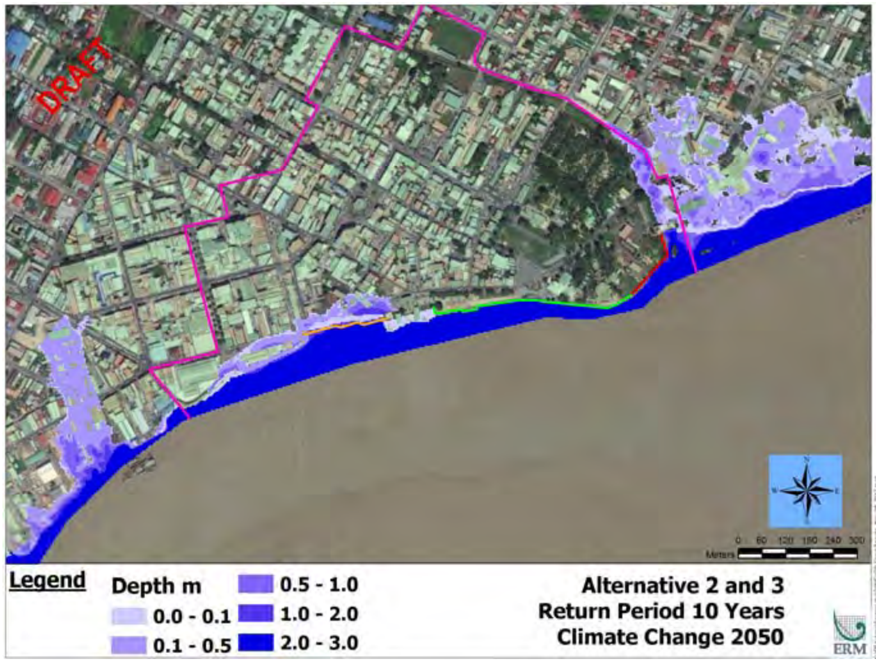


Figure B- 22: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 10-year return period

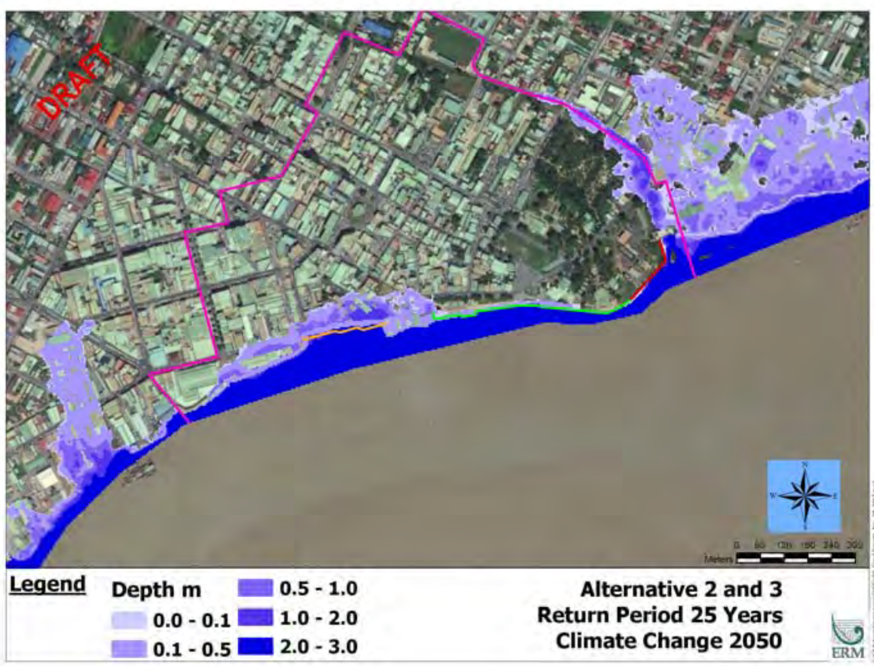


Figure B- 23: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 25-year return period

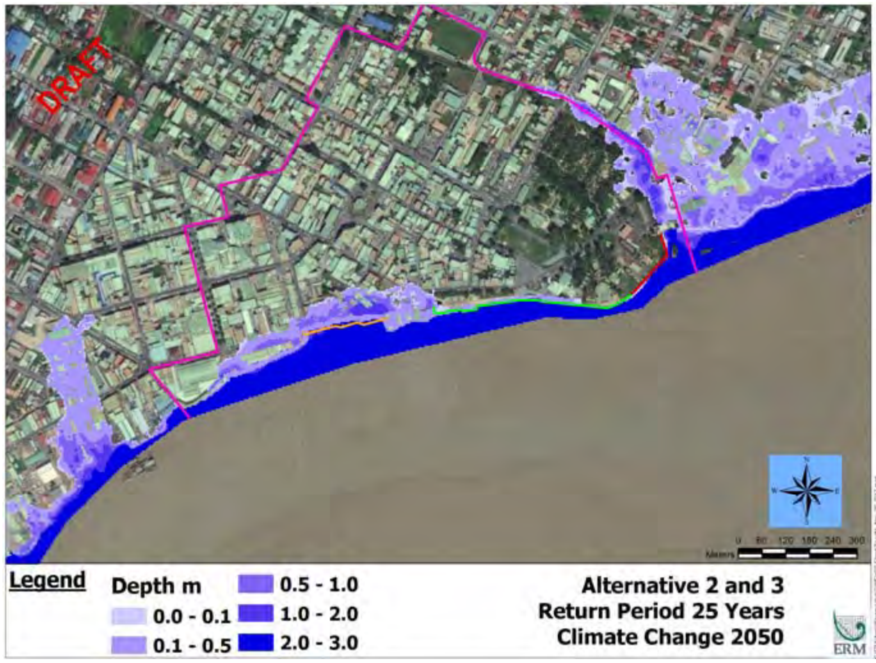


Figure B- 24: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 50-year return period

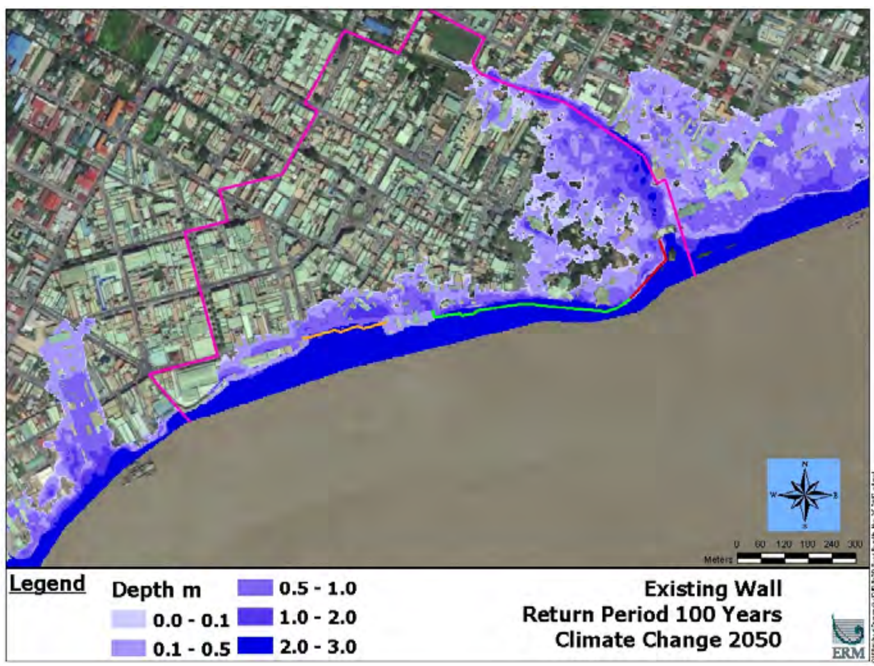


Figure B- 25: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 100-year return period

Table B- 5: Tabular comparison of coastal flooding inundation areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Alt23 CC2050 10Y	Alt23 CC2050 25Y	Alt23 CC2050 50Y	Alt23 CC2050 100Y
0.0 to 0.1	0.06195	0.04597	0.03813	0.03706
0.1 to 0.5	0.18584	0.22030	0.20274	0.19580
0.5 to 1.0	0.06354	0.11976	0.15886	0.18206
1.0 to 3.0	0.04208	0.05224	0.06674	0.07962

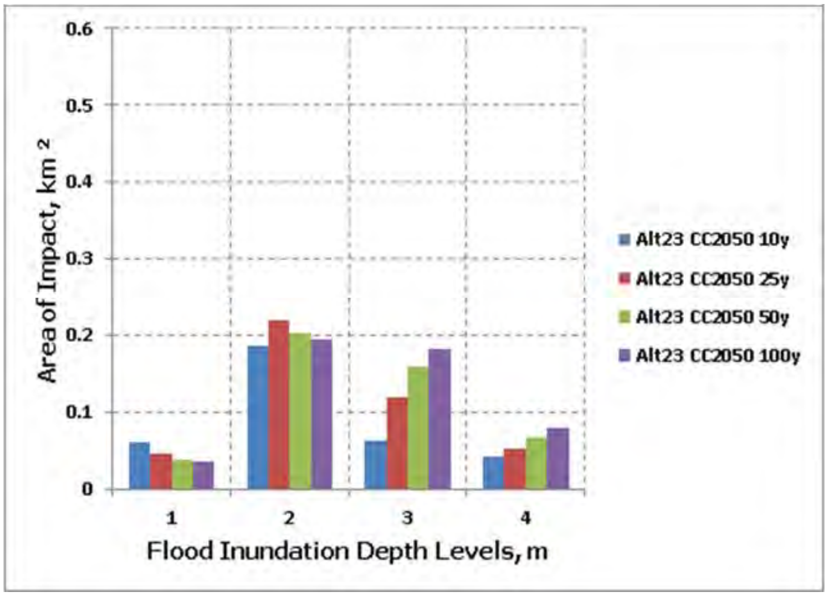


Figure B- 26: Graphical comparison of coastal flooding inundation areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change scenario 2050 at 10-, 25-, 50-, and 100-year return periods

Figure B- 27: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 10-year return period

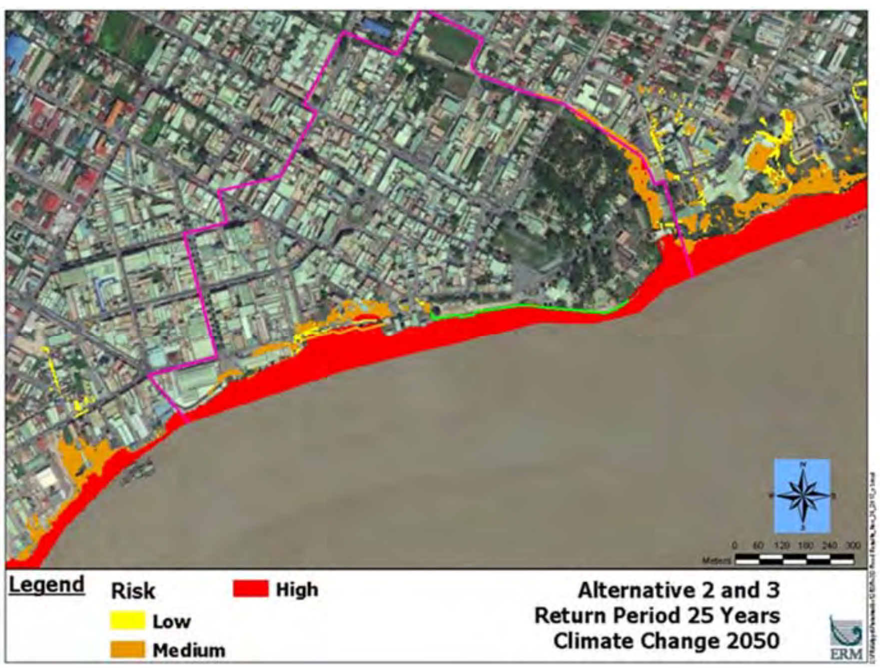


Figure B- 28: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 25-year return period

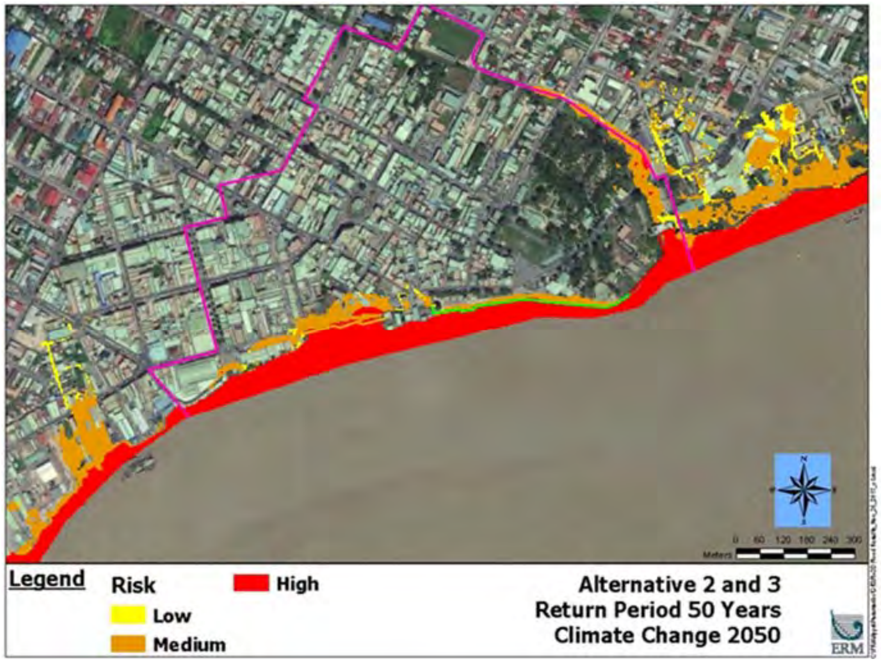


Figure B- 29: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 50-year return period

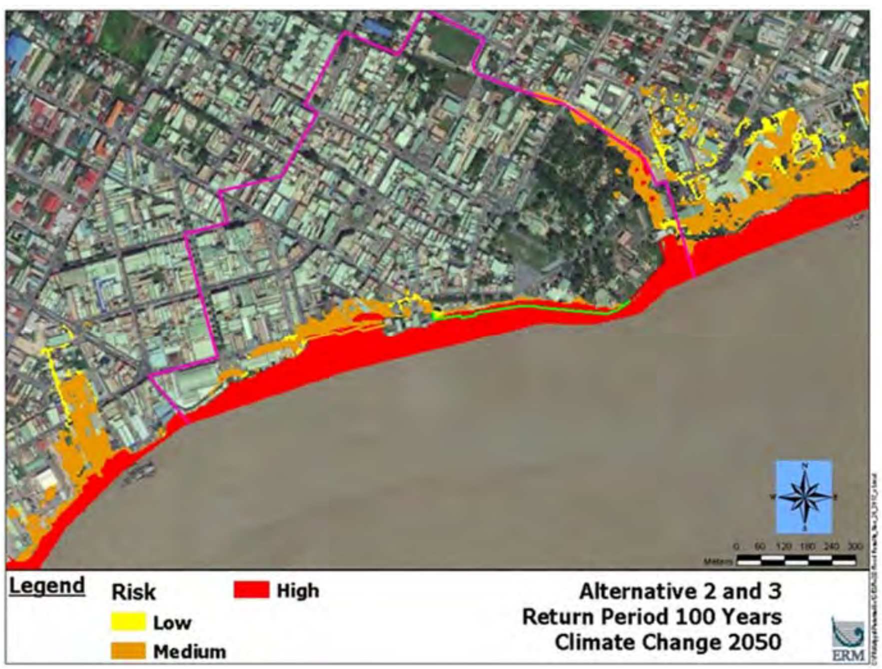


Figure B- 30: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 100-year return period

Table B- 6: Tabular comparison of coastal flooding hazard areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods

Hazard Level	Alt23 CC2050 10Y	Alt23 CC2050 25Y	Alt23 CC2050 50Y	Alt23 CC2050 100Y
Low	0.00562	0.01931	0.02520	0.03072
Medium	0.07435	0.13728	0.18837	0.21690
High	0.03122	0.03470	0.03731	0.04470

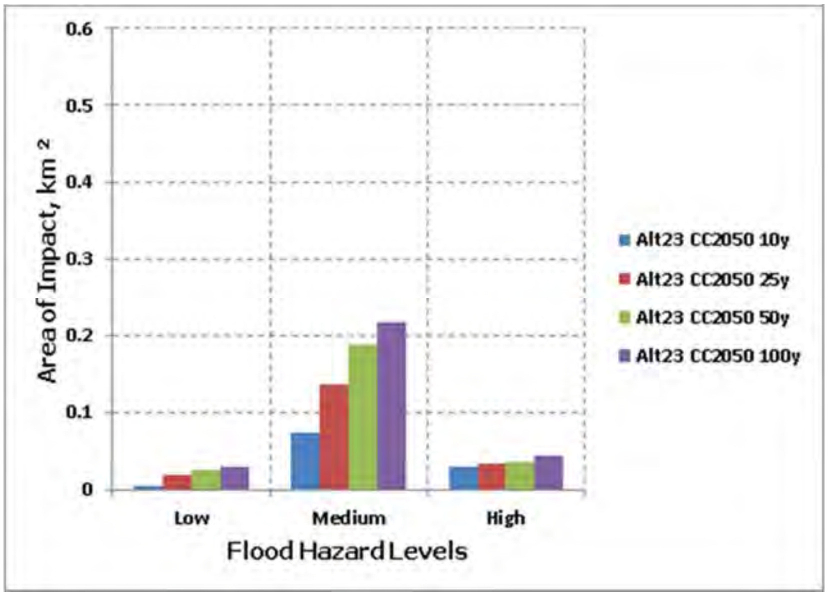


Figure B- 31: Graphical comparison of coastal flooding hazard areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2050 scenario at 10-, 25-, 50-, and 100-year return periods

The coastal flooding inundation of the Study Area predicted by the model with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario is shown in Figure B- 32 to Figure B- 35 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding inundation depth levels for the same scenario are shown in Table B- 7 and presented in Figure B- 36. The corresponding flooding hazard maps were shown in Figure B- 37 to Figure B- 40 for 10-, 25-, 50-, and 100-year return periods. The areas of impact at various flooding hazard levels for the same scenario are shown in Table B- 8 and presented in Figure B- 41. The HHWLs applied along the Suriname River adjacent to the Study Area during FLO-2D model simulation were 2.72 m, 2.83 m, 2.91m and 2.97 m for 10-, 25-, 50-, and 100-year return periods, respectively.

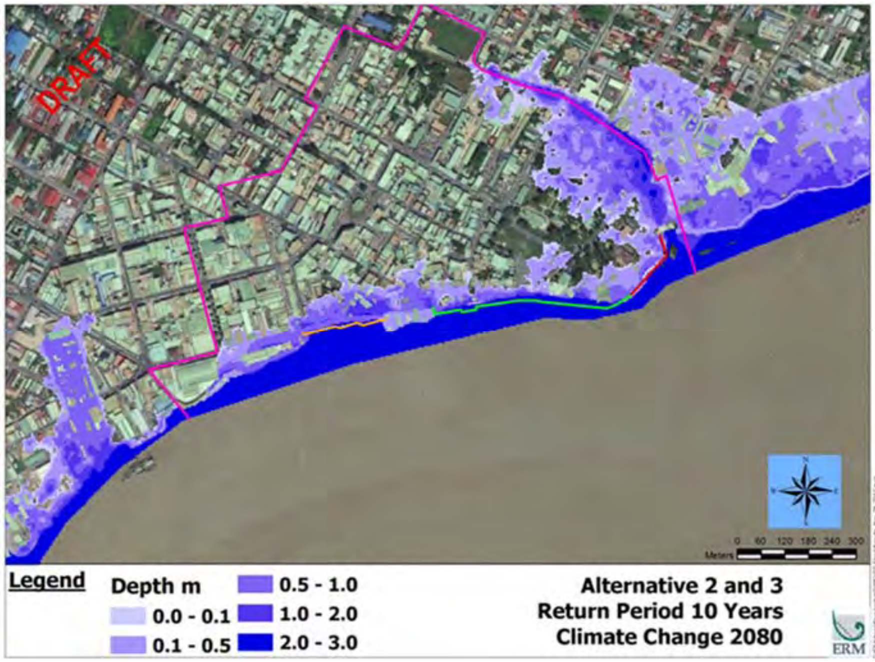


Figure B- 32: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 10-year return period

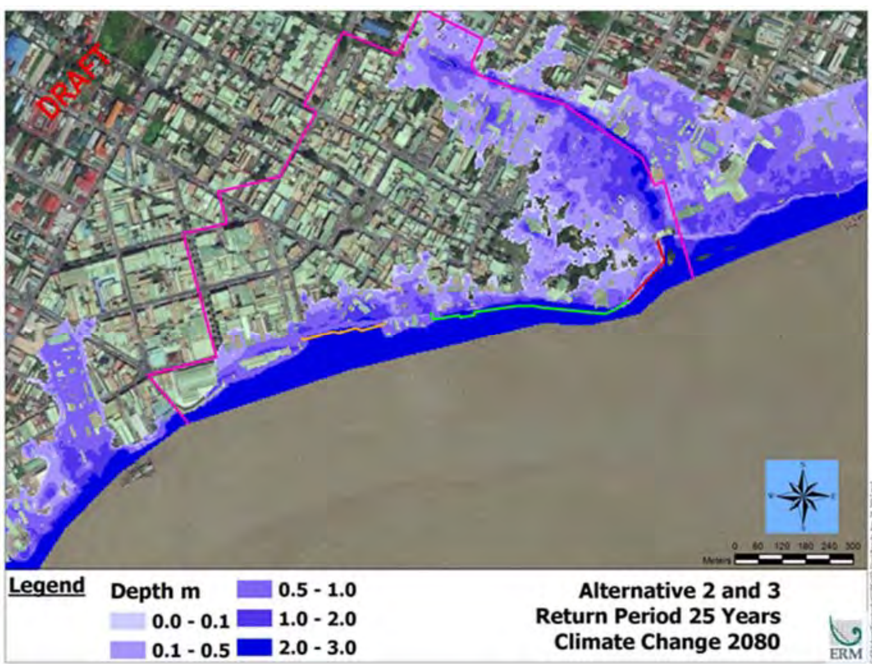


Figure B- 33: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 25-year return period

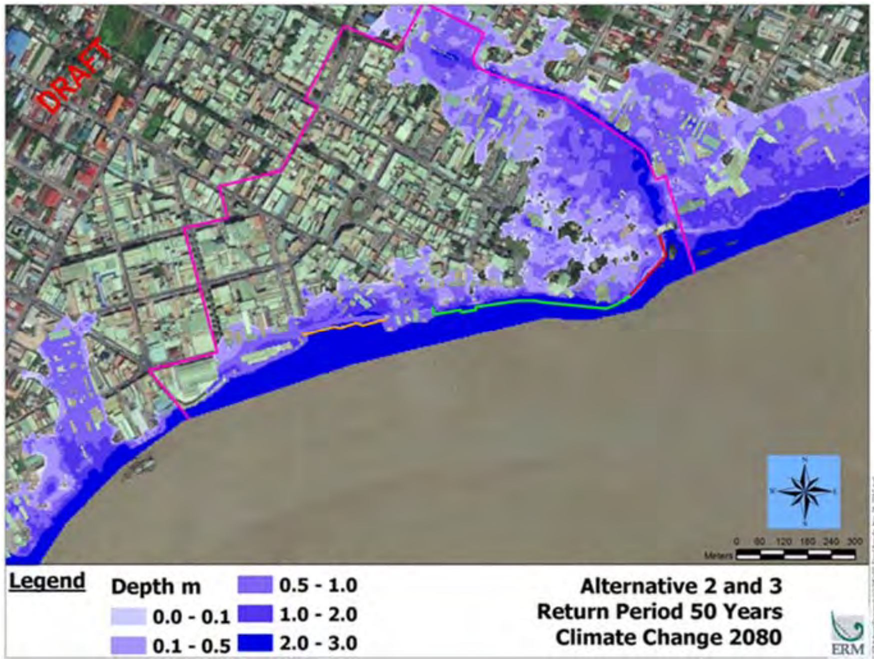


Figure B- 34: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 50-year return period

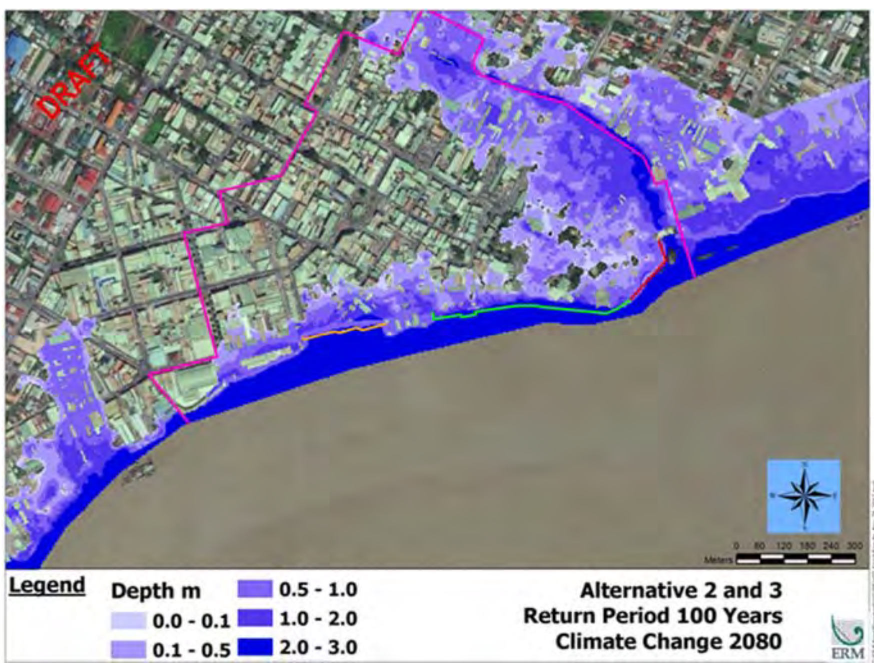


Figure B- 35: Coastal flooding inundation map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 100-year return period

Table B- 7: Tabular comparison of coastal flooding inundation areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Alt23 CC2080 10Y	Alt23 CC2080 25Y	Alt23 CC2080 50Y	Alt23 CC2080 100Y
0.0 to 0.1	0.04725	0.04648	0.04627	0.04848
0.1 to 0.5	0.21235	0.23552	0.22474	0.21477
0.5 to 1.0	0.23546	0.27648	0.29800	0.30547
1.0 to 3.0	0.12051	0.17454	0.21210	0.24213

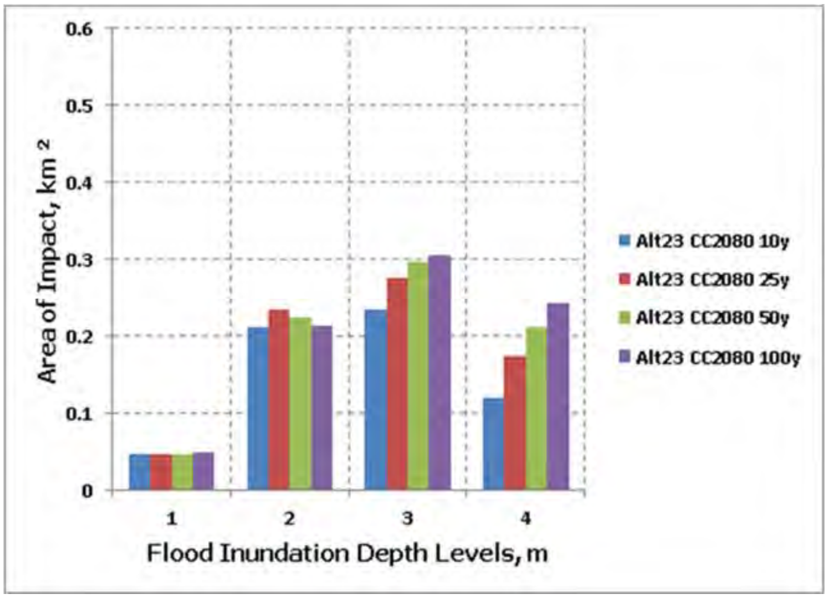


Figure B- 36: Graphical comparison of coastal flooding inundation areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

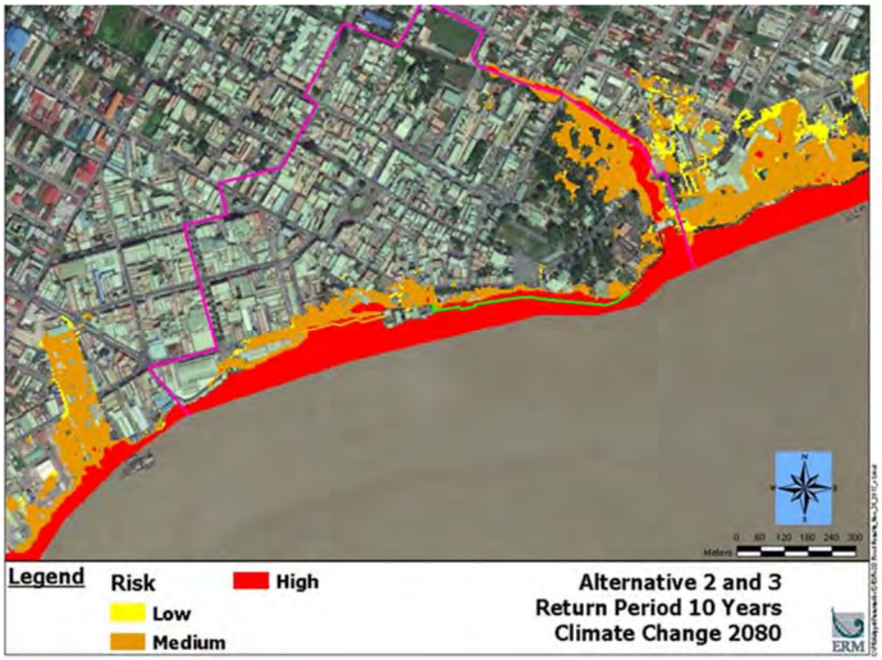


Figure B- 37: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 10-year return period

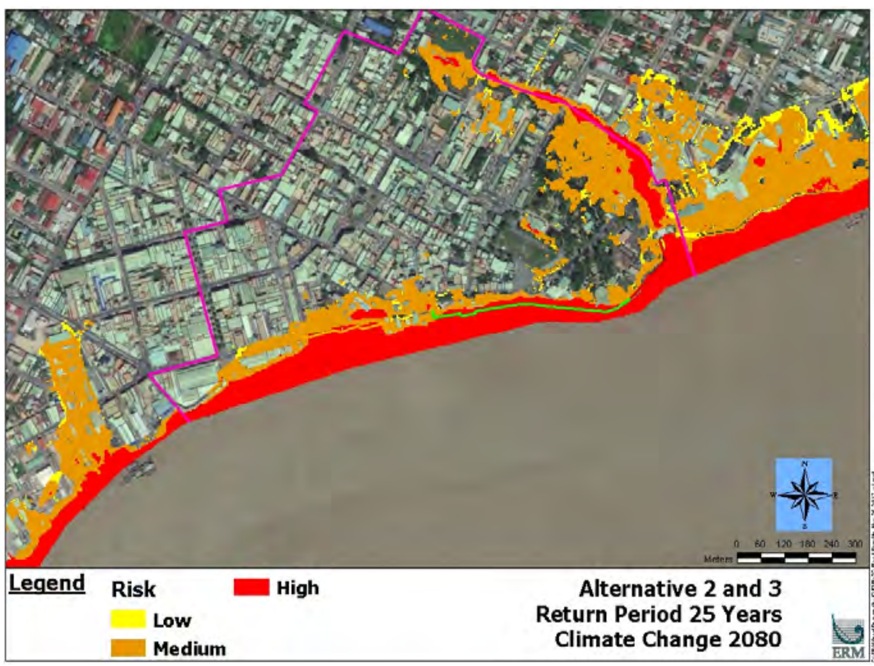


Figure B- 38: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 25-year return period

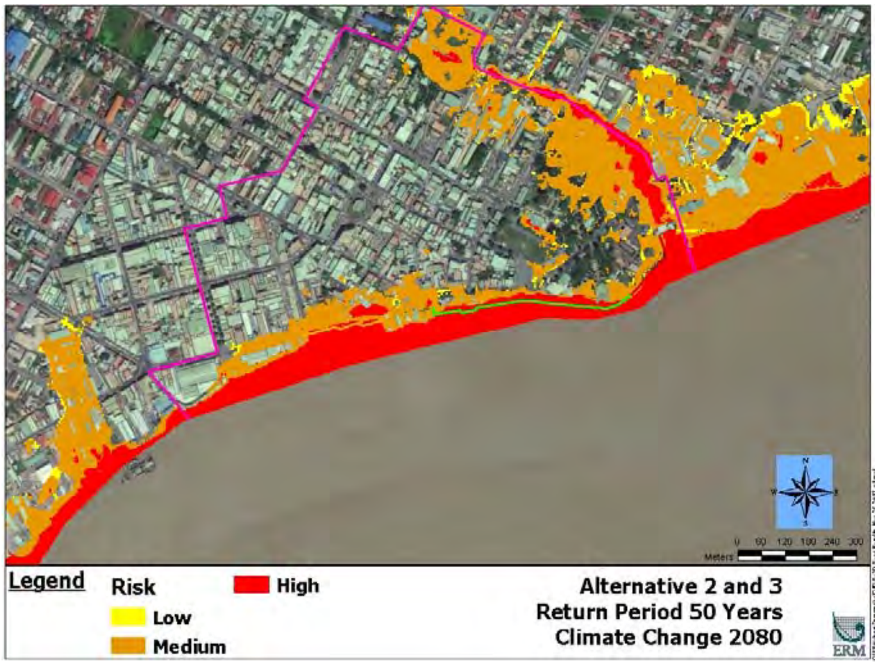


Figure B- 39: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 50-year return period

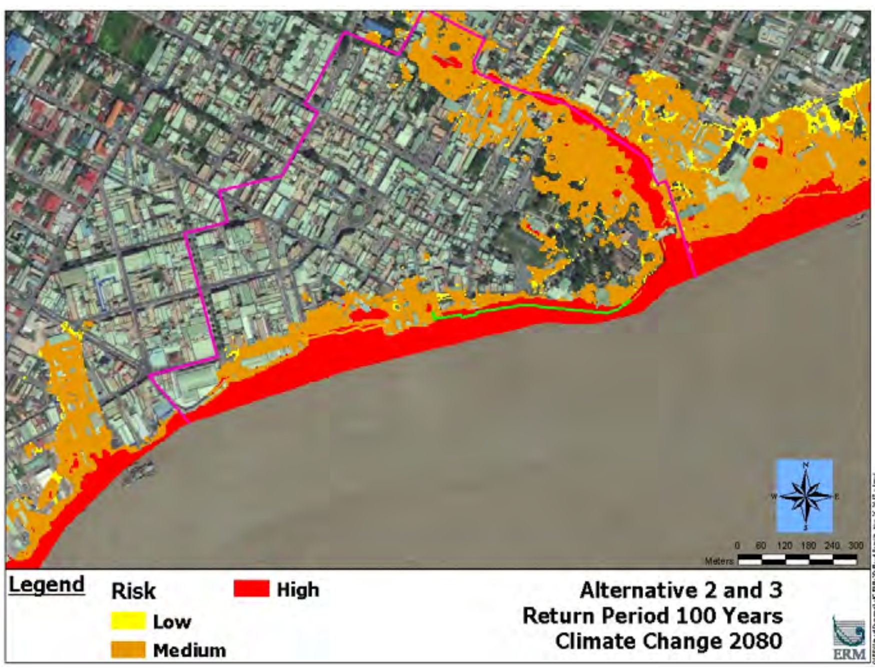


Figure B- 40: Coastal flooding hazard map of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 100-year return period

Table B- 8: Tabular comparison of flood hazard area of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 10-, 25-, 50-, and 100-year return periods

Hazard Level	Alt23 CC2080 10Y	Alt23 CC2080 25Y	Alt23 CC2080 50Y	Alt23 CC2080 100Y
Low	0.03520	0.03835	0.04027	0.04150
Medium	0.29765	0.38242	0.43448	0.46510
High	0.05840	0.06870	0.07620	0.08331

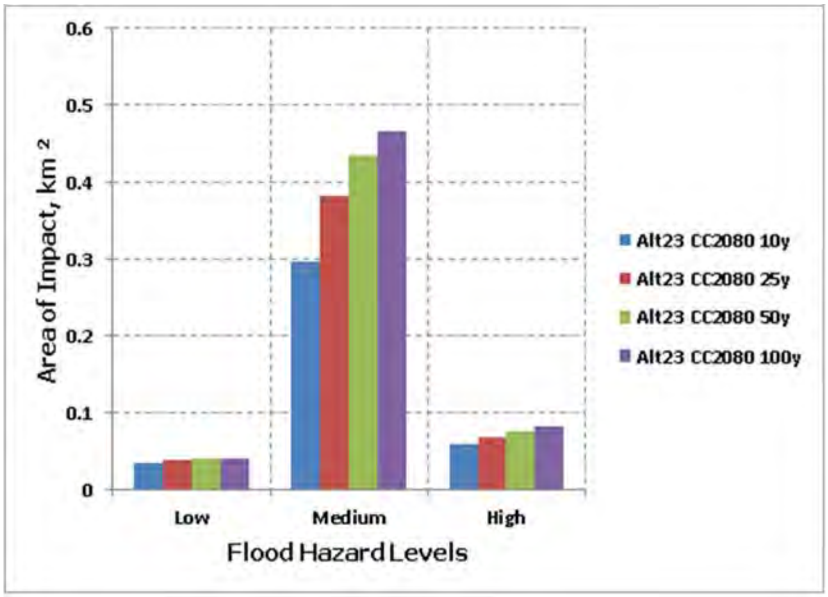


Figure B- 41: Graphical comparison of coastal flooding hazard areas of impact of the Study Area with the Alternative 2 and 3 conceptual designs for the climate change 2080 scenario at 10-, 25-, 50-, and 100- year return periods

APPENDIX C1: HEC-RAS MODEL RESULTS OF THE VAN SOMMELDIJCKSE CANAL WITH THE EXISTING CONFIGURATION

An unsteady state hydraulic analysis was performed in HEC-RAS for both the baseline and the climate change scenarios for all return periods. HEC-RAS was set up using geometrical and flow hydrograph data as mentioned in the above paragraph for various return periods.

Using HEC-GeoRAS, flooding inundation maps based on the water surface profile results exported from HEC-RAS were developed. Developing flood maps using HEC-GeoRAS is based on the simple concept that the water level is determined from hydraulic model HEC-RAS and then examined over the topography of the ground surface in a Digital Elevation Model (DEM). This is performed in two basic steps:

- Construction of the water surface TIN (Triangulated Irregular Network) from the water surface elevations predicted at the cross section.
- Conversion of the water surface TIN into water surface grid. Thereafter, the ground surface grid is subtracted from the water surface grid to obtain water depth map.

The area with the positive values in the water-depth map provides the flooding inundation map.

The flooding inundation of the Canal and its surroundings predicted by the HEC-RAS model for the baseline scenario is shown in Figure C1- 1, Figure C1- 2, and Figure C1- 3 for 25-, 50-, and 100-year return periods, respectively. The areas of impact at various flooding inundation depth levels for the same scenario are shown in Table C1- 1 and presented in Figure C1- 4. The corresponding flooding hazard maps are shown in Figure C1- 5, Figure C1- 6 and Figure C1- 7 for 25-, 50-, and 100-year return periods, respectively. The areas of impact at various flooding hazard levels for the same scenario are shown in Table C1- 2 and presented in Figure C1- 8. The maximum upstream discharges through the Canal during the HEC-RAS model simulations were 31, 35 and 39 m^3/sec for 25-, 50-, and 100-year return periods, respectively. The maximum water surface level specified for the downstream tide hydrograph during the HEC-RAS simulations was 2.11 m, 2.19 m and 2.26 m for 25-, 50-, and 100-year return periods, respectively. The flooding inundation figures depict the maximum inundation that occurs during the simulation time that corresponds to peak catchment flow in the Canal and the simultaneously high tide in the Suriname River. However, the flooding inundation in the Canal and its surroundings changes with time during the time period of simulation due to the time varying flow and tide hydrographs in the upstream and downstream side of the Canal, respectively. Figure C1- 10, Figure C1- 10 and Figure C1- 11 shows flooding inundation map at discrete hours during the simulation time period for 25-, 50-, and 100-year return periods, respectively.

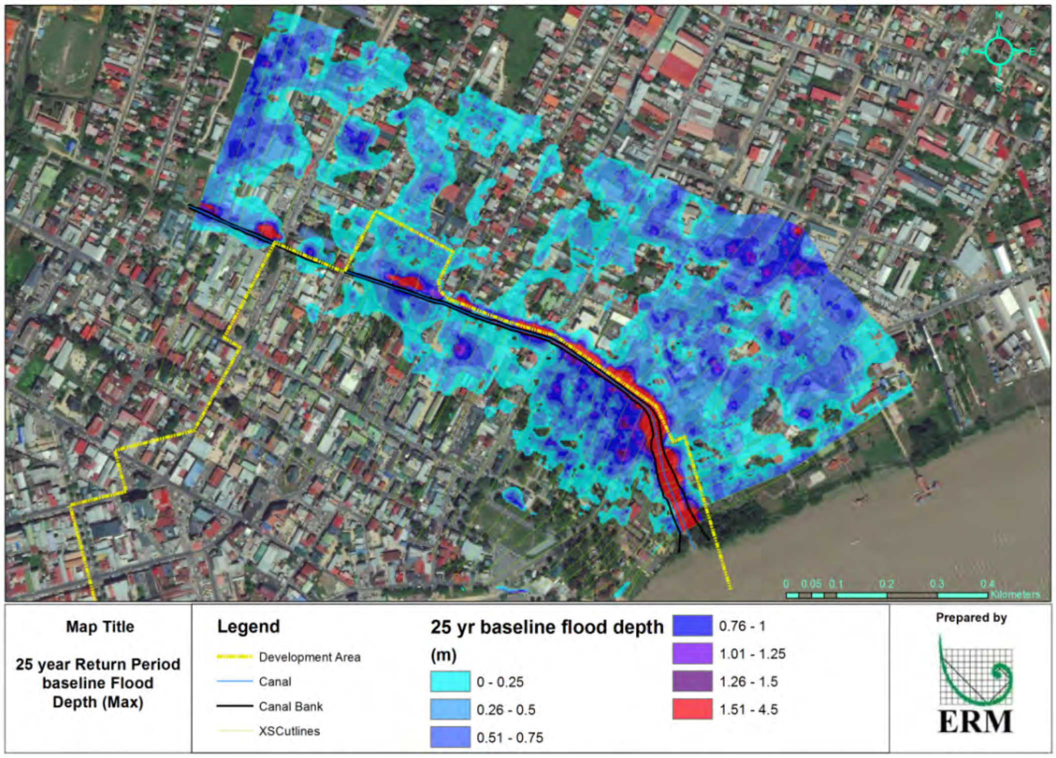


Figure C1- 1: Flooding inundation map of the canal and its surroundings for the baseline scenario at 25-year return period

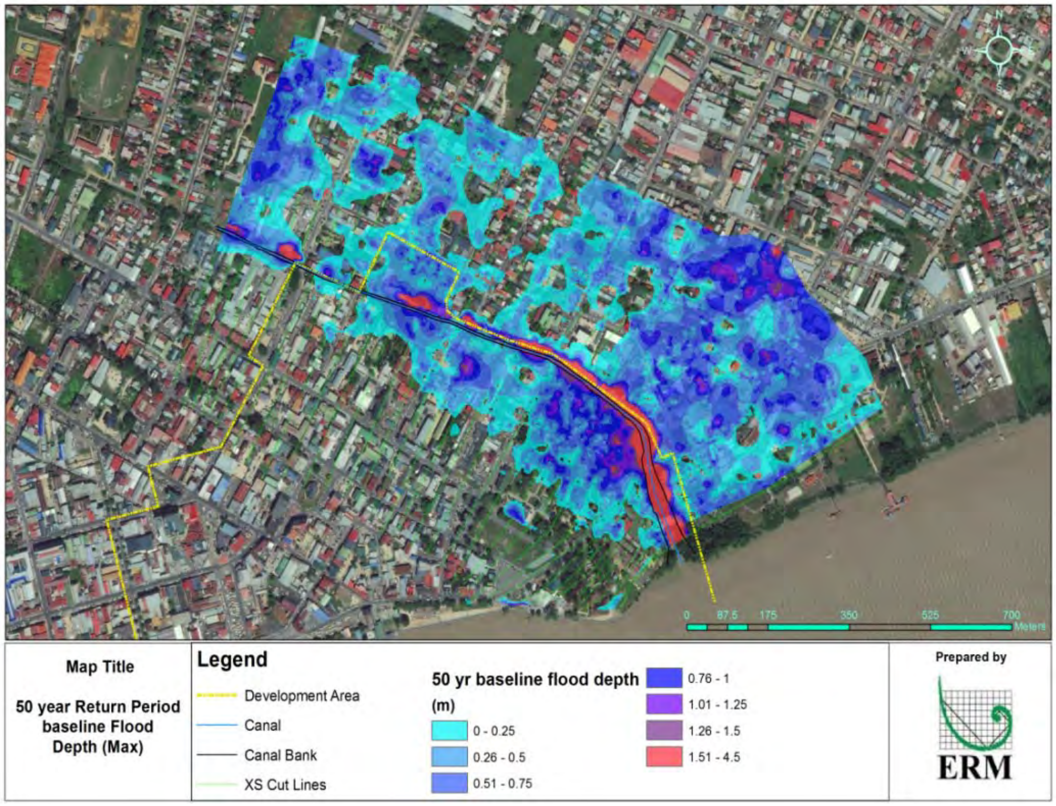


Figure C1- 2: Flooding inundation map of the canal and its surroundings for the baseline scenario at 50-year return period

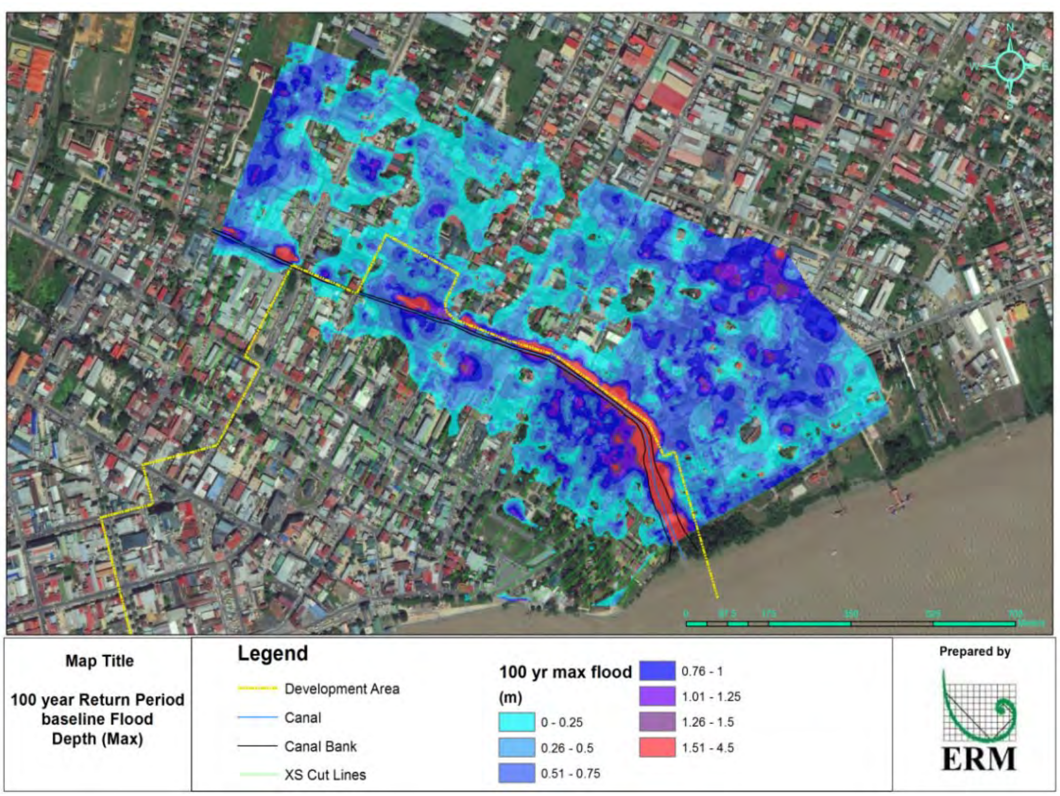


Figure C1- 3: Flooding inundation map of the canal and its surroundings for the baseline scenario at 100-year return period

Table C1- 1: Tabular comparison of flooding inundation areas of impact of the Canal and its surroundings for the baseline scenario at 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Flooding Inundation Area, km^2		
	Baseline 25Y	**Baseline 50Y**	**Baseline 100Y**
0.0 to 0.25	0.1834	0.1680	0.1562
0.26 to 0.5	0.1523	0.1648	0.1708
0.51 to 0.75	0.0981	0.1274	0.1393
0.76 to 1	0.0316	0.0526	0.0690
1.01 to 1.25	0.0096	0.0165	0.0210
1.26 to 1.5	0.0045	0.0056	0.0067
1.51 to 4.5	0.0195	0.0214	0.0224

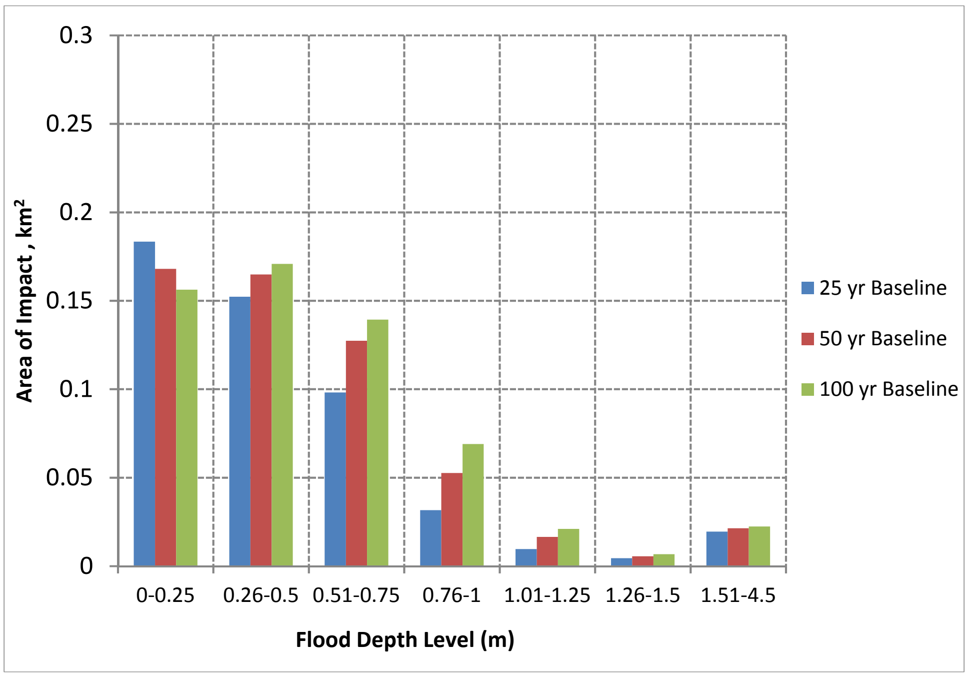


Figure C1- 4: Graphical comparison of flooding inundation areas of impact of the Canal and its surroundings for the baseline scenario at 25-, 50-, and 100-year return periods

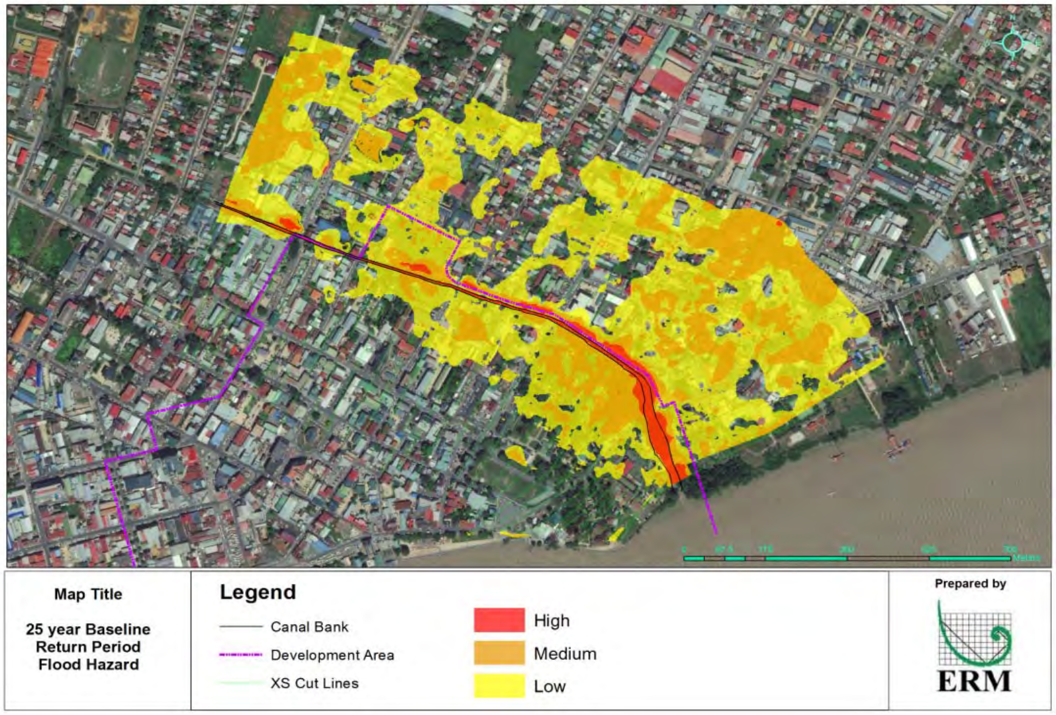


Figure C1- 5: Flooding hazard map of the Canal and its surroundings for the baseline scenario at 25-year return period

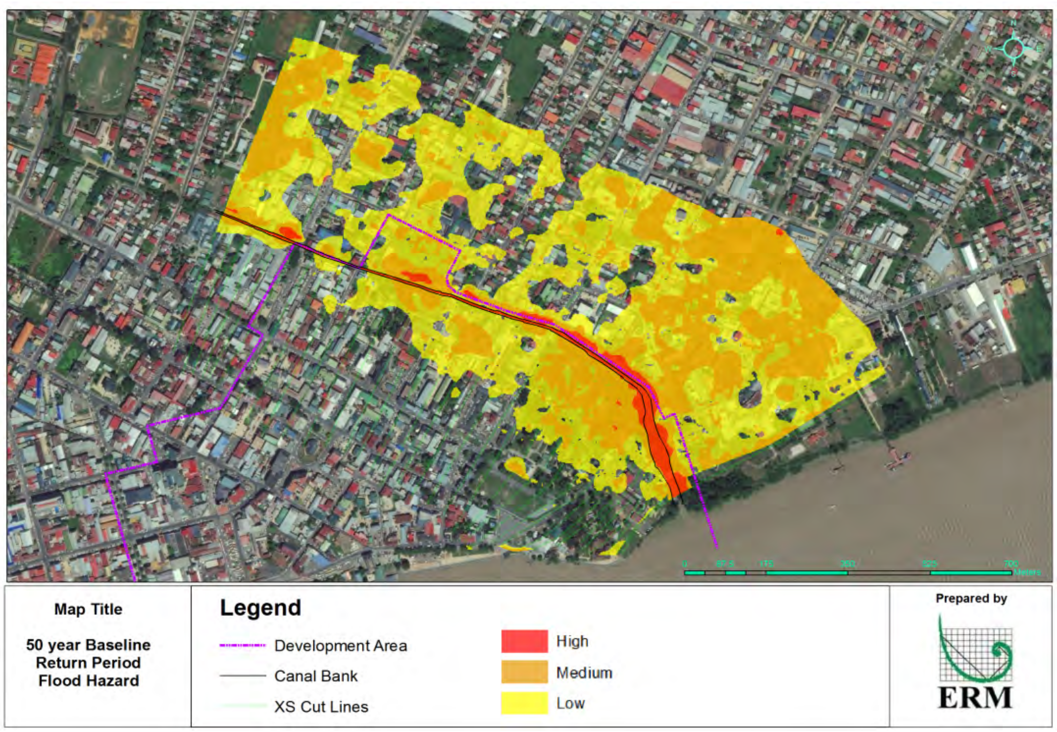


Figure C1- 6: Flooding hazard map of the Canal and its surroundings for the baseline scenario at 50-year return period

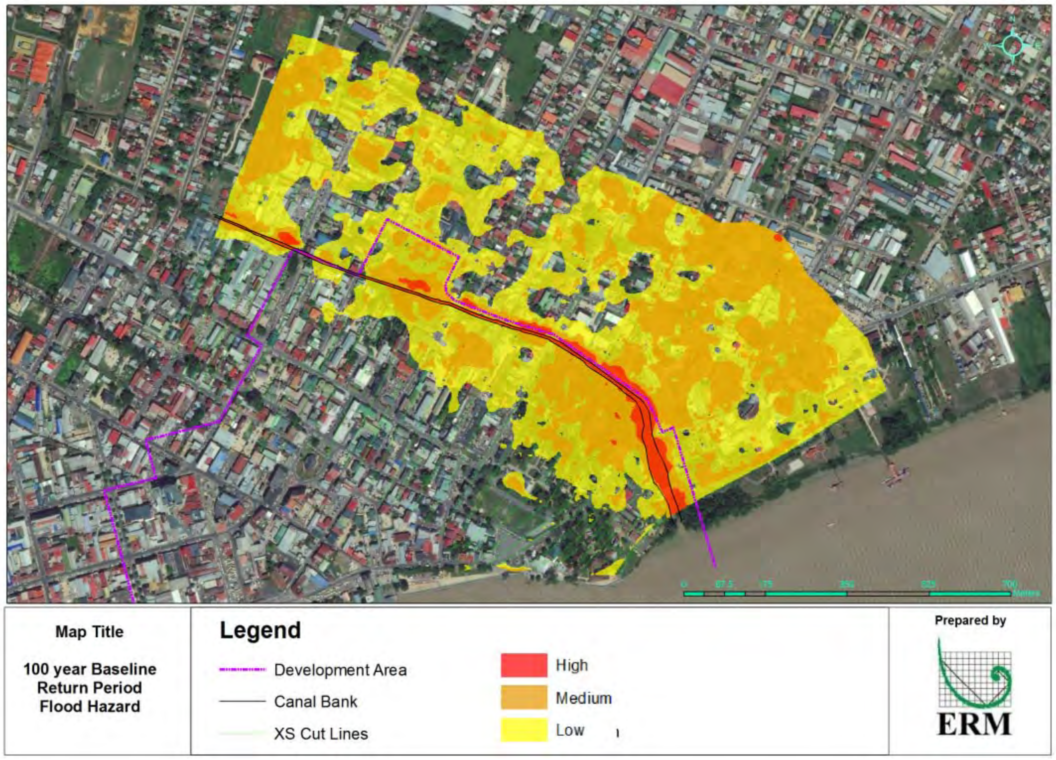


Figure C1- 7: Flooding hazard map of the Canal and its surroundings for the baseline scenario at 100-year return period

Table C1- 2: Tabular comparison of flooding hazard areas of impact of the Canal and its surroundings for the baseline scenario at 10-, 25-, 50-, and 100-year return periods

Risk Level	**Flooding Inundation Area, km²**		
	Baseline 25Y	**Baseline 50Y**	**Baseline 100Y**
Low	0.330	0.330	0.260
Medium	0.150	0.210	0.240
High	0.019	0.021	0.022

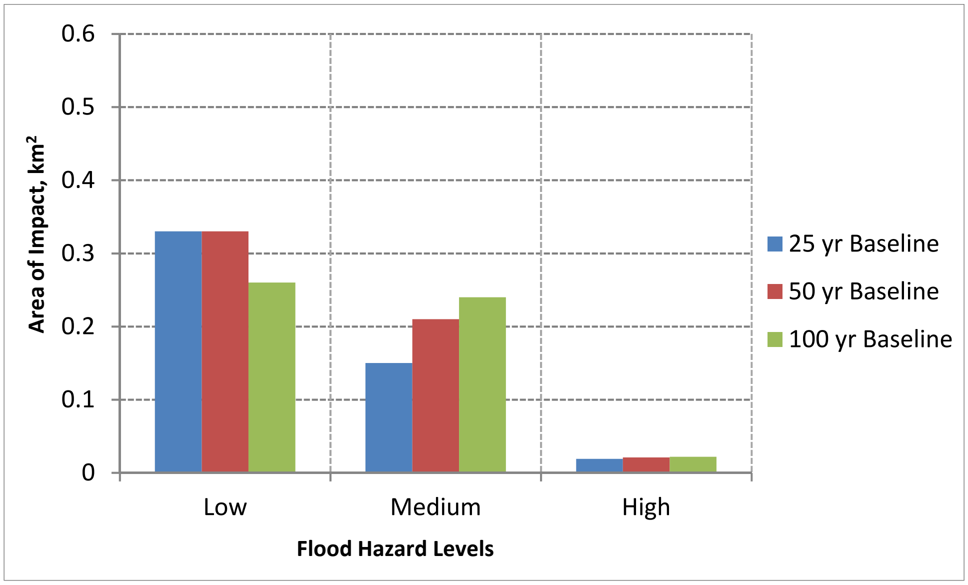


Figure C1- 8: Graphical comparison of flooding inundation areas of impact of the Canal and its surroundings for the baseline scenario at 25-, 50-, and 100-year return periods

Figure C1- 9: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the baseline scenario at 25-year return period

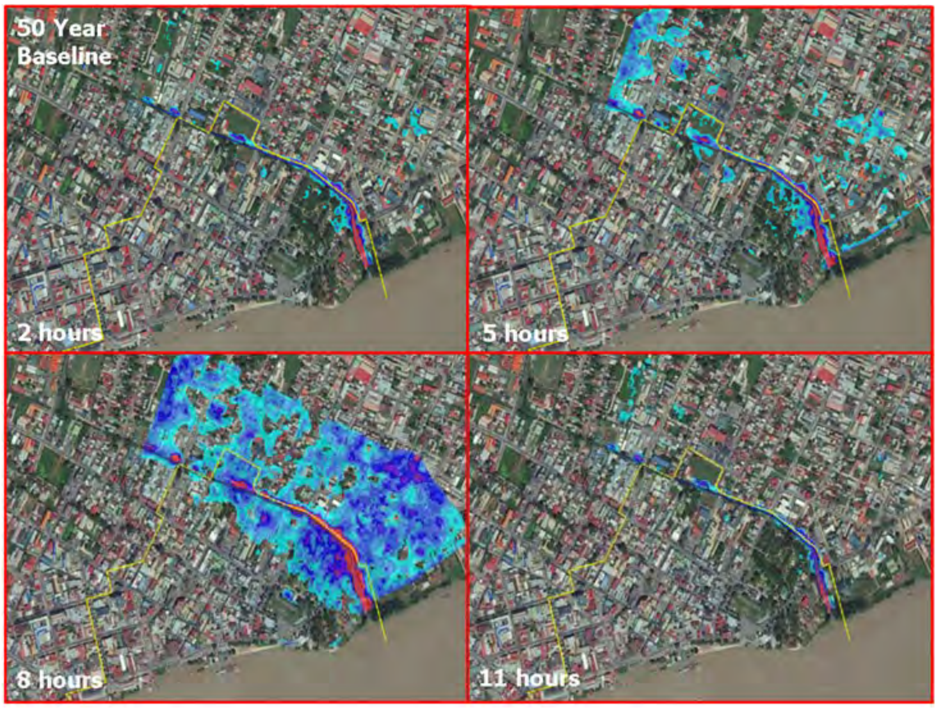


Figure C1- 10: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the baseline scenario at 50-year return period

Figure C1- 11: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the baseline scenario at 100-year return period

The flooding inundation of the Canal and its surroundings predicted by the model for the climate change 2050 scenario is shown in Figure C1- 12, Figure C1- 13, Figure C1- 14 for 25-, 50-, and 100-year return periods, respectively. The areas of impact at various flooding inundation depth levels for the same scenario are shown in Table C1- 3 and presented in Figure C1- 16. The corresponding flooding hazard maps are shown in Figure C1- 16, Figure C1- 17 and Figure C1- 18 for 25-, 50-, and 100-year return periods, respectively. The areas of impact at various flooding hazard levels for the same scenario are shown in Table C1- 4 and presented in Figure C1- 19. The maximum upstream discharges through the Canal during the HEC-RAS model simulations were 34, 38 and 42 m^3/sec for 25-, 50-, and 100-year return periods, respectively. The maximum water surface level specified for the downstream tide hydrograph during the HEC-RAS model simulations was 2.43 m, 2.51 m and 2.58 m for 25-, 50-, and 100-year return periods, respectively. The flooding inundation figures depict the maximum inundation that occurs during the simulation time that corresponds to peak catchment flow in the Canal and the simultaneously high tide in the Suriname River. However, the flooding inundation in the Canal and its surroundings changes with time during the time period of simulation due to the time varying flow and tide hydrographs in the upstream and downstream side of the Canal, respectively. Figure C1- 20, Figure C1- 21 and Figure C1- 22 shows flooding inundation map at discrete hours during the simulation time period for 25-, 50-, and 100-year return periods.

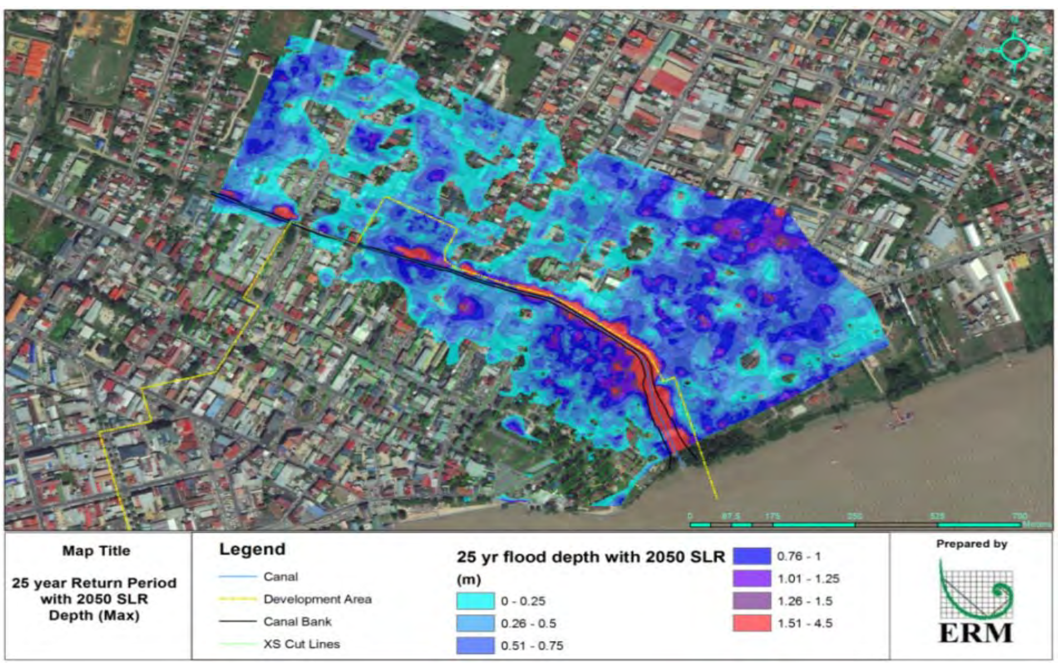


Figure C1- 12: Flooding inundation map of the Canal and its surroundings for the Climate Change 2050 Scenario at 25-year return period

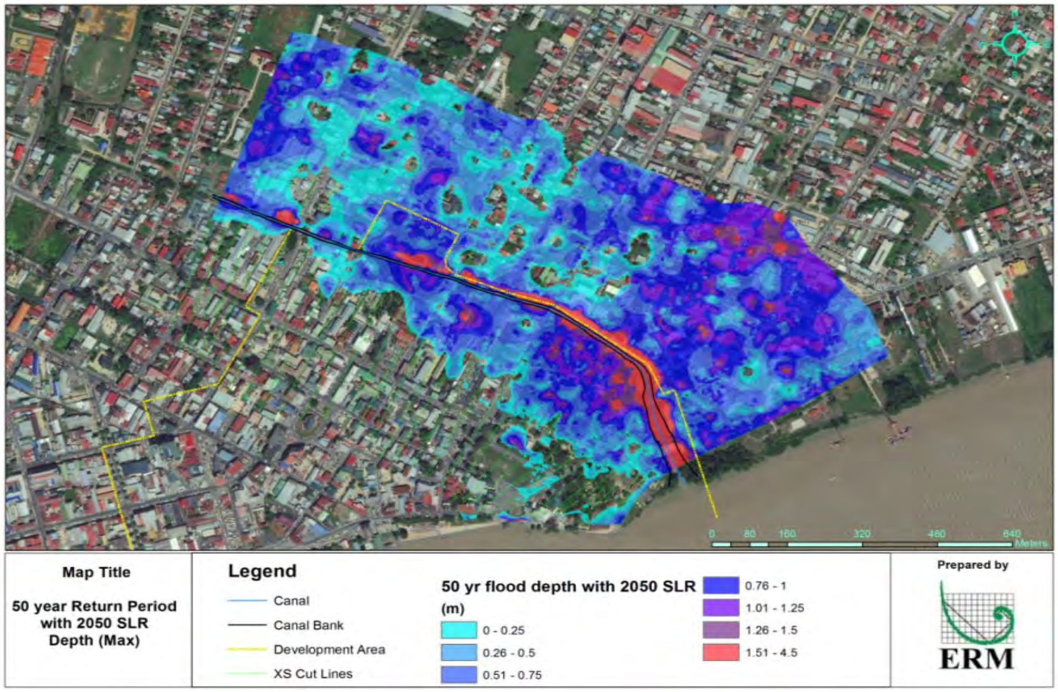


Figure C1- 13: Flooding inundation map of the Canal and its surroundings for the Climate Change 2050 Scenario at 50-year return period

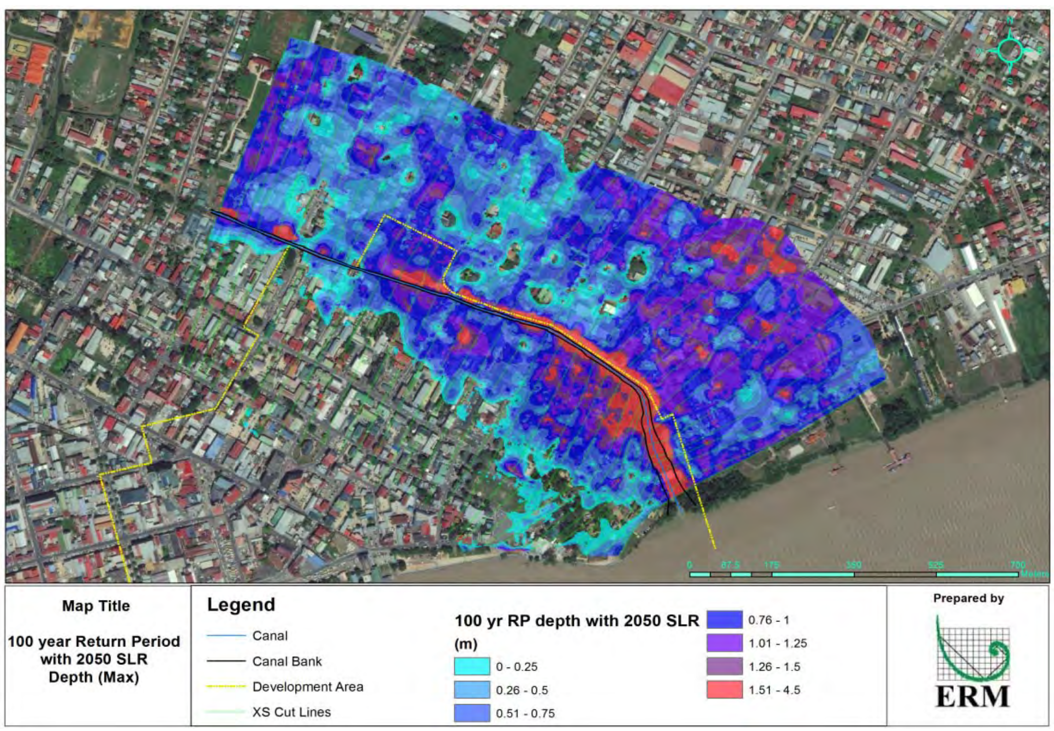


Figure C1- 14: Flooding inundation map of the Canal and its surroundings for the Climate Change 2050 Scenario at 100-year return period

Table C1- 3: Tabular comparison of flooding inundation areas of impact of the Canal and its surroundings for the climate change 2050 scenario at 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Flooding Inundation Area, km²		
	CC2050 25Y	CC2050 50Y	CC2050 100Y
0.0 to 0.25	0.1428	0.1087	0.0735
0.26 to 0.5	0.1790	0.1512	0.1143
0.51 to 0.75	0.1473	0.1709	0.1655
0.76 to 1	0.0831	0.136	0.1656
1.01 to 1.25	0.0261	0.0659	0.1184
1.26 to 1.5	0.0084	0.0204	0.0459
1.51 to 4.5	0.0234	0.0293	0.0423

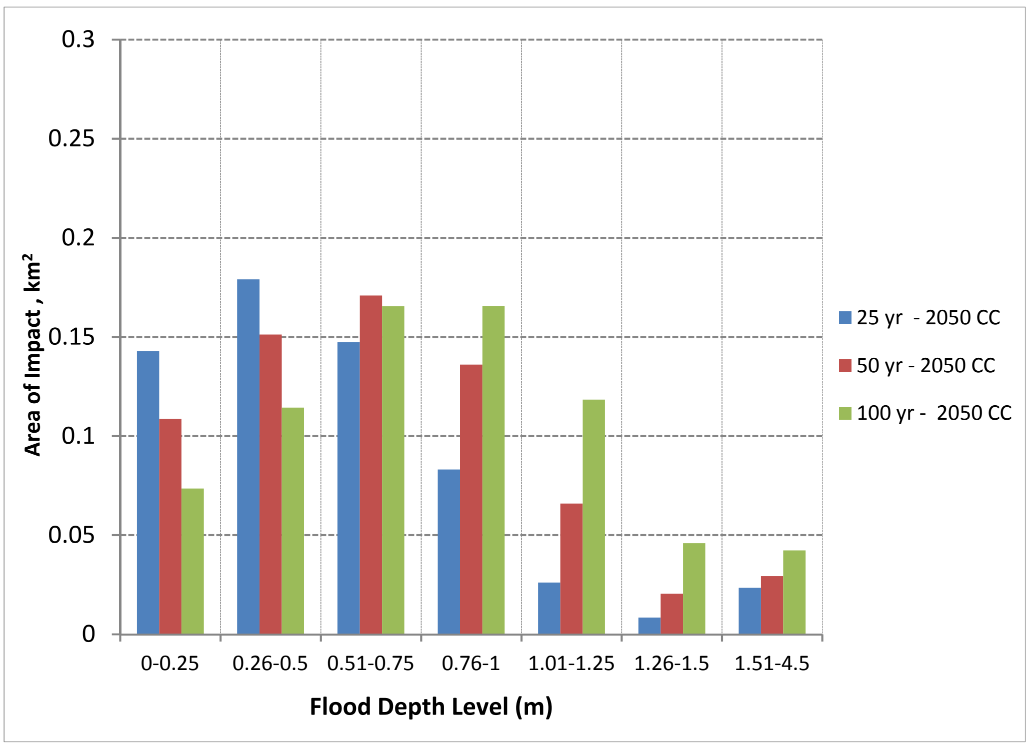


Figure C1- 15: Graphical comparison of flooding inundation areas of impact of the canal and its surroundings for the climate change 2050 scenario at 25-, 50-, and 100-year return periods

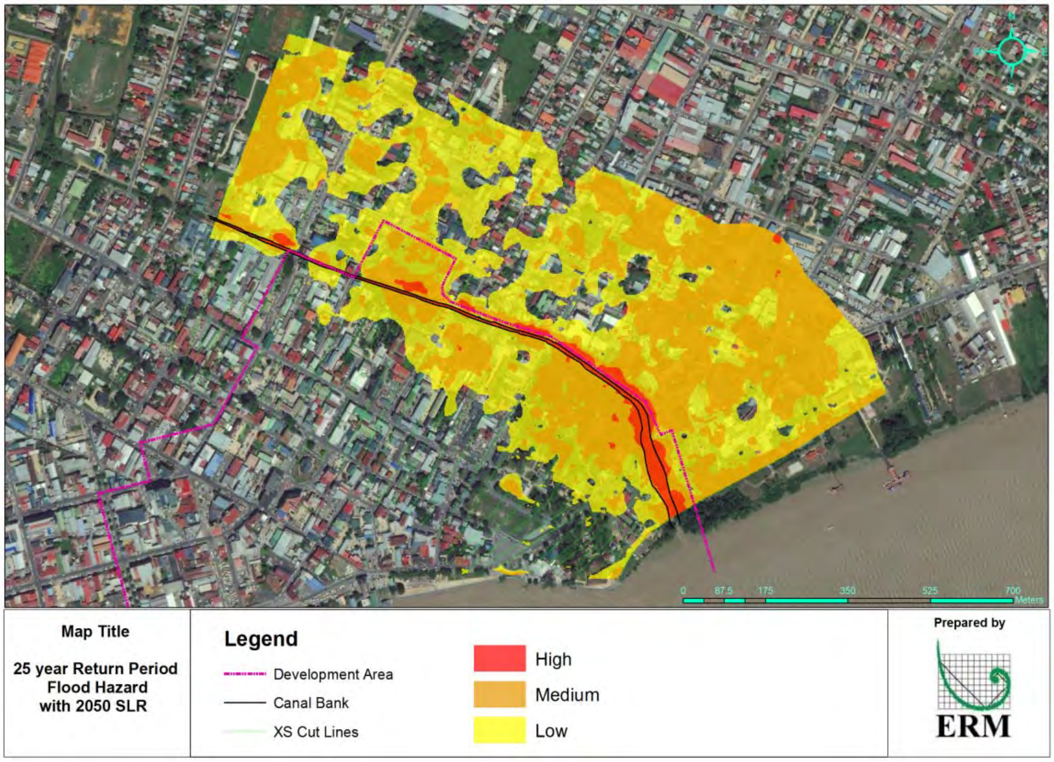


Figure C1- 16: Flooding hazard map of the Canal and its surroundings for the climate change 2050 scenario at 25-year return period

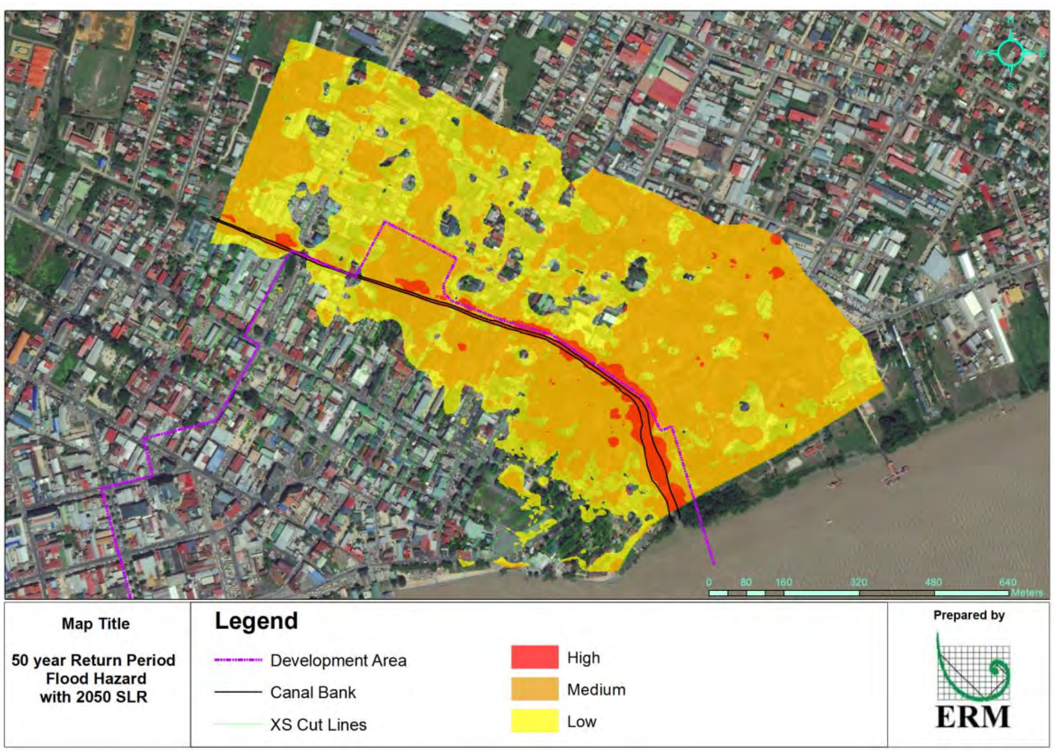


Figure C1- 17: Flooding hazard map of the Canal and its surroundings for the climate change 2050 scenario at 50-year return period

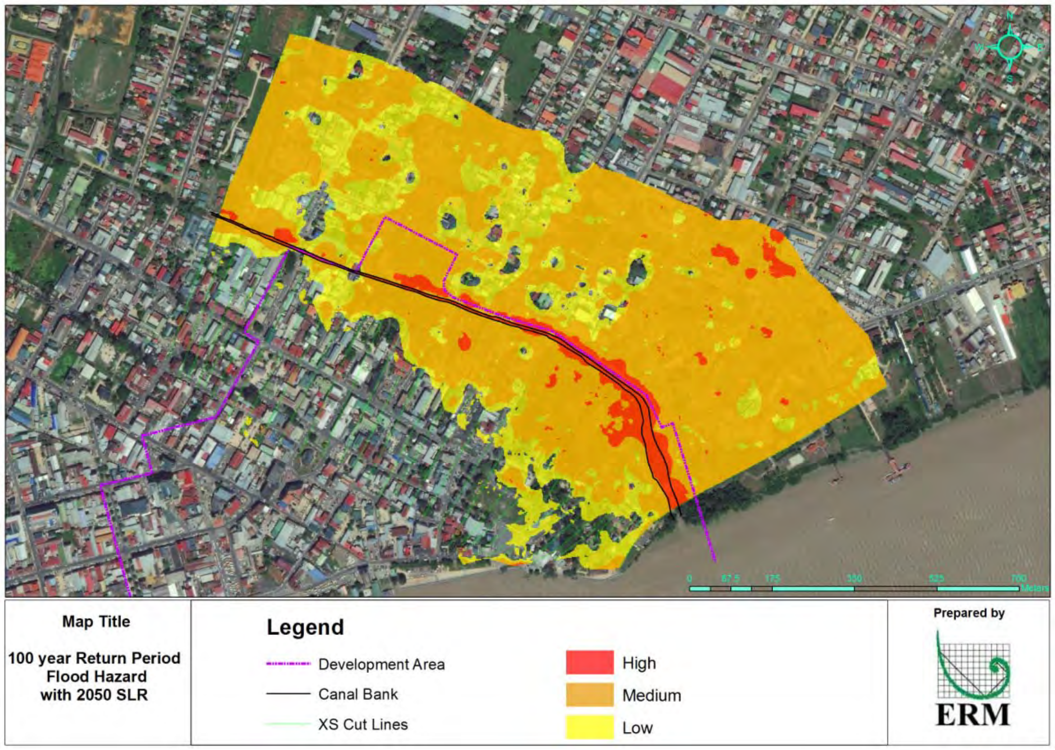


Figure C1- 18: Flooding hazard map of the Canal and its surroundings for the climate change 2050 scenario at 100-year return period

Table C1- 4: Tabular comparison of flooding hazard areas of impact of the Canal and its surroundings for the climate change 2050 scenario at 25-, 50-, and 100-year return periods

Risk Level	**Flooding Hazard Area, km²**		
	CC2050 25Y	**CC2050 50Y**	**CC2050 100Y**
Low	0.31	0.28	0.023
Medium	0.26	0.41	0.029
High	0.19	0.51	0.043

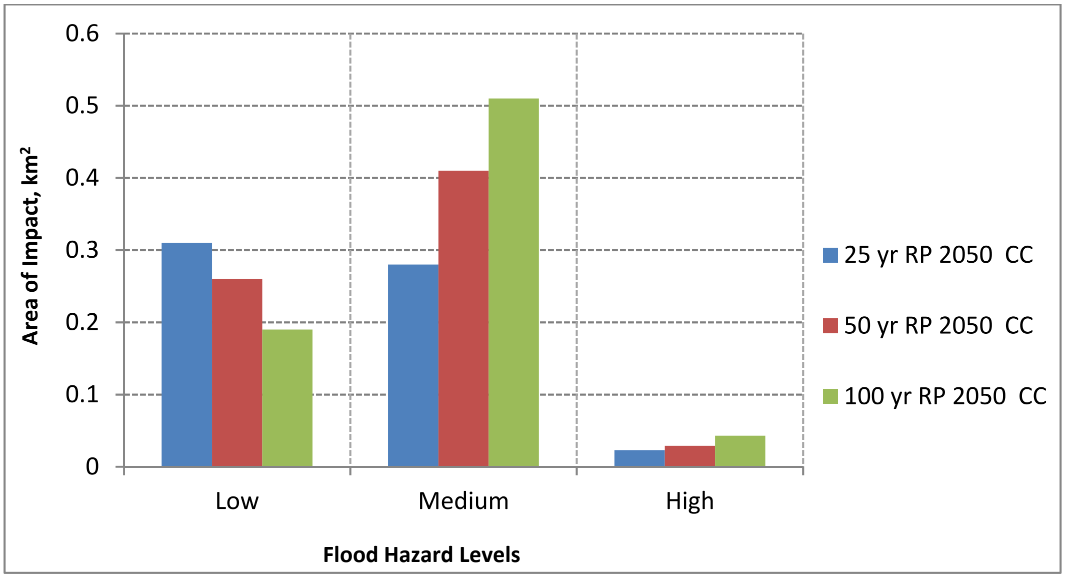


Figure C1- 19: Flooding hazard areas of impact of the Canal and its surroundings for the climate change 2050 scenario at 25-, 50-, and 100-year return periods

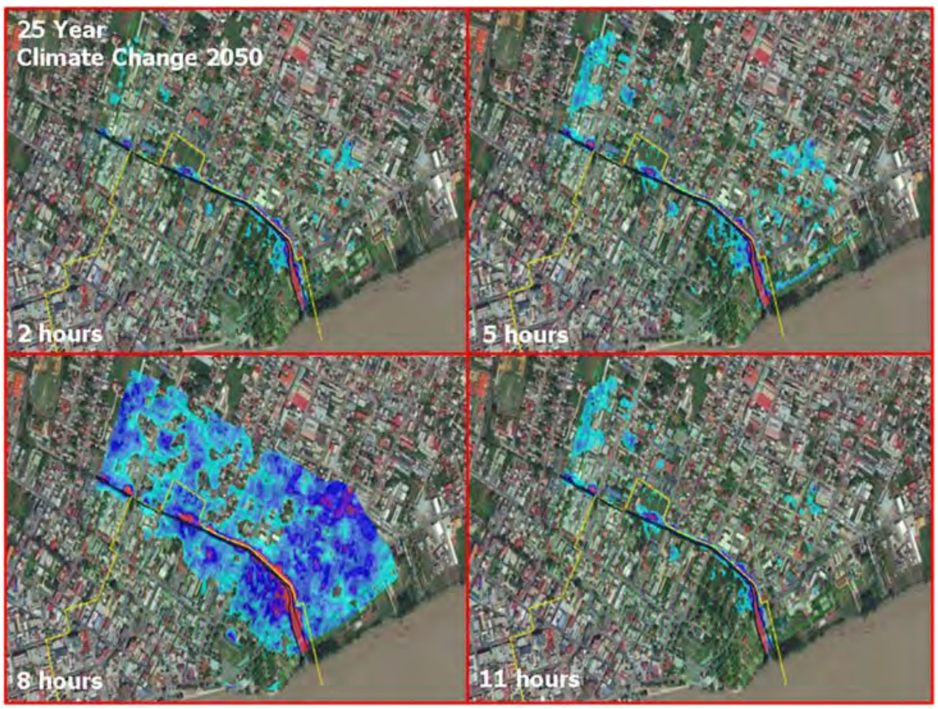


Figure C1- 20: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the climate change 2050 scenario at 25-year

Figure C1- 21: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the climate change 2050 scenario at 50-year return period

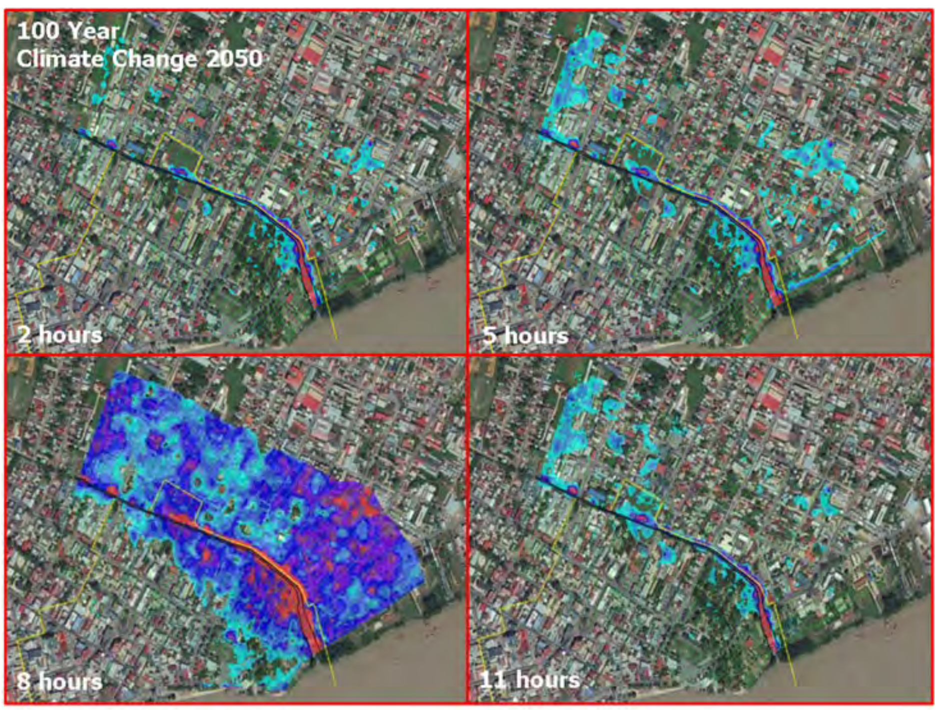


Figure C1- 22: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the climate change 2050 scenario at 100-year return period

The flooding inundation of the Canal and its surroundings predicted by the HEC-RAS model for the climate change 2080 scenario is shown in Figure C1- 23,

Figure C1- 24 and Figure C1- 25 for 25-, 50-, and 100-year return periods, respectively. The areas of impact at various flooding inundation depth levels for the same scenario are shown in Table C1- 5**Error! Reference source not found.** and presented in Figure C1- 26. The corresponding flooding hazard maps are shown in Figure C1- 27, Figure C1- 28 and Figure C1- 29 for 25-, 50-, and 100-year return periods, respectively. The areas of impact at various flooding hazard levels for the same scenario are shown in Table C1- 6 and presented graphically in Figure C1- 30. The maximum upstream discharge through the Canal during HEC-RAS model simulation was 35, 39 and 43 m^3/sec for 25-, 50-, and 100-year return periods, respectively. The maximum water surface level specified for the downstream tide hydrograph during the HEC-RAS model simulations was 2.81 m, 2.89 m and 2.96 m for 25-, 50-, and 100-year return periods, respectively. The flooding inundation figures depict the maximum inundation that occurs during the simulation time that corresponds to peak catchment flow in the Canal and the simultaneously high tide in the Suriname River. However, the flooding inundation in the Canal and its surroundings changes with time during the time period of simulation due to the time varying flow and tide hydrographs in the upstream and downstream side of the Canal, respectively. Figure C1- 31, Figure C1- 32 and Figure C1- 33 shows flooding inundation map at discrete hours during the simulation time period for 25-, 50-, and 100-year return periods, respectively.

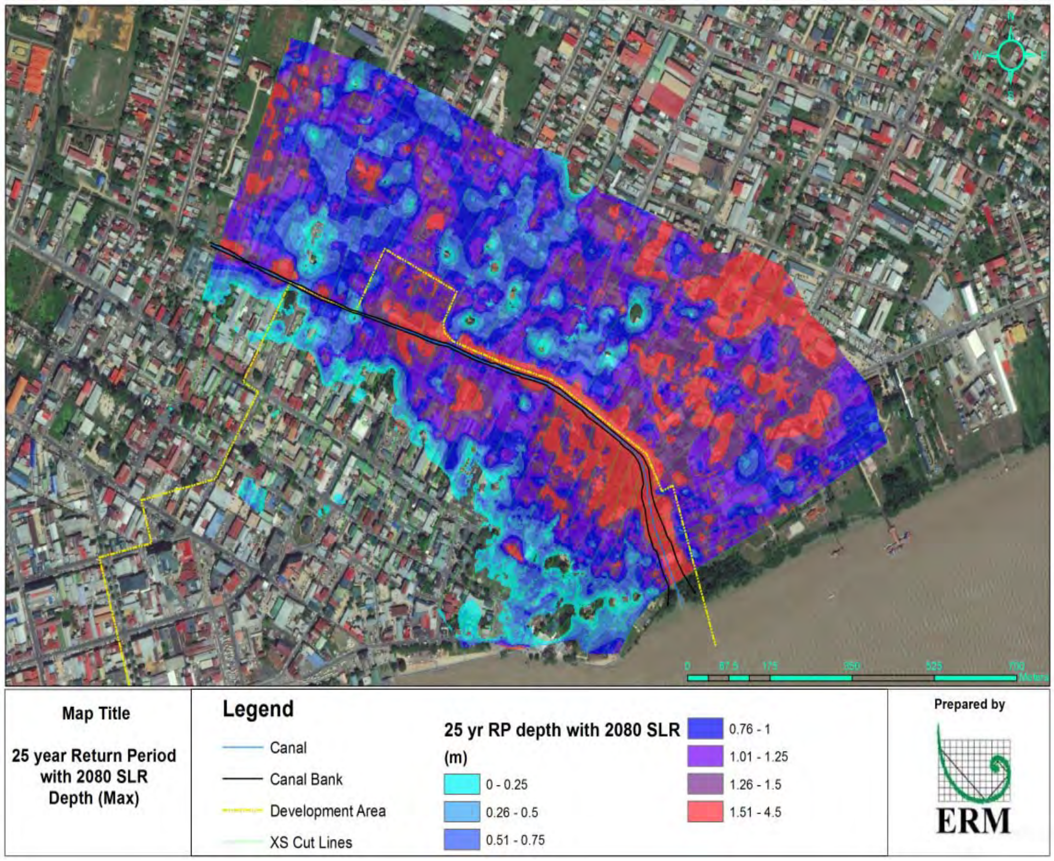
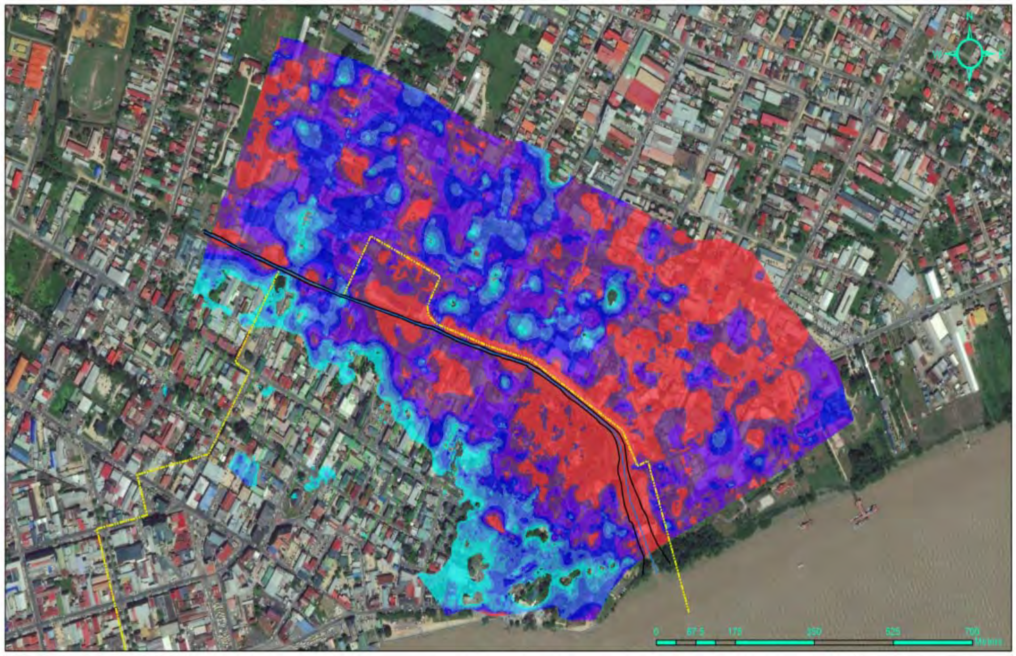
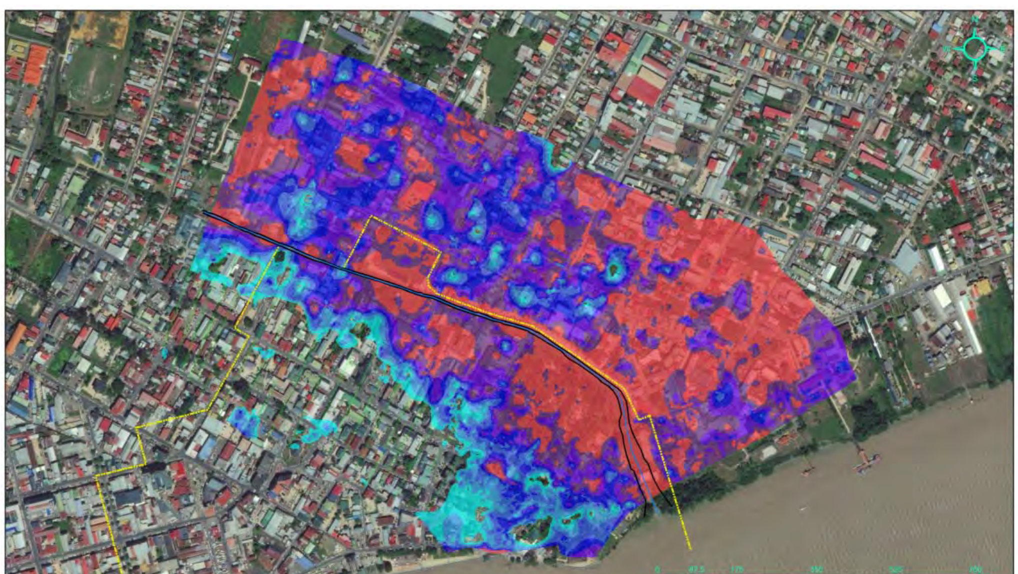


Figure C1- 23: Flooding inundation map of the Canal and its surroundings for the climate change 2080 scenario at 25-year return period



Map Title	Legend		Prepared by
50 year Return Period with 2080 SLR Depth (Max)	Canal Canal Bank Development Area XS Cut Lines	50 yr RP depth with 2080 SLR (m) 0 - 0.25 0.26 - 0.5 0.51 - 0.75 0.76 - 1 1.01 - 1.25 1.26 - 1.5 1.51 - 4.5	ERM

Figure C1- 24: Flooding inundation map of the Canal and its surroundings for the climate change 2080 scenario at 50-year return period



Map Title	Legend		Prepared by
100 year Return Period with 2080 SLR Depth (Max)	Canal Canal Bank Development Area XS Cut Lines	100 yr RP depth with SLR (m) 0 - 0.25 0.26 - 0.5 0.51 - 0.75 0.76 - 1 1.01 - 1.25 1.26 - 1.5 1.51 - 4.5	ERM

Figure C1- 25: Flooding inundation map of the Canal and its surroundings for the climate change 2080 scenario at 100-year return period

Table C1- 5: Tabular comparison of flooding inundation areas of impact of the canal and its surroundings for the climate change 2080 scenario at 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Flooding Inundation Area, km²		
	CC2080 25Y	CC2080 50Y	CC2080 100Y
0.0 to 0.25	0.045	0.0445	0.0399
0.26 to 0.5	0.0546	0.0468	0.0438
0.51 to 0.75	0.0983	0.0724	0.0575
0.76 to 1	0.144	0.1176	0.102
1.01 to 1.25	0.1747	0.1693	0.1506
1.26 to 1.5	0.1441	0.1654	0.1741
1.51 to 4.5	0.1326	0.2017	0.2649

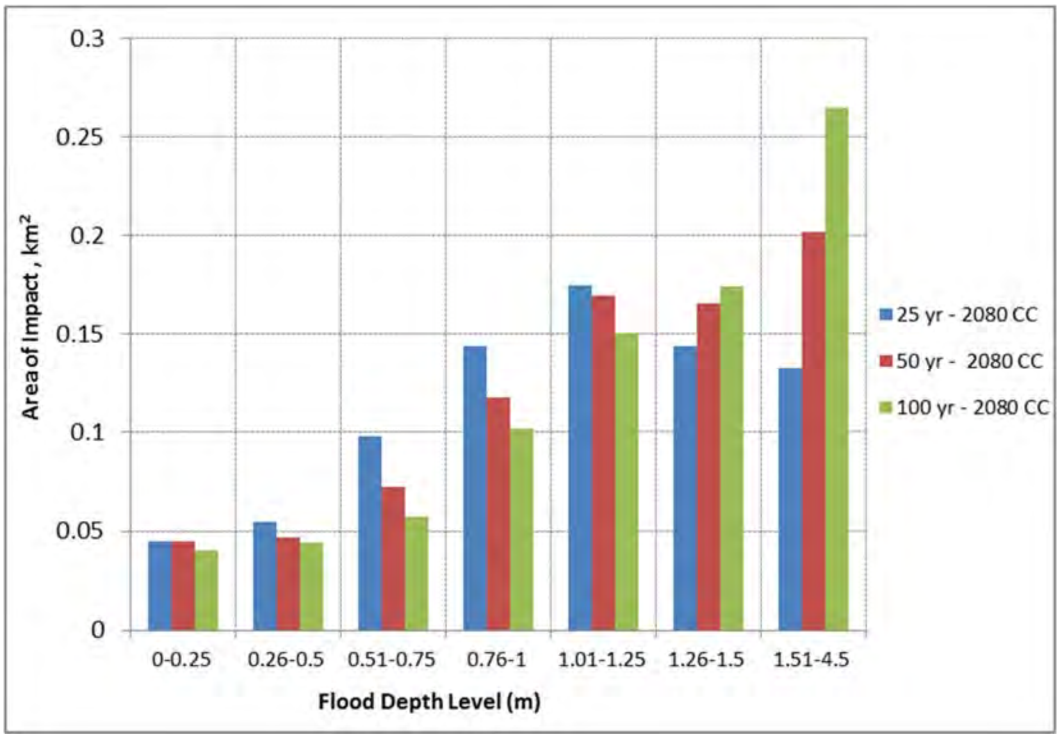


Figure C1- 26: Graphical comparison of flooding inundation area of impact of the Canal and its surroundings for the climate change 2080 scenario at 25-, 50-, and 100-year return periods

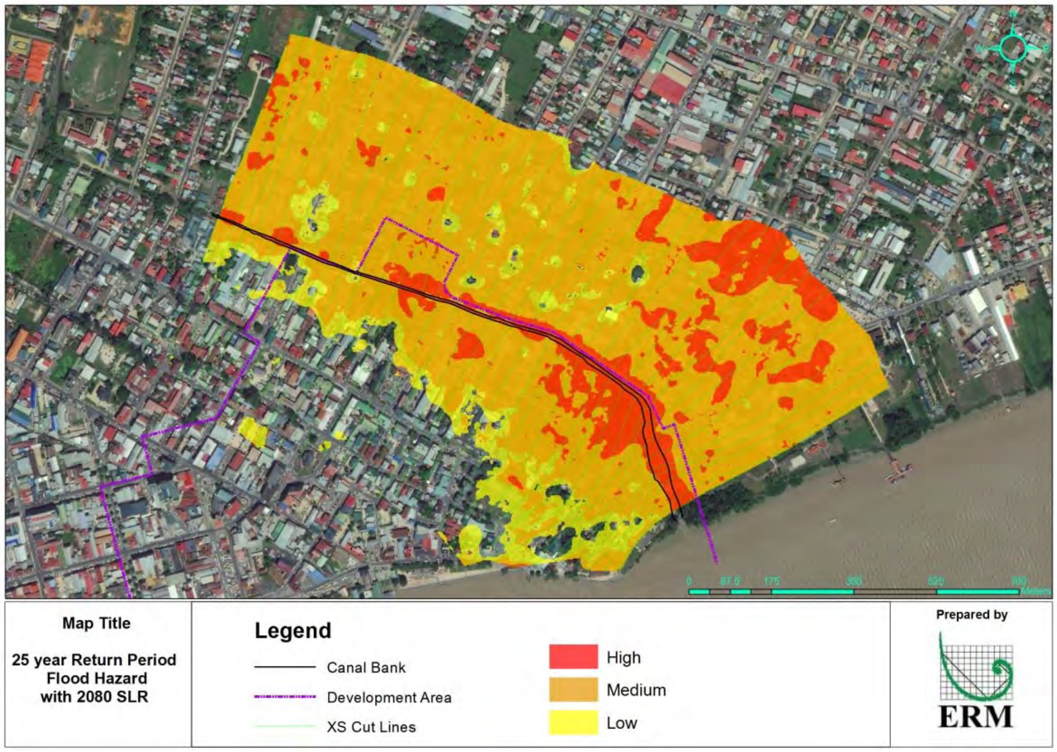


Figure C1- 27: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 25-year return period

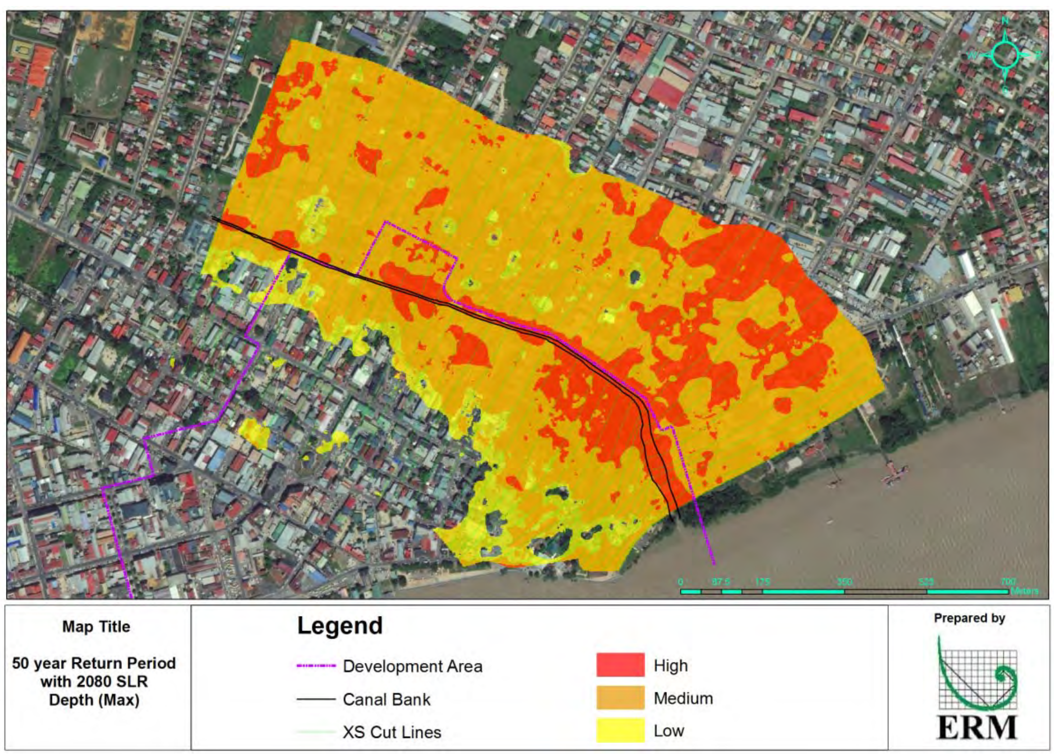


Figure C1- 28: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 50-year return period

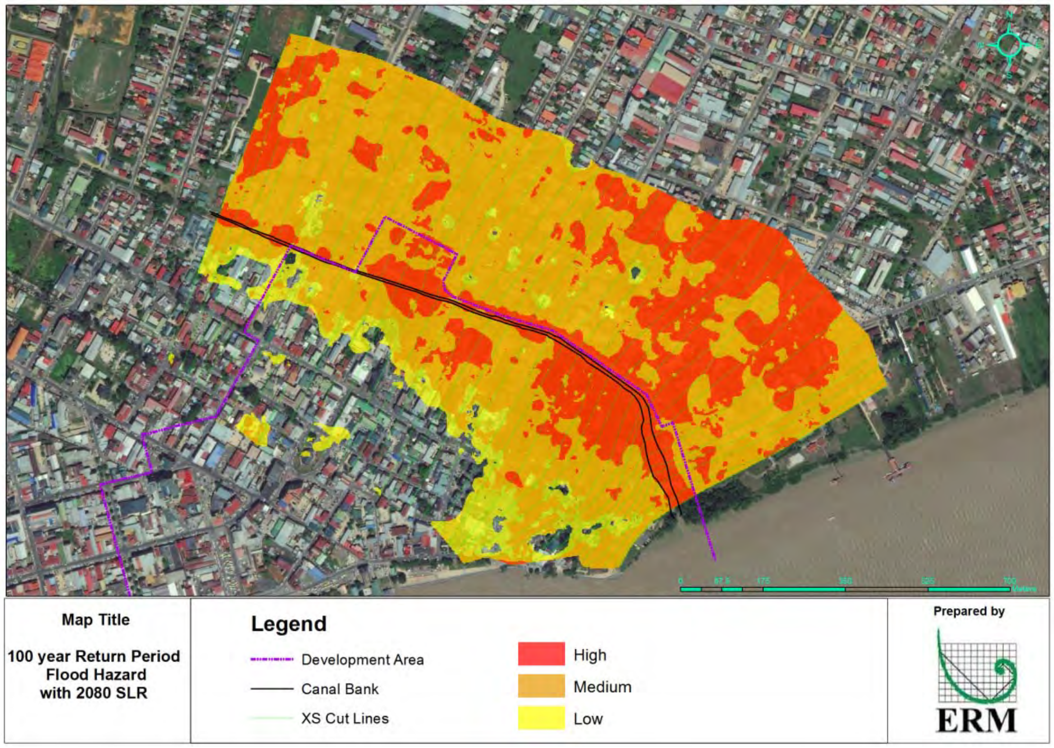


Figure C1- 29: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 100 year return period

Table C1- 6: Tabular comparison of flooding hazard areas of impact of the Canal and its surroundings for the climate change 2080 scenario at 25-, 50-, and 100-year return periods

Risk Level	**Flooding Hazard Area, km²**		
	CC2080 25Y	**CC2080 50Y**	**CC2080 100Y**
Low	0.10	0.09	0.08
Medium	0.58	0.54	0.50
High	0.13	0.20	0.27

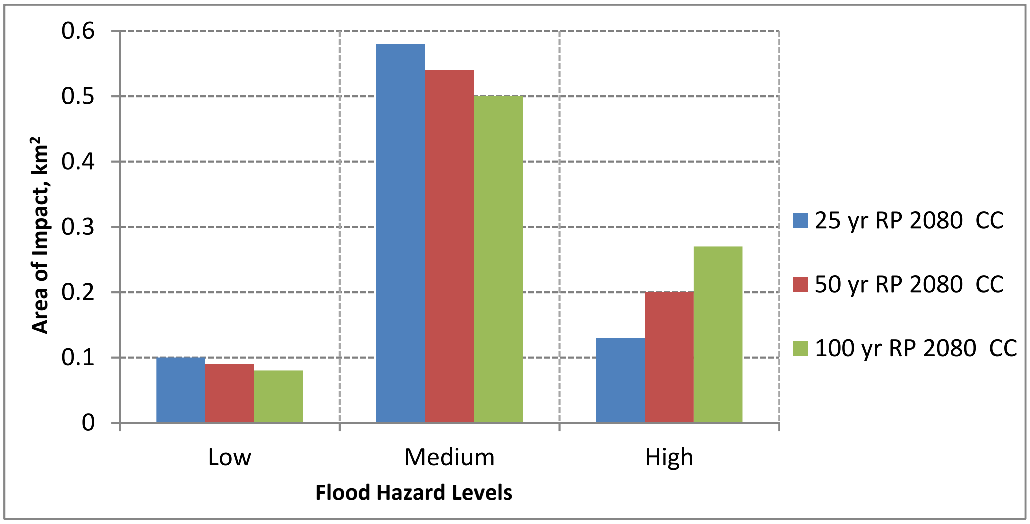


Figure C1- 30: Graphical comparison flooding hazard area of impact of the Canal and its surroundings for the climate change 2080 scenario at 25-, 50-, and 100-year return periods

Figure C1- 31: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the climate change 2080 scenario at 25-year return period

Figure C1- 32: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the climate change 2050 scenario at 50-year return period

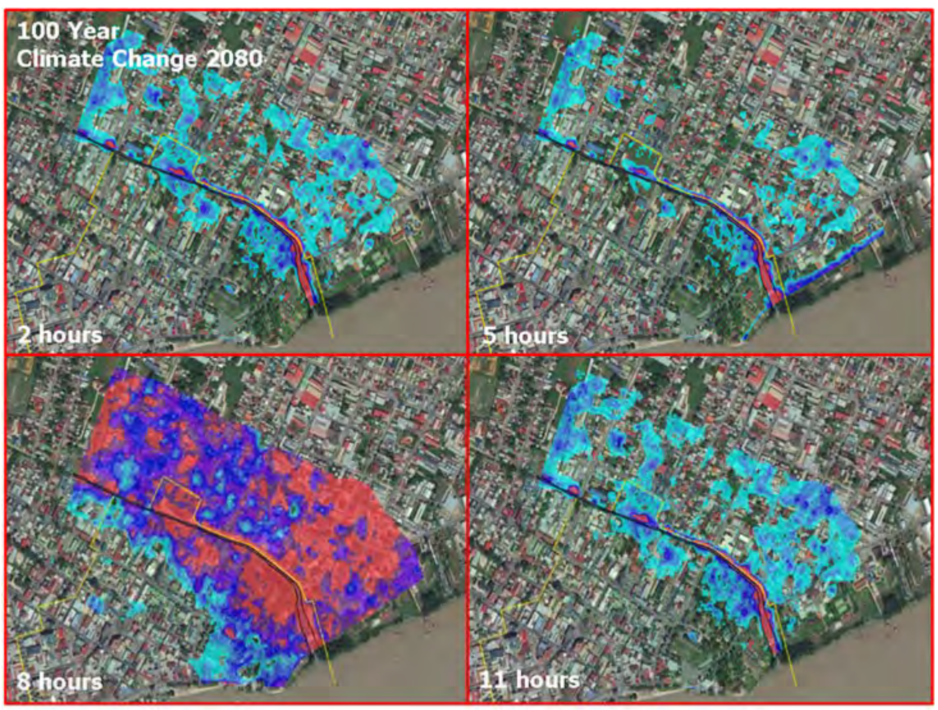


Figure C1- 33: Flooding inundation map of the Canal and its surroundings at discrete hours during the simulation of the climate change 2080 scenario at 100-year return period

APPENDIX C2: HEC-RAS MODEL RESULTS OF THE VAN SOMMELDIJCKSE CANAL WITH THE ADDITION OF THE ALTERNATIVE 4 OPTION

One of the alternative conceptual design options (referred as Alternative 4) identified in the Paramaribo Phase 1 Alternative selection report is adding an additional pump with 4.5 m^3/sec capacity to the already existing two pumps of the same capacity in the Sommeldijckse Canal sluice gate operation complex. The existing HEC-RAS model for the Sommeldijckse Canal was updated with Alternative 4 option by increasing the total pumping capacity to 13.5 m^3/sec. The model simulations were then run for the baseline scenario only at 25-, 50- and 100-year return periods.

The flooding inundation of the Canal and its surroundings predicted by the model for the baseline scenario is shown in Figure C2- 1, Figure C2- 2 and Figure C2- 3 for 25-, 50- and 100-year return periods, respectively. The areas of impact at various flooding inundation depth levels for the same scenario is shown in Table C2- 1 and presented graphically in Figure C2- 4. The corresponding flooding hazard maps are shown in Figure C2- 5, Figure C2- 6, Figure C2- 7 for 25-, 50- and 100-year return periods, respectively. The areas of impact at various flooding hazard levels for the same scenario is shown in Table C2- 2 and presented graphically in Figure C2- 8. The flooding inundation figures depict the maximum inundation that occurs during the simulation time that corresponds to peak catchment flow in the Canal and the simultaneously high tide in the Suriname River. However, the flooding inundation in the Canal and its surroundings changes with time during the time period of simulation due to the time varying flow and tide hydrographs in the upstream and downstream side of the Canal, respectively. Figure C2- 9, Figure C2- 10 and Figure C2- 11 shows flooding inundation map at discrete hours during the simulation time period for the baseline scenario at 25-, 50- and 100-year return periods, respectively.

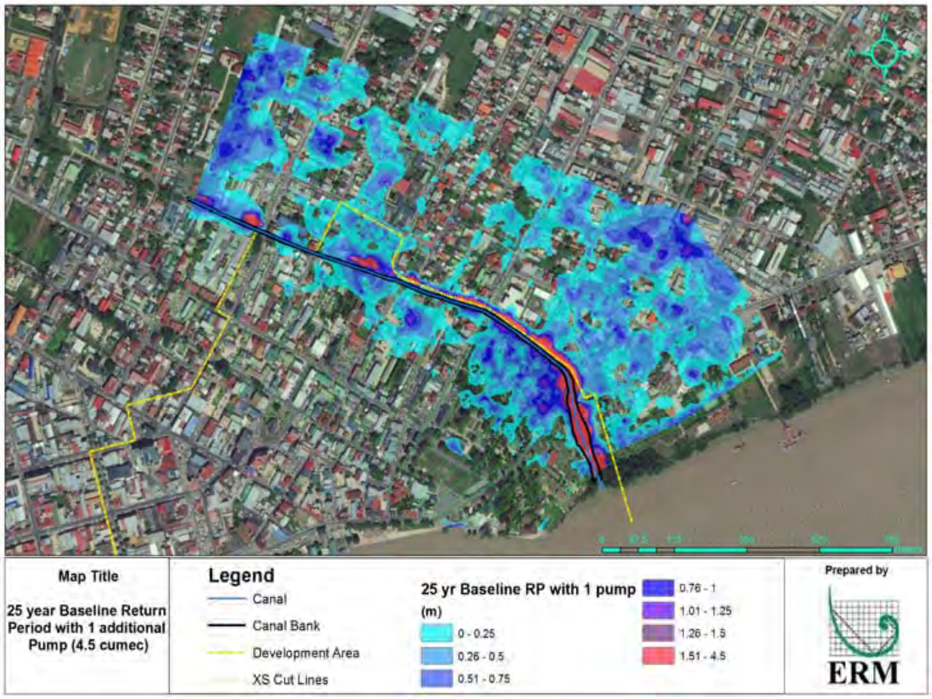


Figure C2- 1: Flooding inundation map of the Canal and its surroundings for the Alternative 4 option and the baseline scenario at 25-year return period

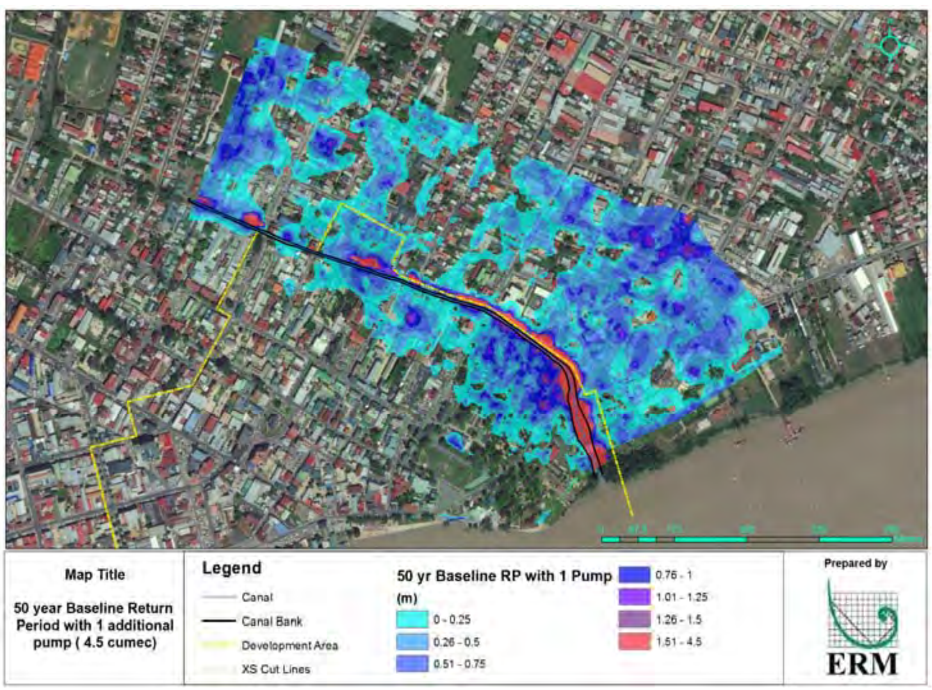


Figure C2- 2: Flooding inundation map of the Canal and its surroundings for the Alternative 4 option and the baseline scenario at 50-year return period

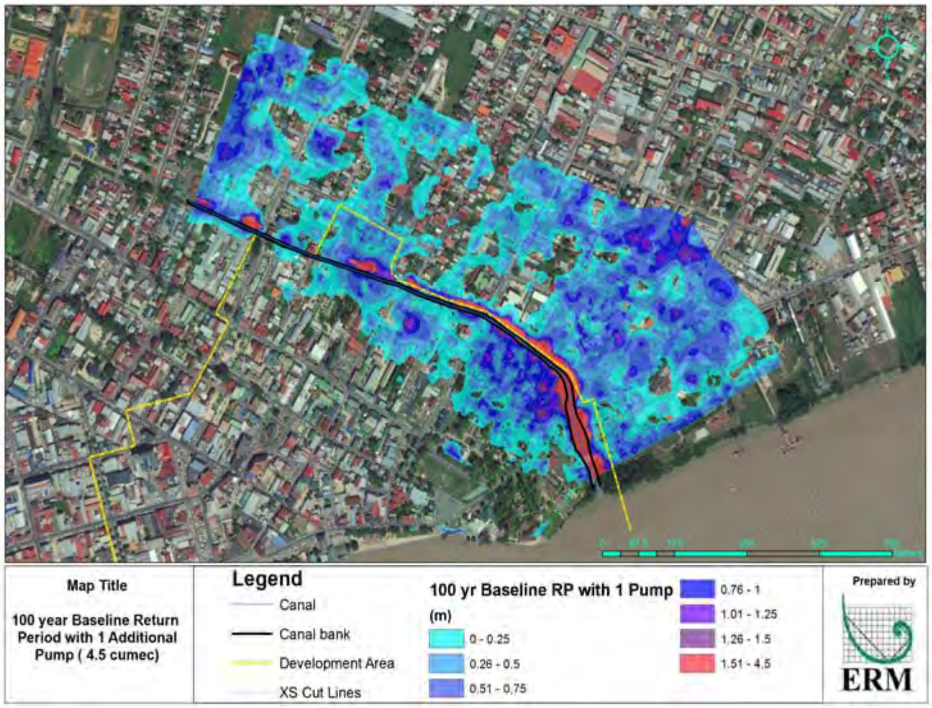


Figure C2- 3: Flooding inundation map of the Canal and its surroundings for the Alternative 4 option and the baseline scenario at 100-year return period

Table C2- 1: Tabular comparison of flooding inundation areas of impact of the Canal and its surroundings for the Alternative 4 option and the baseline scenario at 25-, 50-, and 100-year return periods

Flood Inundation Depth Level, m	Flooding Inundation Area, km²		
	Baseline Alt4 25Y	Baseline Alt4 50Y	Baseline Alt4 100Y
0.0 to 0.25	0.185	0.183	0.178
0.26 to 0.5	0.134	0.154	0.163
0.51 to 0.75	0.065	0.102	0.117
0.76 to 1	0.020	0.034	0.043
1.01 to 1.25	0.005	0.010	0.013
1.26 to 1.5	0.004	0.005	0.005
1.51 to 4.5	0.017	0.020	0.021

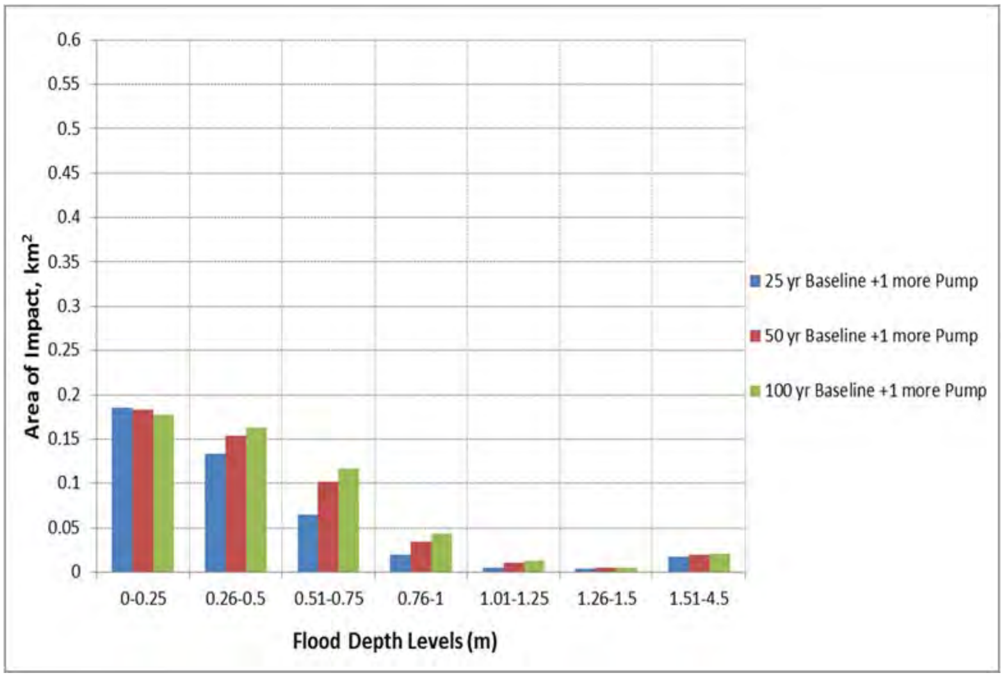


Figure C2- 4: Graphical comparison of flooding inundation areas of impact of the Canal and its surroundings for the Alternative 4 option and the baseline scenario at 25-, 50-, and 100-year return periods

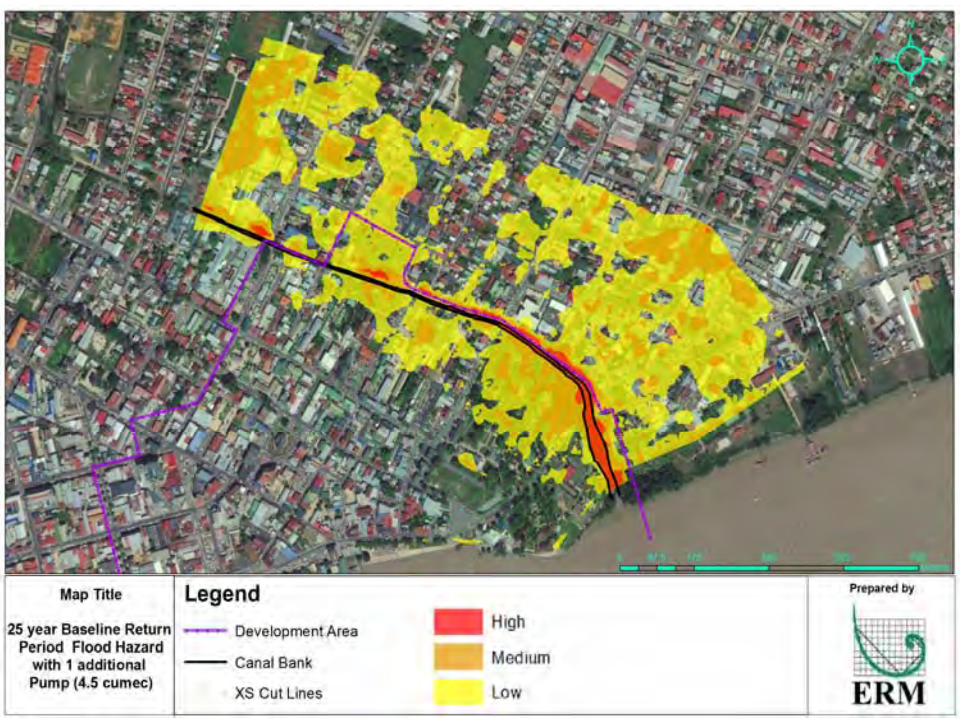


Figure C2- 5: Flooding hazard map of the Canal and its surroundings for the Alternative 4 option and baseline scenario at 25-year return period

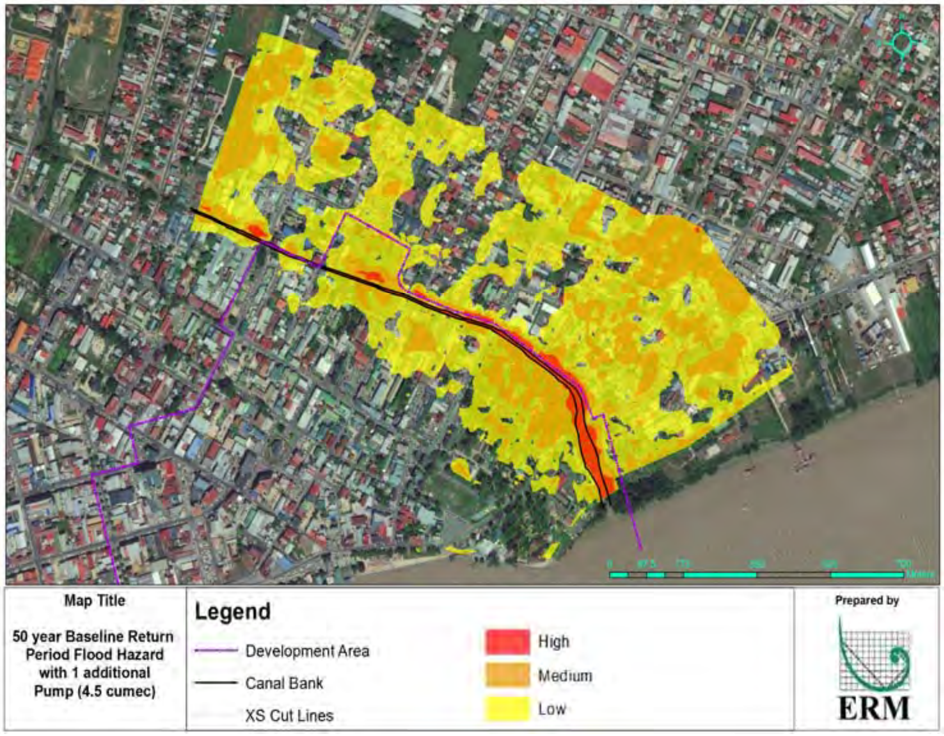


Figure C2- 6: Flooding hazard map of the Canal and its surroundings for the Alternative 4 option and baseline scenario at 50-year return period

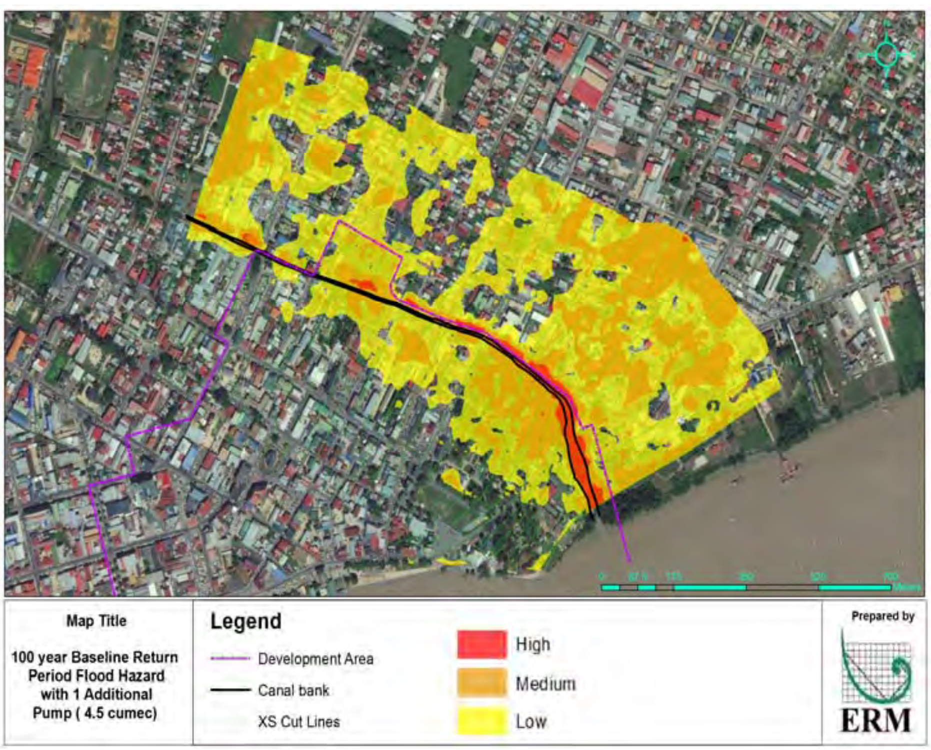


Figure C2- 7: Flooding hazard map of the Canal and its surroundings for the Alternative 4 option and the baseline scenario at 100-year return period

Table C2- 2: Tabular comparison of flooding hazard areas of impact of the Canal and its surroundings for the Altenative 4 option and the baseline scenario at 25-, 50-, and 100-year return periods

Risk Level	Flooding Hazard Area, km²		
	Baseline Alt4 25Y	**Baseline Alt4 50Y**	**Baseline Alt4 100Y**
Low	0.323	0.340	0.341
Medium	0.100	0.160	0.190
High	0.017	0.019	0.021

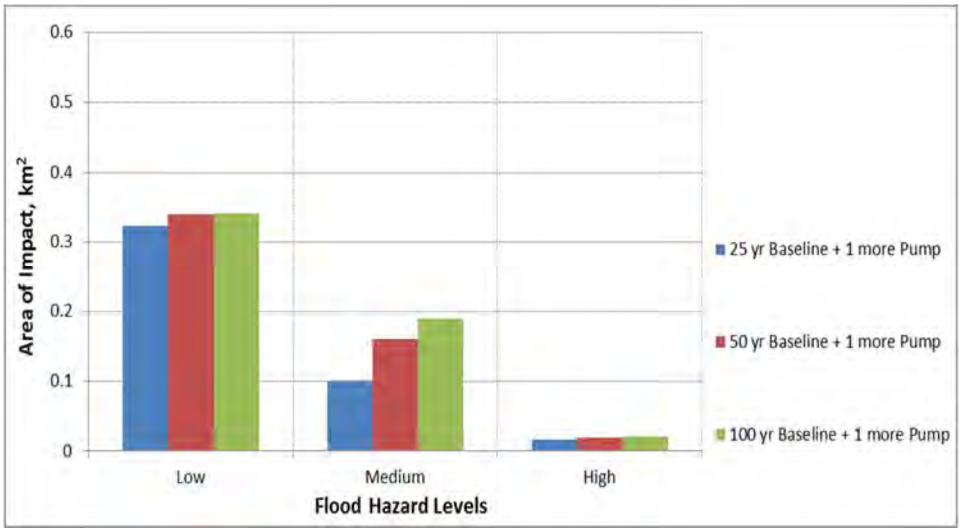


Figure C2- 8: Graphical comparison of flooding hazard areas of impact of the Canal and its surroundings for the Alternative 4 option and the baseline scenario at 25-, 50- and 100-year return periods

Figure C2- 9: Flooding inundation map of the Canal and its surroundings for the Alternative 4 option and the baseline scenario at 25-year return period

Figure C2- 10: Flooding inundation map of the Canal and its surroundings for the Alternative 4 option and baseline scenario at 50-year return period

Figure C2- 11: Flooding inundation map of the Canal and its surroundings for Alternative 4 option and baseline scenario at 100-year return period

APPENDIX C3: COMPARISON OF AREAS OF IMPACT BETWEEN THE EXISTING CANAL CONFIGURATION AND WITH THE ADDITION OF THE ALTERNATIVE 4 OPTION

The comparison of the areas of impact at various flood inundation depth levels between the existing Canal configuration and with the addition of the Alternative 4 option for the baseline scenario at 25-, 50- and 100-year return periods are shown in Table C3- 1 and presented graphically in Figure C3- 1. The area of impact at various flood hazard levels for the same scenario is shown in Table C3- 2 and presented graphically in Figure C3- 2.

Table C3- 1: Tabular comparison of flooding inundation area of the Canal and its surroundings between the existing configuration and with the addition of the Alternative 4 option at 25-, 50- and 100- year return periods

	Flooding Inundation Area, km^2					
Flood Inundation Depth Level, m	**Baseline 25Y**	**Baseline With Alt. 4 25Y**	**Baseline 50Y**	**Baseline With Alt. 4 50Y**	**Baseline 100Y**	**Baseline With Alt. 4 100Y**
0.0 to 0.25	0.1840	0.1850	0.1680	0.1830	0.1562	0.1780
0.26 to 0.5	0.1523	0.1340	0.1648	0.1540	0.1708	0.1630
0.51 to 0.75	0.0981	0.0650	0.1274	0.1020	0.1393	0.1170
0.76 to 1	0.0316	0.0200	0.0526	0.0340	0.0690	0.0430
1.01 to 1.25	0.0096	0.0050	0.0165	0.0102	0.0690	0.0430
1.26 to 1.5	0.0045	0.0040	0.0056	0.0045	0.0067	0.0048
1.51 to 4.5	0.0195	0.0174	0.0214	0.0197	0.0224	0.0206

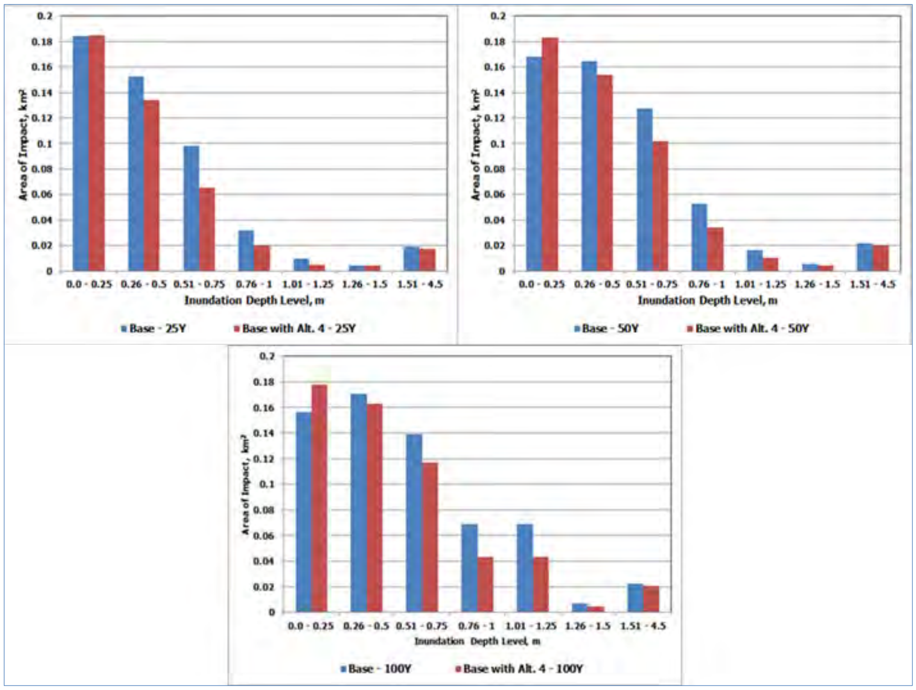


Figure C3- 1: Graphical comparison of flooding inundation areas of impact of the Canal and its surroundings between the existing configuration and with the addition of the Alternative 4 option at 25-, 50- and 100-year return periods

Table C3- 2: Tabular comparison of flooding hazard areas of impact of the Canal and its surroundings between the existing configuration and with the addition of the Alternative 4 option

	Flooding Hazard Area, km²					
Flood Hazard Level, m	**Baseline 25Y**	**Baseline With Alt. 4 25Y**	**Baseline 50Y**	**Baseline With Alt. 4 50Y**	**Baseline 100Y**	**Baseline With Alt. 4 100Y**
Low	0.330	0.323	0.330	0.340	0.344	0.341
Medium	0.150	0.100	0.210	0.160	0.240	0.190
High	0.019	0.017	0.021	0.019	0.022	0.021

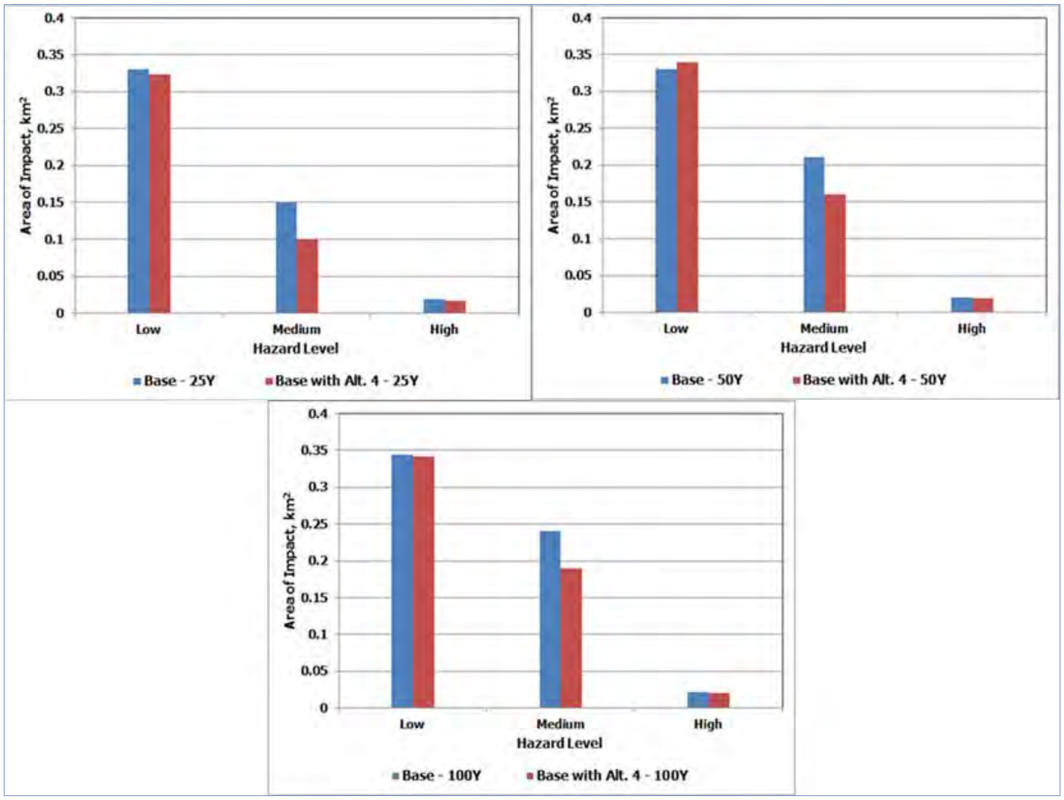


Figure C3- 2: Graphical comparison of flood hazard areas of impact of the Canal and its surroundings between the existing configuration and with the addition of the Alternative 4 option at 25-, 50- and 100-year return periods

From the analysis of the flooding inundation areas of impact for the existing Canal configuration and with the addition of the Alternative 4 option, it can be concluded that the areas of impact associated with the various flood inundation levels are typically decreasing with the addition of one additional pump as part of the Alternative 4 option. This argument holds good for all the three return periods. The climate change scenarios of 2050 and 2080 will also show similar trends and hence are not modelled for this type of analysis. Similarly, from the analysis of flooding hazard areas of impact for the existing Canal configuration and with the addition of the Alternative 4 option, it can be concluded that the areas of impact associated with the low and high hazard levels are not significantly varying with the addition of the Alternative 4 option. However, the medium hazard level areas of impact decreases with the addition of the Alternative 4 option.

APPENDIX D: COMPARISON OF AREAS OF IMPACT BETWEEN THE EXISTING FLOODWALL AND WITH THE ADDITION OF THE ALTERNATIVE 2 AND 3 FLOOD WALLS

The comparison of coastal flooding inundation areas of impact within the Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design floodwall options at 10-, 25-, 50- and 100- year return periods for the baseline, climate change 2020, 2050 and 2080 scenarios in Figure D- 1, Figure D- 2, Figure D- 3 and Figure D- 3, respectively. There is only a slight reduction in the area of impact at all inundation depth levels for the baseline and climate change 2020 scenarios at all the return periods. However, for the climate change 2050 and 2080 scenarios, there is significant reduction in the inundation areas of impact at large return periods.

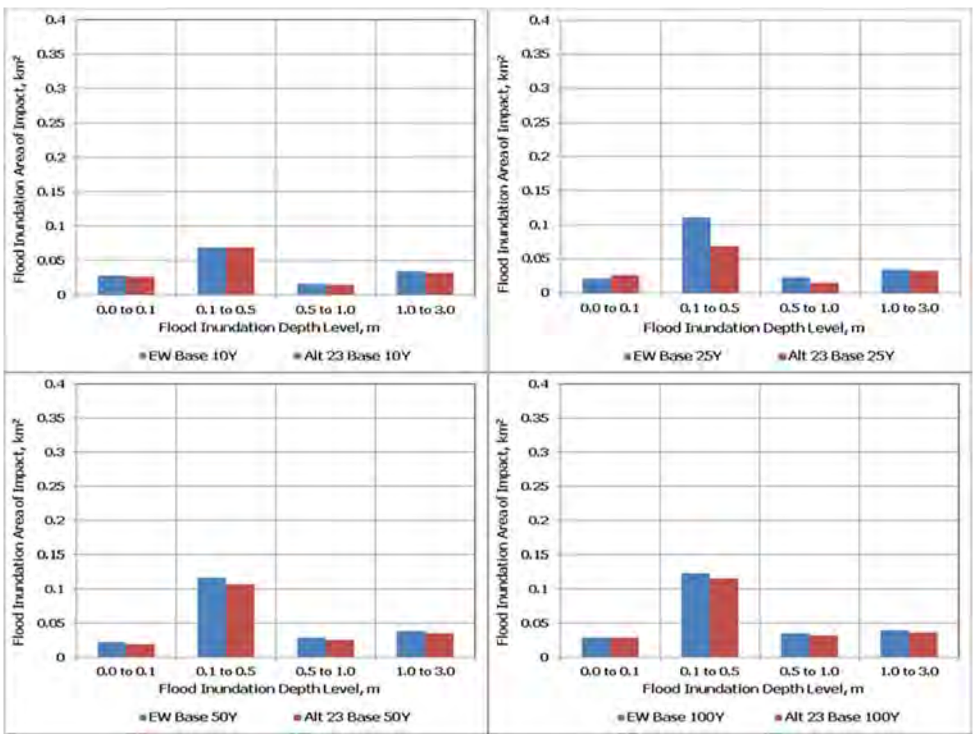


Figure D- 1: Comparison of coastal flooding inundation areas of impact of the Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design floodwalls for the baseline scenario at 10-, 25-, 50- and 100- year return periods

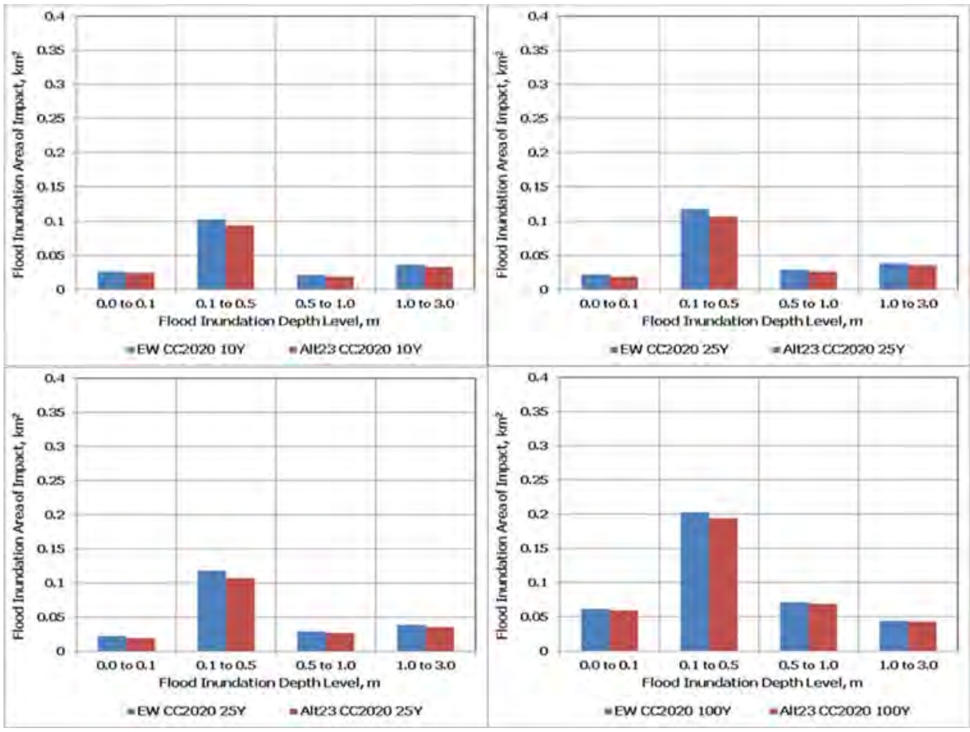


Figure D- 2: Comparison of coastal flooding inundation areas of impact of the Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design improvements for the climate change 2020 scenario at 10-, 25-, 50- and 100- year return periods

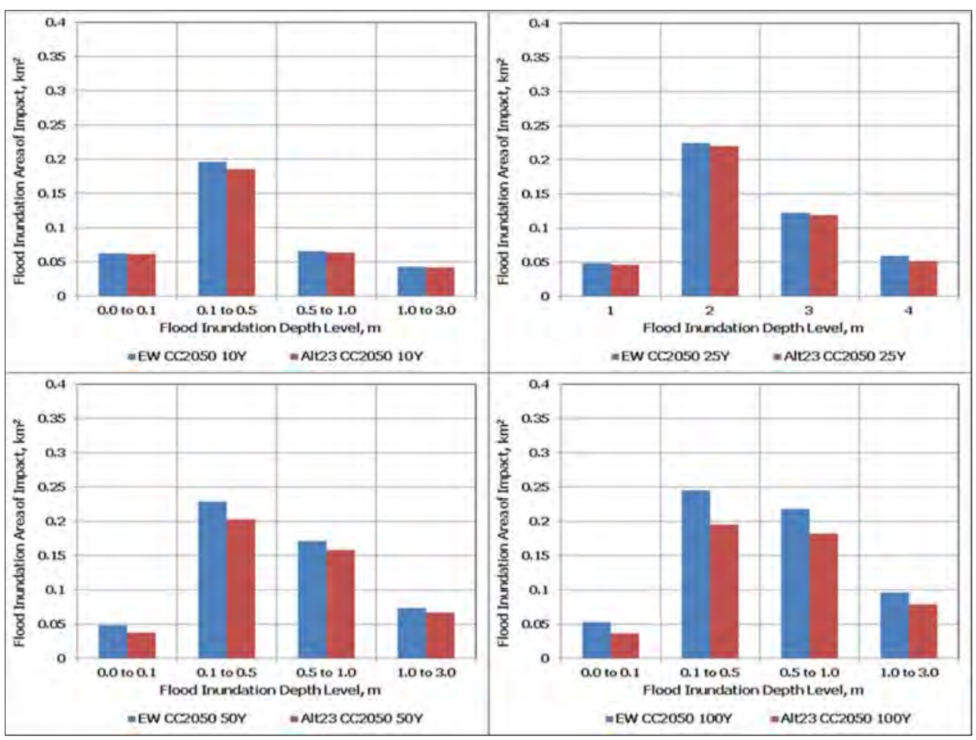


Figure D- 3: Comparison of coastal flooding inundation areas of impact of the Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design floodwalls for the climate change 2050 scenario at 10-, 25-, 50- and 100- year return periods

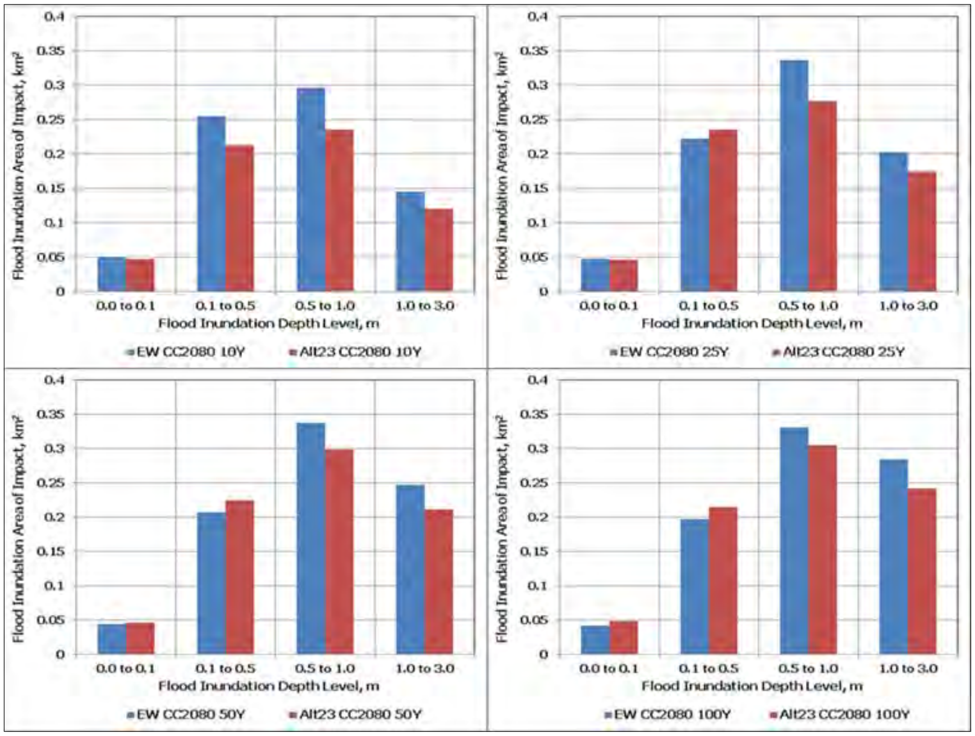


Figure D- 4: Comparison of coastal flooding inundation areas of impact of the existing Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design floodwalls for the climate change 2080 scenario at 10-, 25-, 50-, and 100- year return periods

The comparison of coastal flooding hazard areas of impact of the Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design floodwalls at 10-, 25-, 50- and 100- year return periods for the baseline, climate change 2020, 2050 and 2080 scenarios are shown in Figure D- 5, Figure D- 6, Figure D- 7, Figure D- 8, and respectively. There is a significant reduction in the coastal flooding areas of impact for the medium hazard as compared to other hazard levels for all the scenarios with the addition of the Alternative 2 and 3 floodwalls for the Study Area.

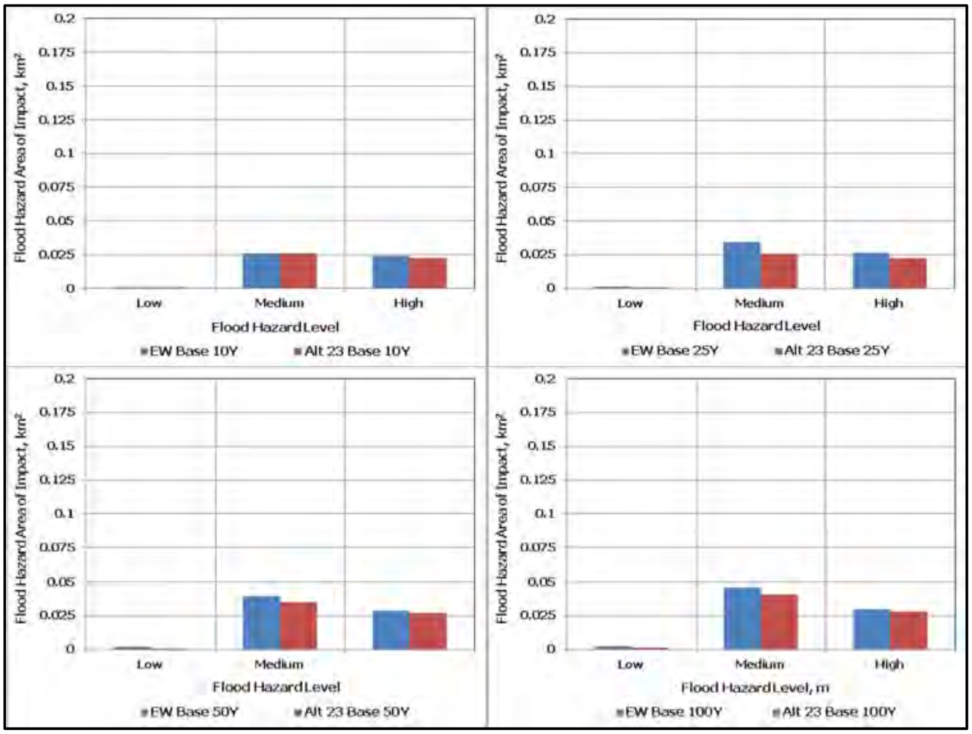


Figure D- 5: Comparison of coastal flooding hazard areas of impact within the Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design floodwalls for the baseline scenario at 10-, 25-, 50-, and 100- year return periods

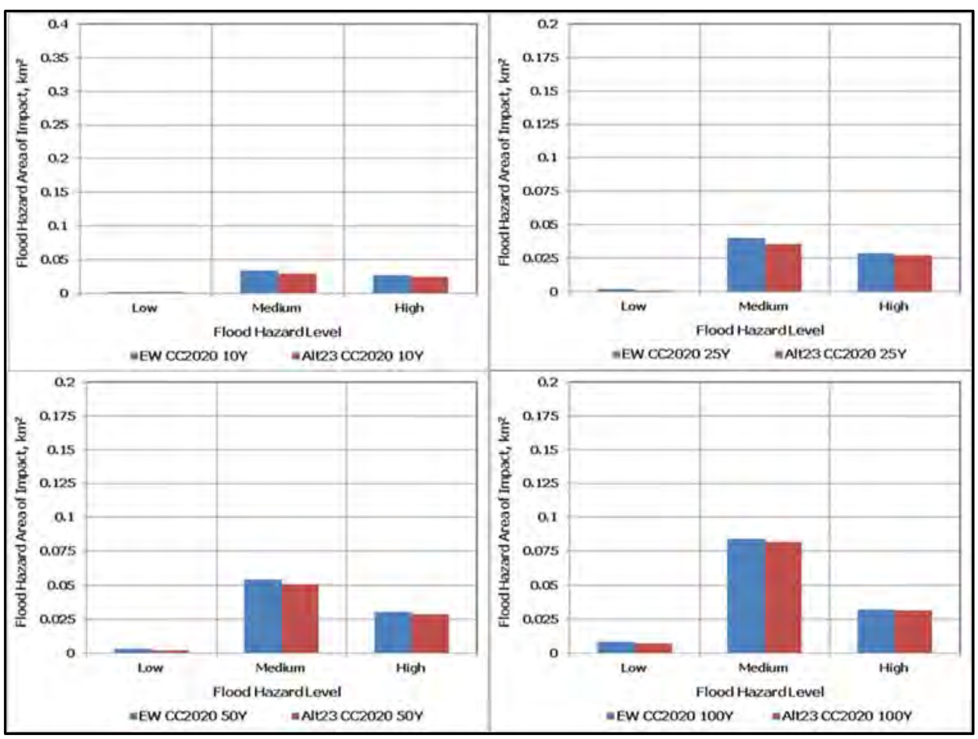


Figure D- 6: Comparison of coastal flooding hazard area of impact of the Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design floodwalls for the climate change 2020 scenario at 10-, 25-, 50-, and 100- year return periods

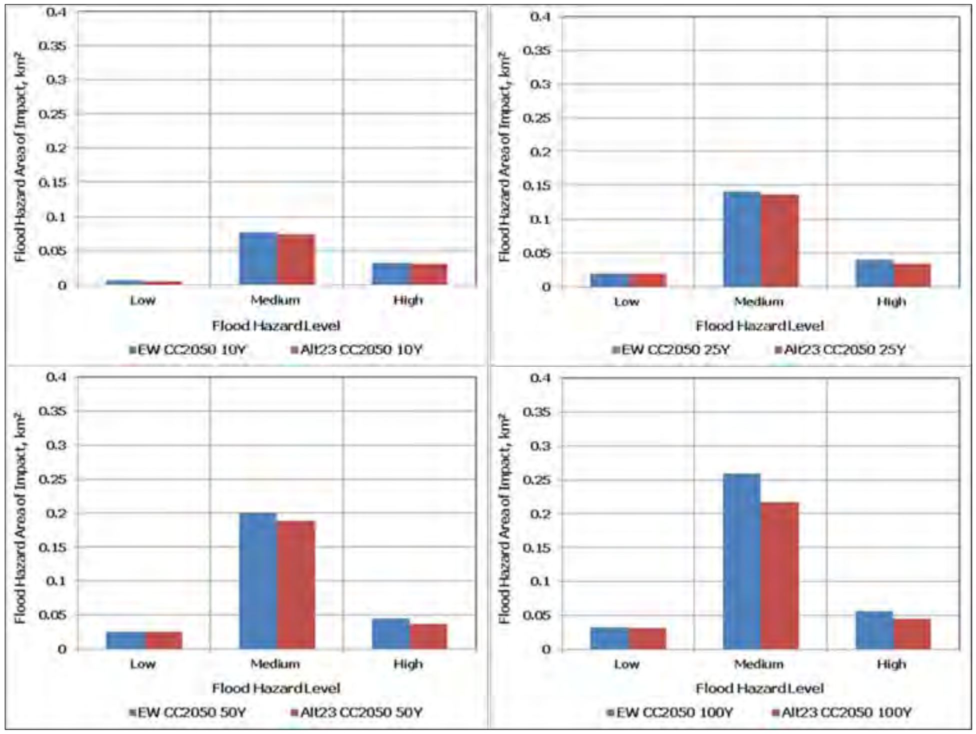


Figure D- 7: Comparison of coastal flooding hazard area of impact within the Study Area between the existing floodwall and the addition of the Alternative 2 and 3 conceptual design floodwalls for the climate change 2050 scenario at 10-, 25-, 50-, and 100- year return periods

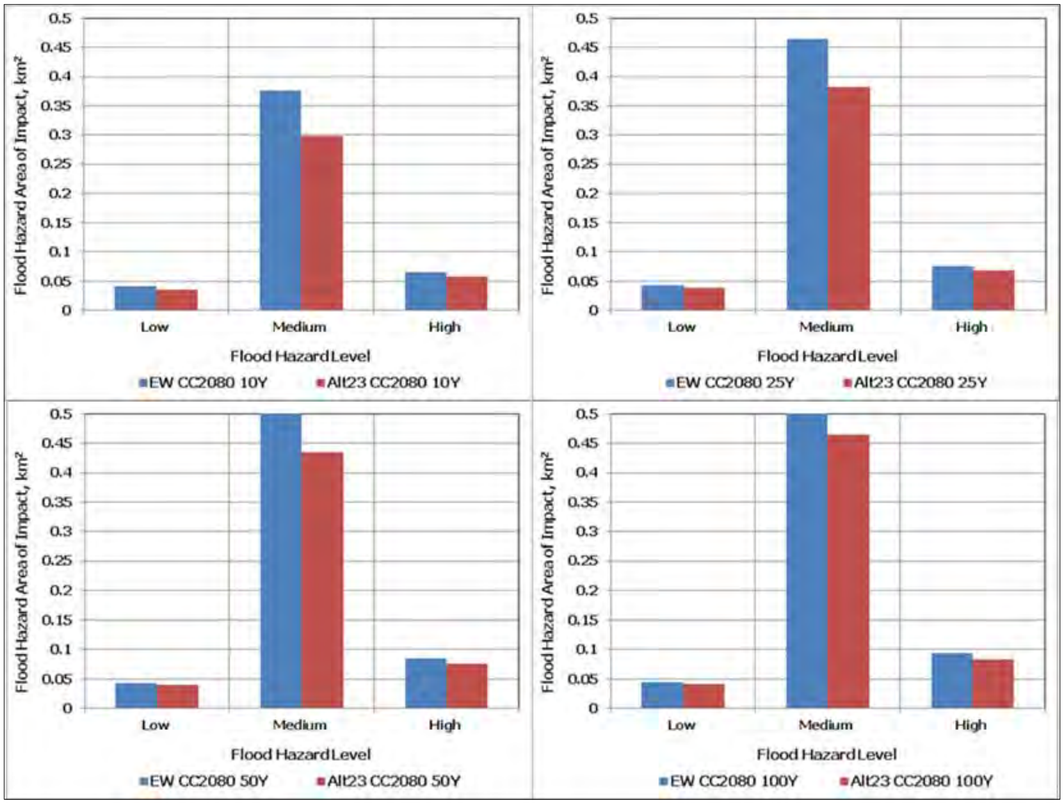


Figure D- 8: Comparison of coastal flooding hazard areas of impact of the Study Area between the existing floodwall and with the addition of the Alternative 2 and 3 conceptual design floodwalls for the climate change 2080 scenario at 10-, 25-, 50-, and 100- year return periods

Annex B - Alternatives Selection: Urban Investments for the Resilience of Paramaribo

Prepared For:

Inter-American Development Bank

Alternatives Selection: Urban Investments for the Resilience of Paramaribo

Final

12 February 2018

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Prepared for:
Inter-American Development Bank

Alternatives Selection: Urban Investments for the Resilience of Paramaribo

Paramaribo Adaptation Fund Project

Final

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http://www.erm.com

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ERM	Environmental Resources Management, Inc.
HWL	high water level
IDB	Inter-American Development Bank
m	meters
M	million
m^3/s	cubic meters per second
NSP	
PS	pump station
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WWTP	wastewater treatment plant

1.0 INTRODUCTION

The purpose of this report is to document the screening, evaluation, and selection of the preferred alternatives (adaptation measures) for preliminary design and subsequent inclusion in the proposal to the Adaptation Fund for Urban Investments for the Resilience of Paramaribo. The adaptation measures are being developed to address the flooding in the urban area of Paramaribo; specifically flooding caused by sea level rise and increased precipitation intensity. This document has been prepared in accordance with the Phase 1 proposal to support Inter-American Development Bank (IDB) in preparing the Full Proposal Document to the Adaption Fund for Urban Investments for the Resilience of Paramaribo.

The proposed alternatives (or adaptation measures) were selected based on a systematic evaluation of several plausible alternatives. The identification of the preferred alternatives was undertaken in two stages. The first stage consisted of identifying a broader universe of technical solutions within the framework of floodwall, green infrastructure, and drainage system improvements that may function separately or as integrated solutions. Order-of-magnitude cost was also developed and the relative evaluation of the alternatives was performed as a means of reducing the alternatives to ones that can be implemented within the available project budgetary limitations and that are most technically and socially acceptable. The second stage consisted of grouping the most technically-acceptable, cost-effective, and implementable of the first stage alternatives for further consideration. The relative merits of the alternative groups in the second stage were compared to support identifying the preferred group of alternatives.

2.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

2.1 INITIAL SCREENING OF ALTERNATIVES

Table 2-1 presents a wide range of potential technologies/alternatives that were initially identified using a variety of sources, including previous experience, local knowledge, and team brainstorming/consultation. Local past experiences on similar projects was considered in determining what might work/ not work, and was incorporated in the Table 2-1 below. These technologies were then evaluated based on site-specific conditions, implementability, cost, and effectiveness. Technologies that were deemed inappropriate based on comparison with these criteria were eliminated from further consideration. Rather than involving the universe of alternatives, the purpose of this initial screening of technologies was to streamline the process and to limit the number of alternatives that will undergo a more detailed evaluation. The focus was to include only those alternatives with a reasonable potential to address the climate change issue, namely inland and coastal flooding. The technologies retained for further evaluation are identified in Table 2-1.

Table 2-1: Initial Technology/Alternative Screening

Technology/Alternatives	Process	Retained	Eliminated	Remarks
Regulation and Policies	Government Policy, Zoning and Land Use Options	✓		Can be used for future development
Business Relocation	Relocate business/market along the shoreline and design the vacated area for recreational use		X	Livelihood and social impact, public resistance, costly
New Flood Protection Wall	Flood protection wall (sheet piles with brick or concrete cap)	✓		Effective, supported by flood model
New Tidal Basin with Flow Controls	Create new tidal basins with flow controls (tidal gates, pumps)		X	Limited space within city center for new infrastructure, costly
Rehabilitate existing old retaining wall	Retrofit existing old retaining wall (sheet piles)	✓		Effective, supported by flood model
Rehabilitation - Existing Flood Control Mechanicals	Rehabilitate/retrofit existing tidal gates, sluice gates, and other flood controls	✓		Effective, supported by flood model
Rehabilitation - Drainage System	Rehabilitate/retrofit existing stormwater infrastructure (improve efficiency of the existing network)	✓		Effective, current status - poorly maintained
Shoreline Erosion Protection/ Stabilization	a) Riprap/gabions/articulated concrete blocks along shoreline	✓		Effective for erosion protection
	b) Timber groins to promote sediment accumulation and vegetative growth in select areas		X	Space constraints, consider using in combination with mangrove establishment
	c) Create buffer with enhanced mangrove	✓		Proven technology in study area
Dredging	Dredging to increase capacity of Suriname River		X	Likely little impact on flood elevation and velocity, costly
Stormwater Retention and Release	a) Install underground stormwater retention system (retention vaults, pipes) and release water at lower rate	✓		Secondary benefit to flood mitigation, including source of water for fire protection
	b) Construct aboveground stormwater retention and release system (swale, ponds) in open spaces	✓		
	Pervious pavement: Use alternative to impervious materials (permeable pavements, vegetation,)	✓		Consider implementing in select areas of city center to reduce runoff
Rainwater Harvesting/Reuse	Retrofit building with storage tanks and reuse water for toilets, etc.,		X	Difficult to implement on a large enough scale to have an impact
New Wastewater Treatment Plant	Separate storm and sewer and install WWTP for sewer		X	Although beneficial, limited impact on flood protection, costly

2.2 *ALTERNATIVE DESCRIPTION*

The technology screening described in Section 2.1 resulted in selecting 14 targeted site-specific alternatives that represent viable options while preserving the concept to mitigate climate change issues considering both inland and coastal flooding. These 14 targeted site-specific alternatives are summarized in Table 2-2 and shown on Figure 1.

A stakeholder engagement was conducted on 8 November 2017 in Paramaribo to present the project and solicit feedback on the identified alternatives. The meeting included presentation of the identified alternatives as well as a description of the criteria used to evaluate the alternatives and identify those that are preferred.

Table 2-2: Site-Specific Alternative Description

Technology/ Alternatives	Site-Specific Alternatives	Description
Regulations and Policies	Alternative 1: Government policy, zoning, and land use options	Incorporates government interventions via poilicies, zoning, and land use limitation with a goal of allowing more open space and green in the city center, enforce built-up area restrictions, enhance water management, update master plan, and implement environmental policies (waste collection).
New Flood Protection Wall	Alternative 2: New flood protection wall from Knuffelsgracht Street to SMS Pier	Includes a new flood protection wall, approximately 250 meters (m) long, for a section from Knuffelsgracht Street to SMS Pier along south side of Waterfront (*Waterkant*) Street. The flood wall consists of metal sheets pushed into the ground several feet below the ground surface. The sheet pile will be reinforced along the embankment side with riprap/stone. The sheet pile will be finished with concrete/brick cap on top with a two- to four-meter wide walkway. Roadside drainage along the wall will be impoved and trees/plants will be planted. Existing historic landing for small boats and a steel jetty that are within the limits of the proposed flood protection wall will be rehabilitated during the wall construction.
Rehabilitate Existing Old Retaining Wall	**Alternative 3**: Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal	Includes replacing part of existing steel sheet piles between Van Sommelsdijck Canal sluice gate and Fort Zeelandia; riprap stone will be added in the embankment to increase passive pressure and bearing capacity of existing piles. Other components include reprofiling clay dike, increasing steel sheet pile wall crest level, and making walkways for pedestrians.
Rehabilitation – Existing Flood Control Mechanicals	**Alternative 4**: Rehabilitate Van Sommelsdijck pumping station and sluice gates	The existing pumping station is old and only partially functioning. This alternative includes adding/refurbishing one pump capacity (4.5 m^3/s), upgrading existing mechanical and electrical system, upgrading sluice gates structures, widening the inland water storage area, and automating operation.
	Alternative 5: Rehabilitate sluice gate and pumping station at Knuffelsgracht Street	This alternative will require new pumps and new sluice gates, including new concrete structure and raising top level for high water level (HWL) protection.
	Alternative 6: Rehabilitate Jodenbree Street sluice gate near Central Market	Involves minor improvement of existing sluice gate near Central Market, adding new gates, raising top level for HWL protection.

Technology/ Alternatives	Site-Specific Alternatives	Description
Rehabilitate Drainage System	**Alternative 7:** Rehabilitate Van Sommelsdijck Canal	Van Sommelsdijck Canal will be rehabilitated starting from the canal pump station to a maximum of 700 meters up-gradient. The expansion includes removing sediments and debris from the existing canal, profiling/regrading the canal to gain appropriate capacity, lining the canal bottom with concrete, and installing concrete/brick retaining wall on both sides of the canal. To add functionality, walkways will be constructed on both sides of the expansion with parking facilities at certain locations. This component also includes rehabilitating drainage (culvert) at Tourtonnelaan Street crossing (upgradient end of the canal rehabilitation section).
	Alternative 8: Rehabilitate drainage system along Waterfront between Knuffelsgracht and SMS Pier	Includes improving existing stormwater and sewer drainage system including pipes and inlet for approximately 300-meter segment of the Waterfront Street between Knuffelsgracht and SMS pier. Undersized/small diameter underground pipes and inlets/outlets will be removed and replaced with larger capacity pipes and inlet/outlet structures. After the pipes and inlet/outlet replacement, the overlying road will be repaved. This upgrade will ensure better collection and discharge through the Knuffelsgracht pump station and sluice gate.
	Alternative 9: Improve Viotte Kreek drainage system	Use large culverts or open "U" concrete channel structure to improve discharge/reduce maintenance for approximately 350 meters between Zwartehovenburg Street and Klipstenen Street.
Shoreline Erosion Protection/ Stabilization	**Alternative 10:** Riprap/gabions/ articulated concrete blocks along shoreline	This alternative focuses on erosion control by using riprap/gabions/articulated concrete blocks for approximately 300 meters of shoreline.
	Alternative 11: Create buffer with enhanced mangrove plantings	The existing mangrove area immediately south of the Van Sommelsdijck Canal pump station will be slightly expanded and enhanced by planting more trees and constructing other natural features (trapping units/wooden quays) to facilitate growth, sediment entrapment, and protection against erosion.
Stormwater Retention and Release	**Alternative 12**: Install underground stormwater retention system	Installation of stormwater retention system such as vaults and large diameter pipes to release water at a lower rate.
	Alternative 13: Construct aboveground stormwater retention and release system	Construction of swales, ponds, or similar features in open spaces. Approximately four such aboveground units are assumed.
	Alternative 14: Construct permeable pavements or similar alternatives to impervious surfaces	Reduction in surface runoff from impervious surfaces by converting existing surfaces to more permeable options. Permeable pavement is assumed to be installed in Keizer Street, Knuffelsgracht bus terminal, along Waterfront, along Viotte and other canals.

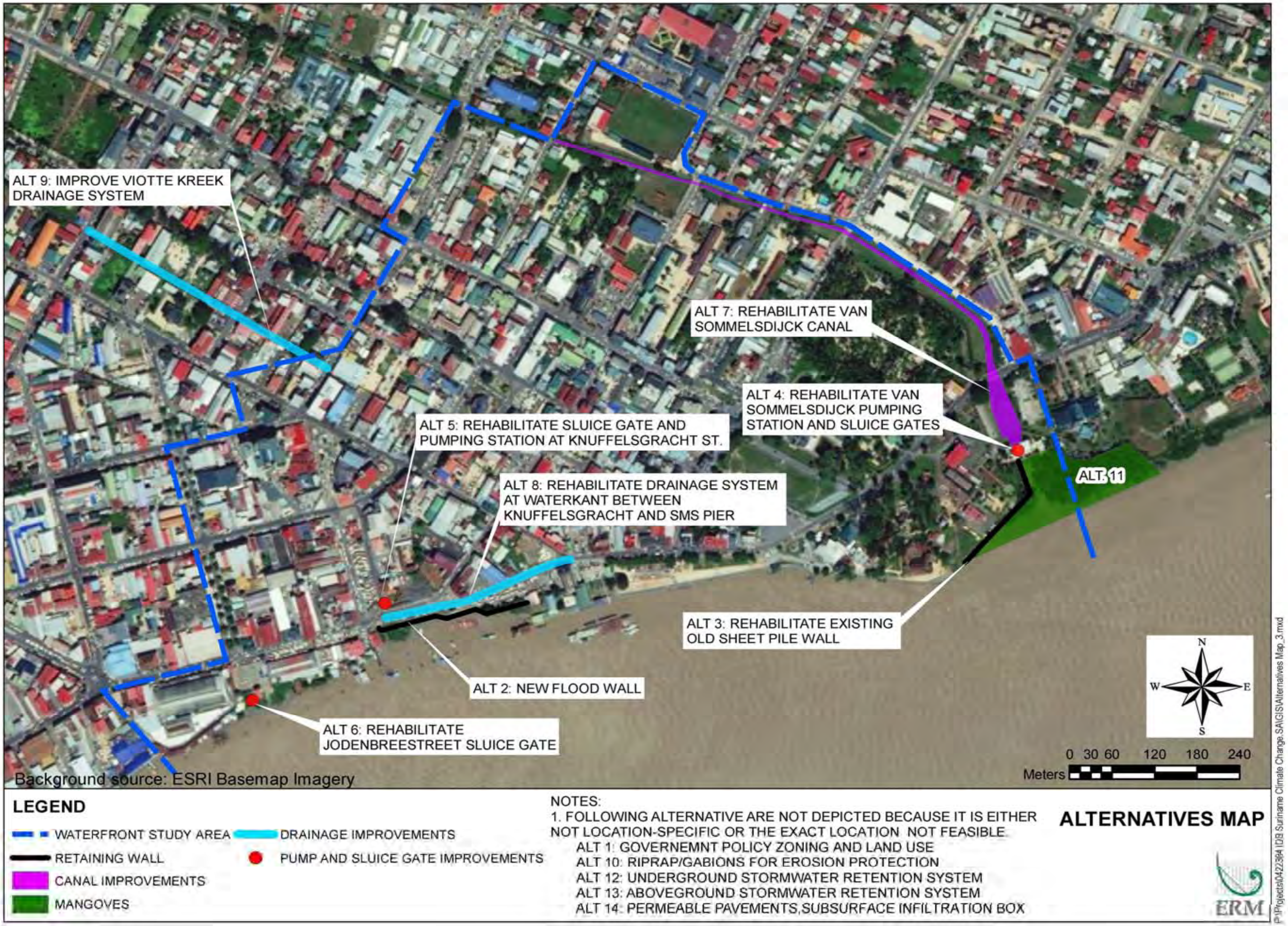

Figure 2-1: The Fourteen Targeted Site-specific Alternatives

3.0 ALTERNATIVE EVALUATION

3.1 EVALUATION CRITERIA

During the initial stage of the alternative formulation, a set of site-specific criteria were developed to assist in evaluating the alternatives identified in Section 2.2. These evaluation critera were broadly classfied into four main categories.

I. Technological achievement
   - Meeting flood protection through design life
   - Technological approaches
   - Integration of green technologies
   - Compatibility with existing flood protection or drainage improvements
   - Capital versus operation and maintenance (O&M)-intensive measures
   - Long-term effectiveness

II. Socio-political achievement
   - Social consideration
   - Regulatory and government involvement
   - Compatibility with UNESCO World Heritage Site restrictions

III. Environmental achievment
   - Stabilization of the river and drainage systems
   - Flood protection
   - Naturalization of the river bank
   - Ecosystem enhancment

IV. Programmatic achievement
   - Implementability
   - Cost

These criteria have been detailed in previous reports/submittals and are not repeated in this report.

3.2 ANALYSIS AND SCORING OF ALTERNATIVES

The 14 site-specific alternatives identified in Section 2.2 were evaluated in detail against the evaluation criteria identified in Section 3.1. A multi-critera evaluation (weighted sum model) was performed to identify the preferred alternatives as discussed below.

First, a numerical value was assigned to each evaluation criteria such that the sum of all numerical points (values) totaled 100. Higher numerical points (value) were assigned to those criteria considered more important. Each alternative was then scored against the evaluation criteria by providing percent weight based on the ability/likelihood of a given alternative to meet that specific criterion. The allocation of percentage weight increases with the increase in ability/likelihood of the alternative to meet the criteria based on the following scale:

If an alternative:

- Meets and/or has significant/numerous positive impact toward the criterion = 100 percent of the total points for that criterion
- Meets and/or has marginal/minor positive impact towards the criterion = 75 percent of the total points for that criterion
- eets and/or has mixed impacts towards the criterion = 50 percent of the total points for that criterion
- Does not meet and/or marginally deviates from the criterion = 25 percent of the total points for that criterion
- Does not meet and/or has several negative impacts towards the criterion = 0 percent of the total points for that criterion

A weighted sum score was calculated for each alternative, and the highest weighed scored alternatives were selected as the preferred alternatives (proposed adaption measures). A detailed multi-criteria decision matrix for alternatives evaluation is provided in Appendix A.

Based on the method discussed, and as presented in Appendix A, the alternatives that scored above 70 are considered a preferred adaptation measure, and are identified in Table 3-1.

Table 3-1: High Ranked Site-Specific Alternative

Site-Specific Alternatives		**Scores**
Alternative 2	New flood protection wall from Knuffelsgracht Street to SMS Pier	73.25
Alternative 3	Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal	78.25
Alternative 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	70
Alternative 5	Rehabilitate sluice gate and pumping station at Knuffelsgracht Street	70
Alternative 7	Rehabilitate Van Sommelsdijck Canal	73.5
Alternative 8	Rehabilitate drainage system along Waterfront between Knuffelsgracht and SMS Pier	70.5
Alternative 11	Create buffer with enhanced mangrove plantings	76.5

4.0 ALTERNATIVES SELECTION

4.1 ALTERNATIVE GROUPS

Formulation of the proposed adaptation measures consists of assembling the seven highest-ranked alternatives (Alternatives 2, 3, 4 5, 7, 8, and 11) into three groups that represent options that best address the critical component of the project, i.e., address the current and future expected flooding in the project area. These three groups, along with projected cost, benefits, and drawbacks of each group, are presented in Table 4-1.

Table 4-1: Alternative Groups

Group	Alternative	Alternative Description	Projected Cost	Total Group Cost	Benefits	Drawbacks
Group A	Alt 2	New flood protection wall from Knuffelsgracht Street to SMS Pier	$5.11 M	$7.80 M	• Strong measure for coastal flood protection • Adaptive to future by increasing wall height • Addresses critical flood area • Address both coastal and inland flooding	• May obstruct view • Inland flood control requires operation of pump and gates • Flood wall overlaps with existing water tax business • Management of potentially impacted sediment
	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	$2.33 M			
	Alt 11	Create buffer with enhanced mangrove plantings	$0.36 M			
Group B	Alt 3	Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal	$2.19 M	$7.21 M	• Minimal construction disturbance to rehabilitate existing wall • Added functionality along canal for walkways • Address both costal flood and limited (reduced segment of canal improvement)	• Critical flood area not addressed • Only portion of canal is rehabilitated • Inland flood control requires pump and gates operation • Management of potentially impacted sediment
	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	$2.33 M			
	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)	$2.33 M			
	Alt 11	Create buffer with enhanced mangrove plantings	$0.36 M			
Group C	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	$2.33 M	$7.57 M	• No view obstruction • Added functionality along canal for walkways • Address both coastal flood and limited (reduced segment of canal improvement)	• Critical flood area partially addressed by new pump station (PS) – Alt 5 • Construction disturbance at new PS – Alt 5 • Inland flood control requires pump and gates operation
	Alt 5	Rehabilitate sluice gate and pumping station at Knuffelsgracht Street	$2.55 M			
	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)	$2.33 M			
	Alt 11	Create buffer with enhanced mangrove	$0.36 M			

* Canal improvement section reduced from 700 m to 250 m

4.2 PROPOSED ADAPTATION MEASURES

As can be seen from Table 4-1, there are several benefits and drawbacks for each group. The review of these benefits and drawbacks, including comparative analysis of these groups, concludes that alternatives within Group A are the preferred adaptation measures; therefore, ERM proposes Group A alternatives to advance to the pre-engineering design stage. The following points were considered for recommending Group A:

1. Group A addresses the critical flood area (proposed new wall location). It manages current and future climate-change-induced flooding. Modeling indicates that the new flood wall prevents coastal flooding in the most flood prone area for the 50-year return period (baseline condition) and for the 25-year return period for 2020 climate change conditions. Beyond 2020 and higher return periods, the flooding is reduced as compared to non-existence of the wall. The model flooding results are based on a wall elevation equivalent to the elevation of the recently constructed flood wall (+3.25 NSP). Flood Wall (+3.25 NSP) is based on a 50 years return period for High Water Level, increased with sea level rise for 50 years, expected wave height and free board. Currently there are no national design standards for flooding. The flood depths and corresponding hazard rankings for different return periods and climate change conditions are presented in the modeling results report.
2. Group A integrates different forms of alternatives; the floodwall to address river front flooding, inland drainage system improvements to address inland flooding, and green infrastructure for shoreline erosion protection and stabilization.
3. These alternatives are spread out and not concentrated in one specific area. The alternatives address both coastal and inland flooding.
4. The Van Sommelsdijck Canal and pumping station is one of the major inland drainage systems in the targeted study area. Improving the operational capacity of this system will have a large impact on inland flooding.

4.3 DESCRIPTION OF GROUP A ALTERNATIVES

1. New Flood Protection Wall: The historic flood wall on the south side of Waterfront Street will be replaced with a modern sheet pile wall extending approximately 250 meters from Knuffelsgracht Street to the SMS Pier. The steel sheet pile wall will be reinforced along the river side with locally available riprap/stone and finished with a concrete/brick cap. A two- to four-meter wide walkway will be installed on the street side with tree/shrub plantings. A schematic of the proposed flood wall is presented in Figure 4-1. Additionally, street side drainage improvements will be implemented, including storm drain rehabilitation. The existing historic landing for small boats and a steel jetty within the limits of the proposed flood protection wall will be rehabilitated during the wall construction.

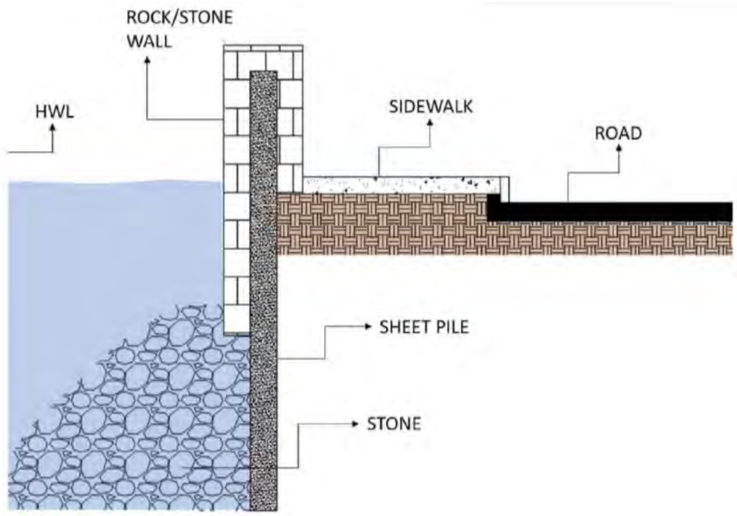

Figure 4-1: Flood Protection Sea Wall Detail

2. Rehabilitate Van Sommelsdijck Pumping Station and Sluice Gates – Currently, two of three pumps at the Van Sommelsdijck Canal pump station are operational. This alternative includes adding a new pump or refurbishing the third pump to restore the original capacity of the pump station. Other improvements include upgrading the outdated mechanical and electrical systems, rehabilitating the sluice gate structures, and increasing the capacity of the water storage area in front of the sluice gates by dredging accumulated sediment.

3. Enhance Mangrove Plantings: The existing mangrove plantings at the Van Sommelsdijck Canal pump station outlet will be enhanced and expanded to provide additional erosion protection. The enhancements will include constructing wooden cribbing to facilitate sediment entrapment and natural vegetation growth. Additional mangrove plantings will be made in this area as well.

Appendix A
Alternatives Evaluation Matrix

MULTI-CRITERIA ALTERNATIVE EVALUATION MATRIX

Alternatives	**Technology/Alternatives**		**Regulation and Policies**	**New Flood Protection Wall**	**Rehabilitate existing old retaining wall**	**Rehabilitation - Existing Flood Control Mechanicals**			**Rehabilitation - Drainage System**			**Shoreline Erosion Protection/Stabilization**		**Stormwater Retention and Release**	
	Alternatives Number		**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**Alternative 5**	**Alternative 6**	**Alternative 7**	**Alternative 8**	**Alternative 9**	**Alternative 10**	**Alternative 11**	**Alternative 12**	**Alternative 13**	**Alternative 14**
	Site-specifc Alternatives		Government policy, zoning and land use options	New flood wall by extending the existing sheet pile wall (old) from Knuffelsgracht street to SMS Pier, with roadside drainage improvements	Rehabilitate existing old sheet pile between Fort Zeelandia and sluice gate in Van Sommelsdijck canal	Rehabilitate Van Sommelsdijck pumping station and sluice gates	Rehabilitate sluice gate and pumping station at Knuffelsgracht street	Rehabilitate/improve Jodenbreestreet sluice gate near Central Market	Rehabilitate Van Sommelsdijck canal	Rehabilitate drainage system at Waterkant between Knuffelsgracht and SMS Pier	Improve Viotte Kreek drainage system (approx. 350 m) between Zwartehovenburgstr and Klipstenen str	Riprap/gabions/articulated concrete blocks along shoreline	Create buffer with enhanced mangrove	Install underground stormwater retention system	Construct above-ground stormwater retention and release system	Construct permeable pavements, sub-surface infiltration box and similar alternatives to improve surfaces
	Alternative Detail Description		Allow more open space and green in city center, enforce built up area restrictions, enhance water management, update masterplan, implement environmental policies (waste collection)	Approx. 250 m length. Use of steel sheet piles with coverage of bricks or concrete. Use of stone in the embankment to avoid debris accumulation. Include walkway of 2-4 meters. Improve road side drainage and add trees/green. Rehabilitate historic landing for small boats. Rehabilitate old steel jetty for use by boat taxis during execution.	Replace part of existing steel sheet piles, add rip rap in embankment to increase passive pressure and bearing capacity of existing piles. Re-profile clay dike, increase crest level, make walk way for pedestrians.	1 x New Pump (4.5 m3/s), rehabilitation and automate functioning. Check/refurbish other pumps. Rehabilitate sluice gates/ structures, incl E&M and inlet/outlet part of canal	New pumps needed, incl E&M, and new sluice gates are required, including new concrete structure and raising top level for HWL protection.	Minor imporvement of existing sluice gate near central market, new gates, raising top level for HWL protection. The culverts in Jodenbreestreet have recently been renewed.	Retaining structures both sides with brick wall finish, length about 700 m each side, increased retention capacity, improved/hard structure canal bottom to minimise maintenance, walkways both sides, restructure road with parking facilities, including rehabilitation drainage crossing Tourtonnelaan	Approx. 300 m length, ensure better collection and discharge through the Knuffelsgracht pump station and sluice gate. Take out all exisiting small outlets in the dilapidated wall along Waterkant (Knuffelsgracht)- see Alt 2; install large diam 1250 mm pipes under new walkway	Use large culverts or open U concrete channel structure to improve discharge/reduce maintenance	Riprap/gabions/articulated concrete blocks along Suriname river bank. Assume 300 m of shoreline. Exact location TBD	Enhance existing mangrove to facilitate growth, entrapment of sediment, protection against erosion (trapping units/wooden quays)	Install retention system such as vaults, large diameter pipes and release water at lower rate.	Construct swale, ponds, or similar features in open spaces. Assume 4 each with each approx, 2,000 m3 capacity. Location to be TBDLocation TBD	Reduce runoff from impervious surfaces by converting existing surfaces to more permeable options. Keizer straat, Knuffelsgracht bus terminal, along Waterkant, along Viotte and other canals, etc
Evaluation Criteria		**Weight**														
	Technology Achievement															
	Meeting flood protection through design life	20	25%	100%	100%	75%	75%	50%	75%	75%	50%	25%	50%	75%	75%	75%
	Technological approaches (Active/Passive)	4	75%	75%	75%	50%	50%	50%	75%	75%	75%	75%	75%	75%	50%	50%
	Integration of green technologies	2	75%	50%	50%	50%	50%	50%	50%	50%	50%	50%	100%	50%	75%	50%
	Compatibility with existing flood protection or drainage improvements	4	25%	75%	100%	75%	75%	75%	75%	75%	75%	50%	75%	75%	25%	25%
	Capital versus O&M- intensive measures	2	100%	75%	75%	50%	50%	50%	75%	75%	75%	75%	75%	75%	50%	50%
	Long-term effectiveness	3	100%	75%	75%	50%	50%	50%	50%	50%	50%	50%	50%	75%	75%	50%
	Socio-political Achievement															
	Social consideration	14	50%	75%	100%	100%	100%	100%	75%	75%	75%	25%	100%	75%	25%	50%
	Regulatory and Governmental Involvement	8	50%	50%	50%	75%	75%	75%	100%	100%	100%	50%	50%	50%	50%	25%
	Compatibility with UNESCO world heritage site restrictions	3	100%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
	Environmental Achievement															
	Stabilization of the river and drainage systems	8	25%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	75%	75%	75%
	Flood protection	8	25%	100%	75%	75%	75%	50%	75%	50%	50%	25%	50%	50%	50%	50%
	Naturalization of the river bank	5	25%	25%	25%	25%	25%	25%	50%	25%	25%	25%	100%	25%	25%	25%
	Ecosystem enhancement	4	50%	25%	25%	25%	25%	25%	50%	25%	25%	25%	100%	25%	75%	25%
	Programmatic Achievement															
	Implementability	5	75%	100%	100%	75%	75%	100%	100%	75%	100%	100%	100%	75%	50%	50%
	Capital Cost	7	100%	25%	50%	50%	50%	100%	50%	75%	75%	100%	100%	75%	50%	100%
	O&M Cost	3	100%	50%	75%	50%	50%	100%	50%	75%	75%	100%	100%	75%	75%	100%
	Total Score	**100**	**50.5**	**73.3**	**78.3**	**70.0**	**70.0**	**69.3**	**73.5**	**70.5**	**66.8**	**50.3**	**76.5**	**65.3**	**54.3**	**56.8**

Scoring Criteria:
If an alternative:
(a) meets with significant positive impacts towards the criterion = 100 % of the total points for that criteria
(b) meets with marginal positive impacts towards the criterion = 75% of the total points for that criteria
(c) meets the criterion =50% of the total points for that criteria
(d) marginally deviates from the criterion = 25% of the total points for that criteria
(e) does not meet and/or has negative impacts towards the criterion = 0% of the total points for that criterion

note:
Preferred Alternatives

Annex C - Benefit Cost Analysis For the Paramaribo Climate Change Adaptation Fund Project

Benefit Cost Analysis

For the Paramaribo Climate Change Adaptation Fund Project - Revised

Prepared For:

Inter-American Development Bank
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July 2018

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Benefit Cost Analysis

Mitigation Alternatives for Suriname

July 2018

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1.0 INTRODUCTION

The Government of Suriname alongside the IDB have requested financing for a series of projects for inclusion in the proposal to the Adaptation Fund for Urban Investments for the Resilience of Paramaribo. The objective of the projects is to help Paramaribo city and the surrounding areas in adapting to the projected incidents related to climate change in the area. ERM, working closely with IDB and Suriname stakeholders, has developed five alternative projects for consideration. This report provides a detailed Benefit Cost Analysis (BCA) of the projects.

The alternative projects were developed using a two stage process. The first stage identified a broad range of technical solutions such as floodwalls, green infrastructure, and drainage systems that could function separately or as integrated solutions. These alternatives were then screened based on preliminary costs, technical feasibility, and social acceptance. This step resulted in 14 alternatives, which were discussed with Suriname stakeholders at a workshop. These 14 alternatives were scored based on specific criteria in the following achievement categories: technological, socio-political, environmental, and programmatic achievement. Based on multi-criteria scoring, the following alternatives were retained for consideration. In order to maintain consistency with the Phase 1 Report, the BCA uses the same Alternative numbers.

The alternatives under consideration are:

- Alternative 2 – A new flood wall located immediately east of the Knuffelsgracht Street and Waterfront (Waterkant) Street intersection along the bank of the Suriname River to extend the existing sheet pile wall to address both the baseline and predicted flooding in these areas.

- Alternative 3 - Rehabilitate the old sheet pile wall between Fort Zeelandia and sluice gate in Van Sommeldijckse Canal to address both the baseline and predicted flooding in these areas.

- Alternative 4 - Rehabilitation of the Van Sommeldijck Canal pump station and sluice gates to increase the pumping capacity of discharging from the canal to the Suriname River. This alternative also includes mangrove planting to reduce the flood velocity and erosion.[1]

- Alternative 5 – Rehabilitation of the sluice gate and pumping station at Knuffelsgracht Street to improve flood control capabilities.

- Alternative 7 - Dredging the Sommeldijckse Canal at the pump inlet to increase water storage capacity.

The final step was creating groups of Alternatives. The goal is create options that best address current and future flooding in the project area. These alternatives have been combined into 3 groups for evaluation:

- Group A: Alternatives 2 and 4
- Group B: Alternatives 3, 4 and 7
- Group C: Alternatives 4, 5 and 7

The results of the BCA show that the estimated net present value of benefits for Group A are $25.8 million. For Group B, the net present value of benefits are $8.1 million. Group C has estimated value of $1.0 million.

[1] The mangrove planting was originally a separate alternative; however, it is always included with Alternative 4, so they are now considered a single alternative. The outlet of the Pumping Station Van Sommelsdijck is where the Mangrove area starts. The proposal is to improve the outlet by excavating deposited sediments and constructing Sediment Trapping Units (STU) along the outflow channel. These STUs in turn will facilitate the growth of mangrove tree, which provide flood protection.

2.0 ASSUMPTIONS AND METHODOLOGY

ERM conducted the BCA to assess which groups of projects provide the highest positive net value. Benefits are principally measured as the reduction in total damages from floods with the projects compared to the damages that would occur without the projects, under the scenario where climate change increases the frequency and severity of floods over time. Costs include both capital and operating costs.

2.1 PROJECT BENEFITS

The primary approach for measuring benefits of the alternatives is a standard analysis of the avoided costs under climate change scenario. Only a single climate change scenario is used in the analysis. The impact of climate change is measured at 3 different dates, 2020, 2050 and 2080. The impact of climate change is estimated using a linear interpolation from these points.

Below are the specific components of the equation used.

$$Present\ Value\ of\ Benefits(PVB) = Avoided\ Costs = D_{wo} - D_w$$

Where:

D_{wo} = flooding costs without an alternative under climate change scenario

D_w = flooding costs with the alternative under climate change scenario

Damages are calculated using the following equation:

$$D_{w,}D_{wo} = \sum_t \sum_i \sum_r \quad (Value_{ti} * EVI_{ir} * p_r)/1.12^{t-2018}$$

Where:

t = year, from 2019 to 2090

i = parcel size measured in m^2 (same parcels used in the flood modeling)

r = return periods of 10, 25, 50 and 100 years.

p_r =annual flooding probability for return periods (i.e. 10 , 4%, 2%, 1%)

$Value_{ti}$ = estimated value of the assets on each parcel. The values vary by type of land use (see Section 3.1). Values vary by time *t* as well. The expected annual growth rate in population of Suriname is 1.1 percent per year for the next 30 years (ERM 2017b). The BCA uses this same growth rate for value for the entire 72-year period. World Bank data indicates that the long term GDP growth rate has been 1.3 percent per year since 1970 (World Bank 2018).

EVI_{ir} = Economic vulnerability index is the percentage of maximum potentially damaged asset value that will be lost if a flood of return period r occurs. EVI varies by parcel to reflect the type of land use and the hazard level (i.e., low, medium, high).

p_r = the probability of flooding event occurring in year *t* for return period *r* (e.g., p_r = 0.10 for a 10 year flood and 0.01 for a 100 year flood). The damages in any year is the sum of the probability weighted damages for all return periods.

1.12^{t-2018} = the discount factor to convert each future year's average annual damages into 2018 dollars. The 12 percent discount rate is the standard rate used by IDB for all of its projects.

2.2 *CAPITAL COSTS*

The capital costs are the direct and indirect construction costs. Direct construction costs are based on unit rates derived from similar projects. The unit rate is inclusive of all direct labor, materials, and transportation[2]. Multiplying unit rates by associated quantities required for construction yields the total direct construction cost. Labor costs are converted to economic costs by removing transfer payments, namely taxes, from skilled labor costs and accounting for relative employment of unskilled laborers following the method in Roche 2016. The final conversion factor is 0.92.[3]

Indirect construction costs include Design, Construction Management, Permits and Regulations, and a Contingency allocation. These costs were derived as a percentage of economic construction costs as follows, based on industry expertise:

- Design: 12%

[2] Derived from ERM industry experience.

[3] For skilled labor: 1÷(1+tr), where tr = 0.27 and is comprised of a 4% payroll tax and a 23% income tax (Roche 2016). For unskilled labor: 0.712 reported in Roche 2016 is scaled by the ratio of 20-year average unemployment rate, 22.2%, to the 2016 unemployment rate used by Roche 2016, 20%. Roche 2016 reports labor cost as 40% of total construction costs; 25% unskilled and 15% skilled labor.

- Construction Management: 16%
- Contingency: 12%

Additionally, Alternatives 4 and 5 require replacing capital equipment in the pumps and sluice gates. Replacement is assumed to start and finish during project years 25 and 50[4]. Capital replacement is estimated to cost 50 percent of initial capital costs.

2.3 OPERATING AND MAINTENANCE COSTS

Operating and Maintenance (O&M) costs were calculated for all alternatives for 72 years, which is the useful life of Alternative 2. For Alternatives 4 and 5, annual O&M costs are 4 percent to account for maintenance related to pumps and sluice gates. For all other alternatives, annual O&M costs are estimated at 2 percent of direct construction costs[5]. Figure 10 shows the present value of the annual O&M costs for each project alternative computed as:

$$PV(OM)_i = \sum_t OM_{i,t} * DF_t$$

Where,

PV(OM) = Present value O&M cost for project alternative *i*

OM = Annual O&M cost for project alternative *i* in year *t*

DF = Discount factor in year *t* = $\frac{1}{(1.12)^t}$

[4] In this instance large vertical pumps in steel housing are being used where the housing will last for 25- 30 years. The impeller of the pump may have shorter life, however as the pumps are not being used on a continuous basis and the sluice gates are acting as the primary control mechanism, ERM has assumed the pumps will last for 25- 30 years.

[5] For most of the civil works presented in the alternative analysis, the O&M cost will be very low – mainly related to clean-up and minor repair as there are no moving parts. As such, ERM used 2% for comparative analysis based on industry experience.

3.0 ECONOMIC BENEFITS

This section describes the results for calculating the discounted present value of the benefits of the alternatives. $Value_{ti}$ is uncertain; therefore, the BCA combines data from a variety of sources in order to provide a robust estimate. The $Value_{ti}$ is estimated using a two-step process. Section 3.1 describes the first step of estimating the assets that are at risk. Section 3.2 describes the process that adjusts for the fact that the sole use of asset values underestimates avoided costs. This is because asset values exclude lost income and indirect effects.

It is important to note that the benefits from the projects only include income and built asset value. The value of reducing injuries and fatalities are not included in the benefits, which results in an underestimate of the benefits and net present value of the projects. The fatalities from flooding can be significant. For example, the 2005 floods in nearby Guyana killed 34 people (ECLAC 2009). Therefore, although not quantified, it is quite possible that in the absence of the proposed alternatives, floods may cause fatalities over the next 72 years and that implementing the projects would reduce the number of fatalities. Similarly, Alternative 4 would reduce flooding risk at two hospitals. Although the benefits include the avoided damage to the structures, they do not include the benefits to the local population of being able to maintain operations at the hospitals.

3.1 ASSET VALUE AT RISK

The starting point for the value per parcel is the information provided by local realtors and summarized in Figure 1 (ERM 2017a). This data was used for the Hazard and Risk Assessment (HRA) for Paramaribo. However, these values do not represent the total value at risk from flooding and need to be scaled. The total value of all land in the HRA study area using the Figure 1 values is $172 billion, according to ERM calculations. The estimated GDP of the HRA study region is $4.98 billion (World Bank Statistics 2018), which implies an asset to GDP ratio of 39.7. A recent study of global wealth estimated that the value of physical assets are about 3.2 times larger than annual GDP (Arcadis 2015). The study conducted an analysis of 32 countries ranging in size from Ghana to China and included Brazil and Chile in South America. The study found a fairly stable relationship for the asset/GDP ratio. Implied by this study is that initial asset values should be multiplied by a scalar of 0.08 = 3.2/39.7.

Value at risk can also be estimated using regression equations developed by H-M-S 2017. The regressions provide information to estimate construction cost per m^2 of the physical structure footprint. The value per m^2 of land area at risk is calculated by removing depreciation and the portion of value comprised of material undamaged by flooding (e.g., brick, masonry). The value at risk using this approach averaged 0.19 times the values in Figure 1 across all land use types.[6]

IDB's 2016 cost-benefit analysis of the Paramaribo Urban Rehabilitation Program provides a third source of information of value at risk. It reports market values of commercial and residential structures based on an onsite survey of buildings. The value m^2 land area remaining after removing the value of bare land and the portion comprised of flood-resistant material averaged 0.51 times the values in Figure 1 across all land use types.

Based on these calculations, ERM decided that the Figure 1 values could be useful for relative asset values by type of land use, but should be scaled to reflect the magnitude of values from the Arcadis 2015, H-M-S 2017 and Roche 2016 studies. In the final analysis, initial asset values derived by ERM were multiplied by the average of the land use value-weighted average from each study, 0.26 = (0.08 + 0.19 + 0.51) ÷ 3.

Figure 1: Summary of Land/Asset Values

Land Use	**Mean Value (USD$/$m^2$)**
Low Density Residential	$450
Medium Density Residential	$350
High Density Residential	$220
High Density Housing – Informal or Government	$220
Agriculture and Livestock	$35
Medium/Low Density Farmstead Residential	$55
Commercial	$550
Institutional (schools, government, etc)	$950
Industrial	$550
Park/Reserve/Roundabout	$400
Cultural Heritage	$1500
Cemetery	$85
Open Field (Some Vegetation)	$32
Field where Development is Prevalent	$85
Dense Vegetation and Forest	$100
Water/Canals	$55

Source: ERM. 2017a. This is a list of all potential land use values. Not all of these land use types are affected in the study area for this analysis.

6 Land uses other than residential, commercial and industrial were treated as residential land.

3.2 *TOTAL DAMAGES*

For the second step, the physical asset damages needed to be calibrated to reflect losses in income and other indirect effects. This calibration requires a total damage/asset damage ratio. ERM reviewed numerous studies which are suitable for this purpose (Figure 2, ECLAC 2009; ECLAC 2010; World Bank). Despite employing different methodologies and metrics and evaluating different types of climate events, the studies show that the total damage/asset damage ratio ranges between 1.02 and 1.97. No individual estimate is a perfect match for flooding in urban areas in Suriname, therefore ERM used an average of all the estimates, 1.46, to reflect the long-run ratio. This measure took into account a relevance weight assigned by ERM to reflect studies most applicable to this study, with a strong focus on urban flooding.[7] The total damage/asset ratio of 1.46 is multiplied by asset value scalar, 0.26, for a combined scaling factor of 0.38.

Figure 2: Estimates of Total Damages/Asset Damage Ratios

Nation	Event	Total Damage / Asset Damage	Relevance Weight	Relative Weight	Weighted Ratio
Anguilla	Hurricane Luis (1995)	1.22	2	0.03	0.04
Bahamas	Hurricane Frances and Jeanne (2004)	1.57	1	0.02	0.03
Belize	Hurricane Dean (2007)	1.88	1	0.02	0.03
Belize	Hurricane Keith (2000)	1.33	4	0.07	0.09
Belize	Tropical Depression 16	1.71	4	0.07	0.12
Belize	Tropical Depression 16	1.14	4	0.07	0.08
Cayman Islands	Hurricane Ivan (2004)	1.21	4	0.07	0.08
Cayman Islands	Hurricane Paloma (2008)	1.19	1	0.02	0.02
Dominica	Hurricane Dean (2007)	1.29	3	0.05	0.07
Dominican Republic	Hurricane Frances & Jeanne (2004)	1.97	4	0.07	0.13
Grenada	Hurricane Ivan (2004)	1.12	2	0.03	0.04
Guyana	Floods (2005)	1.10	4	0.07	0.07
Haiti	Hurricane Jeanne (2004)	1.84	4	0.07	0.12
Haiti	Tropical Storm Fay (2008)	1.88	3	0.05	0.10

[7] Relevance weight: 4 = flood in urban area, 3 = flood in rural, 2 = natural disasters other than floods in urban areas, 1 = natural disasters other than floods in rural area

Jamaica	Hurricane Ivan (2004)	1.65	4	0.07	0.11
Jamaica	Hurricane Michelle (2001)	1.02	3	0.05	0.05
Netherlands Antilles	Hurricane Luis (1995)	1.79	2	0.03	0.06
St. Lucia	Hurricane Dean (2007)	1.58	3	0.05	0.08
Suriname	Floods (2006)	1.05	3	0.05	0.05
Turks and Caicos	Hurricane Hanna (2008)	1.74	1	0.02	0.03
World Bank	Typical Values Used	1.70	2	0.03	0.06
			59	1.00	1.46

Notes: Tropical Depression 16 included two estimates; 1.71 based on estimated damages in Belize and 1.14 based on modeled impact on capital costs.
Source: ECLAC 2009; ECLAC 2010; World Bank 1.

Most of the estimates in Figure 2 are produced by the Economic Commission for Latin America and the Caribbean (ECLAC), which prepares damage and loss assessments for climate related disasters in the Caribbean. ECLAC measures the costs resulting from natural disasters such as hurricanes and floods, in four categories: economic (e.g., national output and GDP), social (e.g., housing, health), infrastructural (e.g., roads, bridges, power, water, telecommunications), and environmental (e.g., ecosystems and natural resources). Impacts are further broken down into direct or primary damages and indirect or secondary damages. ERM calculated the total damage/asset damage ratio for individual events by dividing the total damages (which is the sum of direct and indirect impacts) by the direct damages.

A 2010 ECLAC report shows the results for 18 events from 1990 to 2008, primarily hurricanes and tropical storms, but also two floods, in Guyana in 2005 and in Suriname in 2006. The total damage/asset damage ratios for the floods are 1.10 and 1.05, respectively. ERM also calculated the overall ratio for the other 16 events by calculating the ratio for each event and then taking the median of the ratios over 16 events. The median is used as the measure of central tendency rather than the average because there are a few outlier observations that heavily influence the mean. Further, because this study includes damage types that are uncommon in Suriname (e.g., social and agriculture), ERM also calculated a weighted ratio. The average annual losses for each type of impact for which data is available (i.e., agriculture, commerce and industry, infrastructure, and residential (social)) were used to create weights that were applied to the median ratio for each category to calculate the overall weighted median.

In addition, a 2009 ECLAC report measures the impact of Tropical Depression 16 on Belize. Although this was a storm event, most of the impact of was due to flooding. The study shows an overall total damage/asset damage ratio of 1.71. Finally, a third study provides a comprehensive assessment of sea level rise on the Caribbean economies (Simpson et al. 2010). Results for individual companies are provided, as well as overall results for the impact on GDP and capital costs for reconstruction. Therefore, the total damage/asset damage ratio can be estimated as (GDP + Capital Costs) / (Capital Costs). The report provides results for mid-range and high sea level rise scenarios for 2050 and 2080. Finally, the model also includes the value 1.7, which is typically used by IDB.

After applying the scalars for assets at risk and total damages, ERM estimates that present value of the average annual losses from flooding over the 72 year period range from just under $1,400 million under current conditions (i.e., baseline) to about $1,700 million under climate change conditions. Figure 3 shows the magnitude of these damages graphically. These damages are calculated assuming that none of the alternatives are implemented. However, if the alternatives are undertaken, some of these damages will not occur. The avoided damages from project implementation form the basis for the benefits measured in this section.

Figure 3: Flooding Damages under Baseline and Climate Change Scenarios

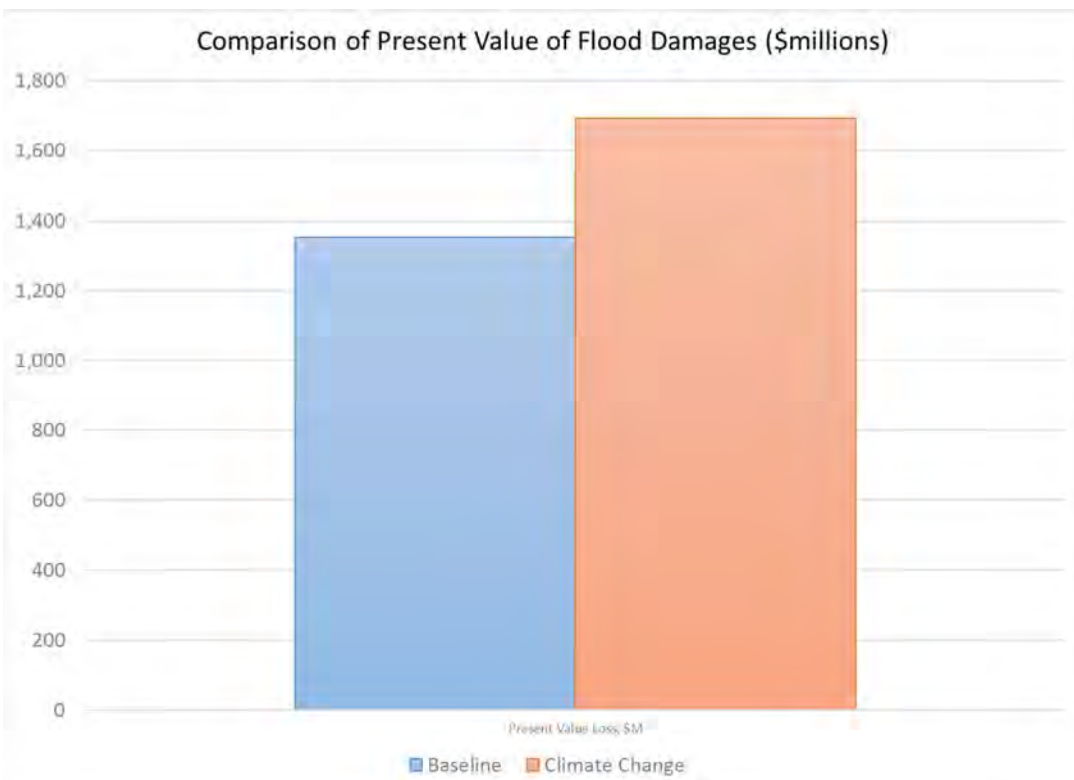
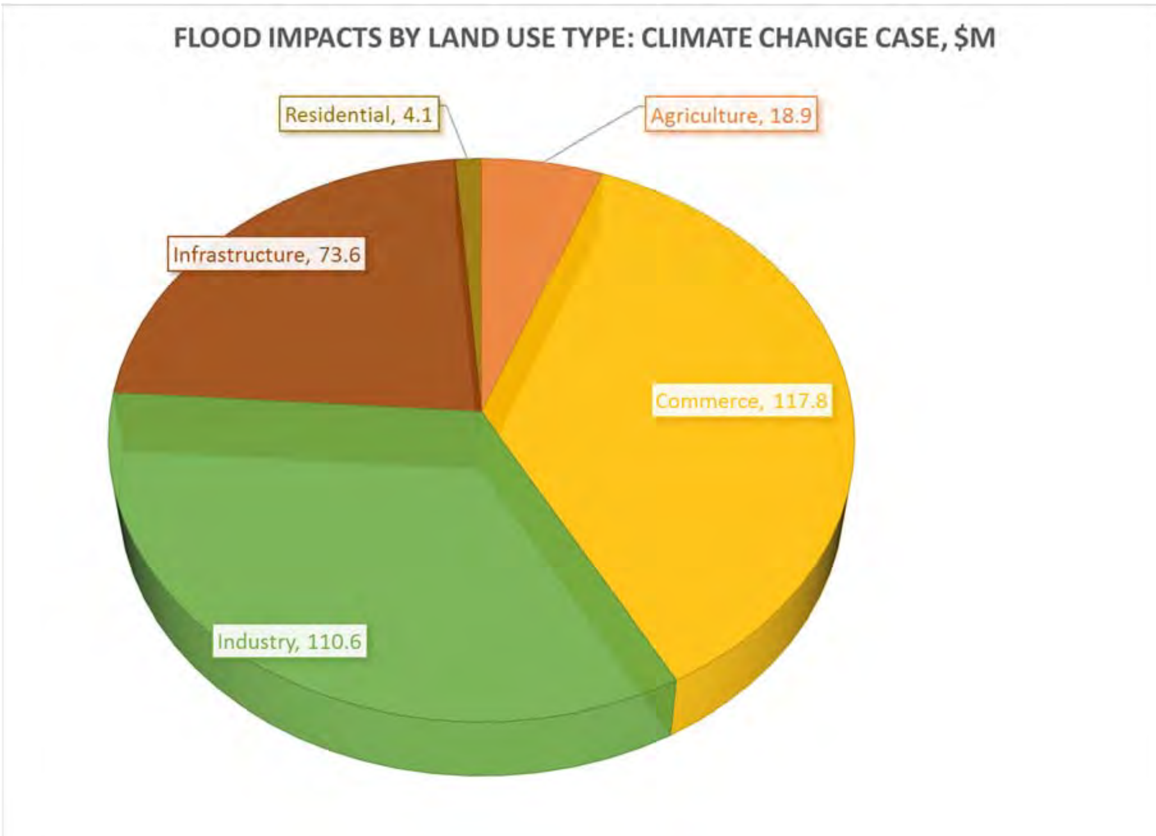


Figure 4 shows the percentage of total damages from climate change (in absence of the projects) by land use type. Damages are predominantly in the Commercial and Industrial sectors, with only a small portion of impacts in the Agriculture and Residential sectors.

Figure 4: Flooding Damages by Land Use Type



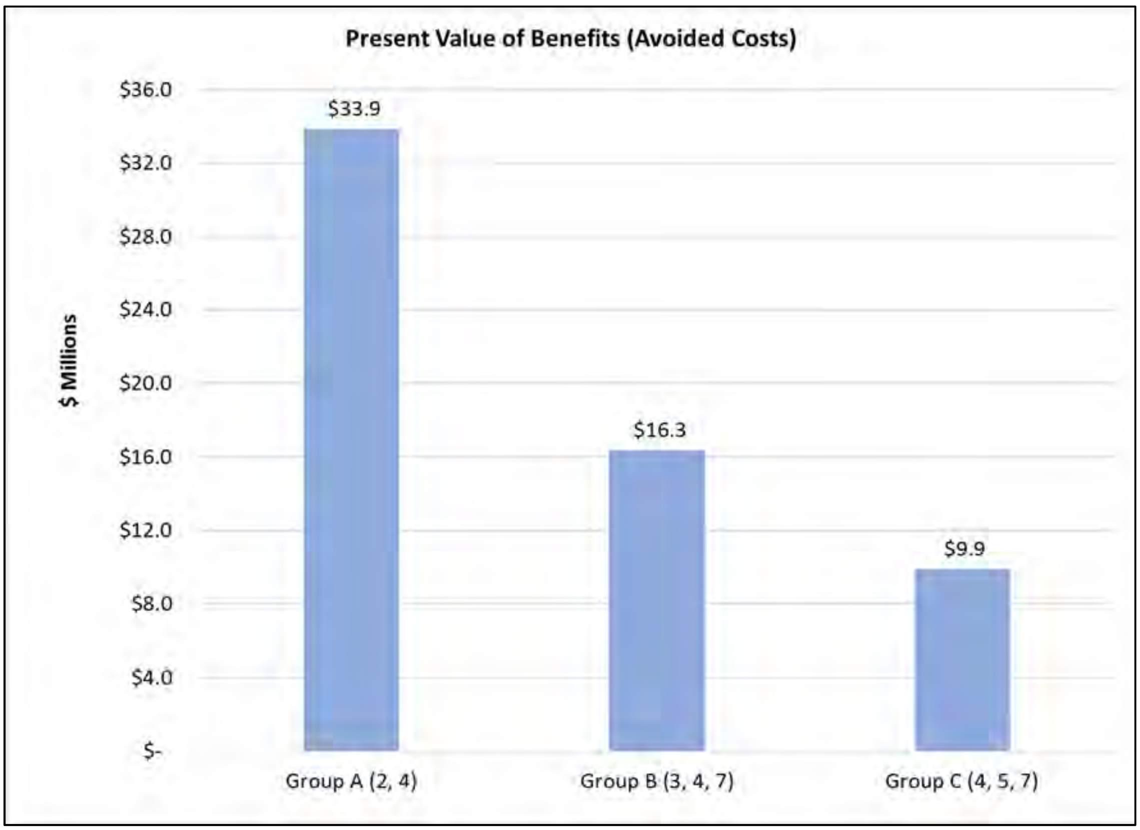
3.3 SUMMARY

Figure 5 shows the present value of the avoided costs of the alternatives. The data shows that Alternative 2 provides the highest level of benefits, while Alternative 5 provides the lowest. Figure 6 shows that Group A, which includes Alternative 2, provides the highest estimated benefits.

Figure 5: Present Value of Benefits, by Alternative, $mil

Project Alternative	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 7
PV Avoided Costs, $M	29.0	7.6	4.8	1.2	3.9

Figure 6: Present Value of Benefits, by Group



4.0 ECONOMIC COSTS

Economic Costs were calculated using the assumptions from Sections 2.2 and 2.3. This section summarizes the results of the calculations. Figure 7 summarizes the detailed capital costs for each project alternative, while Figure 8 summarizes the results for the O&M costs.

Figure 7: Capital Costs of Project Alternatives, $mil

Cost Component	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 7
Construction	2.8	1.4	2.0	1.6	1.5
Design	0.3	0.2	0.3	0.2	0.2
CM	0.4	0.2	0.3	0.3	0.2
Contingency	0.5	0.2	0.4	0.2	0.2
Total Capital Costs	3.9	2.0	3.0	2.3	2.1

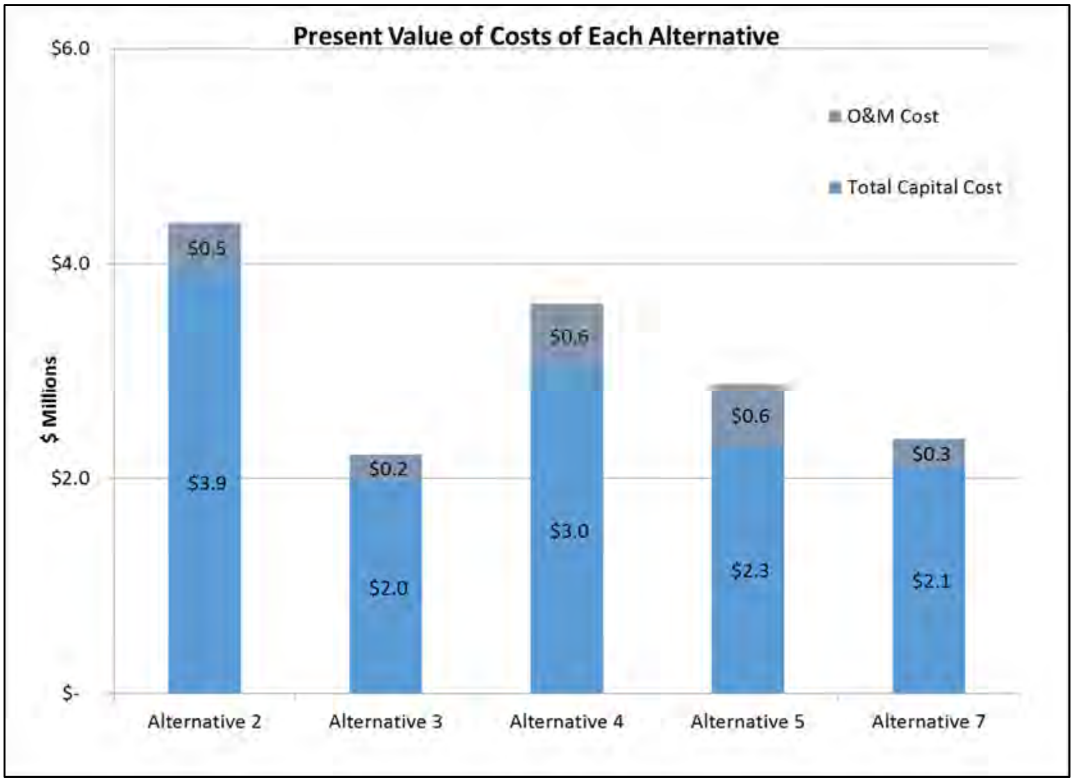
Notes: a/ ERM incorporated the cost associated with temporary relocation of the water taxis into Alternative 2, which is the only alternative that obstructs the waterfront. b/ ERM reduced capital costs on Alternative 7 by 50 percent based on the reduction of the effective area of the alternative.

Figure 8: Annual and Present Value Operating and Maintenance Costs, $mil

Cost Component	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 7
Present Value O&M	0.46	0.25	0.60	0.58	0.27
Annual O&M	0.06	0.03	0.08	0.07	0.03

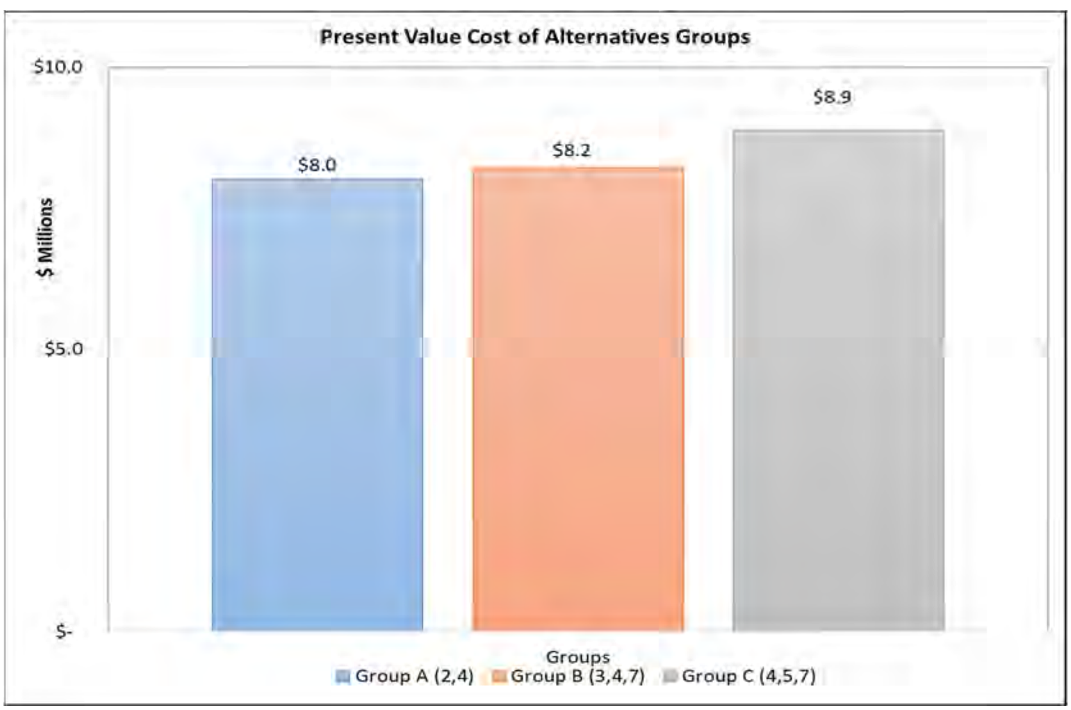
Totaling the capital costs and present value annual O&M costs yields the total present value cost of each project alternative. Figure 9 shows present value costs of each alternative broken down by capital and O&M components. As shown in Figure 10, by design, each group of alternatives has similar costs, ranging from $8.0 to $8.9 million.

Figure 9: Present Value of Costs of Each Alternative



Notes: ERM reduced capital costs on Alternative 7 by 50 percent based on the reduction of the effective area of the alternative.

Figure 10: Present Value Cost of Alternatives Groups



5.0 ECONOMIC RETURNS

This section provides the net present value (NPV) of the alternatives (and alternative groups). The NPV shown in Figure 11 and Figure 12 is calculated as:

NPV = Total Present Value of Benefits – Total Present Value of Costs

Figures 11 and 12 also include the economic rate of return (ERR), which is the discount rate at which the NPV becomes zero. Figure 11 shows that four of the alternatives have a positive NPV, with Alternative 2 having the highest value of $24.7 million. Similarly, Figure 12 shows that all Groups have a positive NPV, with Group A having the largest positive value at $25.8 because Group A includes Alternative 2. For all of the alternatives (and groups) that have a positive NPV, the ERR is above the discount rate being used in the analysis (12 percent).

Figure 11: Net Present Value of Alternatives ($millions)

Alternative	*PV Total Benefits*	*PV Total Costs*	*PV Net Benefits*	*ERR*
2	$29.0	$4.4	**$24.7**	**36.5%**
3	$7.6	$2.2	**$5.4**	**15.3%**
4	$4.8	$3.6	**$1.2**	**14.7%**
5	$1.2	$2.9	**$(1.7)**	**5.8%**
7	$3.9	$2.4	**$1.5**	**14.7%**

Figure 12: Net Present Value by Group of Alternatives ($millions)

Group Name	*PV Total Benefits*	*PV Total Costs*	*PV Net Benefits*	*ERR*
Group A (2,4)	$33.9	$8.0	**$25.8**	**27.3%**
Group B (3,4,7)	$16.3	$8.2	**$8.1**	**15.0%**
Group C (4,5,7)	$9.9	$8.9	**$1.0**	**12.8%**

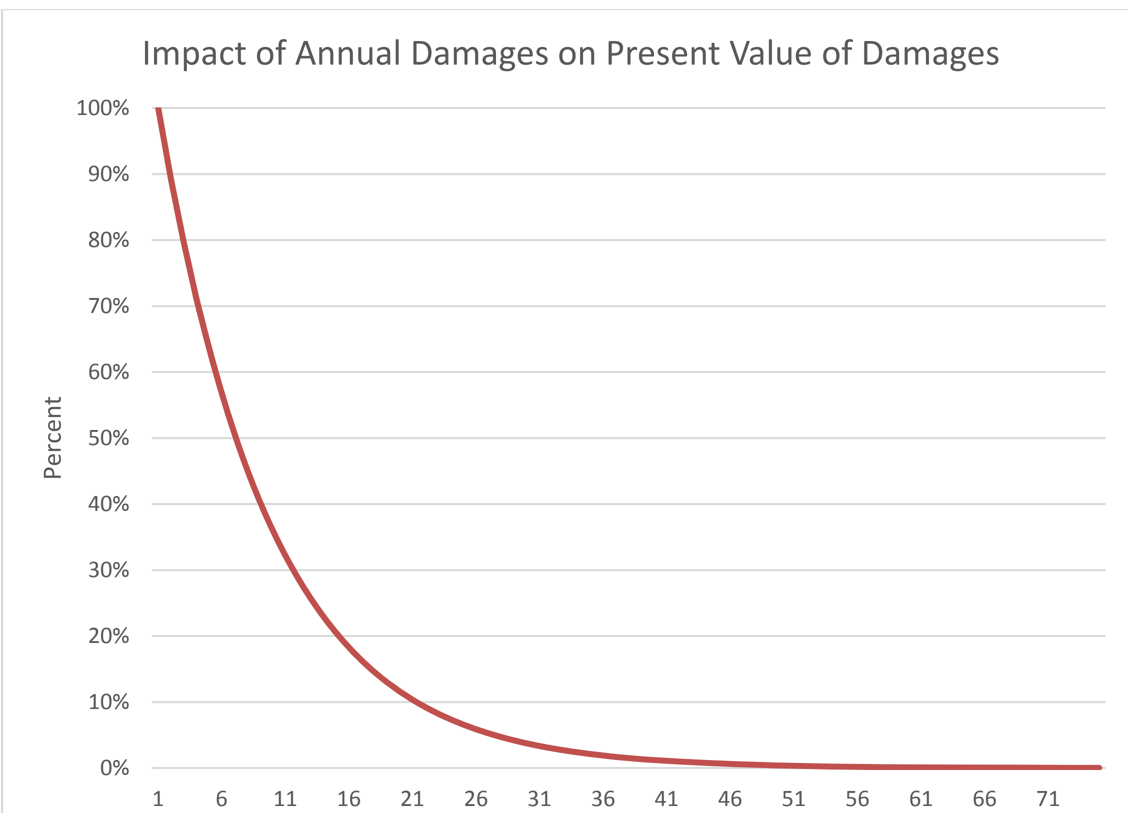
6.0 *SENSITIVITY ANALYSIS*

Uncertainty exists about the value for several key variables describing the economic costs and benefits of the climate risk reduction projects. Monte Carlo simulation is used to quantify the impact of this uncertainty on the estimated economic returns for each of the three project sites. This section details ERM's construct of the Monte Carlo simulation and presents findings for the robustness of the estimated economic returns.

6.1 *SENSITIVITY TO DISCOUNT RATE*

Although the discount rate is fixed at 12 percent, it is worth noting the impact it has on net present values. Figure 13 demonstrates the impact of the 12 percent discount rate over time. After 15 years, about 20 percent of annual damages are included in the present value of damages. By year 30, only about 3 percent of annual damages affect the present value. Because climate change impacts are stronger in the later years, using the 12 percent discount rate to calculate present value significantly reduces the impact of climate change and the future average annual losses and avoided costs from the projects.

Figure 13: Impact of Annual Damages on Present Value of Damages using a 12 Percent Discount Rate



6.2 *MONTE CARLO ANALYSIS*

ERM's Monte Carlo analysis includes variables whose range of potential values could have an impact on NPV. The variables cover all of the significant aspects of capital and O&M costs and benefits. ERM selected the probability distributions for each of the variables except two, based on professional judgement. For the total damage/asset damage ratio and unemployment rate, there was sufficient data to use maximum likelihood estimation to select a distribution. The mean values from each of the distributions are generally close to, but not identical to the values used in the main report, because of the shape of the distributions. As a result, the mean NPV values from the Monte Carlo do not equal the NPV in the main report.[8]

The Monte Carlo model comprised 10,000 trials.[9] Each trial yielded an estimate of the net benefits of each of the three climate risk reduction projects based on a different random draw from the probability distributions for the variables (see Figure 14).

Figure 14: Probability Distributions for Economic Returns Model Variables

Category / Variable	Units	Distribution	Min	Mean/Likely	Max
Asset Values					
Asset Value Scalar	%	 Triangular	0.0805	0.2604	0.5128
Total Damage/Asset Damage	%	 Uniform*	1.00362	1.495	1.98638
Project Costs					
Contingency / Construction & Indirect	%	 Triangular	0.10	0.17	0.25
Indirect Cost / Construction Cost	%	 Triangular	0.23	0.27	0.32
Labor Cost / Construction Cost	%	 Beta Pert	0.33	0.42	0.60
O&M Cost / Construction Cost – Alternatives 2,3,7	%	 Triangular	0.010	0.027	0.050

[8] For the purposes of a more inclusive sensitivity analysis, additional factors that may affect the costs are included for some alternatives (e.g., capital replacement cost, unemployment rate).

[9] ERM used the Palisade Corporation's @RISK 6.2

Category / Variable	Units	Distribution		Min	Mean/Likely	Max
O&M Cost / Construction Cost – Alternatives 4 and 5	%		Triangular	0.020	0.043	0.070
Capital Replacement Cost %	%		Triangular	0.42	0.51	0.60
Unemployment Rate	%		Exponential*	14.64	21.81	+∞
Skilled Labor Economic Cost Factor (1/ Tax Rate)	%		Uniform	1.120	1.270	1.420

6.3 PROBABILITY DISTRIBUTION OF NET BENEFITS

Figures 15 and 16a-c show the probability and cumulative probability density functions for the NPV from the climate risk reduction projects in Groups A, B and C generated by the Monte Carlo analysis. The key result is that despite all of the uncertainty, the probability that economic returns exceed $0 is 99.9 percent for Group A and 70 percent for Group B. For Group C, there is a 45 percent chance of a positive NPV. The graphs also show that the 90 percent confidence interval does not include 0 for Group A, while it does include 0 for Groups B and C.

Figure 15: Cumulative Distribution Functions of Net Benefits for Groups A, B, C

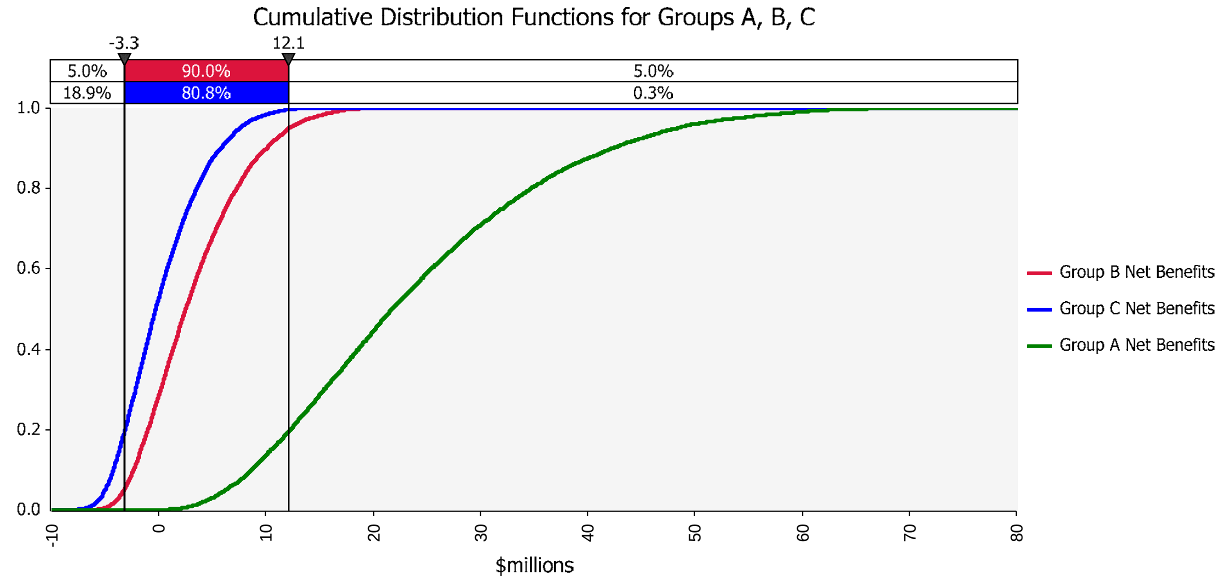


Figure 16a: Probability Distribution of Net Present Value for Group A

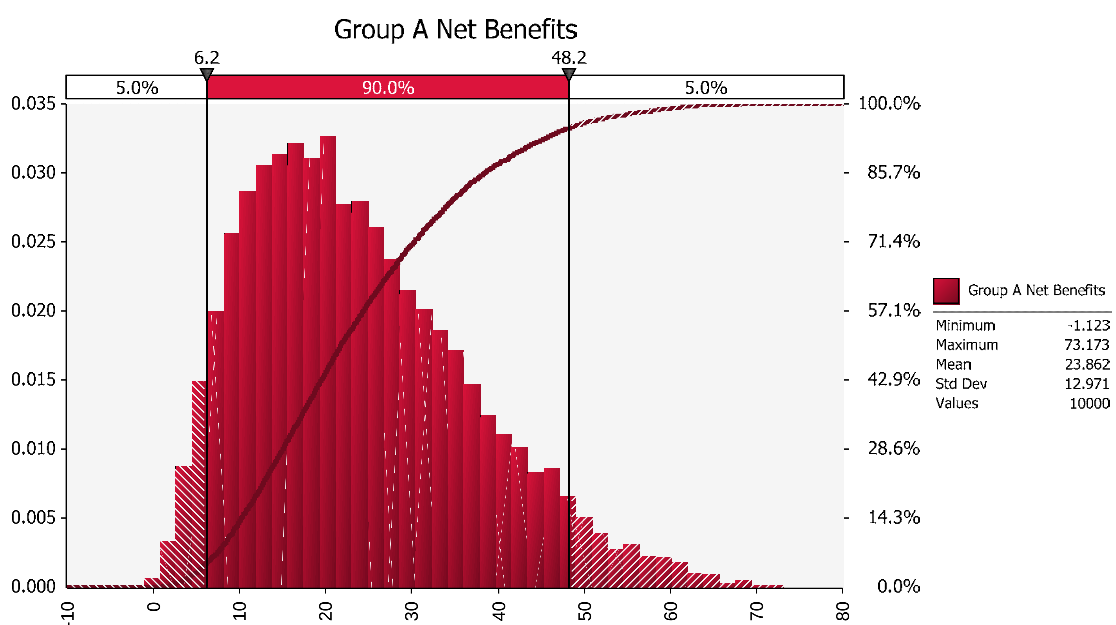


Figure 16b: Probability Distribution of Net Present Value for Group B

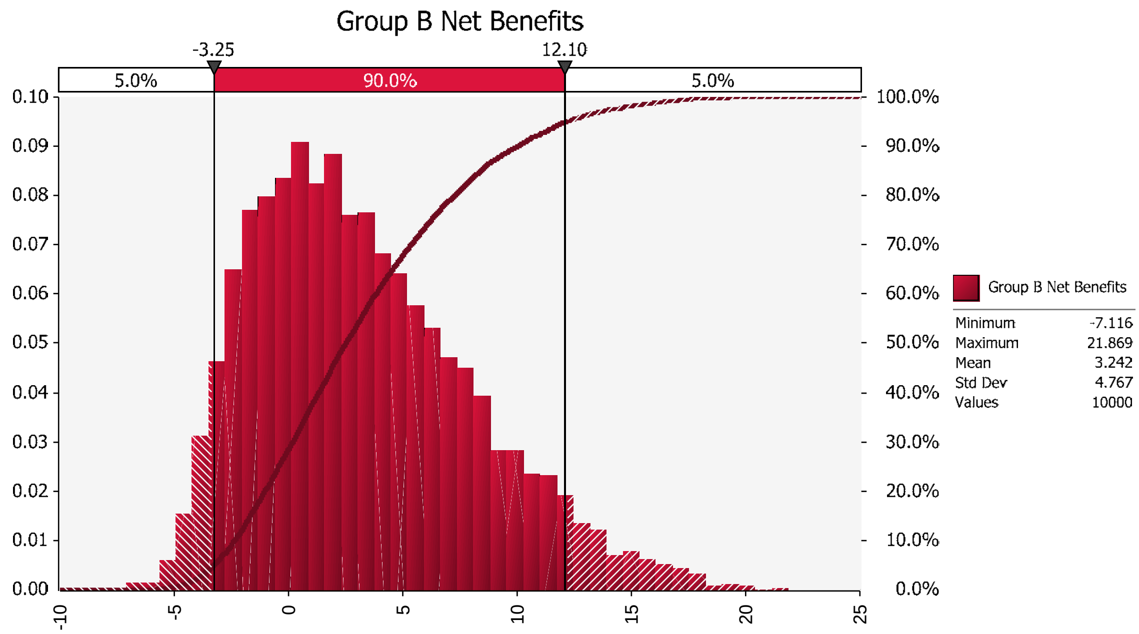
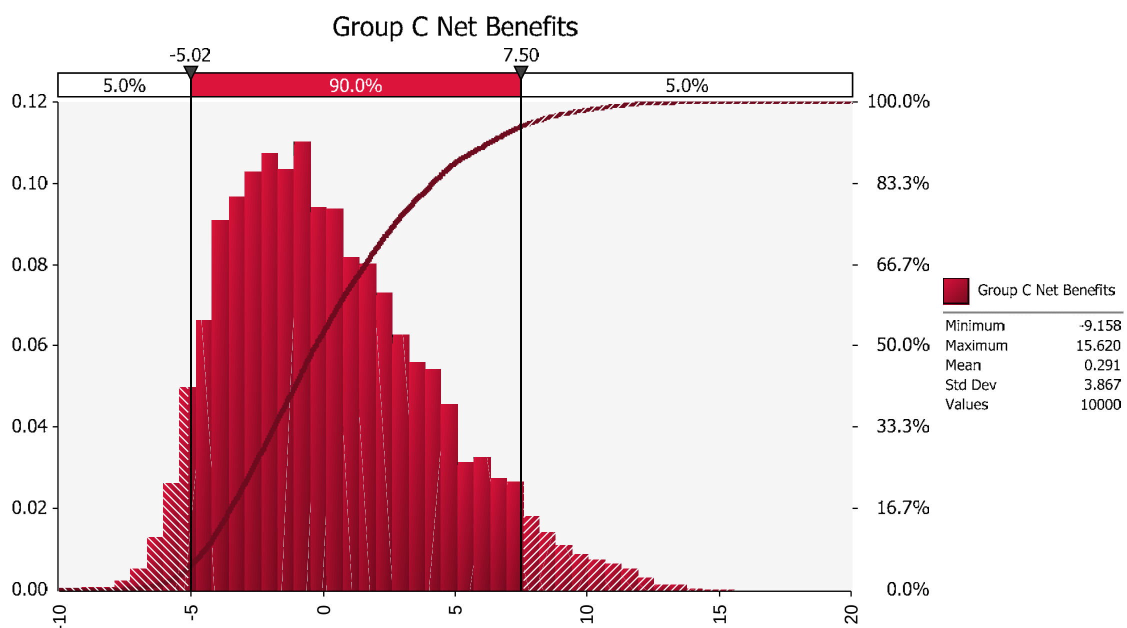


Figure 16c: Probability Distribution of Net Present Value for Group C



6.4 SENSITIVITY OF NET BENEFITS TO KEY VARIABLES

Figure 17 shows the value for each variable (and the percentage change in the variable from its mean value) that would be required to drive the net present value to zero (all other variables are held constant at their mean). For example, in the Monte Carlo model the mean value for the asset value scalar is 1.5. In order for the NPV for Group A to be $0, the Damage/Asset scalar would need to be 0.39, or decline by 74 percent from its mean value. In fact, the lowest practicable value for Damage/Asset scalar is 1.0, which further suggests that the Group A results are robust.

The sensitivity of the results to the variables is also summarized in the tornado diagrams in Figures 18 a-c. The tornado diagram shows the impact of the range of each model variable on the overall mean net present value. The asset value scalar and total damage/asset damage scalar have the most significant potential impact on the results.

Figure 17: Sensitivity of the Probability of Positive Economic Returns to Model Variables

		Group A		*Group B*		*Group C*	
Monte Carlo Variable	***Mean***	***NPV=$0***	***%Change***	***NPV=$0***	***%Change***	***NPV=$0***	***%Change***
Damage/Asset Ratio	1.50	0.39	-74%	1.08	-28%	0.34	-77%
Asset Value Ratio	0.26	0.07	-74%	0.19	-28%	0.06	-77%
Contingency Cost	0.17	4.59	2651%	0.72	335%	4.63	2678%
O&M Cost (Alt 2,3,7)	0.03	1.06	3898%	0.15	473%	1.08	3974%
O&M Cost (Alt 4,5)	0.04	1.49	3350%	0.23	439%	1.50	3371%
Indirect Cost/ Construction Cost	0.27	4.83	1668%	0.88	221%	4.88	1686%
Capital Replacement Cost %	0.51	39.11	7636%	8.70	1621%	39.59	7732%
Labor/Construction Cost	0.42	-9.63	N/A	-1.07	N/A	-9.75	N/A
Unemployment	21.81	293.21	1245%	58.40	168%	296.14	1258%
Skilled Labor CF	1.27	-29.12	N/A	-2.40	N/A	-29.41	N/A

Figure 18a: Tornado Diagram, Group A

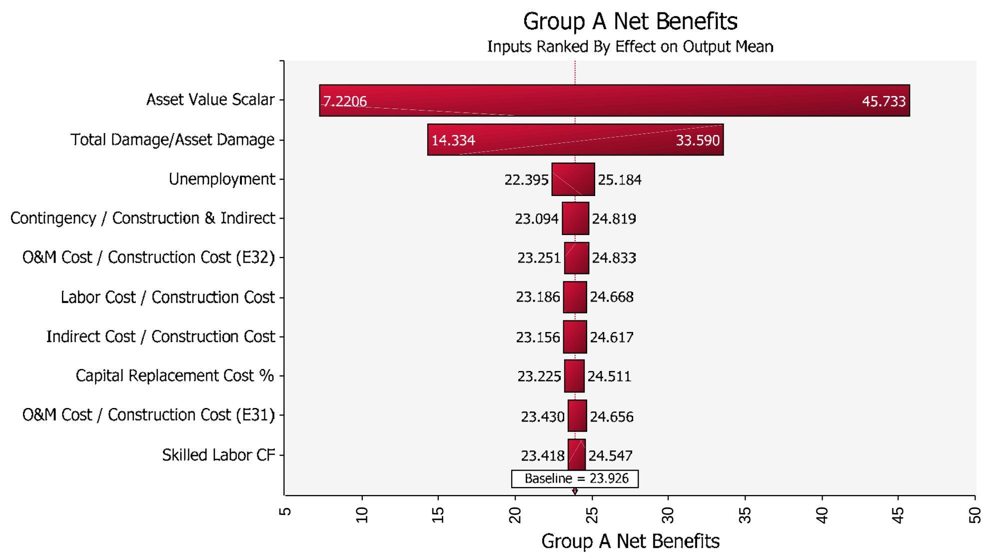


Figure 18b: Tornado Diagram, Group B

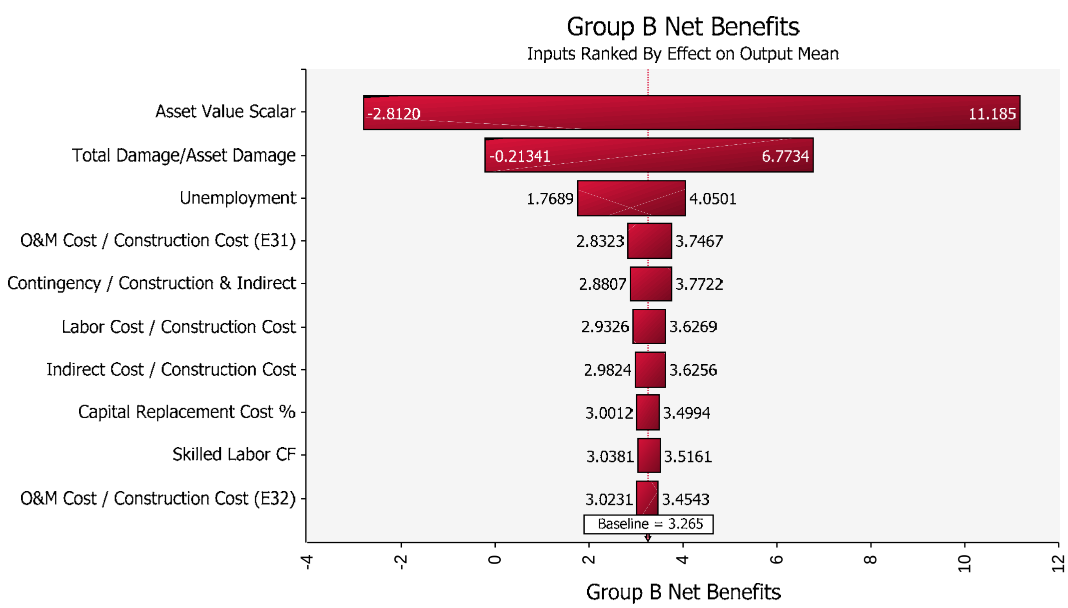
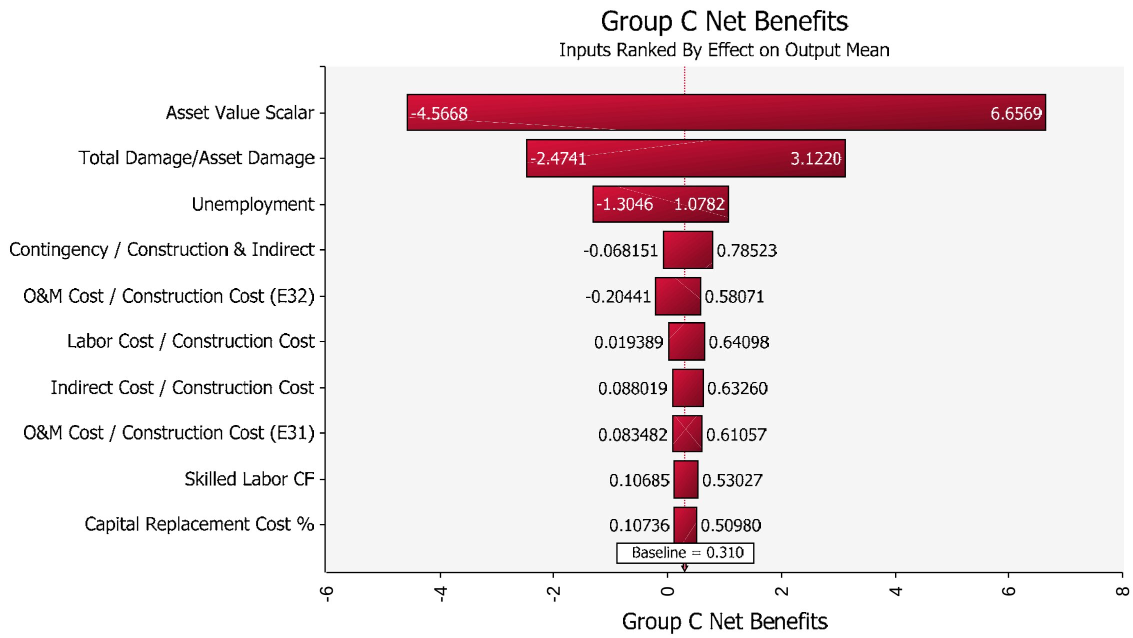


Figure 18c: Tornado Diagram, Group C



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Annex D – Engineering Design Documents, Cost Analysis, and Schedule

MEMO

To : ERM
From : ILACO Suriname NV

File : IS-331
Project : Adaptation Study Paramaribo

Subject : Preliminary Design Floodwall Waterkant, Section Knuffelsgracht- Riverside
Version : final
Date : 11 July 2018

Contents

1. General/ Project area

The project area is at the Waterkant of Paramaribo, from Heiligenweg/Knuffelsgracht to the existing Parking for Public Transport at the bar/restaurant Riverside.

2. Existing condition

The total area under consideration is part of Waterkant, the waterfront of Paramaribo, stretching from Knuffelsgracht up to the Fort Zeelandia. The project area, Knuffelsgracht until Riverside, is considered the lowest section of the entire Waterkant area.

The present shore protection consists of a brick retaining wall and has collapsed at several sections, mainly due to erosion and wear and tear over time (probably more than 80 years old). The crest level height or side of the asphalt road varies between NSP +1.90 m and NSP +2.35 m, which is not sufficient for a permanent long term flood protection against high water levels.

The river shore area is filled with debris and partly overgrown by grass/low trees. These sections apparently are silted up by sediment from the river during high tide.

The area adjacent to the front wall is predominantly used for public purposes. There is a Landing Place for Water Taxis that transport passengers and light weight goods from Paramaribo to Meerzorg and vice versa. Furthermore, there is a parking for Public Transport. A jewelry/gold trading shop is located at the western end of the project area and a bar/restaurant Riverside at the eastern end.

A jewelry shop, medical doctor’s office and small grocery shop are located at the opposite of the water taxi landing across the road.

There are currently three (3) public toilet facilities in the area (walking distance max. 200 m from the water taxi landing).

It is noted that some fish boats/trawlers often also are parked for overnight stay in the river in front of the section.

3. Design criteria

The following water levels are used for the designs:

Water level/height	Value	Remarks
Mean Sea level (MSL)	NSP+0.22 m	
Low Water Spring (LWS)	NSP-1.30 m	To check stability sheet pile
High Water Level (HWL)	NSP+2.53 m(*)	1:50 years return period
Sea level rise (SLR)	0.08 m (*)	1.5 mm/year, so 0.08 m in 50 years
Design HWL	NSP+2.61 m (*)	
Design wave height	0.50-0.60 m	Estimated. The wave height further downstream at the river mouth is about 0.8 m. It was estimated in 2011 that the wave height would be reduced further upstream.

(*) Source: Wave and water level heights for Coronie (sea dike) and Suriname River defense project by WL-Delft Hydraulics, 2005

Other design aspects:
In the designs of the proposed flood protection works, the following is taken into account:
- use similar structure as in other sections for similar maintenance program;
- use of erosion control measures;
- maintain open view to/from river;
- maintain existing Landing (water taxi) at the Waterkant
- avoid negative impact on existing buildings and structures

The existing flood wall at Waterkant (near food stalls/Parliament and Fort Zeelandia) has been designed in 2011 for a crest level of NSP +3.25 m, based on the same conditions and water levels mentioned above. Therefore, the same crest level will be used for the new flood wall at Knuffelsgracht-Riverside. The crest level can be easily raised in the future if deemed necessary (e.g. higher rate of SLR).

The floodwall is designed to allow an overtopping of 3 l/s/m. This means that a drainage system has to be present behind the flood wall to discharge surplus water.

The technical design life of the flood wall should be at least 75 years, same as the flood wall as in the other sections. The steel sheet piles need to be coated to protect against immediate corrosion. It is assumed that the design life can be extended with minimum extra maintenance.

The expected maximum river flow velocity in the section of the flood wall is about 2 m /s. The flow velocity in this section will probably be lower as the section lies between structures that go further into the river and impose an obstruction for the flows.
The rip-rap will be designed with a slope not steeper than 1(V):3(H).

For the execution of works, the following is taken into account:
- Works can be executed from land and/or water, depending on accessibility;
- Working in sections to minimize hindrance;
- There is an option to temporarily close the south part of the road (period: few weeks/months) in consultation with the ministry of Public Works and Traffic police
- Minimize impacts on temporary re-location of water taxis
- Temporarily re-locate busses nearby parking or re-organize current bus-stop

4. Design of Flood Wall Waterkant

4.1 Steel sheet pile retaining wall

The proposed flood wall consists of a steel sheet piling wall, protected by a bed of rip-rap rocks grade 10-60 kg upon a geotextile with PP fabric. The steel sheet piles are not anchored. The rip rap is not only for future erosion control, but also for sufficient passive pressure to keep the steel sheet piles stable.
See Appendix 1 for the stability and geotechnical analysis of the steel sheet pile flood wall.

This type of structure has already been successfully applied in the other parts of the Waterkant flood wall, in Nieuw Amsterdam (District Commewijne) and at Domburg (District Wanica).

The existing shore bed level is rather high due to sedimentation with silt from the river, so part of the shore must be excavated to enable the placement of the geotextile and rocks.

The existing grass/low trees on the embankment (west side) will be removed. It is expected that grass/small trees may grow again as sedimentation will continue after construction.

The intention is to maintain most of the existing trees on the east side near Riverside restaurants as much as possible. It is not sure how many trees can be saved, as this depends on the hindrance the trees will impose for driving the piles into the ground. After completion, this area will be landscaped with green and trees.

4.2 Footpath

The current footpath will be rehabilitated and extended in the new situation (new flood wall is about 3 m from the existing retaining wall). The rehabilitation will include new pavement.

4.3 Drainage

Along the flood wall, under the new footpath, a new rain water sewer will be placed. The existing rainwater inlets will be connected to the new sewer. This sewer will discharge collected water to the river through few (2-3) outlets with non return valves to protect inflow during high water level.

4.4 Landing for Water Taxis

The landing, including its roof/shed structure, will be rehabilitated and the entrance will be made suitable to enter after construction of the new flood wall.
The edge between street and ramp will be raised to protect against high water level. The new structure will include stairs and ramp to overcome the height differences. The rehabilitation and upgrading works will be further detailed in the detailed design stage.

The waiting area may require some seats/bench, will be determined in the detailed design stage.

4.5 Old jetty (ferry to Meerzorg)

The old jetty, a Bailey type bridge, lies about 100 meters west of the Landing for the water taxis. It is part of the abandoned Roll-on Roll-off ferry going to Meerzorg on the other side of the Suriname river. The remains (deck and some structural parts) of the jetty shall be rehabilitated for temporary use by the Water Taxis during the construction period of the new flood wall and rehabilitation of the landing. The end part (water side) of the old jetty will be equipped with a temporary floating pontoon structure to allow passengers off and on loading during different tides.

It is noted that the construction of the new flood wall may be executed in two distinct sections: east and west of the existing landing for the water taxis. This means that the water taxis may continue their operations on one side of the landing, while works are executed on the other side. The rehabilitated jetty may then be used only for a short period so that relocation of water taxis is minimized.

Further details of such operation will be determined in the execution phase, depending on the contractor's equipment and works sequence. It shall be discussed with the selected Contractor to ensure that proper safety measures are included and that this work method does not impact the work progress.

4.6 Parking area for Public Transport

Part of the existing parking will be used during construction of the flood wall. This may take few months. The parking area will be rehabilitated afterwards, including improvement of the drainage.
A re-arrangement of the parking of busses will be required. During construction the buses will be relocated to the parking in the general area along Riverside/Broki and along the main road in close cooperation with the Traffic Police. One section of the main road can be closed temporarily, if required. In addition, extra temporary parking space during day time may be rented from private property owners nearby. However, this resource will be only needed in case other options are not sufficient.

4.7 Other facilities

Other facilities to be included are to be determined in close cooperation with the Ministry of Public Works. This includes, e.g. street lights, waste bins, trees/green areas, etc.

Appendices

1 Design flood wall Waterkant: Knuffelsgracht-Riverside (sheet pile stability analysis)

2 Drawings

Report for D-Sheet Piling 17.1

Design of Diaphragm and Sheet Pile Walls
Developed by Deltares

Company:	Royal HaskoningDHV
Date of report:	12/7/2017
Time of report:	1:11:00 PM
Date of calculation:	12/5/2017
Time of calculation:	2:56:56 PM
Filename:	C:\..\BF8005 Knuffelsgracht\Prelim design sheet pile Knuffelsgracht
Project identification:	Knuffelgracht - Riverside Flood defence and erosion protection Preliminary design SUL2750

Verification according to National Annex of Eurocode 7 in the Netherlands (NEN 9997-1:2016)

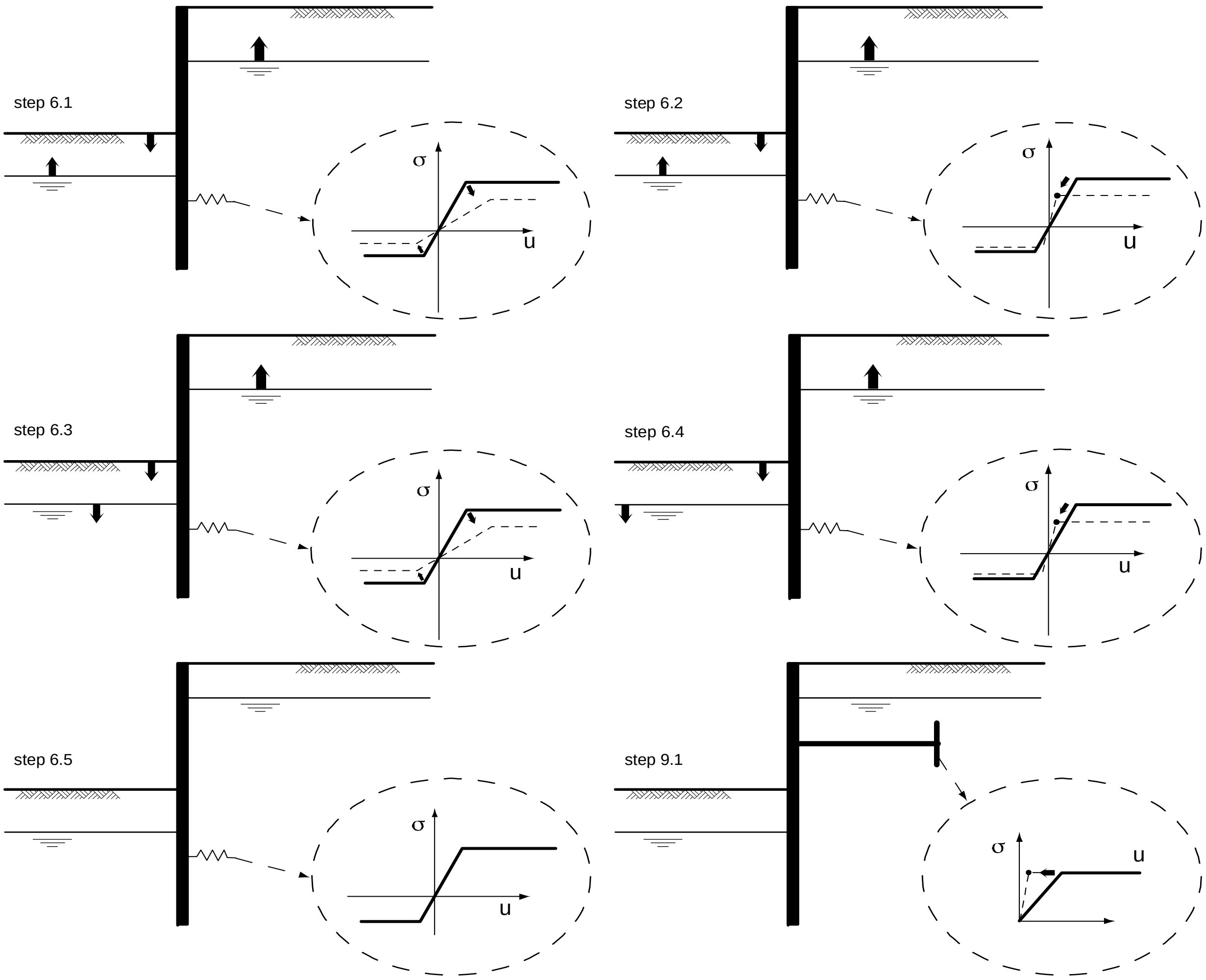
1 Table of Contents

2 Summary

2.1 Overview per Stage and Test

Stage nr.	Verification type	Displace-ment [mm]	Moment [kNm]	Shear force [kN]	Mob. perc. moment [%]	Mob. perc. resistance [%]	Vertical balance
1	EC7(NL)-Step 6.3		-4.85	-2.06	**0.0**	38.0	---
1	EC7(NL)-Step 6.4		-2.58	-1.59	**0.0**	37.9	---
1	EC7(NL)-Step 6.5	0.0	0.06	0.04	**0.0**	28.6	---
1	EC7(NL)-Step 6.5 * 1.20		0.07	0.05			
2	EC7(NL)-Step 6.3		-14.46	-10.60	**0.0**	40.6	---
2	EC7(NL)-Step 6.4		-9.08	-9.24	**0.0**	40.4	---
2	EC7(NL)-Step 6.5	1.1	-2.19	-1.45	**0.0**	29.8	---
2	EC7(NL)-Step 6.5 * 1.20		-2.62	-1.75			
3	EC7(NL)-Step 6.3		-244.46	81.47	**0.0**	51.3	---
3	EC7(NL)-Step 6.4		-198.67	74.38	**0.0**	51.6	---
3	EC7(NL)-Step 6.5	63.5	-137.23	43.42	**0.0**	39.0	---
3	EC7(NL)-Step 6.5 * 1.20		-164.68	52.10			
4	EC7(NL)-Step 6.3		-137.06	45.76	**0.0**	49.4	---
4	EC7(NL)-Step 6.4		-133.25	44.50	**0.0**	49.3	---
4	EC7(NL)-Step 6.5	**64.6**	-127.90	38.75	**0.0**	38.5	---
4	EC7(NL)-Step 6.5 * 1.20		-153.48	46.50			
5	EC7(NL)-Step 6.1		**-342.23**	113.16	**0.0**	**76.1**	---
5	EC7(NL)-Step 6.2		**-342.23**	**113.35**	**0.0**	76.0	---
5	EC7(NL)-Step 6.3		**-342.23**	113.16	**0.0**	**76.1**	---
5	EC7(NL)-Step 6.4		**-342.23**	**113.35**	**0.0**	76.0	---
5	EC7(NL)-Step 6.5	63.0	-127.97	-52.19	**0.0**	50.0	---
5	EC7(NL)-Step 6.5 * 1.20		-153.56	-62.63			
Max		**64.6**	**-342.23**	**113.35**	**0.0**	**76.1**	---

2.2 CUR Verification Steps



3 Input Data for all Stages

3.1 General Input Data

Verification according to National Annex of Eurocode 7 in the Netherlands (NEN 9997-1:2016)

Model	Sheet piling
Check vertical balance	No
Number of construction stages	5
Unit weight of water	9.81 kN/m³
Number of curves for spring characteristics	3
Unloading curve on spring characteristic	No
Elastic calculation	Yes

3.2 Sheet Piling Properties

Length	14.00 m
Level top side	3.25 m
Number of sections	1

3.2.1 General properties

Section name	From [m]	To [m]	Material type	Acting width [m]
AZ 19 -700	-10.75	3.25	Steel	1.00

3.2.2 Stiffness EI (elastic behaviour)

Section name	Elastic stiffness EI [kNm²/m']	Red. factor on EI [-]	Corrected elas. stiffness EI [kNm²]	Note to reduction factor
AZ 19 -700	8.2698E+04	1.00	8.2698E+04	

3.2.3 Maximum allowable moments

Section name	Mr;char;el [kNm/m']	Modification factor [-]	Material factor [-]	Red. factor allow. moment [-]	Mr;d;el [kNm]
AZ 19 -700	664.00	1.00	1.00	1.00	664.00

3.3 Calculation Options

First stage represents initial situation	Yes
Calculation refinement	Fine
Reduce delta(s) according to CUR	Yes
Verification	EC7 NA NL - method B: Partial factors (design values) in verifie Eurocode 7 using the factors as described in the National Annex of the Netherlands. It is basically design approach III.

Verification of stage	1: Current surface
Used partial factor set	RC 1

Factors on loads

- Permanent load, unfavourable	1.00
- Permanent load, favourable	1.00
- Variable load, unfavourable	1.00
- Variable load, favourable	0.00

Material factors

- Cohesion	1.15
- Tangent phi	1.15

- Delta (wall friction angle)	1.15
- Modulus of low representative subgrade reaction	1.30

Geometry modification

- Increase retaining height	10.00 %
- Maximum increase retaining height	0.50 m
- Reduction in phreatic line on passive side	0.20 m
- Raise in phreatic line on passive side	0.20 m
- Raise in phreatic line on active side	0.05 m

Verification of stage: 2: Installation loads

Used partial factor set: RC 1

Factors on loads

- Permanent load, unfavourable	1.00
- Permanent load, favourable	1.00
- Variable load, unfavourable	1.00
- Variable load, favourable	0.00

Material factors

- Cohesion	1.15
- Tangent phi	1.15
- Delta (wall friction angle)	1.15
- Modulus of low representative subgrade reaction	1.30

Geometry modification

- Increase retaining height	10.00 %
- Maximum increase retaining height	0.50 m
- Reduction in phreatic line on passive side	0.20 m
- Raise in phreatic line on passive side	0.20 m
- Raise in phreatic line on active side	0.05 m

Verification of stage: 3: Fill

Used partial factor set: RC 1

Factors on loads

- Permanent load, unfavourable	1.00
- Permanent load, favourable	1.00
- Variable load, unfavourable	1.00
- Variable load, favourable	0.00

Material factors

- Cohesion	1.15
- Tangent phi	1.15
- Delta (wall friction angle)	1.15
- Modulus of low representative subgrade reaction	1.30

Geometry modification

- Increase retaining height	10.00 %
- Maximum increase retaining height	0.50 m
- Reduction in phreatic line on passive side	0.20 m
- Raise in phreatic line on passive side	0.20 m
- Raise in phreatic line on active side	0.05 m

Verification of stage: 4: Life time

Used partial factor set: RC 2

Factors on loads

- Permanent load, unfavourable	1.00
- Permanent load, favourable	1.00
- Variable load, unfavourable	1.10
- Variable load, favourable	0.00

Material factors

- Cohesion	1.25
- Tangent phi	1.18
- Delta (wall friction angle)	1.18
- Modulus of low representative subgrade reaction	1.30

Geometry modification	
- Increase retaining height	10.00 %
- Maximum increase retaining height	0.50 m
- Reduction in phreatic line on passive side	0.00 mUser defined
- Raise in phreatic line on active side	0.00 mUser defined

Verification of stage	5: Sudden drop

Used partial factor set	RC 2

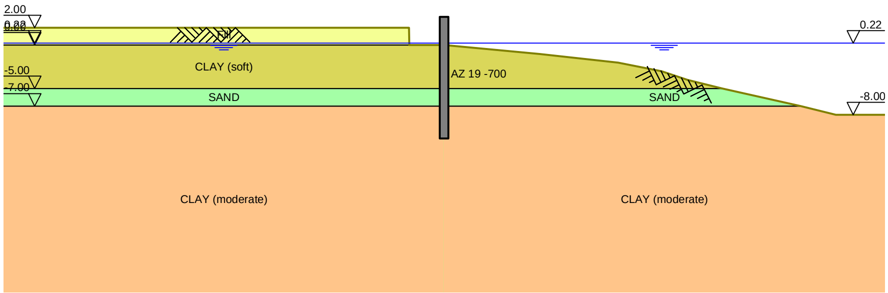
Factors on loads	
- Permanent load, unfavourable	1.00
- Permanent load, favourable	1.00
- Variable load, unfavourable	1.10
- Variable load, favourable	0.00

Material factors	
- Cohesion	1.25
- Tangent phi	1.18
- Delta (wall friction angle)	1.18
- Modulus of low representative subgrade reaction	1.30

Geometry modification	
- Increase retaining height	10.00 %
- Maximum increase retaining height	0.50 m
- Reduction in phreatic line on passive side	0.00 mUser defined
- Raise in phreatic line on active side	0.00 mUser defined

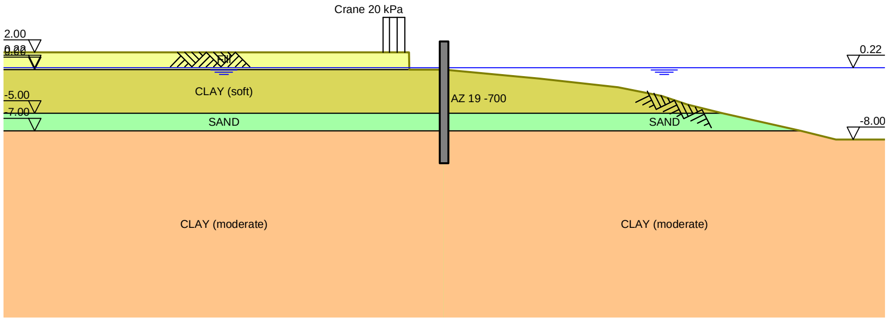
4 Outline Stage 1: Current surface

Outline - Stage 1: Current surface



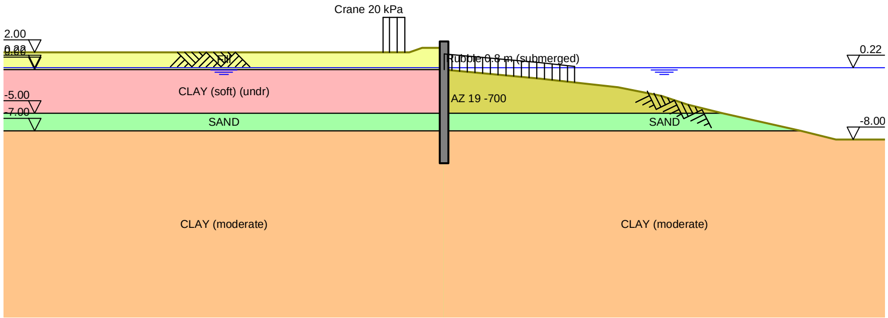
5 Outline Stage 2: Installation loads

Outline - Stage 2: Installation loads



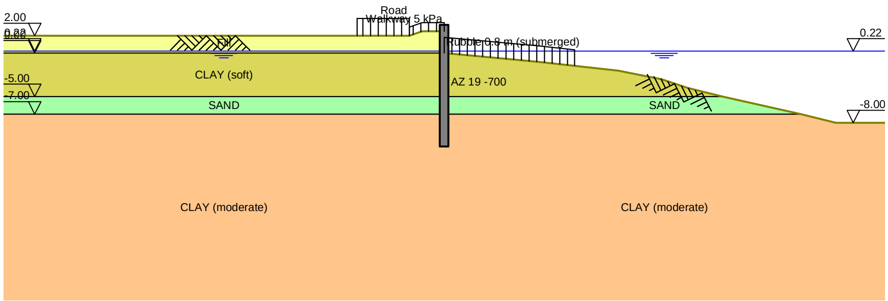
6 Outline Stage 3: Fill

Outline - Stage 3: Fill



7 Outline Stage 4: Life time

Outline - Stage 4: Life time



8 Step 6.5 Stage 4: Life time

8.1 Input Data Left

8.1.1 Calculation Method

Calculation method: C, phi, delta

8.1.2 Water Level

Water level: 0.22 [m]

8.1.3 Surface

X [m]	Y [m]
0.00	2.50
2.50	2.50
4.00	2.00

8.1.4 Soil Material Properties in Profile: CPT Sondering 10-12

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Unit weight Sat. [kN/m³]	Cohesion [kN/m²]	Friction angle phi [degree]	Delta friction angle [degree]
Fill	2.50	18.00	20.00	0.00	32.50	16.60
CLAY (soft)	0.00	14.00	14.00	5.00	17.50	8.75
SAND	-5.00	18.00	20.00	0.00	30.00	20.00
CLAY (moderate)	-7.00	16.00	16.00	5.00	20.00	10.00

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Fill	2.50	1.00	1.00	Fine
CLAY (soft)	0.00	1.00	1.00	Fine
SAND	-5.00	1.00	1.00	Fine
CLAY (moderate)	-7.00	1.00	1.00	Fine

Layer name	Level	Earth pressure coefficients			Additional pore pressure	
		Active	Neutral	Passive	Top	Bottom
	[m]	[-]	[-]	[-]	[kN/m²]	[kN/m²]
Fill	2.50	n.a.	n.a.	n.a.	0.00	0.00
CLAY (soft)	0.00	n.a.	n.a.	n.a.	0.00	0.00
SAND	-5.00	n.a.	n.a.	n.a.	0.00	0.00
CLAY (moderate)	-7.00	n.a.	n.a.	n.a.	0.00	0.00

8.1.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level	Branch 1		Branch 2	
		Top	Bottom	Top	Bottom
	[m]	[kN/m³]	[kN/m³]	[kN/m³]	[kN/m³]
Fill	2.50	20000.00	20000.00	10000.00	10000.00
CLAY (soft)	0.00	2000.00	2000.00	800.00	800.00
SAND	-5.00	12000.00	12000.00	6000.00	6000.00
CLAY (moderate)	-7.00	4000.00	4000.00	2000.00	2000.00

Layer name	Level	Branch 3	
		Top	Bottom
	[m]	[kN/m³]	[kN/m³]
Fill	2.50	5000.00	5000.00
CLAY (soft)	0.00	500.00	500.00
SAND	-5.00	3000.00	3000.00
CLAY (moderate)	-7.00	800.00	800.00

8.1.6 Surcharge Loads

Name	Distance [m]	Load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Walkway 5 kPa	0.00	5.00	Unfavourable (D-Sheet Piling)	Variable
	4.00	5.00		
Road	4.00	10.00	Unfavourable (D-Sheet Piling)	Variable
	10.00	10.00		

8.2 Calculated Earth Pressure Coefficients Left

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
1	2.37	1.9	43.2	0.26	0.68	5.84
2	2.23	2.6	57.2	0.26	0.51	5.84
3	2.10	3.2	71.2	0.26	0.42	5.85
4	1.97	3.8	85.3	0.26	0.36	5.85
5	1.83	4.3	95.8	0.26	0.34	5.86
6	1.83	4.6	102.8	0.26	0.34	5.86
7	1.70	5.1	90.3	0.26	0.32	4.68
8	1.57	5.7	90.6	0.26	0.31	4.18
9	1.43	6.3	95.8	0.26	0.30	3.99
10	1.30	6.9	107.9	0.26	0.29	4.10
11	1.17	7.4	119.0	0.26	0.29	4.24
12	1.17	7.7	127.2	0.26	0.29	4.35
13	1.03	8.2	140.9	0.26	0.29	4.54
14	0.90	8.8	161.7	0.26	0.29	4.85
15	0.77	9.4	185.8	0.27	0.29	5.21
16	0.63	10.1	202.7	0.27	0.29	5.34
17	0.50	10.5	213.1	0.27	0.30	5.37
18	0.50	10.8	218.1	0.27	0.30	5.38
19	0.44	11.0	222.4	0.27	0.29	5.40
20	0.39	11.2	228.3	0.27	0.29	5.41
21	0.33	11.5	234.1	0.27	0.29	5.42
22	0.28	11.8	240.0	0.27	0.29	5.44
23	0.22	11.9	244.4	0.27	0.29	5.45
24	0.22	12.0	246.5	0.27	0.29	5.45
25	0.18	12.1	248.5	0.27	0.29	5.46
26	0.13	12.2	251.1	0.27	0.29	5.46
27	0.09	12.4	253.7	0.27	0.28	5.47
28	0.04	12.5	256.3	0.27	0.28	5.48
29	0.00	12.6	258.2	0.27	0.28	5.51
30	0.00	16.3	116.7	0.35	0.35	2.48
31	-0.13	16.6	117.2	0.35	0.50	2.47
32	-0.26	16.9	118.0	0.35	0.50	2.47
33	-0.39	17.2	118.7	0.36	0.50	2.46
34	-0.52	17.5	119.5	0.36	0.50	2.45
35	-0.65	17.8	120.1	0.36	0.50	2.44
36	-0.65	17.9	120.5	0.36	0.50	2.44
37	-0.78	18.1	121.1	0.36	0.50	2.44
38	-0.91	18.4	123.2	0.37	0.50	2.46
39	-1.04	18.7	129.6	0.37	0.50	2.56
40	-1.17	18.7	115.4	0.37	0.50	2.26
41	-1.30	18.8	95.2	0.37	0.50	1.85
42	-1.30	18.9	95.5	0.36	0.50	1.85
43	-1.42	19.0	96.0	0.36	0.50	1.85
44	-1.55	19.1	96.7	0.36	0.50	1.84
45	-1.67	19.2	97.4	0.36	0.50	1.84
46	-1.79	19.4	98.0	0.36	0.50	1.84
47	-1.92	19.5	98.6	0.36	0.49	1.84
48	-1.92	19.6	98.9	0.36	0.49	1.83
49	-2.04	19.7	99.4	0.36	0.50	1.83
50	-2.16	19.8	100.2	0.36	0.50	1.83
51	-2.29	19.9	100.9	0.36	0.50	1.83
52	-2.41	20.1	101.6	0.36	0.50	1.83

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
53	-2.53	20.2	102.2	0.36	0.50	1.83
54	-2.53	20.3	102.5	0.36	0.50	1.82
55	-2.66	20.4	103.1	0.36	0.50	1.82
56	-2.78	20.5	103.9	0.36	0.50	1.82
57	-2.90	20.6	104.6	0.36	0.51	1.82
58	-3.03	20.8	105.4	0.36	0.51	1.82
59	-3.15	20.9	106.0	0.36	0.51	1.82
60	-3.15	21.0	107.3	0.36	0.51	1.83
61	-3.27	21.1	111.5	0.36	0.51	1.90
62	-3.40	21.2	117.1	0.36	0.51	1.97
63	-3.52	21.4	122.4	0.36	0.51	2.05
64	-3.64	21.8	127.8	0.36	0.51	2.12
65	-3.77	23.0	131.8	0.38	0.52	2.18
66	-3.77	23.0	134.5	0.38	0.52	2.21
67	-3.89	23.1	138.0	0.38	0.52	2.26
68	-4.01	23.2	139.4	0.38	0.52	2.26
69	-4.14	23.4	140.5	0.38	0.52	2.26
70	-4.26	23.5	141.5	0.38	0.52	2.26
71	-4.38	23.6	142.3	0.38	0.52	2.26
72	-4.38	23.7	142.8	0.37	0.52	2.26
73	-4.51	23.8	143.6	0.37	0.53	2.26
74	-4.63	23.9	144.6	0.37	0.53	2.26
75	-4.75	24.0	145.7	0.37	0.53	2.26
76	-4.88	24.2	146.8	0.37	0.53	2.26
77	-5.00	24.3	147.6	0.37	0.53	2.24
78	-5.00	16.8	379.8	0.25	0.53	5.72
79	-5.13	17.1	383.9	0.25	0.34	5.70
80	-5.27	17.4	389.7	0.25	0.34	5.68
81	-5.40	17.7	396.0	0.25	0.35	5.66
82	-5.53	18.0	402.6	0.25	0.35	5.65
83	-5.67	19.1	407.7	0.26	0.35	5.64
84	-5.67	19.3	411.1	0.26	0.35	5.64
85	-5.80	19.6	416.3	0.27	0.35	5.63
86	-5.93	20.0	422.1	0.27	0.36	5.61
87	-6.07	20.4	421.7	0.27	0.36	5.51
88	-6.20	20.8	420.5	0.27	0.36	5.40
89	-6.33	21.0	419.6	0.27	0.36	5.33
90	-6.33	21.2	419.0	0.27	0.36	5.28
91	-6.47	21.5	435.0	0.27	0.37	5.41
92	-6.60	21.9	446.3	0.27	0.37	5.46
93	-6.73	22.3	453.9	0.27	0.37	5.47
94	-6.87	22.7	461.4	0.27	0.37	5.47
95	-7.00	23.0	467.1	0.27	0.37	5.50
96	-7.00	31.1	218.9	0.36	0.37	2.57
97	-7.13	31.4	220.3	0.37	0.53	2.57
98	-7.25	31.7	222.2	0.37	0.53	2.57
99	-7.38	32.0	224.0	0.37	0.53	2.57
100	-7.50	32.4	225.8	0.37	0.53	2.57
101	-7.63	32.6	227.2	0.37	0.54	2.57
102	-7.63	32.8	228.1	0.37	0.54	2.57
103	-7.75	33.1	229.5	0.37	0.54	2.57
104	-7.88	33.4	231.5	0.37	0.54	2.57
105	-8.00	33.8	237.5	0.37	0.54	2.61
106	-8.13	34.1	245.2	0.37	0.54	2.68
107	-8.25	34.4	251.0	0.37	0.54	2.72
108	-8.25	34.5	254.8	0.37	0.63	2.75
109	-8.38	34.8	260.5	0.37	0.63	2.80
110	-8.50	35.2	258.2	0.38	0.63	2.75
111	-8.63	35.7	239.5	0.38	0.63	2.53
112	-8.75	36.1	226.1	0.38	0.63	2.37
113	-8.88	36.5	227.4	0.38	0.63	2.37
114	-8.88	36.7	228.3	0.38	0.63	2.38
115	-9.00	37.1	229.7	0.38	0.63	2.38
116	-9.13	37.5	231.4	0.39	0.63	2.38

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
117	-9.25	38.0	233.2	0.39	0.63	2.38
118	-9.38	38.5	235.0	0.39	0.63	2.38
119	-9.50	38.8	236.3	0.39	0.63	2.38
120	-9.50	39.1	237.2	0.39	0.63	2.38
121	-9.63	39.4	238.6	0.39	0.63	2.38
122	-9.75	39.9	240.4	0.39	0.63	2.38
123	-9.88	40.4	242.1	0.40	0.63	2.38
124	-10.00	40.9	243.9	0.40	0.63	2.38
125	-10.13	41.2	245.3	0.40	0.63	2.38
126	-10.13	41.5	246.2	0.40	0.63	2.38
127	-10.25	42.4	247.5	0.41	0.63	2.38
128	-10.38	40.4	249.3	0.39	0.64	2.38
129	-10.50	41.3	251.1	0.39	0.64	2.38
130	-10.63	41.6	252.9	0.39	0.64	2.38
131	-10.75	41.8	254.2	0.39	0.64	2.38

8.3 Calculated force from a layer Left

Name	Force
Fill	32.99
CLAY (soft)	124.60
SAND	48.97
CLAY (moderate)	212.23

8.4 Input Data Right

8.4.1 Calculation Method

Calculation method: C, phi, delta

8.4.2 Water Level

Water level: 0.22 [m]

8.4.3 Surface

X [m]	Y [m]
0.00	0.00
11.00	-1.00
20.00	-2.00
25.00	-3.00
28.00	-4.00
32.00	-5.00
41.00	-7.00
45.00	-8.00

8.4.4 Soil Material Properties in Profile: CPT Sondering 10-12

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Sat. [kN/m³]	Cohesion [kN/m²]	Friction angle phi [degree]	Delta friction angle [degree]
Fill	2.50	18.00	20.00	0.00	32.50	16.60
CLAY (soft)	0.00	14.00	14.00	5.00	17.50	8.75
SAND	-5.00	18.00	20.00	0.00	30.00	20.00
CLAY (moderate)	-7.00	16.00	16.00	5.00	20.00	10.00

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Fill	2.50	1.00	1.00	Fine
CLAY (soft)	0.00	1.00	1.00	Fine
SAND	-5.00	1.00	1.00	Fine
CLAY (moderate)	-7.00	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Fill	2.50	n.a.	n.a.	n.a.	0.00	0.00
CLAY (soft)	0.00	n.a.	n.a.	n.a.	0.00	0.00
SAND	-5.00	n.a.	n.a.	n.a.	0.00	0.00
CLAY (moderate)	-7.00	n.a.	n.a.	n.a.	0.00	0.00

8.4.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1		Branch 2	
		Top [kN/m³]	Bottom [kN/m³]	Top [kN/m³]	Bottom [kN/m³]
Fill	2.50	20000.00	20000.00	10000.00	10000.00
CLAY (soft)	0.00	2000.00	2000.00	800.00	800.00
SAND	-5.00	12000.00	12000.00	6000.00	6000.00
CLAY (moderate)	-7.00	4000.00	4000.00	2000.00	2000.00

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Fill	2.50	5000.00	5000.00
CLAY (soft)	0.00	500.00	500.00
SAND	-5.00	3000.00	3000.00
CLAY (moderate)	-7.00	800.00	800.00

8.4.6 Surcharge Loads

Name	Distance [m]	Load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Rubble 0.8 m (submerged)	0.00	9.10	Favourable (D-Sheet Piling)	Permanent
	15.00	9.10		

8.5 Calculated Earth Pressure Coefficients Right

Segment number	Level [m]	Horizontal pressure		Fictive earth pressure coefficients		
		Active [kN/m²]	Passive [kN/m²]	Ka [-]	Ko [-]	Kp [-]
1	-0.13	0.0	33.3	0.00	0.86	3.59
2	-0.26	0.0	34.4	0.00	0.88	3.55
3	-0.39	0.0	35.4	0.00	0.91	3.48
4	-0.52	0.0	36.5	0.00	0.95	3.41
5	-0.65	0.0	37.2	0.00	0.97	3.36
6	-0.65	0.0	37.8	0.00	0.97	3.33
7	-0.78	0.0	38.6	0.00	1.00	3.29
8	-0.91	0.0	39.6	0.00	1.02	3.24
9	-1.04	0.0	40.6	0.00	1.04	3.19
10	-1.17	0.0	41.7	0.00	1.06	3.15
11	-1.30	0.0	42.5	0.00	1.08	3.12
12	-1.30	0.0	43.0	0.00	1.08	3.10
13	-1.42	0.0	43.7	0.00	1.09	3.07
14	-1.55	0.0	44.7	0.00	1.10	3.04
15	-1.67	0.0	45.7	0.00	1.10	3.00
16	-1.79	0.0	46.7	0.00	1.11	2.97
17	-1.92	0.0	47.5	0.00	1.11	2.95
18	-1.92	0.0	48.0	0.00	1.11	2.94
19	-2.04	0.0	48.7	0.00	1.12	2.92
20	-2.16	1.0	49.7	0.06	1.12	2.89
21	-2.29	2.3	50.7	0.13	1.12	2.87
22	-2.41	2.5	51.7	0.14	1.12	2.85
23	-2.53	2.7	52.4	0.15	1.12	2.83
24	-2.53	2.8	52.9	0.15	1.12	2.82
25	-2.66	3.0	53.7	0.16	1.11	2.81
26	-2.78	3.2	54.6	0.16	1.11	2.79
27	-2.90	3.5	55.6	0.17	1.11	2.77
28	-3.03	3.7	56.6	0.18	1.10	2.75

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
29	-3.15	3.9	57.4	0.18	1.10	2.74
30	-3.15	4.0	57.9	0.19	1.10	2.73
31	-3.27	4.2	58.6	0.19	1.09	2.72
32	-3.40	4.4	59.6	0.20	1.09	2.71
33	-3.52	4.6	60.6	0.21	1.08	2.69
34	-3.64	4.9	61.6	0.21	1.07	2.68
35	-3.77	5.0	62.3	0.22	1.07	2.67
36	-3.77	5.2	62.8	0.22	1.07	2.66
37	-3.89	5.3	63.6	0.22	1.06	2.65
38	-4.01	5.6	64.5	0.23	1.05	2.64
39	-4.14	5.8	65.5	0.23	1.05	2.63
40	-4.26	6.0	66.5	0.24	1.04	2.62
41	-4.38	6.2	67.3	0.24	1.03	2.61
42	-4.38	6.3	67.8	0.24	1.03	2.61
43	-4.51	6.5	68.5	0.25	1.03	2.60
44	-4.63	6.7	69.5	0.25	1.02	2.59
45	-4.75	7.0	70.5	0.25	1.01	2.58
46	-4.88	7.2	71.5	0.26	1.01	2.57
47	-5.00	7.4	72.2	0.26	0.98	2.51
48	-5.00	7.9	177.8	0.27	0.98	6.06
49	-5.13	8.2	175.6	0.27	0.82	5.79
50	-5.27	8.6	177.1	0.27	0.80	5.59
51	-5.40	9.0	177.9	0.27	0.79	5.39
52	-5.53	9.3	182.8	0.27	0.77	5.33
53	-5.67	9.6	186.9	0.27	0.76	5.30
54	-5.67	9.8	189.7	0.27	0.76	5.28
55	-5.80	10.1	194.2	0.27	0.75	5.26
56	-5.93	10.5	191.1	0.27	0.74	5.00
57	-6.07	10.8	186.4	0.27	0.73	4.71
58	-6.20	11.2	193.3	0.27	0.72	4.73
59	-6.33	11.5	198.4	0.27	0.71	4.74
60	-6.33	11.7	201.9	0.27	0.71	4.75
61	-6.47	12.0	207.1	0.28	0.70	4.76
62	-6.60	12.3	214.0	0.28	0.70	4.77
63	-6.73	12.7	220.9	0.28	0.69	4.79
64	-6.87	13.1	227.8	0.28	0.68	4.80
65	-7.00	13.4	233.0	0.28	0.68	4.85
66	-7.00	15.3	114.8	0.32	0.68	2.37
67	-7.13	15.5	116.1	0.32	0.81	2.37
68	-7.25	15.8	117.8	0.32	0.81	2.37
69	-7.38	16.2	118.0	0.32	0.81	2.34
70	-7.50	16.5	118.5	0.32	0.80	2.32
71	-7.63	16.7	119.7	0.32	0.80	2.32
72	-7.63	16.9	120.5	0.32	0.80	2.32
73	-7.75	17.1	121.7	0.33	0.80	2.31
74	-7.88	17.5	123.3	0.33	0.79	2.31
75	-8.00	17.8	124.9	0.33	0.79	2.31
76	-8.13	18.1	126.4	0.33	0.79	2.31
77	-8.25	18.4	127.5	0.33	0.78	2.31
78	-8.25	18.5	128.3	0.33	0.78	2.30
79	-8.38	18.8	129.4	0.33	0.78	2.30
80	-8.50	19.1	70.5	0.34	0.78	1.24
81	-8.63	19.4	82.6	0.34	0.77	1.43
82	-8.75	19.7	93.4	0.34	0.77	1.60
83	-8.88	20.0	108.3	0.34	0.77	1.84
84	-8.88	20.1	107.1	0.34	0.77	1.81
85	-9.00	20.4	107.5	0.34	0.77	1.80
86	-9.13	20.7	108.8	0.34	0.76	1.80
87	-9.25	21.0	110.8	0.34	0.76	1.81
88	-9.38	21.4	112.8	0.34	0.76	1.82
89	-9.50	21.6	114.5	0.35	0.76	1.83
90	-9.50	21.8	115.5	0.35	0.76	1.84
91	-9.63	22.0	117.6	0.35	0.76	1.85
92	-9.75	22.3	120.4	0.35	0.75	1.88

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
93	-9.88	22.7	123.4	0.35	0.75	1.90
94	-10.00	23.0	126.6	0.35	0.75	1.93
95	-10.13	23.2	129.4	0.35	0.75	1.96
96	-10.13	23.4	131.4	0.35	0.75	1.98
97	-10.25	23.6	134.2	0.35	0.75	2.00
98	-10.38	24.0	138.0	0.35	0.74	2.04
99	-10.50	24.3	143.2	0.35	0.74	2.09
100	-10.63	24.6	146.3	0.36	0.74	2.11
101	-10.75	24.9	147.6	0.36	0.74	2.12

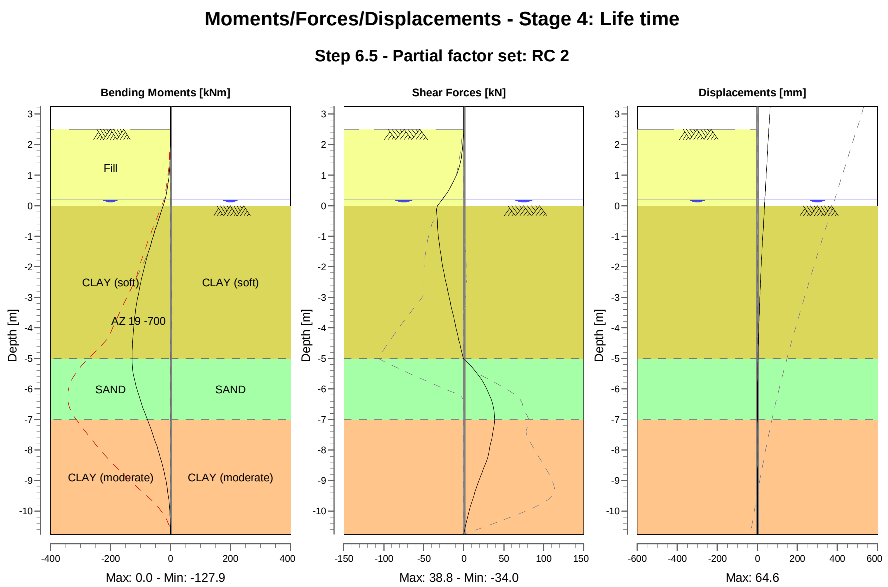
8.6 Calculated force from a layer Right

Name	Force
Fill	0.00
CLAY (soft)	156.82
SAND	88.53
CLAY (moderate)	173.50

8.7 Calculation Results

Number of iterations: 3

8.7.1 Charts of Moments, Forces and Displacements

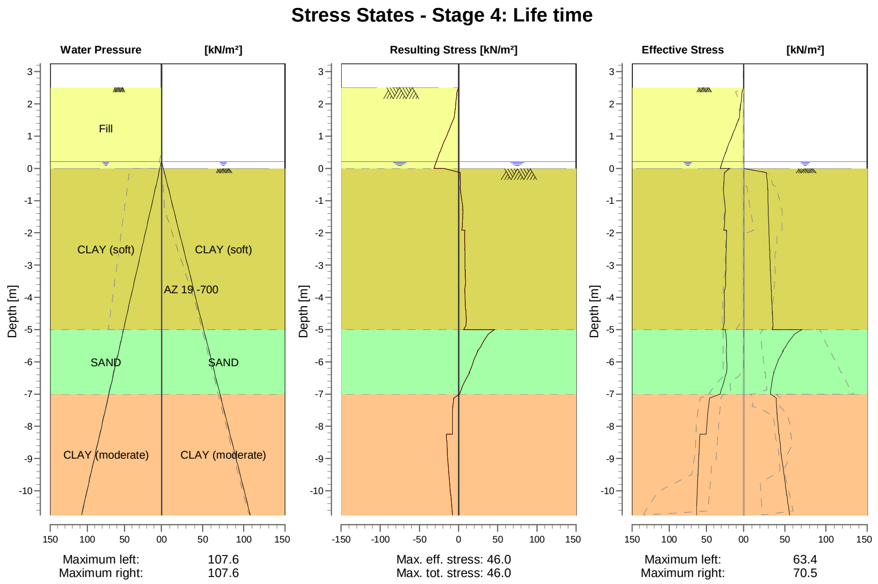


8.7.2 Moments, Forces and Displacements

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
1	3.25	0.00	0.00	**64.6**
1	2.88	0.00	0.00	61.3
2	2.88	0.00	0.00	61.3
2	2.50	0.00	0.00	57.9
3	2.50	0.00	0.00	57.9
3	1.83	-0.47	-1.82	52.1

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
4	1.83	-0.47	-1.79	52.1
4	1.17	-3.03	-6.81	46.2
5	1.17	-3.02	-6.80	46.2
5	0.50	-11.22	-19.05	40.3
6	0.50	-11.22	-19.05	40.3
6	0.22	-17.56	-26.38	37.8
7	0.22	-17.56	-26.38	37.8
7	0.00	-24.07	-32.95	35.9
8	0.00	-24.07	-32.95	35.9
8	-0.65	-45.83	-32.83	30.4
9	-0.65	-45.83	-32.82	30.4
9	-1.30	-66.46	-30.25	25.0
10	-1.30	-66.46	-30.25	25.0
10	-1.92	-84.11	-27.11	20.3
11	-1.92	-84.11	-27.12	20.3
11	-2.53	-99.30	-22.14	15.9
12	-2.53	-99.30	-22.15	15.9
12	-3.15	-111.38	-17.01	12.0
13	-3.15	-111.38	-17.00	12.0
13	-3.77	-120.19	-11.62	8.6
14	-3.77	-120.19	-11.60	8.6
14	-4.38	-125.76	-6.36	5.8
15	-4.38	-125.76	-6.37	5.8
15	-5.00	**-127.90**	-0.71	3.6
16	-5.00	-127.89	-0.84	3.6
16	-5.67	-120.34	21.38	1.8
17	-5.67	-120.33	21.44	1.8
17	-6.33	-101.45	34.06	0.6
18	-6.33	-101.45	34.04	0.6
18	-7.00	-76.70	**38.75**	0.0
19	-7.00	-76.70	38.74	0.0
19	-7.63	-53.52	34.86	-0.2
20	-7.63	-53.52	34.86	-0.2
20	-8.25	-33.26	30.00	-0.1
21	-8.25	-33.26	30.00	-0.1
21	-8.88	-17.45	20.72	0.1
22	-8.88	-17.45	20.71	0.1
22	-9.50	-7.16	12.42	0.4
23	-9.50	-7.16	12.42	0.4
23	-10.13	-1.64	5.48	0.8
24	-10.13	-1.64	5.48	0.8
24	-10.75	0.00	0.00	1.1
Max		**-127.90**	**38.75**	**64.6**
Max, minor nodes incl.		-127.90	38.75	64.6

8.7.3 Charts of Stresses



8.7.4 Stresses

Node number	Level	Left				Right			
		Effective stress	Water stress	Stat*	Mob*	Effective stress	Water stress	Stat*	Mob*
	[m]	[kN/m²]	[kN/m²]		[%]	[kN/m²]	[kN/m²]		[%]
1	3.25	0.00	0.00	-		0.00	0.00	-	
1	2.88	0.00	0.00	-		0.00	0.00	-	
2	2.88	0.00	0.00	-		0.00	0.00	-	
2	2.50	0.00	0.00	-		0.00	0.00	-	
3	2.50	0.00	0.00	A		0.00	0.00	-	
3	1.83	4.28	0.00	A		0.00	0.00	-	
4	1.83	4.59	0.00	A		0.00	0.00	-	
4	1.17	12.42	0.00	1	10	0.00	0.00	-	
5	1.17	12.76	0.00	1	10	0.00	0.00	-	
5	0.50	23.76	0.00	1	11	0.00	0.00	-	
6	0.50	23.99	0.00	1	11	0.00	0.00	-	
6	0.22	28.32	0.00	1	12	0.00	0.00	-	
7	0.22	28.42	0.00	1	12	0.00	0.00	-	
7	0.00	31.39	2.16	1	12	0.00	2.16	-	
8	0.00	18.24	2.16	1	16	0.00	2.16	A	
8	-0.65	27.04	8.53	1	22	29.20	8.53	2	78
9	-0.65	27.15	8.53	1	22	29.46	8.53	2	78
9	-1.30	24.44	14.91	1		29.94	14.91	2	70
10	-1.30	24.55	14.91	1		30.20	14.91	2	70
10	-1.92	26.59	20.96	1		30.68	20.96	2	65
11	-1.92	22.82	20.96	1		30.93	20.96	2	65
11	-2.53	23.41	27.01	1		31.47	27.01	2	60
12	-2.53	23.48	27.01	1		31.72	27.01	2	60
12	-3.15	23.87	33.06	1		32.35	33.06	2	56
13	-3.15	23.94	33.06	1		32.60	33.06	2	56
13	-3.77	25.50	39.11	1		33.37	39.11	2	54
14	-3.77	25.57	39.11	1		33.62	39.11	2	54
14	-4.38	25.60	45.16	1		34.56	45.16	2	51
15	-4.38	25.66	45.16	1		34.81	45.16	2	51
15	-5.00	27.76	51.21	1		34.57	51.21	1	49

Node number	Level [m]	Left				Right			
		Effective stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob* [%]	Effective stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob* [%]
16	-5.00	24.48	51.21	1		70.52	51.21	1	41
16	-5.67	23.14	57.75	1		47.48	57.75	1	26
17	-5.67	23.34	57.75	1		47.98	57.75	1	26
17	-6.33	23.00	64.29	1		36.69	64.29	1	19
18	-6.33	22.80	64.29	1		37.16	64.29	1	19
18	-7.00	31.42	70.83	1		32.72	70.83	1	14
19	-7.00	31.74	70.83	1		32.93	70.83	1	29
19	-7.63	48.13	76.96	1	21	40.43	76.96	1	
20	-7.63	48.37	76.96	1	21	40.72	76.96	1	
20	-8.25	50.35	83.09	1	20	42.72	83.09	1	
21	-8.25	58.52	83.09	1	23	43.00	83.09	1	
21	-8.88	59.90	89.22	1		45.64	89.22	1	42
22	-8.88	60.13	89.22	1		45.92	89.22	1	43
22	-9.50	61.17	95.35	1		48.91	95.35	1	43
23	-9.50	61.40	95.35	1		49.19	95.35	1	43
23	-10.13	62.31	101.48	1		52.34	101.48	1	41
24	-10.13	62.54	101.48	1		52.61	101.48	1	40
24	-10.75	63.42	107.62	1		55.82	107.62	1	38

*
Stat Status (A=active, P=passive, Number is branche, 0 is unloading)
Mob Percentage passive mobilized

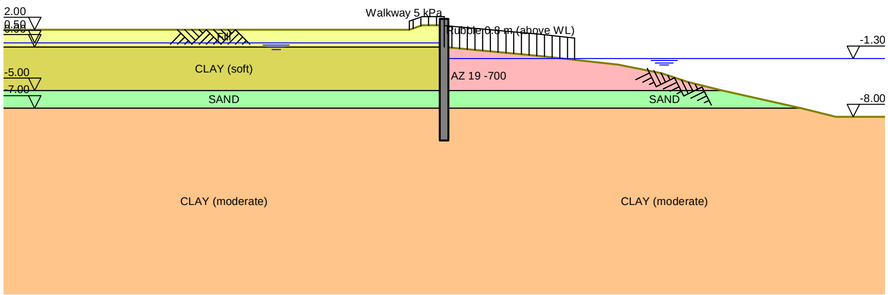
8.7.5 Percentage mobilized resistance

Horizontal soil pressure	Left [kN]	Right [kN]
Effective	418.8	418.9
Water	590.3	590.3
Total	1009.1	1009.1

Considered as passive side	Right
Maximum passive effective resistance	1088.55 kN
Mobilized passive effective resistance	418.85 kN
Percentage mobilized resistance	38.5 %

9 Outline Stage 5: Sudden drop

Outline - Stage 5: Sudden drop



10 Step 6.3 Stage 5: Sudden drop

10.1 Input Data Left

10.1.1 Calculation Method

Calculation method: C, phi, delta

10.1.2 Water Level

Water level: 0.50 [m]

10.1.3 Surface

X [m]	Y [m]
0.00	2.50
2.50	2.50
4.00	2.00

10.1.4 Soil Material Properties in Profile: CPT10-12 drop left

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Sat. [kN/m³]	Cohesion [kN/m²]	Friction angle phi [degree]	Delta friction angle [degree]
Fill	2.50	18.00	20.00	0.00	28.47	18.39
CLAY (soft)	0.00	14.00	14.00	4.00	15.02	7.51
SAND	-5.00	18.00	20.00	0.00	26.17	17.45
CLAY (moderate)	-7.00	16.00	16.00	4.00	17.21	8.61

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Fill	2.50	1.00	1.00	Fine
CLAY (soft)	0.00	1.00	1.00	Fine
SAND	-5.00	1.00	1.00	Fine
CLAY (moderate)	-7.00	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients Active [-]	Neutral [-]	Passive [-]	Additional pore pressure Top [kN/m²]	Bottom [kN/m²]
Fill	2.50	n.a.	n.a.	n.a.	0.00	0.00
CLAY (soft)	0.00	n.a.	n.a.	n.a.	0.00	-2.80
SAND	-5.00	n.a.	n.a.	n.a.	-2.80	-2.80
CLAY (moderate)	-7.00	n.a.	n.a.	n.a.	-2.80	-2.80

10.1.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1 Top [kN/m³]	Branch 1 Bottom [kN/m³]	Branch 2 Top [kN/m³]	Branch 2 Bottom [kN/m³]
Fill	2.50	15384.62	15384.62	7692.31	7692.31
CLAY (soft)	0.00	1538.46	1538.46	615.38	615.38
SAND	-5.00	9230.77	9230.77	4615.38	4615.38
CLAY (moderate)	-7.00	3076.92	3076.92	1538.46	1538.46

Layer name	Level [m]	Branch 3 Top [kN/m³]	Branch 3 Bottom [kN/m³]
Fill	2.50	3846.15	3846.15
CLAY (soft)	0.00	384.62	384.62
SAND	-5.00	2307.69	2307.69
CLAY (moderate)	-7.00	615.38	615.38

10.1.6 Surcharge Loads

Name	Distance [m]	Load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Walkway 5 kPa	0.00	5.50	Unfavourable (D-Sheet Piling)	Variable
	4.00	5.50		

10.2 Calculated Earth Pressure Coefficients Left

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
1	2.37	2.4	39.2	0.30	0.73	4.96
2	2.23	3.1	51.1	0.30	0.57	4.97
3	2.10	3.8	63.0	0.30	0.49	4.97
4	1.97	4.5	74.9	0.30	0.44	4.97
5	1.83	5.1	83.9	0.30	0.40	4.98
6	1.83	5.4	89.8	0.30	0.40	4.98
7	1.70	6.0	79.7	0.30	0.38	4.02
8	1.57	6.7	74.7	0.30	0.36	3.37
9	1.43	7.4	79.6	0.30	0.35	3.25
10	1.30	8.1	88.1	0.30	0.34	3.28
11	1.17	8.7	94.7	0.30	0.34	3.32
12	1.17	9.0	99.2	0.30	0.34	3.34
13	1.03	9.6	106.2	0.30	0.34	3.38
14	0.90	10.3	115.7	0.30	0.33	3.43
15	0.77	11.0	125.6	0.31	0.33	3.49
16	0.63	11.7	135.7	0.31	0.33	3.54
17	0.50	12.3	143.4	0.31	0.33	3.59
18	0.50	12.5	146.5	0.31	0.33	3.60
19	0.44	12.6	148.1	0.31	0.33	3.61
20	0.39	12.8	150.2	0.31	0.32	3.61
21	0.33	13.0	152.4	0.31	0.32	3.62
22	0.28	13.1	154.6	0.31	0.31	3.63
23	0.22	13.3	156.4	0.31	0.31	3.64
24	0.22	13.3	157.4	0.31	0.31	3.64
25	0.18	13.4	158.8	0.31	0.31	3.65
26	0.13	13.6	160.7	0.31	0.31	3.66
27	0.09	13.7	162.5	0.31	0.31	3.67
28	0.04	13.8	164.5	0.31	0.31	3.68
29	0.00	13.9	165.9	0.31	0.31	3.70
30	0.00	19.1	53.1	0.43	0.43	1.18
31	-0.10	19.4	53.6	0.43	0.49	1.19
32	-0.20	19.6	54.2	0.43	0.49	1.19
33	-0.30	19.9	54.8	0.43	0.48	1.19
34	-0.40	20.2	55.5	0.44	0.48	1.20
35	-0.50	20.4	55.9	0.44	0.48	1.20
36	-0.50	20.5	56.2	0.44	0.48	1.20
37	-0.58	20.7	56.6	0.44	0.48	1.21
38	-0.66	20.9	57.0	0.44	0.48	1.21
39	-0.74	21.1	58.2	0.45	0.48	1.23
40	-0.82	21.3	61.7	0.45	0.48	1.29
41	-0.90	21.3	64.4	0.44	0.48	1.34
42	-0.90	21.2	66.2	0.44	0.48	1.38
43	-0.98	21.3	68.7	0.44	0.48	1.42
44	-1.06	21.4	72.0	0.44	0.48	1.48
45	-1.14	21.5	75.1	0.44	0.48	1.54
46	-1.22	21.7	78.1	0.44	0.49	1.59
47	-1.30	21.8	80.3	0.44	0.49	1.63
48	-1.30	21.8	82.2	0.44	0.49	1.66
49	-1.42	22.0	90.9	0.44	0.49	1.82
50	-1.55	22.2	98.3	0.44	0.49	1.96
51	-1.67	22.3	99.3	0.44	0.49	1.96
52	-1.79	22.5	100.3	0.44	0.50	1.96
53	-1.92	22.7	101.0	0.44	0.49	1.96
54	-1.92	22.7	101.5	0.44	0.49	1.96

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
55	-2.04	22.9	102.2	0.44	0.49	1.97
56	-2.16	23.1	103.2	0.44	0.50	1.97
57	-2.29	23.3	104.2	0.44	0.50	1.97
58	-2.41	23.4	105.3	0.44	0.50	1.97
59	-2.53	23.6	106.0	0.44	0.51	1.98
60	-2.53	23.7	106.5	0.44	0.51	1.98
61	-2.66	23.8	107.3	0.44	0.51	1.98
62	-2.78	24.0	108.4	0.44	0.51	1.98
63	-2.90	24.2	109.4	0.44	0.52	1.98
64	-3.03	24.4	110.4	0.44	0.52	1.99
65	-3.15	24.5	111.2	0.44	0.52	1.99
66	-3.15	24.6	111.8	0.44	0.52	1.99
67	-3.27	24.7	112.5	0.44	0.53	1.99
68	-3.40	24.9	113.6	0.44	0.53	1.99
69	-3.52	25.1	114.7	0.44	0.53	2.00
70	-3.64	25.2	115.7	0.44	0.53	2.00
71	-3.77	25.3	116.5	0.43	0.54	2.00
72	-3.77	25.2	117.1	0.43	0.54	2.00
73	-3.89	25.1	117.9	0.43	0.54	2.00
74	-4.01	24.9	119.0	0.42	0.55	2.01
75	-4.14	24.7	120.1	0.41	0.55	2.01
76	-4.26	24.7	121.1	0.41	0.55	2.01
77	-4.38	24.8	122.0	0.41	0.56	2.01
78	-4.38	24.9	122.5	0.41	0.56	2.01
79	-4.51	25.1	123.3	0.41	0.56	2.01
80	-4.63	25.3	124.4	0.41	0.56	2.02
81	-4.75	25.5	125.5	0.41	0.56	2.02
82	-4.88	25.7	126.6	0.41	0.57	2.02
83	-5.00	25.8	127.4	0.41	0.57	2.00
84	-5.00	17.7	275.1	0.28	0.57	4.28
85	-5.13	17.9	278.9	0.28	0.39	4.28
86	-5.27	18.3	284.2	0.28	0.39	4.28
87	-5.40	18.6	289.5	0.27	0.40	4.28
88	-5.53	18.9	294.9	0.27	0.40	4.28
89	-5.67	19.2	299.0	0.27	0.40	4.28
90	-5.67	19.4	301.7	0.27	0.40	4.28
91	-5.80	19.6	305.9	0.27	0.41	4.28
92	-5.93	20.0	311.4	0.27	0.41	4.28
93	-6.07	21.0	315.7	0.28	0.41	4.26
94	-6.20	20.8	316.7	0.28	0.42	4.21
95	-6.33	20.8	317.3	0.27	0.42	4.16
96	-6.33	20.8	317.7	0.27	0.42	4.13
97	-6.47	20.9	318.3	0.27	0.42	4.09
98	-6.60	20.8	312.5	0.26	0.43	3.95
99	-6.73	20.0	312.7	0.25	0.43	3.89
100	-6.87	21.3	318.5	0.26	0.43	3.90
101	-7.00	21.7	322.8	0.26	0.43	3.92
102	-7.00	30.3	164.2	0.37	0.43	1.99
103	-7.13	30.6	165.4	0.37	0.58	1.99
104	-7.25	31.1	166.9	0.37	0.59	1.99
105	-7.38	31.5	168.4	0.37	0.59	1.99
106	-7.50	31.9	170.0	0.37	0.59	1.99
107	-7.63	32.3	171.2	0.38	0.59	1.99
108	-7.63	32.5	171.9	0.38	0.68	1.99
109	-7.75	32.8	173.1	0.38	0.68	2.00
110	-7.88	33.2	174.6	0.38	0.68	2.00
111	-8.00	33.6	176.4	0.38	0.69	2.00
112	-8.13	34.0	180.6	0.38	0.69	2.03
113	-8.25	34.4	184.2	0.38	0.69	2.06
114	-8.25	34.6	186.6	0.38	0.69	2.08
115	-8.38	34.9	190.2	0.39	0.69	2.11
116	-8.50	35.3	195.0	0.39	0.69	2.14
117	-8.63	35.7	199.3	0.39	0.69	2.17
118	-8.75	36.1	213.3	0.39	0.69	2.31

Segment number	Level [m]	Horizontal pressure		Fictive earth pressure coefficients		
		Active [kN/m²]	Passive [kN/m²]	Ka [-]	Ko [-]	Kp [-]
119	-8.88	36.5	214.6	0.39	0.69	2.31
120	-8.88	36.8	215.4	0.39	0.69	2.31
121	-9.00	37.2	216.7	0.40	0.69	2.31
122	-9.13	37.7	218.3	0.40	0.69	2.31
123	-9.25	38.3	220.0	0.40	0.69	2.31
124	-9.38	38.8	221.7	0.40	0.69	2.31
125	-9.50	39.2	222.9	0.41	0.69	2.31
126	-9.50	39.5	223.7	0.41	0.69	2.31
127	-9.63	39.9	225.0	0.41	0.69	2.31
128	-9.75	40.4	226.7	0.41	0.69	2.31
129	-9.88	41.0	228.3	0.41	0.69	2.31
130	-10.00	41.5	230.0	0.42	0.70	2.31
131	-10.13	41.9	231.3	0.42	0.70	2.31
132	-10.13	42.2	232.1	0.42	0.70	2.31
133	-10.25	42.6	233.3	0.42	0.70	2.31
134	-10.38	43.2	235.0	0.42	0.70	2.31
135	-10.50	44.8	236.7	0.44	0.70	2.31
136	-10.63	45.1	238.4	0.44	0.70	2.31
137	-10.75	45.3	239.6	0.44	0.70	2.31

10.3 Calculated force from a layer Left

Name	Force
Fill	20.58
CLAY (soft)	116.69
SAND	39.48
CLAY (moderate)	231.24

10.4 Input Data Right

10.4.1 Calculation Method

Calculation method: C, phi, delta

10.4.2 Water Level

Water level: -1.30 [m]

10.4.3 Surface

X [m]	Y [m]
0.00	-0.50
11.00	-1.50
20.00	-2.50
25.00	-3.50
28.00	-4.50
32.00	-5.50
41.00	-7.50
45.00	-8.50

10.4.4 Soil Material Properties in Profile: CPT10-12 drop right

Layer name	Level [m]	Unit weight		Cohesion [kN/m²]	Friction angle phi [degree]	Delta friction angle [degree]
		Unsat [kN/m³]	Sat. [kN/m³]			
Fill	2.50	18.00	20.00	0.00	28.47	18.39
CLAY (soft) (un...	0.00	14.00	14.00	16.00	0.00	0.00
SAND	-5.00	18.00	20.00	0.00	26.17	17.45
CLAY (moderate)	-7.00	16.00	16.00	4.00	17.21	8.61

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Fill	2.50	1.00	1.00	Fine
CLAY (soft) (un...	0.00	1.00	1.00	Fine
SAND	-5.00	1.00	1.00	Fine
CLAY (moderate)	-7.00	1.00	1.00	Fine

Layer name	Level	Earth pressure coefficients			Additional pore pressure	
		Active	Neutral	Passive	Top	Bottom
	[m]	[-]	[-]	[-]	[kN/m²]	[kN/m²]
Fill	2.50	n.a.	n.a.	n.a.	0.00	0.00
CLAY (soft) (un...	0.00	n.a.	n.a.	n.a.	0.00	15.20
SAND	-5.00	n.a.	n.a.	n.a.	15.20	15.20
CLAY (moderate)	-7.00	n.a.	n.a.	n.a.	15.20	15.20

10.4.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level	Branch 1		Branch 2	
		Top	Bottom	Top	Bottom
	[m]	[kN/m³]	[kN/m³]	[kN/m³]	[kN/m³]
Fill	2.50	15384.62	15384.62	7692.31	7692.31
CLAY (soft) (un...	0.00	1538.46	1538.46	615.38	615.38
SAND	-5.00	9230.77	9230.77	4615.38	4615.38
CLAY (moderate)	-7.00	3076.92	3076.92	1538.46	1538.46

Layer name	Level	Branch 3	
		Top	Bottom
	[m]	[kN/m³]	[kN/m³]
Fill	2.50	3846.15	3846.15
CLAY (soft) (un...	0.00	384.62	384.62
SAND	-5.00	2307.69	2307.69
CLAY (moderate)	-7.00	615.38	615.38

10.4.6 Surcharge Loads

Name	Distance [m]	Load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Rubble 0.8 m (above WL)	0.00	12.35	Favourable (D-Sheet Piling)	Permanent
	15.00	12.35		

10.5 Calculated Earth Pressure Coefficients Right

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
1	-0.58	0.0	39.8	0.00	0.99	3.51
2	-0.66	0.0	40.6	0.00	0.82	3.41
3	-0.74	0.0	41.4	0.00	0.84	3.27
4	-0.82	0.0	42.2	0.00	0.87	3.13
5	-0.90	0.0	42.7	0.00	0.89	3.04
6	-0.90	0.0	43.1	0.00	0.89	2.98
7	-0.98	0.0	43.7	0.00	0.91	2.90
8	-1.06	0.0	44.5	0.00	0.92	2.80
9	-1.14	0.0	45.2	0.00	0.94	2.71
10	-1.22	0.0	46.0	0.00	0.95	2.63
11	-1.30	0.0	46.6	0.00	0.96	2.57
12	-1.30	0.0	46.8	0.00	0.96	2.55
13	-1.42	0.0	46.8	0.00	0.97	2.55
14	-1.55	0.0	46.7	0.00	0.97	2.54
15	-1.67	0.0	46.7	0.00	0.98	2.53
16	-1.79	0.0	46.7	0.00	0.98	2.53
17	-1.92	0.0	46.7	0.00	0.99	2.52
18	-1.92	0.0	46.7	0.00	0.99	2.52
19	-2.04	0.0	0.8	0.00	0.04	0.04
20	-2.16	0.0	0.8	0.00	0.04	0.04
21	-2.29	0.0	0.8	0.00	0.04	0.04

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
22	-2.41	0.0	0.8	0.00	0.04	0.04
23	-2.53	0.0	0.8	0.00	0.04	0.04
24	-2.53	0.0	0.8	0.00	0.04	0.04
25	-2.66	0.0	0.8	0.00	0.04	0.04
26	-2.78	0.0	0.8	0.00	0.04	0.04
27	-2.90	0.0	0.8	0.00	0.04	0.04
28	-3.03	0.0	0.8	0.00	0.04	0.04
29	-3.15	0.0	0.8	0.00	0.04	0.04
30	-3.15	0.0	0.8	0.00	0.04	0.04
31	-3.27	0.0	0.8	0.00	0.04	0.04
32	-3.40	0.0	0.8	0.00	0.04	0.04
33	-3.52	0.0	0.8	0.00	0.04	0.04
34	-3.64	0.0	0.8	0.00	0.04	0.04
35	-3.77	0.0	0.8	0.00	0.04	0.04
36	-3.77	0.0	0.8	0.00	0.04	0.04
37	-3.89	0.0	0.8	0.00	0.04	0.04
38	-4.01	0.0	0.8	0.00	0.04	0.04
39	-4.14	0.0	0.8	0.00	0.04	0.04
40	-4.26	0.0	0.8	0.00	0.04	0.04
41	-4.38	0.0	0.8	0.00	0.04	0.04
42	-4.38	0.0	0.8	0.00	0.04	0.04
43	-4.51	0.0	0.8	0.00	0.04	0.04
44	-4.63	0.0	0.8	0.00	0.04	0.04
45	-4.75	0.0	0.8	0.00	0.04	0.04
46	-4.88	0.0	0.8	0.00	0.04	0.04
47	-5.00	0.0	0.8	0.00	0.04	0.04
48	-5.00	0.0	96.0	0.00	1.17	4.63
49	-5.13	0.0	98.2	0.00	0.88	4.52
50	-5.27	0.0	100.5	0.00	0.87	4.38
51	-5.40	0.0	103.0	0.00	0.85	4.25
52	-5.53	0.0	105.6	0.00	0.83	4.15
53	-5.67	0.0	107.2	0.00	0.80	4.06
54	-5.67	0.0	108.8	0.00	0.80	4.02
55	-5.80	0.0	110.8	0.00	0.79	3.96
56	-5.93	0.0	113.2	0.00	0.78	3.87
57	-6.07	0.0	116.1	0.00	0.77	3.80
58	-6.20	0.0	118.7	0.00	0.76	3.74
59	-6.33	0.0	120.8	0.00	0.75	3.69
60	-6.33	0.0	122.1	0.00	0.75	3.66
61	-6.47	0.0	124.1	0.00	0.74	3.62
62	-6.60	0.0	127.1	0.00	0.73	3.57
63	-6.73	0.0	129.8	0.00	0.72	3.53
64	-6.87	0.0	132.7	0.00	0.72	3.48
65	-7.00	0.0	134.9	0.00	0.71	3.49
66	-7.00	0.0	8.5	0.00	0.22	0.22
67	-7.13	0.0	19.5	0.00	0.49	0.49
68	-7.25	0.0	31.5	0.00	0.78	0.78
69	-7.38	0.0	40.9	0.00	0.82	1.00
70	-7.50	0.0	48.5	0.00	0.82	1.17
71	-7.63	0.0	53.4	0.00	0.82	1.27
72	-7.63	0.0	56.0	0.00	0.82	1.32
73	-7.75	0.0	59.8	0.00	0.82	1.39
74	-7.88	0.0	63.3	0.00	0.82	1.45
75	-8.00	0.0	65.4	0.00	0.81	1.48
76	-8.13	0.0	67.1	0.00	0.81	1.49
77	-8.25	0.0	68.5	0.00	0.81	1.51
78	-8.25	0.0	69.4	0.00	0.81	1.52
79	-8.38	0.0	70.7	0.00	0.81	1.53
80	-8.50	0.0	72.2	0.00	0.80	1.54
81	-8.63	0.0	73.8	0.00	0.80	1.55
82	-8.75	0.0	75.3	0.00	0.80	1.56
83	-8.88	0.0	76.3	0.00	0.80	1.56
84	-8.88	0.0	77.0	0.00	0.80	1.57
85	-9.00	0.0	86.0	0.00	0.79	1.73

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
86	-9.13	0.0	95.0	0.00	0.79	1.88
87	-9.25	0.0	95.7	0.00	0.79	1.87
88	-9.38	0.0	96.5	0.00	0.79	1.86
89	-9.50	0.0	97.2	0.00	0.78	1.86
90	-9.50	18.9	97.6	0.36	0.78	1.85
91	-9.63	19.9	98.2	0.37	0.78	1.85
92	-9.75	20.2	99.1	0.38	0.78	1.84
93	-9.88	20.6	100.0	0.38	0.78	1.83
94	-10.00	20.9	101.0	0.38	0.78	1.83
95	-10.13	21.1	101.7	0.38	0.78	1.83
96	-10.13	21.3	102.2	0.38	0.78	1.82
97	-10.25	21.6	102.9	0.38	0.77	1.82
98	-10.38	21.9	104.0	0.38	0.77	1.82
99	-10.50	22.2	105.0	0.38	0.77	1.81
100	-10.63	22.6	106.1	0.39	0.77	1.81
101	-10.75	22.8	107.0	0.39	0.77	1.81

10.6 Calculated force from a layer Right

Name	Force
Fill	0.00
CLAY (soft) (undr)	66.92
SAND	224.27
CLAY (moderate)	151.42

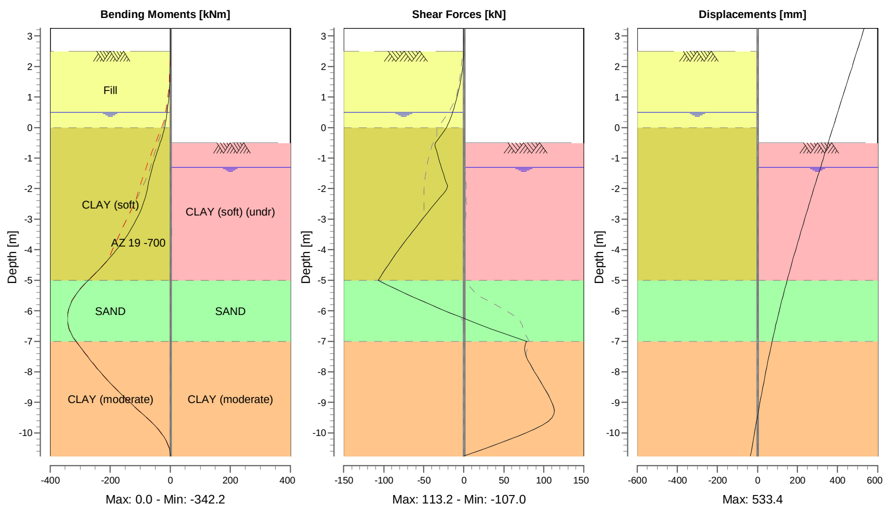
10.7 Calculation Results

Number of iterations: 9

10.7.1 Charts of Moments, Forces and Displacements

Moments/Forces/Displacements - Stage 5: Sudden drop

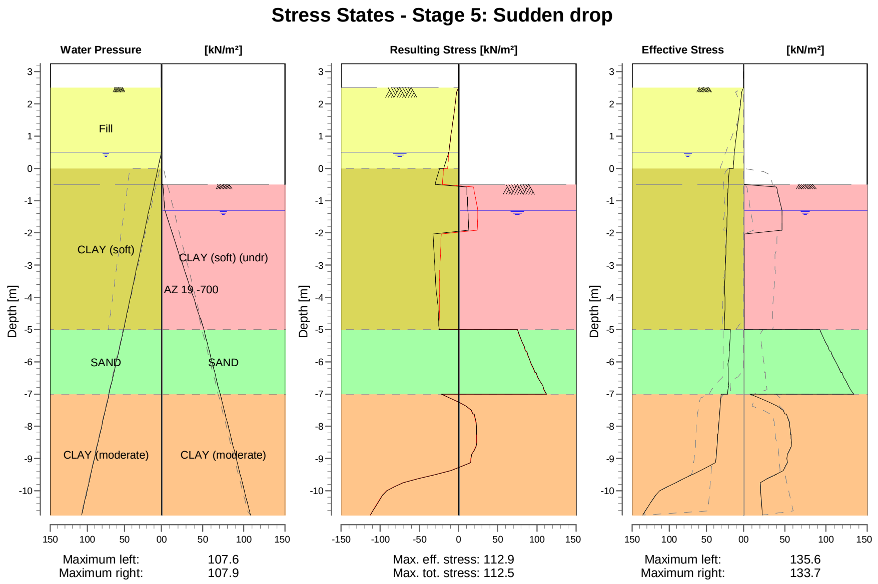
Step 6.3 - Partial factor set: RC 2



10.7.2 Moments, Forces and Displacements

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
1	3.25	0.00	0.00	**533.4**
1	2.88	0.00	0.00	515.4
2	2.88	0.00	0.00	515.4
2	2.50	0.00	0.00	497.3
3	2.50	0.00	0.00	497.3
3	1.83	-0.56	-2.18	465.3
4	1.83	-0.57	-2.15	465.3
4	1.17	-3.44	-6.85	433.2
5	1.17	-3.44	-6.84	433.2
5	0.50	-10.24	-13.94	401.1
6	0.50	-10.24	-13.94	401.1
6	0.22	-14.67	-17.92	387.7
7	0.22	-14.67	-17.92	387.7
7	0.00	-19.03	-21.77	377.1
8	0.00	-19.03	-21.76	377.1
8	-0.50	-33.18	-35.32	353.2
9	-0.50	-33.18	-35.32	353.2
9	-0.90	-47.04	-32.64	334.1
10	-0.90	-47.04	-32.64	334.1
10	-1.30	-59.19	-28.03	315.1
11	-1.30	-59.19	-28.03	315.1
11	-1.92	-74.14	-20.32	286.0
12	-1.92	-74.14	-20.32	286.0
12	-2.53	-91.19	-37.30	257.3
13	-2.53	-91.19	-37.30	257.3
13	-3.15	-120.09	-56.30	229.0
14	-3.15	-120.09	-56.30	229.0
14	-3.77	-160.47	-74.49	201.3
15	-3.77	-160.47	-74.47	201.3
15	-4.38	-211.64	-91.21	174.3
16	-4.38	-211.64	-91.22	174.3
16	-5.00	-272.76	-106.89	148.3
17	-5.00	-272.75	-107.01	148.3
17	-5.67	-326.58	-53.28	121.5
18	-5.67	-326.58	-53.22	121.5
18	-6.33	**-342.01**	8.14	96.6
19	-6.33	**-342.01**	8.12	96.6
19	-7.00	-313.65	78.49	73.4
20	-7.00	-313.65	78.48	73.4
20	-7.63	-265.43	80.23	53.2
21	-7.63	-265.43	80.24	53.2
21	-8.25	-211.04	94.10	34.3
22	-8.25	-211.05	94.12	34.3
22	-8.88	-147.78	107.76	16.4
23	-8.88	-147.79	107.89	16.4
23	-9.50	-78.12	110.27	-0.9
24	-9.50	-78.07	**110.36**	-0.9
24	-10.13	-20.93	65.58	-17.8
25	-10.13	-20.95	65.37	-17.8
25	-10.75	0.00	0.00	-34.5
Max		**-342.01**	**110.36**	**533.4**
Max, minor nodes incl.		-342.23	113.16	533.4

10.7.3 Charts of Stresses



10.7.4 Stresses

Node number	Level	Left				Right			
		Effective stress	Water stress	Stat*	Mob*	Effective stress	Water stress	Stat*	Mob*
	[m]	[kN/m²]	[kN/m²]		[%]	[kN/m²]	[kN/m²]		[%]
1	3.25	0.00	0.00	-		0.00	0.00	-	
1	2.88	0.00	0.00	-		0.00	0.00	-	
2	2.88	0.00	0.00	-		0.00	0.00	-	
2	2.50	0.00	0.00	-		0.00	0.00	-	
3	2.50	0.00	0.00	A		0.00	0.00	-	
3	1.83	5.07	0.00	A		0.00	0.00	-	
4	1.83	5.43	0.00	A		0.00	0.00	-	
4	1.17	8.67	0.00	A		0.00	0.00	-	
5	1.17	9.03	0.00	A		0.00	0.00	-	
5	0.50	12.26	0.00	A		0.00	0.00	-	
6	0.50	12.49	0.00	A		0.00	0.00	-	
6	0.22	13.26	2.75	A		0.00	0.00	-	
7	0.22	13.33	2.75	A	8	0.00	0.00	-	
7	0.00	14.00	4.91	A	8	0.00	0.00	-	
8	0.00	19.26	4.91	A	36	0.00	0.00	-	
8	-0.50	20.53	9.53	A		0.00	0.00	-	
9	-0.50	20.65	9.53	A		0.02	1.52	P	
9	-0.90	21.41	13.23	A		42.73	2.74	P	
10	-0.90	21.34	13.23	A		43.12	2.74	P	
10	-1.30	21.87	16.93	A		46.59	3.95	P	
11	-1.30	21.94	16.93	A		46.78	3.95	P	
11	-1.92	22.77	22.63	A		46.68	11.88	P	
12	-1.92	22.86	22.63	A		46.67	11.88	P	
12	-2.53	23.70	28.34	A		0.81	19.80	P	
13	-2.53	23.79	28.34	A		0.81	19.80	P	
13	-3.15	24.62	34.04	A		0.81	27.72	P	
14	-3.15	24.71	34.04	A		0.81	27.72	P	
14	-3.77	25.38	39.75	A		0.81	35.65	P	
15	-3.77	25.30	39.75	A		0.81	35.65	P	
15	-4.38	24.91	45.45	A		0.81	43.57	P	

Node number	Level [m]	Left Effective stress [kN/m²]	Left Water stress [kN/m²]	Left Stat*	Left Mob* [%]	Right Effective stress [kN/m²]	Right Water stress [kN/m²]	Right Stat*	Right Mob* [%]
16	-4.38	25.02	45.45	A		0.81	43.57	P	
16	-5.00	25.71	51.16	A		0.79	51.50	P	
17	-5.00	17.56	51.16	A		92.58	51.50	P	
17	-5.67	19.07	57.70	A		104.23	58.04	P	
18	-5.67	19.24	57.70	A		105.87	58.04	P	
18	-6.33	20.70	64.23	A		118.04	64.58	P	
19	-6.33	20.70	64.23	A		119.43	64.58	P	
19	-7.00	21.66	70.78	A		133.67	71.12	P	
20	-7.00	30.34	70.78	A		8.43	71.12	P	
20	-7.63	32.28	76.91	A		50.37	77.25	3	95
21	-7.63	32.49	76.91	A		52.03	77.25	3	93
21	-8.25	34.37	83.04	A		56.90	83.38	3	83
22	-8.25	34.58	83.04	A		57.53	83.38	3	83
22	-8.88	36.50	89.17	A		53.23	89.51	2	70
23	-8.88	36.78	89.17	A		53.50	89.51	2	70
23	-9.50	69.25	95.30	1	31	38.65	95.64	1	
24	-9.50	69.50	95.30	1	31	38.92	95.64	1	
24	-10.13	117.86	101.43	2	51	21.07	101.77	A	
25	-10.13	118.23	101.43	2	51	21.24	101.77	A	
25	-10.75	135.64	107.56	2	57	22.76	107.90	A	

*
Stat Status (A=active, P=passive, Number is branche, 0 is unloading)
Mob Percentage passive mobilized

10.7.5 Percentage mobilized resistance

Horizontal soil pressure	Left [kN]	Right [kN]
Effective	408.0	442.6
Water	597.7	563.0
Total	1005.7	1005.7

Considered as passive side Right
Maximum passive effective resistance 581.86 kN
Mobilized passive effective resistance 442.62 kN
Percentage mobilized resistance 76.1 %

11 Step 6.4 Stage 5: Sudden drop

11.1 Input Data Left

11.1.1 Calculation Method

Calculation method: C, phi, delta

11.1.2 Water Level

Water level: 0.50 [m]

11.1.3 Surface

X [m]	Y [m]
0.00	2.50
2.50	2.50
4.00	2.00

11.1.4 Soil Material Properties in Profile: CPT10-12 drop left

Layer name	Level	Unit weight		Cohesion	Friction angle phi	Delta friction angle
		Unsat	Sat.			
	[m]	[kN/m³]	[kN/m³]	[kN/m²]	[degree]	[degree]
Fill	2.50	18.00	20.00	0.00	28.47	18.39
CLAY (soft)	0.00	14.00	14.00	4.00	15.02	7.51
SAND	-5.00	18.00	20.00	0.00	26.17	17.45
CLAY (moderate)	-7.00	16.00	16.00	4.00	17.21	8.61

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Fill	2.50	1.00	1.00	Fine
CLAY (soft)	0.00	1.00	1.00	Fine
SAND	-5.00	1.00	1.00	Fine
CLAY (moderate)	-7.00	1.00	1.00	Fine

Layer name	Level	Earth pressure coefficients			Additional pore pressure	
		Active	Neutral	Passive	Top	Bottom
	[m]	[-]	[-]	[-]	[kN/m²]	[kN/m²]
Fill	2.50	n.a.	n.a.	n.a.	0.00	0.00
CLAY (soft)	0.00	n.a.	n.a.	n.a.	0.00	-2.80
SAND	-5.00	n.a.	n.a.	n.a.	-2.80	-2.80
CLAY (moderate)	-7.00	n.a.	n.a.	n.a.	-2.80	-2.80

11.1.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level	Branch 1		Branch 2	
		Top	Bottom	Top	Bottom
	[m]	[kN/m³]	[kN/m³]	[kN/m³]	[kN/m³]
Fill	2.50	45000.00	45000.00	22500.00	22500.00
CLAY (soft)	0.00	4500.00	4500.00	1800.00	1800.00
SAND	-5.00	27000.00	27000.00	13500.00	13500.00
CLAY (moderate)	-7.00	9000.00	9000.00	4500.00	4500.00

Layer name	Level	Branch 3	
		Top	Bottom
	[m]	[kN/m³]	[kN/m³]
Fill	2.50	11250.00	11250.00
CLAY (soft)	0.00	1125.00	1125.00
SAND	-5.00	6750.00	6750.00
CLAY (moderate)	-7.00	1800.00	1800.00

11.1.6 Surcharge Loads

Name	Distance [m]	Load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Walkway 5 kPa	0.00	5.50	Unfavourable (D-Sheet Piling)	Variable
	4.00	5.50		

11.2 Calculated Earth Pressure Coefficients Left

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
1	2.37	2.4	39.2	0.30	0.73	4.96
2	2.23	3.1	51.1	0.30	0.57	4.97
3	2.10	3.8	63.0	0.30	0.49	4.97
4	1.97	4.5	74.9	0.30	0.44	4.97
5	1.83	5.1	83.9	0.30	0.40	4.98
6	1.83	5.4	89.8	0.30	0.40	4.98
7	1.70	6.0	79.7	0.30	0.38	4.02
8	1.57	6.7	74.7	0.30	0.36	3.37
9	1.43	7.4	79.6	0.30	0.35	3.25
10	1.30	8.1	88.1	0.30	0.34	3.28
11	1.17	8.7	94.7	0.30	0.34	3.32
12	1.17	9.0	99.2	0.30	0.34	3.34
13	1.03	9.6	106.2	0.30	0.34	3.38
14	0.90	10.3	115.7	0.30	0.33	3.43
15	0.77	11.0	125.6	0.31	0.33	3.49
16	0.63	11.7	135.7	0.31	0.33	3.54
17	0.50	12.3	143.4	0.31	0.33	3.59
18	0.50	12.5	146.5	0.31	0.33	3.60
19	0.44	12.6	148.1	0.31	0.33	3.61
20	0.39	12.8	150.2	0.31	0.32	3.61
21	0.33	13.0	152.4	0.31	0.32	3.62
22	0.28	13.1	154.6	0.31	0.31	3.63
23	0.22	13.3	156.4	0.31	0.31	3.64
24	0.22	13.3	157.4	0.31	0.31	3.64
25	0.18	13.4	158.8	0.31	0.31	3.65
26	0.13	13.6	160.7	0.31	0.31	3.66
27	0.09	13.7	162.5	0.31	0.31	3.67
28	0.04	13.8	164.5	0.31	0.31	3.68
29	0.00	13.9	165.9	0.31	0.31	3.70
30	0.00	19.1	53.1	0.43	0.43	1.18
31	-0.10	19.4	53.6	0.43	0.49	1.19
32	-0.20	19.6	54.2	0.43	0.49	1.19
33	-0.30	19.9	54.8	0.43	0.48	1.19
34	-0.40	20.2	55.5	0.44	0.48	1.20
35	-0.50	20.4	55.9	0.44	0.48	1.20
36	-0.50	20.5	56.2	0.44	0.48	1.20
37	-0.58	20.7	56.6	0.44	0.48	1.21
38	-0.66	20.9	57.0	0.44	0.48	1.21
39	-0.74	21.1	58.2	0.45	0.48	1.23
40	-0.82	21.3	61.7	0.45	0.48	1.29
41	-0.90	21.3	64.4	0.44	0.48	1.34
42	-0.90	21.2	66.2	0.44	0.48	1.38
43	-0.98	21.3	68.7	0.44	0.48	1.42
44	-1.06	21.4	72.0	0.44	0.48	1.48
45	-1.14	21.5	75.1	0.44	0.48	1.54
46	-1.22	21.7	78.1	0.44	0.49	1.59
47	-1.30	21.8	80.3	0.44	0.49	1.63
48	-1.30	21.8	82.2	0.44	0.49	1.66
49	-1.42	22.0	90.9	0.44	0.49	1.82
50	-1.55	22.2	98.3	0.44	0.49	1.96
51	-1.67	22.3	99.3	0.44	0.49	1.96
52	-1.79	22.5	100.3	0.44	0.50	1.96
53	-1.92	22.7	101.0	0.44	0.49	1.96
54	-1.92	22.7	101.5	0.44	0.49	1.96

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
55	-2.04	22.9	102.2	0.44	0.49	1.97
56	-2.16	23.1	103.2	0.44	0.50	1.97
57	-2.29	23.3	104.2	0.44	0.50	1.97
58	-2.41	23.4	105.3	0.44	0.50	1.97
59	-2.53	23.6	106.0	0.44	0.51	1.98
60	-2.53	23.7	106.5	0.44	0.51	1.98
61	-2.66	23.8	107.3	0.44	0.51	1.98
62	-2.78	24.0	108.4	0.44	0.51	1.98
63	-2.90	24.2	109.4	0.44	0.52	1.98
64	-3.03	24.4	110.4	0.44	0.52	1.99
65	-3.15	24.5	111.2	0.44	0.52	1.99
66	-3.15	24.6	111.8	0.44	0.52	1.99
67	-3.27	24.7	112.5	0.44	0.53	1.99
68	-3.40	24.9	113.6	0.44	0.53	1.99
69	-3.52	25.1	114.7	0.44	0.53	2.00
70	-3.64	25.2	115.7	0.44	0.53	2.00
71	-3.77	25.3	116.5	0.43	0.54	2.00
72	-3.77	25.2	117.1	0.43	0.54	2.00
73	-3.89	25.1	117.9	0.43	0.54	2.00
74	-4.01	24.9	119.0	0.42	0.55	2.01
75	-4.14	24.7	120.1	0.41	0.55	2.01
76	-4.26	24.7	121.1	0.41	0.55	2.01
77	-4.38	24.8	122.0	0.41	0.56	2.01
78	-4.38	24.9	122.5	0.41	0.56	2.01
79	-4.51	25.1	123.3	0.41	0.56	2.01
80	-4.63	25.3	124.4	0.41	0.56	2.02
81	-4.75	25.5	125.5	0.41	0.56	2.02
82	-4.88	25.7	126.6	0.41	0.57	2.02
83	-5.00	25.8	127.4	0.41	0.57	2.00
84	-5.00	17.7	275.1	0.28	0.57	4.28
85	-5.13	17.9	278.9	0.28	0.39	4.28
86	-5.27	18.3	284.2	0.28	0.39	4.28
87	-5.40	18.6	289.5	0.27	0.40	4.28
88	-5.53	18.9	294.9	0.27	0.40	4.28
89	-5.67	19.2	299.0	0.27	0.40	4.28
90	-5.67	19.4	301.7	0.27	0.40	4.28
91	-5.80	19.6	305.9	0.27	0.41	4.28
92	-5.93	20.0	311.4	0.27	0.41	4.28
93	-6.07	21.0	315.7	0.28	0.41	4.26
94	-6.20	20.8	316.7	0.28	0.42	4.21
95	-6.33	20.8	317.3	0.27	0.42	4.16
96	-6.33	20.8	317.7	0.27	0.42	4.13
97	-6.47	20.9	318.3	0.27	0.42	4.09
98	-6.60	20.8	312.5	0.26	0.43	3.95
99	-6.73	20.0	312.7	0.25	0.43	3.89
100	-6.87	21.3	318.5	0.26	0.43	3.90
101	-7.00	21.7	322.8	0.26	0.43	3.92
102	-7.00	30.3	164.2	0.37	0.43	1.99
103	-7.13	30.6	165.4	0.37	0.58	1.99
104	-7.25	31.1	166.9	0.37	0.59	1.99
105	-7.38	31.5	168.4	0.37	0.59	1.99
106	-7.50	31.9	170.0	0.37	0.59	1.99
107	-7.63	32.3	171.2	0.38	0.59	1.99
108	-7.63	32.5	171.9	0.38	0.68	1.99
109	-7.75	32.8	173.1	0.38	0.68	2.00
110	-7.88	33.2	174.6	0.38	0.68	2.00
111	-8.00	33.6	176.4	0.38	0.69	2.00
112	-8.13	34.0	180.6	0.38	0.69	2.03
113	-8.25	34.4	184.2	0.38	0.69	2.06
114	-8.25	34.6	186.6	0.38	0.69	2.08
115	-8.38	34.9	190.2	0.39	0.69	2.11
116	-8.50	35.3	195.0	0.39	0.69	2.14
117	-8.63	35.7	199.3	0.39	0.69	2.17
118	-8.75	36.1	213.3	0.39	0.69	2.31

Segment number	Level [m]	Horizontal pressure		Fictive earth pressure coefficients		
		Active [kN/m²]	Passive [kN/m²]	Ka [-]	Ko [-]	Kp [-]
119	-8.88	36.5	214.6	0.39	0.69	2.31
120	-8.88	36.8	215.4	0.39	0.69	2.31
121	-9.00	37.2	216.7	0.40	0.69	2.31
122	-9.13	37.7	218.3	0.40	0.69	2.31
123	-9.25	38.3	220.0	0.40	0.69	2.31
124	-9.38	38.8	221.7	0.40	0.69	2.31
125	-9.50	39.2	222.9	0.41	0.69	2.31
126	-9.50	39.5	223.7	0.41	0.69	2.31
127	-9.63	39.9	225.0	0.41	0.69	2.31
128	-9.75	40.4	226.7	0.41	0.69	2.31
129	-9.88	41.0	228.3	0.41	0.69	2.31
130	-10.00	41.5	230.0	0.42	0.70	2.31
131	-10.13	41.9	231.3	0.42	0.70	2.31
132	-10.13	42.2	232.1	0.42	0.70	2.31
133	-10.25	42.6	233.3	0.42	0.70	2.31
134	-10.38	43.2	235.0	0.42	0.70	2.31
135	-10.50	44.8	236.7	0.44	0.70	2.31
136	-10.63	45.1	238.4	0.44	0.70	2.31
137	-10.75	45.3	239.6	0.44	0.70	2.31

11.3 Calculated force from a layer Left

Name	Force
Fill	20.58
CLAY (soft)	116.69
SAND	39.48
CLAY (moderate)	231.13

11.4 Input Data Right

11.4.1 Calculation Method

Calculation method: C, phi, delta

11.4.2 Water Level

Water level: -1.30 [m]

11.4.3 Surface

X [m]	Y [m]
0.00	-0.50
11.00	-1.50
20.00	-2.50
25.00	-3.50
28.00	-4.50
32.00	-5.50
41.00	-7.50
45.00	-8.50

11.4.4 Soil Material Properties in Profile: CPT10-12 drop right

Layer name	Level [m]	Unit weight		Cohesion [kN/m²]	Friction angle phi [degree]	Delta friction angle [degree]
		Unsat [kN/m³]	Sat. [kN/m³]			
Fill	2.50	18.00	20.00	0.00	28.47	18.39
CLAY (soft) (un...	0.00	14.00	14.00	16.00	0.00	0.00
SAND	-5.00	18.00	20.00	0.00	26.17	17.45
CLAY (moderate)	-7.00	16.00	16.00	4.00	17.21	8.61

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Fill	2.50	1.00	1.00	Fine
CLAY (soft) (un...	0.00	1.00	1.00	Fine
SAND	-5.00	1.00	1.00	Fine
CLAY (moderate)	-7.00	1.00	1.00	Fine

Layer name	Level	Earth pressure coefficients			Additional pore pressure	
		Active	Neutral	Passive	Top	Bottom
	[m]	[-]	[-]	[-]	[kN/m²]	[kN/m²]
Fill	2.50	n.a.	n.a.	n.a.	0.00	0.00
CLAY (soft) (un...	0.00	n.a.	n.a.	n.a.	0.00	15.20
SAND	-5.00	n.a.	n.a.	n.a.	15.20	15.20
CLAY (moderate)	-7.00	n.a.	n.a.	n.a.	15.20	15.20

11.4.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level	Branch 1		Branch 2	
		Top	Bottom	Top	Bottom
	[m]	[kN/m³]	[kN/m³]	[kN/m³]	[kN/m³]
Fill	2.50	45000.00	45000.00	22500.00	22500.00
CLAY (soft) (un...	0.00	4500.00	4500.00	1800.00	1800.00
SAND	-5.00	27000.00	27000.00	13500.00	13500.00
CLAY (moderate)	-7.00	9000.00	9000.00	4500.00	4500.00

Layer name	Level	Branch 3	
		Top	Bottom
	[m]	[kN/m³]	[kN/m³]
Fill	2.50	11250.00	11250.00
CLAY (soft) (un...	0.00	1125.00	1125.00
SAND	-5.00	6750.00	6750.00
CLAY (moderate)	-7.00	1800.00	1800.00

11.4.6 Surcharge Loads

Name	Distance [m]	Load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Rubble 0.8 m (above WL)	0.00	12.35	Favourable (D-Sheet Piling)	Permanent
	15.00	12.35		

11.5 Calculated Earth Pressure Coefficients Right

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
1	-0.58	0.0	39.8	0.00	0.99	3.51
2	-0.66	0.0	40.6	0.00	0.82	3.41
3	-0.74	0.0	41.4	0.00	0.84	3.27
4	-0.82	0.0	42.2	0.00	0.87	3.13
5	-0.90	0.0	42.7	0.00	0.89	3.04
6	-0.90	0.0	43.1	0.00	0.89	2.98
7	-0.98	0.0	43.7	0.00	0.91	2.90
8	-1.06	0.0	44.5	0.00	0.92	2.80
9	-1.14	0.0	45.2	0.00	0.94	2.71
10	-1.22	0.0	46.0	0.00	0.95	2.63
11	-1.30	0.0	46.6	0.00	0.96	2.57
12	-1.30	0.0	46.8	0.00	0.96	2.55
13	-1.42	0.0	46.8	0.00	0.97	2.55
14	-1.55	0.0	46.7	0.00	0.97	2.54
15	-1.67	0.0	46.7	0.00	0.98	2.53
16	-1.79	0.0	46.7	0.00	0.98	2.53
17	-1.92	0.0	46.7	0.00	0.99	2.52
18	-1.92	0.0	46.7	0.00	0.99	2.52
19	-2.04	0.0	0.8	0.00	0.04	0.04
20	-2.16	0.0	0.8	0.00	0.04	0.04
21	-2.29	0.0	0.8	0.00	0.04	0.04

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
22	-2.41	0.0	0.8	0.00	0.04	0.04
23	-2.53	0.0	0.8	0.00	0.04	0.04
24	-2.53	0.0	0.8	0.00	0.04	0.04
25	-2.66	0.0	0.8	0.00	0.04	0.04
26	-2.78	0.0	0.8	0.00	0.04	0.04
27	-2.90	0.0	0.8	0.00	0.04	0.04
28	-3.03	0.0	0.8	0.00	0.04	0.04
29	-3.15	0.0	0.8	0.00	0.04	0.04
30	-3.15	0.0	0.8	0.00	0.04	0.04
31	-3.27	0.0	0.8	0.00	0.04	0.04
32	-3.40	0.0	0.8	0.00	0.04	0.04
33	-3.52	0.0	0.8	0.00	0.04	0.04
34	-3.64	0.0	0.8	0.00	0.04	0.04
35	-3.77	0.0	0.8	0.00	0.04	0.04
36	-3.77	0.0	0.8	0.00	0.04	0.04
37	-3.89	0.0	0.8	0.00	0.04	0.04
38	-4.01	0.0	0.8	0.00	0.04	0.04
39	-4.14	0.0	0.8	0.00	0.04	0.04
40	-4.26	0.0	0.8	0.00	0.04	0.04
41	-4.38	0.0	0.8	0.00	0.04	0.04
42	-4.38	0.0	0.8	0.00	0.04	0.04
43	-4.51	0.0	0.8	0.00	0.04	0.04
44	-4.63	0.0	0.8	0.00	0.04	0.04
45	-4.75	0.0	0.8	0.00	0.04	0.04
46	-4.88	0.0	0.8	0.00	0.04	0.04
47	-5.00	0.0	0.8	0.00	0.04	0.04
48	-5.00	0.0	96.0	0.00	1.17	4.63
49	-5.13	0.0	98.2	0.00	0.88	4.52
50	-5.27	0.0	100.5	0.00	0.87	4.38
51	-5.40	0.0	103.0	0.00	0.85	4.25
52	-5.53	0.0	105.6	0.00	0.83	4.15
53	-5.67	0.0	107.2	0.00	0.80	4.06
54	-5.67	0.0	108.8	0.00	0.80	4.02
55	-5.80	0.0	110.8	0.00	0.79	3.96
56	-5.93	0.0	113.2	0.00	0.78	3.87
57	-6.07	0.0	116.1	0.00	0.77	3.80
58	-6.20	0.0	118.7	0.00	0.76	3.74
59	-6.33	0.0	120.8	0.00	0.75	3.69
60	-6.33	0.0	122.1	0.00	0.75	3.66
61	-6.47	0.0	124.1	0.00	0.74	3.62
62	-6.60	0.0	127.1	0.00	0.73	3.57
63	-6.73	0.0	129.8	0.00	0.72	3.53
64	-6.87	0.0	132.7	0.00	0.72	3.48
65	-7.00	0.0	134.9	0.00	0.71	3.49
66	-7.00	0.0	8.5	0.00	0.22	0.22
67	-7.13	0.0	19.5	0.00	0.49	0.49
68	-7.25	0.0	31.5	0.00	0.78	0.78
69	-7.38	0.0	40.9	0.00	0.82	1.00
70	-7.50	0.0	48.5	0.00	0.82	1.17
71	-7.63	0.0	53.4	0.00	0.82	1.27
72	-7.63	0.0	56.0	0.00	0.82	1.32
73	-7.75	0.0	59.8	0.00	0.82	1.39
74	-7.88	0.0	63.3	0.00	0.82	1.45
75	-8.00	0.0	65.4	0.00	0.81	1.48
76	-8.13	0.0	67.1	0.00	0.81	1.49
77	-8.25	0.0	68.5	0.00	0.81	1.51
78	-8.25	0.0	69.4	0.00	0.81	1.52
79	-8.38	0.0	70.7	0.00	0.81	1.53
80	-8.50	0.0	72.2	0.00	0.80	1.54
81	-8.63	0.0	73.8	0.00	0.80	1.55
82	-8.75	0.0	75.3	0.00	0.80	1.56
83	-8.88	0.0	76.3	0.00	0.80	1.56
84	-8.88	0.0	77.0	0.00	0.80	1.57
85	-9.00	0.0	86.0	0.00	0.79	1.73

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Horizontal pressure Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
86	-9.13	0.0	95.0	0.00	0.79	1.88
87	-9.25	0.0	95.7	0.00	0.79	1.87
88	-9.38	0.0	96.5	0.00	0.79	1.86
89	-9.50	0.0	97.2	0.00	0.78	1.86
90	-9.50	18.9	97.6	0.36	0.78	1.85
91	-9.63	19.9	98.2	0.37	0.78	1.85
92	-9.75	20.2	99.1	0.38	0.78	1.84
93	-9.88	20.6	100.0	0.38	0.78	1.83
94	-10.00	20.9	101.0	0.38	0.78	1.83
95	-10.13	21.1	101.7	0.38	0.78	1.83
96	-10.13	21.3	102.2	0.38	0.78	1.82
97	-10.25	21.6	102.9	0.38	0.77	1.82
98	-10.38	21.9	104.0	0.38	0.77	1.82
99	-10.50	22.2	105.0	0.38	0.77	1.81
100	-10.63	22.6	106.1	0.39	0.77	1.81
101	-10.75	22.8	107.0	0.39	0.77	1.81

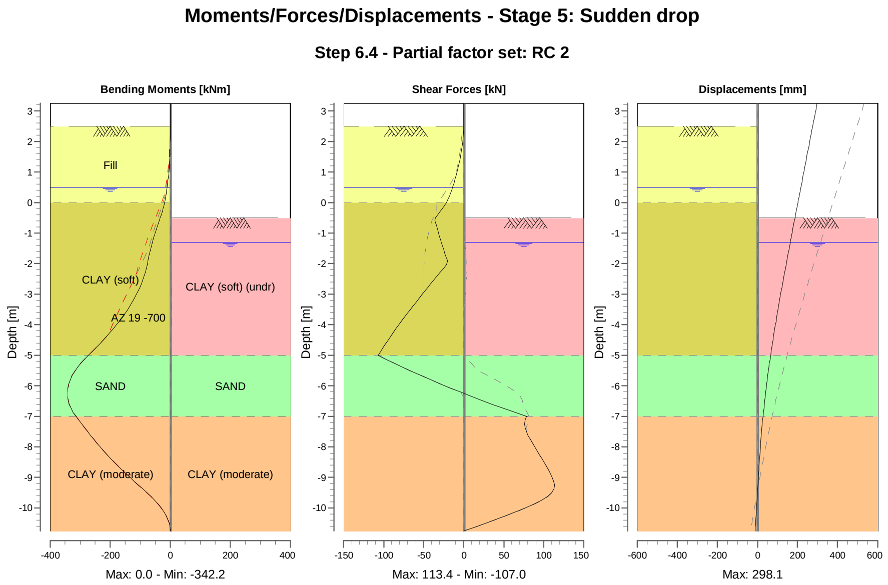
11.6 Calculated force from a layer Right

Name	Force
Fill	0.00
CLAY (soft) (undr)	66.92
SAND	224.27
CLAY (moderate)	151.30

11.7 Calculation Results

Number of iterations: 11

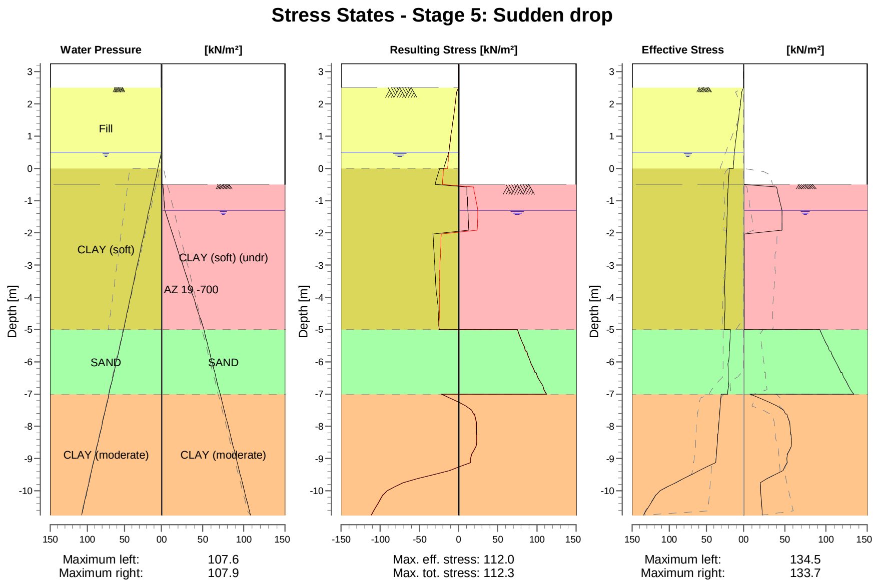
11.7.1 Charts of Moments, Forces and Displacements



11.7.2 Moments, Forces and Displacements

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
1	3.25	0.00	0.00	**298.1**
1	2.88	0.00	0.00	287.0
2	2.88	0.00	0.00	287.0
2	2.50	0.00	0.00	275.9
3	2.50	0.00	0.00	275.9
3	1.83	-0.56	-2.18	256.2
4	1.83	-0.57	-2.15	256.2
4	1.17	-3.44	-6.85	236.5
5	1.17	-3.44	-6.84	236.5
5	0.50	-10.24	-13.94	216.7
6	0.50	-10.24	-13.94	216.7
6	0.22	-14.67	-17.92	208.5
7	0.22	-14.67	-17.92	208.5
7	0.00	-19.03	-21.77	202.0
8	0.00	-19.03	-21.76	202.0
8	-0.50	-33.18	-35.32	187.3
9	-0.50	-33.18	-35.32	187.3
9	-0.90	-47.04	-32.64	175.6
10	-0.90	-47.04	-32.64	175.6
10	-1.30	-59.19	-28.03	164.0
11	-1.30	-59.19	-28.03	164.0
11	-1.92	-74.14	-20.32	146.4
12	-1.92	-74.14	-20.32	146.4
12	-2.53	-91.19	-37.30	129.1
13	-2.53	-91.19	-37.30	129.1
13	-3.15	-120.09	-56.30	112.2
14	-3.15	-120.09	-56.30	112.2
14	-3.77	-160.47	-74.49	95.9
15	-3.77	-160.47	-74.47	95.9
15	-4.38	-211.64	-91.21	80.3
16	-4.38	-211.64	-91.22	80.3
16	-5.00	-272.76	-106.89	65.8
17	-5.00	-272.75	-107.01	65.8
17	-5.67	-326.58	-53.28	51.4
18	-5.67	-326.58	-53.22	51.4
18	-6.33	**-342.01**	8.14	38.8
19	-6.33	**-342.01**	8.12	38.8
19	-7.00	-313.65	78.49	28.0
20	-7.00	-313.65	78.48	28.0
20	-7.63	-265.42	80.36	19.3
21	-7.63	-265.42	80.37	19.3
21	-8.25	-210.86	94.45	12.0
22	-8.25	-210.86	94.48	12.0
22	-8.88	-147.37	108.07	5.6
23	-8.88	-147.39	108.30	5.6
23	-9.50	-77.59	**110.01**	0.0
24	-9.50	-77.55	**110.01**	0.0
24	-10.13	-20.76	65.10	-5.3
25	-10.13	-20.78	64.91	-5.3
25	-10.75	0.00	0.00	-10.5
Max		**-342.01**	**110.01**	**298.1**
Max, minor nodes incl.		-342.23	113.35	298.1

11.7.3 Charts of Stresses



11.7.4 Stresses

Node number	Level [m]	Left Effective stress [kN/m²]	Left Water stress [kN/m²]	Left Stat*	Left Mob* [%]	Right Effective stress [kN/m²]	Right Water stress [kN/m²]	Right Stat*	Right Mob* [%]
1	3.25	0.00	0.00	-		0.00	0.00	-	
1	2.88	0.00	0.00	-		0.00	0.00	-	
2	2.88	0.00	0.00	-		0.00	0.00	-	
2	2.50	0.00	0.00	-		0.00	0.00	-	
3	2.50	0.00	0.00	A		0.00	0.00	-	
3	1.83	5.07	0.00	A		0.00	0.00	-	
4	1.83	5.43	0.00	A		0.00	0.00	-	
4	1.17	8.67	0.00	A		0.00	0.00	-	
5	1.17	9.03	0.00	A		0.00	0.00	-	
5	0.50	12.26	0.00	A		0.00	0.00	-	
6	0.50	12.49	0.00	A		0.00	0.00	-	
6	0.22	13.26	2.75	A		0.00	0.00	-	
7	0.22	13.33	2.75	A	8	0.00	0.00	-	
7	0.00	14.00	4.91	A	8	0.00	0.00	-	
8	0.00	19.26	4.91	A	36	0.00	0.00	-	
8	-0.50	20.53	9.53	A		0.00	0.00	-	
9	-0.50	20.65	9.53	A		0.02	1.52	P	
9	-0.90	21.41	13.23	A		42.73	2.74	P	
10	-0.90	21.34	13.23	A		43.12	2.74	P	
10	-1.30	21.87	16.93	A		46.59	3.95	P	
11	-1.30	21.94	16.93	A		46.78	3.95	P	
11	-1.92	22.77	22.63	A		46.68	11.88	P	
12	-1.92	22.86	22.63	A		46.67	11.88	P	
12	-2.53	23.70	28.34	A		0.81	19.80	P	
13	-2.53	23.79	28.34	A		0.81	19.80	P	
13	-3.15	24.62	34.04	A		0.81	27.72	P	
14	-3.15	24.71	34.04	A		0.81	27.72	P	
14	-3.77	25.38	39.75	A		0.81	35.65	P	
15	-3.77	25.30	39.75	A		0.81	35.65	P	
15	-4.38	24.91	45.45	A		0.81	43.57	P	

Node number	Level [m]	Left Effective stress [kN/m²]	Left Water stress [kN/m²]	Left Stat*	Left Mob* [%]	Right Effective stress [kN/m²]	Right Water stress [kN/m²]	Right Stat*	Right Mob* [%]
16	-4.38	25.02	45.45	A		0.81	43.57	P	
16	-5.00	25.71	51.16	A		0.79	51.50	P	
17	-5.00	17.56	51.16	A		92.58	51.50	P	
17	-5.67	19.07	57.70	A		104.23	58.04	P	
18	-5.67	19.24	57.70	A		105.87	58.04	P	
18	-6.33	20.70	64.23	A		118.04	64.58	P	
19	-6.33	20.70	64.23	A		119.43	64.58	P	
19	-7.00	21.66	70.78	A		133.67	71.12	P	
20	-7.00	30.34	70.78	A		8.43	71.12	P	
20	-7.63	32.28	76.91	A		50.99	77.25	3	96
21	-7.63	32.49	76.91	A		52.65	77.25	3	95
21	-8.25	34.37	83.04	A		57.04	83.38	3	84
22	-8.25	34.58	83.04	A		57.66	83.38	3	83
22	-8.88	36.50	89.17	A		52.91	89.51	2	70
23	-8.88	36.78	89.17	A		53.18	89.51	2	69
23	-9.50	70.17	95.30	1	31	37.73	95.64	1	
24	-9.50	70.42	95.30	1	31	38.00	95.64	1	
24	-10.13	117.50	101.43	2	51	21.07	101.77	A	
25	-10.13	117.87	101.43	2	51	21.24	101.77	A	
25	-10.75	134.49	107.56	2	56	22.76	107.90	A	

*
Stat Status (A=active, P=passive, Number is branche, 0 is unloading)
Mob Percentage passive mobilized

11.7.5 Percentage mobilized resistance

Horizontal soil pressure	Left [kN]	Right [kN]
Effective	407.9	442.5
Water	597.7	563.0
Total	1005.6	1005.5

Considered as passive side	Right
Maximum passive effective resistance	581.86 kN
Mobilized passive effective resistance	442.50 kN
Percentage mobilized resistance	76.0 %

12 Step 6.5 Stage 5: Sudden drop

12.1 Input Data Left

12.1.1 Calculation Method

Calculation method: C, phi, delta

12.1.2 Water Level

Water level: 0.50 [m]

12.1.3 Surface

X [m]	Y [m]
0.00	2.50
2.50	2.50
4.00	2.00

12.1.4 Soil Material Properties in Profile: CPT10-12 drop left

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Unit weight Sat. [kN/m³]	Cohesion [kN/m²]	Friction angle phi [degree]	Delta friction angle [degree]
Fill	2.50	18.00	20.00	0.00	32.50	16.60
CLAY (soft)	0.00	14.00	14.00	5.00	17.50	8.75
SAND	-5.00	18.00	20.00	0.00	30.00	20.00
CLAY (moderate)	-7.00	16.00	16.00	5.00	20.00	10.00

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Fill	2.50	1.00	1.00	Fine
CLAY (soft)	0.00	1.00	1.00	Fine
SAND	-5.00	1.00	1.00	Fine
CLAY (moderate)	-7.00	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients Active [-]	Earth pressure coefficients Neutral [-]	Earth pressure coefficients Passive [-]	Additional pore pressure Top [kN/m²]	Additional pore pressure Bottom [kN/m²]
Fill	2.50	n.a.	n.a.	n.a.	0.00	0.00
CLAY (soft)	0.00	n.a.	n.a.	n.a.	0.00	-2.80
SAND	-5.00	n.a.	n.a.	n.a.	-2.80	-2.80
CLAY (moderate)	-7.00	n.a.	n.a.	n.a.	-2.80	-2.80

12.1.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1 Top [kN/m³]	Branch 1 Bottom [kN/m³]	Branch 2 Top [kN/m³]	Branch 2 Bottom [kN/m³]
Fill	2.50	20000.00	20000.00	10000.00	10000.00
CLAY (soft)	0.00	2000.00	2000.00	800.00	800.00
SAND	-5.00	12000.00	12000.00	6000.00	6000.00
CLAY (moderate)	-7.00	4000.00	4000.00	2000.00	2000.00

Layer name	Level [m]	Branch 3 Top [kN/m³]	Branch 3 Bottom [kN/m³]
Fill	2.50	5000.00	5000.00
CLAY (soft)	0.00	500.00	500.00
SAND	-5.00	3000.00	3000.00
CLAY (moderate)	-7.00	800.00	800.00

12.1.6 Surcharge Loads

Name	Distance [m]	Load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Walkway 5 kPa	0.00	5.00	Unfavourable (D-Sheet Piling)	Variable
	4.00	5.00		

12.2 Calculated Earth Pressure Coefficients Left

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
1	2.37	1.9	43.2	0.26	0.68	5.84
2	2.23	2.6	57.2	0.26	0.51	5.84
3	2.10	3.2	71.2	0.26	0.42	5.85
4	1.97	3.8	85.3	0.26	0.36	5.85
5	1.83	4.3	95.8	0.26	0.32	5.86
6	1.83	4.6	102.8	0.26	0.32	5.86
7	1.70	5.1	90.3	0.26	0.30	4.68
8	1.57	5.7	89.4	0.26	0.28	4.13
9	1.43	6.3	91.2	0.26	0.27	3.80
10	1.30	6.9	101.2	0.26	0.26	3.85
11	1.17	7.4	109.1	0.26	0.26	3.89
12	1.17	7.7	114.5	0.26	0.26	3.92
13	1.03	8.2	122.7	0.26	0.26	3.97
14	0.90	8.8	134.1	0.27	0.27	4.03
15	0.77	9.4	145.8	0.27	0.27	4.10
16	0.63	10.1	157.8	0.27	0.27	4.17
17	0.50	10.5	167.0	0.27	0.27	4.23
18	0.50	10.7	170.7	0.27	0.27	4.25
19	0.44	10.8	172.6	0.27	0.27	4.25
20	0.39	11.0	175.2	0.27	0.27	4.26
21	0.33	11.1	177.8	0.27	0.27	4.27
22	0.28	11.3	180.5	0.27	0.27	4.29
23	0.22	11.4	182.6	0.27	0.27	4.30
24	0.22	11.5	183.9	0.27	0.27	4.30
25	0.18	11.6	185.5	0.27	0.27	4.31
26	0.13	11.7	187.8	0.27	0.27	4.32
27	0.09	11.8	190.0	0.27	0.27	4.33
28	0.04	11.9	192.3	0.27	0.27	4.35
29	0.00	12.0	194.0	0.27	0.27	4.38
30	0.00	15.3	62.1	0.34	0.34	1.40
31	-0.13	15.6	62.8	0.35	0.44	1.40
32	-0.26	15.9	63.6	0.35	0.44	1.40
33	-0.39	16.3	64.4	0.36	0.44	1.41
34	-0.52	16.6	65.3	0.36	0.44	1.41
35	-0.65	16.9	65.9	0.36	0.44	1.42
36	-0.65	17.0	66.3	0.36	0.44	1.42
37	-0.78	17.3	69.7	0.37	0.44	1.48
38	-0.91	17.6	76.7	0.37	0.44	1.61
39	-1.04	17.9	83.3	0.37	0.44	1.73
40	-1.17	18.0	89.5	0.37	0.45	1.84
41	-1.30	18.1	93.9	0.37	0.45	1.92
42	-1.30	18.2	96.5	0.37	0.45	1.97
43	-1.42	18.3	109.1	0.37	0.45	2.21
44	-1.55	18.5	114.3	0.37	0.45	2.29
45	-1.67	18.6	115.4	0.37	0.46	2.30
46	-1.79	18.8	116.5	0.37	0.46	2.30
47	-1.92	18.9	117.3	0.37	0.45	2.30
48	-1.92	19.0	117.9	0.37	0.45	2.30
49	-2.04	19.2	118.7	0.37	0.46	2.30
50	-2.16	19.3	119.9	0.37	0.46	2.30
51	-2.29	19.5	121.0	0.37	0.46	2.31
52	-2.41	19.7	122.2	0.37	0.47	2.31
53	-2.53	19.8	123.1	0.37	0.47	2.31
54	-2.53	19.9	123.6	0.37	0.47	2.31

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
55	-2.66	20.0	124.5	0.37	0.47	2.31
56	-2.78	20.2	125.7	0.37	0.47	2.31
57	-2.90	20.4	126.9	0.37	0.48	2.32
58	-3.03	20.6	128.1	0.37	0.48	2.32
59	-3.15	20.7	129.0	0.37	0.48	2.32
60	-3.15	20.8	129.6	0.37	0.48	2.32
61	-3.27	20.9	130.5	0.37	0.49	2.32
62	-3.40	21.1	131.7	0.37	0.49	2.33
63	-3.52	21.3	132.9	0.37	0.49	2.33
64	-3.64	21.4	134.1	0.37	0.49	2.33
65	-3.77	21.5	135.0	0.37	0.50	2.33
66	-3.77	21.6	135.6	0.37	0.50	2.33
67	-3.89	21.6	136.5	0.37	0.50	2.33
68	-4.01	21.6	137.8	0.37	0.51	2.34
69	-4.14	21.4	139.0	0.36	0.51	2.34
70	-4.26	21.2	140.2	0.35	0.51	2.34
71	-4.38	21.1	141.2	0.35	0.52	2.34
72	-4.38	21.1	141.8	0.35	0.52	2.34
73	-4.51	21.3	142.7	0.35	0.52	2.34
74	-4.63	21.5	144.0	0.35	0.52	2.34
75	-4.75	21.6	145.2	0.35	0.52	2.35
76	-4.88	21.8	146.5	0.35	0.53	2.35
77	-5.00	22.0	147.4	0.35	0.53	2.33
78	-5.00	15.0	391.7	0.23	0.53	6.13
79	-5.13	15.2	394.4	0.23	0.33	6.08
80	-5.27	15.5	399.0	0.23	0.33	6.03
81	-5.40	15.8	404.3	0.23	0.34	6.00
82	-5.53	16.1	410.2	0.23	0.34	5.97
83	-5.67	16.3	414.8	0.23	0.34	5.96
84	-5.67	16.4	418.0	0.23	0.34	5.95
85	-5.80	16.6	422.9	0.23	0.35	5.94
86	-5.93	16.9	429.0	0.23	0.35	5.92
87	-6.07	17.2	429.0	0.23	0.35	5.81
88	-6.20	17.5	427.4	0.23	0.36	5.69
89	-6.33	17.7	426.3	0.23	0.36	5.61
90	-6.33	19.4	425.6	0.25	0.36	5.55
91	-6.47	18.2	413.9	0.23	0.36	5.33
92	-6.60	18.1	415.9	0.23	0.37	5.27
93	-6.73	18.1	423.6	0.23	0.37	5.28
94	-6.87	17.2	431.3	0.21	0.37	5.29
95	-7.00	18.3	437.0	0.22	0.37	5.33
96	-7.00	26.6	187.3	0.32	0.37	2.27
97	-7.13	25.3	188.6	0.31	0.54	2.27
98	-7.25	26.2	190.3	0.31	0.54	2.27
99	-7.38	26.6	192.0	0.32	0.54	2.28
100	-7.50	27.0	193.7	0.32	0.54	2.28
101	-7.63	27.3	195.0	0.32	0.54	2.28
102	-7.63	27.5	195.8	0.32	0.54	2.28
103	-7.75	27.7	197.1	0.32	0.55	2.28
104	-7.88	28.1	199.0	0.32	0.55	2.28
105	-8.00	28.5	204.7	0.32	0.55	2.33
106	-8.13	28.8	212.1	0.33	0.55	2.39
107	-8.25	29.1	217.7	0.33	0.55	2.44
108	-8.25	29.3	221.4	0.33	0.64	2.47
109	-8.38	29.6	226.9	0.33	0.64	2.52
110	-8.50	29.9	239.4	0.33	0.64	2.64
111	-8.63	30.3	251.6	0.33	0.64	2.75
112	-8.75	30.7	253.5	0.33	0.64	2.75
113	-8.88	30.9	254.9	0.33	0.64	2.75
114	-8.88	31.1	255.9	0.33	0.64	2.75
115	-9.00	31.5	257.3	0.34	0.64	2.75
116	-9.13	32.0	259.2	0.34	0.64	2.75
117	-9.25	32.4	261.2	0.34	0.65	2.74
118	-9.38	32.9	263.1	0.34	0.65	2.74

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Horizontal pressure Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
119	-9.50	33.3	264.5	0.35	0.65	2.74
120	-9.50	33.5	265.5	0.35	0.65	2.74
121	-9.63	33.9	266.9	0.35	0.65	2.74
122	-9.75	34.4	268.8	0.35	0.65	2.74
123	-9.88	34.9	270.8	0.35	0.65	2.74
124	-10.00	35.4	272.7	0.36	0.65	2.74
125	-10.13	35.7	274.1	0.36	0.65	2.74
126	-10.13	36.0	275.1	0.36	0.65	2.74
127	-10.25	36.4	276.5	0.36	0.65	2.74
128	-10.38	36.8	278.5	0.36	0.65	2.74
129	-10.50	37.3	280.4	0.36	0.65	2.74
130	-10.63	38.5	282.3	0.37	0.65	2.74
131	-10.75	38.5	283.8	0.37	0.65	2.74

12.3 Calculated force from a layer Left

Name	Force
Fill	19.76
CLAY (soft)	98.03
SAND	33.66
CLAY (moderate)	197.83

12.4 Input Data Right

12.4.1 Calculation Method

Calculation method: C, phi, delta

12.4.2 Water Level

Water level: -1.30 [m]

12.4.3 Surface

X [m]	Y [m]
0.00	0.00
11.00	-1.00
20.00	-2.00
25.00	-3.00
28.00	-4.00
32.00	-5.00
41.00	-7.00
45.00	-8.00

12.4.4 Soil Material Properties in Profile: CPT10-12 drop right

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Unit weight Sat. [kN/m³]	Cohesion [kN/m²]	Friction angle phi [degree]	Delta friction angle [degree]
Fill	2.50	18.00	20.00	0.00	32.50	16.60
CLAY (soft) (un...	0.00	14.00	14.00	20.00	0.00	0.00
SAND	-5.00	18.00	20.00	0.00	30.00	20.00
CLAY (moderate)	-7.00	16.00	16.00	5.00	20.00	10.00

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Fill	2.50	1.00	1.00	Fine
CLAY (soft) (un...	0.00	1.00	1.00	Fine
SAND	-5.00	1.00	1.00	Fine
CLAY (moderate)	-7.00	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Fill	2.50	n.a.	n.a.	n.a.	0.00	0.00
CLAY (soft) (un...	0.00	n.a.	n.a.	n.a.	0.00	15.20
SAND	-5.00	n.a.	n.a.	n.a.	15.20	15.20
CLAY (moderate)	-7.00	n.a.	n.a.	n.a.	15.20	15.20

12.4.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1		Branch 2	
		Top [kN/m³]	Bottom [kN/m³]	Top [kN/m³]	Bottom [kN/m³]
Fill	2.50	20000.00	20000.00	10000.00	10000.00
CLAY (soft) (un...	0.00	2000.00	2000.00	800.00	800.00
SAND	-5.00	12000.00	12000.00	6000.00	6000.00
CLAY (moderate)	-7.00	4000.00	4000.00	2000.00	2000.00

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Fill	2.50	5000.00	5000.00
CLAY (soft) (un...	0.00	500.00	500.00
SAND	-5.00	3000.00	3000.00
CLAY (moderate)	-7.00	800.00	800.00

12.4.6 Surcharge Loads

Name	Distance [m]	Load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Rubble 0.8 m (above WL)	0.00	12.35	Favourable (D-Sheet Piling)	Permanent
	15.00	12.35		

12.5 Calculated Earth Pressure Coefficients Right

Segment number	Level [m]	Horizontal pressure		Fictive earth pressure coefficients		
		Active [kN/m²]	Passive [kN/m²]	Ka [-]	Ko [-]	Kp [-]
1	-0.13	0.0	49.0	0.00	0.83	3.71
2	-0.26	0.0	50.3	0.00	0.83	3.50
3	-0.39	0.0	51.5	0.00	0.86	3.29
4	-0.52	0.0	52.8	0.00	0.88	3.11
5	-0.65	0.0	53.7	0.00	0.91	2.99
6	-0.65	0.0	54.3	0.00	0.91	2.92
7	-0.78	0.0	55.3	0.00	0.93	2.82
8	-0.91	0.0	56.5	0.00	0.95	2.70
9	-1.04	0.0	57.8	0.00	0.96	2.60
10	-1.17	0.0	59.1	0.00	0.98	2.50
11	-1.30	0.0	60.0	0.00	0.99	2.44
12	-1.30	0.0	60.3	0.00	0.99	2.42
13	-1.42	0.0	60.3	0.00	1.00	2.42
14	-1.55	0.0	60.3	0.00	1.01	2.41
15	-1.67	0.0	60.2	0.00	1.02	2.41
16	-1.79	0.0	60.2	0.00	1.03	2.40
17	-1.92	0.0	60.2	0.00	1.04	2.40
18	-1.92	0.0	60.2	0.00	1.04	2.40
19	-2.04	0.0	60.2	0.00	1.05	2.39
20	-2.16	0.0	60.1	0.00	1.05	2.39
21	-2.29	0.0	60.1	0.00	1.06	2.38
22	-2.41	0.0	60.1	0.00	1.07	2.38
23	-2.53	0.0	60.1	0.00	1.07	2.37
24	-2.53	0.0	60.1	0.00	1.07	2.37
25	-2.66	0.0	1.7	0.00	0.07	0.07
26	-2.78	0.0	1.7	0.00	0.07	0.07
27	-2.90	0.0	1.7	0.00	0.07	0.07
28	-3.03	0.0	1.7	0.00	0.07	0.07

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
29	-3.15	0.0	1.7	0.00	0.07	0.07
30	-3.15	0.0	1.7	0.00	0.07	0.07
31	-3.27	0.0	1.7	0.00	0.07	0.07
32	-3.40	0.0	1.7	0.00	0.07	0.07
33	-3.52	0.0	1.7	0.00	0.06	0.06
34	-3.64	0.0	1.7	0.00	0.06	0.06
35	-3.77	0.0	1.7	0.00	0.06	0.06
36	-3.77	0.0	1.7	0.00	0.06	0.06
37	-3.89	0.0	1.7	0.00	0.06	0.06
38	-4.01	0.0	1.7	0.00	0.06	0.06
39	-4.14	0.0	1.7	0.00	0.06	0.06
40	-4.26	0.0	1.7	0.00	0.06	0.06
41	-4.38	0.0	1.7	0.00	0.06	0.06
42	-4.38	0.0	1.7	0.00	0.06	0.06
43	-4.51	0.0	1.7	0.00	0.06	0.06
44	-4.63	0.0	1.7	0.00	0.06	0.06
45	-4.75	0.0	1.7	0.00	0.06	0.06
46	-4.88	0.0	1.7	0.00	0.06	0.06
47	-5.00	0.0	1.7	0.00	0.06	0.06
48	-5.00	0.0	133.3	0.00	1.09	4.90
49	-5.13	0.0	136.1	0.00	0.72	4.83
50	-5.27	0.0	139.4	0.00	0.71	4.74
51	-5.40	0.0	142.4	0.00	0.70	4.64
52	-5.53	0.0	145.6	0.00	0.69	4.56
53	-5.67	0.0	148.2	0.00	0.68	4.51
54	-5.67	0.0	149.8	0.00	0.68	4.47
55	-5.80	0.0	152.1	0.00	0.67	4.42
56	-5.93	0.0	155.6	0.00	0.66	4.36
57	-6.07	0.0	158.9	0.00	0.65	4.30
58	-6.20	0.0	162.5	0.00	0.65	4.26
59	-6.33	0.0	164.9	0.00	0.64	4.22
60	-6.33	0.0	166.7	0.00	0.64	4.20
61	-6.47	0.0	169.5	0.00	0.63	4.17
62	-6.60	0.0	173.1	0.00	0.63	4.13
63	-6.73	0.0	176.8	0.00	0.62	4.10
64	-6.87	0.0	180.5	0.00	0.62	4.07
65	-7.00	0.0	12.2	0.00	0.27	0.27
66	-7.00	0.0	12.2	0.00	0.27	0.27
67	-7.13	0.0	12.2	0.00	0.27	0.27
68	-7.25	0.0	12.2	0.00	0.26	0.26
69	-7.38	0.0	10.1	0.00	0.22	0.22
70	-7.50	0.0	24.0	0.00	0.50	0.50
71	-7.63	0.0	32.8	0.00	0.68	0.68
72	-7.63	0.0	38.0	0.00	0.74	0.78
73	-7.75	0.0	44.8	0.00	0.74	0.91
74	-7.88	0.0	52.6	0.00	0.74	1.06
75	-8.00	0.0	59.3	0.00	0.74	1.17
76	-8.13	0.0	65.4	0.00	0.73	1.28
77	-8.25	0.0	69.6	0.00	0.73	1.35
78	-8.25	0.0	72.2	0.00	0.73	1.39
79	-8.38	0.0	75.7	0.00	0.73	1.44
80	-8.50	0.0	79.8	0.00	0.73	1.50
81	-8.63	0.0	82.1	0.00	0.73	1.53
82	-8.75	0.0	94.2	0.00	0.72	1.73
83	-8.88	0.0	111.3	0.00	0.72	2.03
84	-8.88	0.0	111.6	0.00	0.72	2.02
85	-9.00	0.0	112.3	0.00	0.72	2.01
86	-9.13	0.0	113.3	0.00	0.72	2.01
87	-9.25	0.0	114.2	0.00	0.72	2.00
88	-9.38	0.0	115.2	0.00	0.72	1.99
89	-9.50	0.0	116.0	0.00	0.72	1.99
90	-9.50	0.0	116.4	0.00	0.72	1.99
91	-9.63	0.0	117.2	0.00	0.71	1.98
92	-9.75	0.0	118.3	0.00	0.71	1.98

Segment number	Level	Horizontal pressure		Fictive earth pressure coefficients		
		Active	Passive	Ka	Ko	Kp
	[m]	[kN/m²]	[kN/m²]	[-]	[-]	[-]
93	-9.88	0.0	119.3	0.00	0.71	1.97
94	-10.00	0.0	120.5	0.00	0.71	1.97
95	-10.13	0.0	121.3	0.00	0.71	1.97
96	-10.13	0.0	121.9	0.00	0.71	1.97
97	-10.25	0.0	122.8	0.00	0.71	1.97
98	-10.38	2.0	124.1	0.03	0.71	1.97
99	-10.50	21.1	125.3	0.33	0.71	1.96
100	-10.63	21.4	126.7	0.33	0.71	1.97
101	-10.75	21.6	127.8	0.33	0.70	1.97

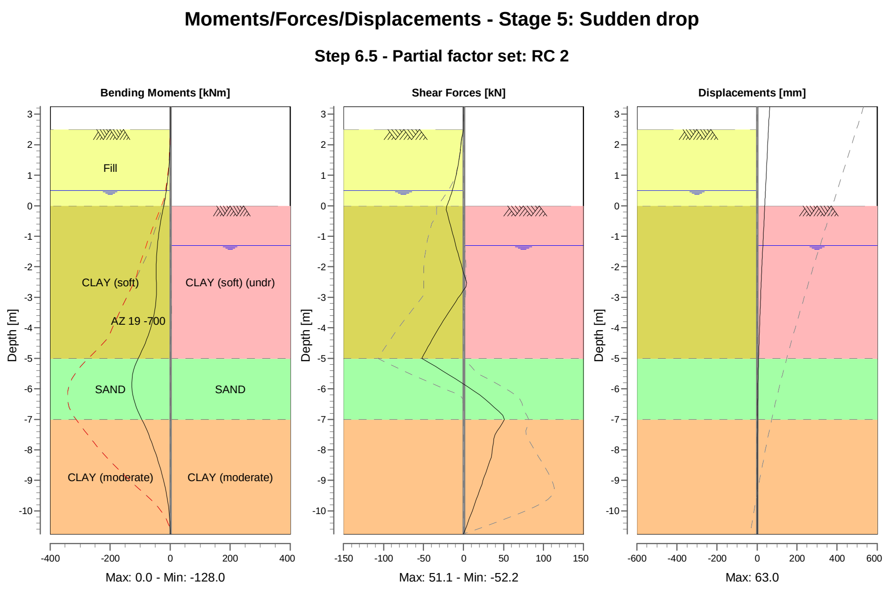
12.6 Calculated force from a layer Right

Name	Force
Fill	0.00
CLAY (soft) (undr)	101.89
SAND	136.25
CLAY (moderate)	145.44

12.7 Calculation Results

Number of iterations: 6

12.7.1 Charts of Moments, Forces and Displacements

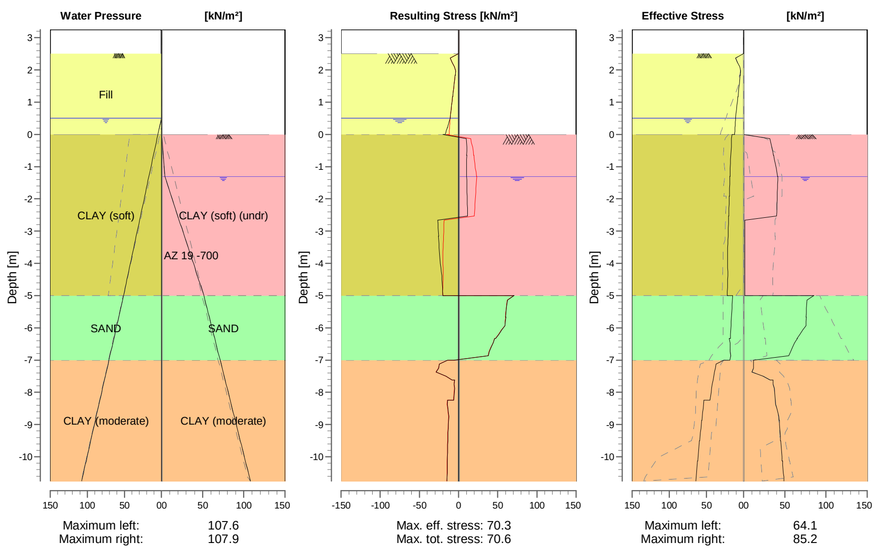


12.7.2 Moments, Forces and Displacements

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
1	3.25	0.00	0.00	**63.0**
1	2.88	0.00	0.00	60.2
2	2.88	0.00	0.00	60.2
2	2.50	0.00	0.00	57.3
3	2.50	0.00	-0.06	57.3
3	1.83	-1.49	-4.04	52.3

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
4	1.83	-1.49	-3.96	52.3
4	1.17	-5.35	-7.96	47.2
5	1.17	-5.35	-7.95	47.2
5	0.50	-12.57	-14.04	42.2
6	0.50	-12.57	-14.04	42.2
6	0.22	-16.96	-17.52	40.1
7	0.22	-16.96	-17.52	40.1
7	0.00	-21.18	-20.95	38.5
8	0.00	-21.18	-20.95	38.5
8	-0.65	-33.87	-16.31	33.7
9	-0.65	-33.87	-16.30	33.7
9	-1.30	-42.30	-9.66	29.2
10	-1.30	-42.30	-9.66	29.2
10	-1.92	-46.25	-3.10	25.0
11	-1.92	-46.25	-3.10	25.0
11	-2.53	-46.05	3.83	21.1
12	-2.53	-46.05	3.83	21.1
12	-3.15	-47.34	-9.93	17.4
13	-3.15	-47.34	-9.92	17.4
13	-3.77	-58.22	-25.21	13.9
14	-3.77	-58.21	-25.19	13.9
14	-4.38	-78.18	-39.28	10.6
15	-4.38	-78.18	-39.28	10.6
15	-5.00	-106.39	-52.06	7.8
16	-5.00	-106.38	**-52.19**	7.8
16	-5.67	**-127.09**	-10.71	5.2
17	-5.67	**-127.09**	-10.63	5.2
17	-6.33	-121.23	26.68	3.4
18	-6.33	-121.23	26.65	3.4
18	-7.00	-94.11	51.14	2.1
19	-7.00	-94.11	51.11	2.1
19	-7.63	-66.56	37.92	1.4
20	-7.63	-66.56	37.92	1.4
20	-8.25	-43.90	34.50	1.1
21	-8.25	-43.90	34.50	1.1
21	-8.88	-25.03	26.12	0.9
22	-8.88	-25.03	26.12	0.9
22	-9.50	-11.26	17.82	0.8
23	-9.50	-11.26	17.82	0.8
23	-10.13	-2.84	9.05	0.8
24	-10.13	-2.84	9.05	0.8
24	-10.75	0.00	0.00	0.9
Max		**-127.09**	**-52.19**	**63.0**
Max, minor nodes incl.		-127.97	-52.19	63.0

12.7.3 Charts of Stresses



12.7.4 Stresses

Node number	Level	Left				Right			
		Effective stress	Water stress	Stat*	Mob*	Effective stress	Water stress	Stat*	Mob*
	[m]	[kN/m²]	[kN/m²]		[%]	[kN/m²]	[kN/m²]		[%]
1	3.25	0.00	0.00	-		0.00	0.00	-	
1	2.88	0.00	0.00	-		0.00	0.00	-	
2	2.88	0.00	0.00	-		0.00	0.00	-	
2	2.50	0.00	0.00	-		0.00	0.00	-	
3	2.50	0.02	0.00	P		0.00	0.00	-	
3	1.83	4.28	0.00	A		0.00	0.00	-	
4	1.83	4.59	0.00	A		0.00	0.00	-	
4	1.17	7.41	0.00	A	7	0.00	0.00	-	
5	1.17	7.72	0.00	A	7	0.00	0.00	-	
5	0.50	10.54	0.00	A	6	0.00	0.00	-	
6	0.50	10.74	0.00	A	6	0.00	0.00	-	
6	0.22	11.41	2.75	A	6	0.00	0.00	-	
7	0.22	11.47	2.75	A	6	0.00	0.00	-	
7	0.00	12.05	4.91	A	6	0.00	0.00	-	
8	0.00	15.35	4.91	A	25	0.03	0.00	P	
8	-0.65	16.96	10.92	A		36.07	1.98	2	67
9	-0.65	17.13	10.92	A		36.68	1.98	2	67
9	-1.30	18.17	16.93	A		41.27	3.95	2	69
10	-1.30	18.26	16.93	A		41.60	3.95	2	69
10	-1.92	19.04	22.63	A		40.76	11.88	2	68
11	-1.92	19.13	22.63	A		40.76	11.88	2	68
11	-2.53	19.91	28.34	A		40.07	19.80	2	67
12	-2.53	20.00	28.34	A		40.07	19.80	2	67
12	-3.15	20.78	34.04	A		1.67	27.72	P	
13	-3.15	20.87	34.04	A		1.67	27.72	P	
13	-3.77	21.62	39.75	A		1.67	35.65	P	
14	-3.77	21.66	39.75	A		1.67	35.65	P	
14	-4.38	21.16	45.45	A		1.67	43.57	P	
15	-4.38	21.23	45.45	A		1.67	43.57	P	
15	-5.00	21.86	51.16	A		1.63	51.50	P	

Node number	Level [m]	Left				Right			
		Effective stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob* [%]	Effective stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob* [%]
16	-5.00	14.90	51.16	A		85.19	51.50	2	66
16	-5.67	16.17	57.70	A		75.73	58.04	2	52
17	-5.67	16.31	57.70	A		76.45	58.04	2	52
17	-6.33	17.59	64.23	A		64.85	64.58	1	40
18	-6.33	19.29	64.23	A		65.25	64.58	1	40
18	-7.00	18.27	70.78	A		12.15	71.12	P	
19	-7.00	26.62	70.78	A		12.18	71.12	P	
19	-7.63	40.87	76.91	1		32.40	77.25	3	
20	-7.63	41.11	76.91	1		35.66	77.25	3	
20	-8.25	44.98	83.04	1		38.50	83.38	2	55
21	-8.25	53.16	83.04	1		38.74	83.38	2	54
21	-8.88	56.21	89.17	1		43.15	89.51	1	39
22	-8.88	56.44	89.17	1		43.39	89.51	1	39
22	-9.50	59.01	95.30	1		44.93	95.64	1	39
23	-9.50	59.25	95.30	1		45.17	95.64	1	39
23	-10.13	61.59	101.43	1		46.97	101.77	1	39
24	-10.13	61.83	101.43	1		47.20	101.77	1	39
24	-10.75	64.11	107.56	1		49.09	107.90	1	39

*
Stat Status (A=active, P=passive, Number is branche, 0 is unloading)
Mob Percentage passive mobilized

12.7.5 Percentage mobilized resistance

Horizontal soil pressure	Left [kN]	Right [kN]
Effective	349.3	383.6
Water	597.7	563.4
Total	947.0	947.0

Considered as passive side Right
Maximum passive effective resistance 766.54 kN
Mobilized passive effective resistance 383.59 kN
Percentage mobilized resistance 50.0 %

End of Report

LEGEND

- Sheet pile
- Edge road
- Existing parking lot
- New footpath
- Bush
- Rip-rap 10-60kg
- Existing mooning pile
- Existing pile

REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

Client:
ERM

Ingenieursbureau:
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ILACO

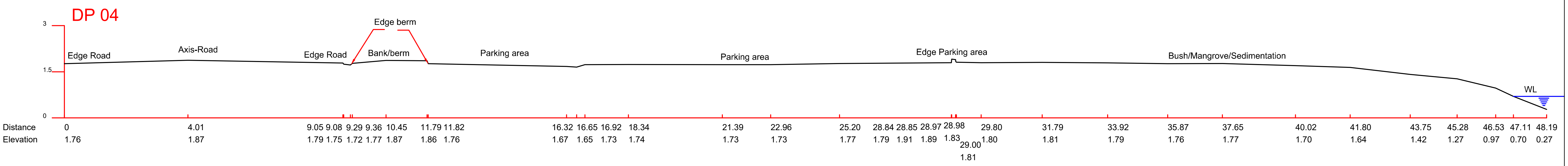
ADAPTATION STUDY PARAMARIBO

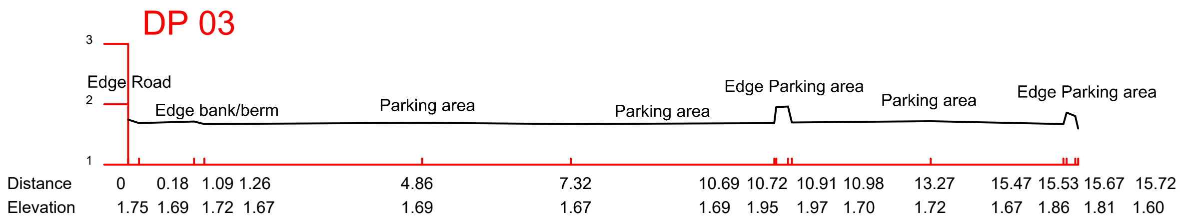
PRELIMINARY DESIGN FLOOD WALL WATERKANT
OVERVIEW SITUATION SECTION KNUFFELSGRACHT-RIVER SIDE

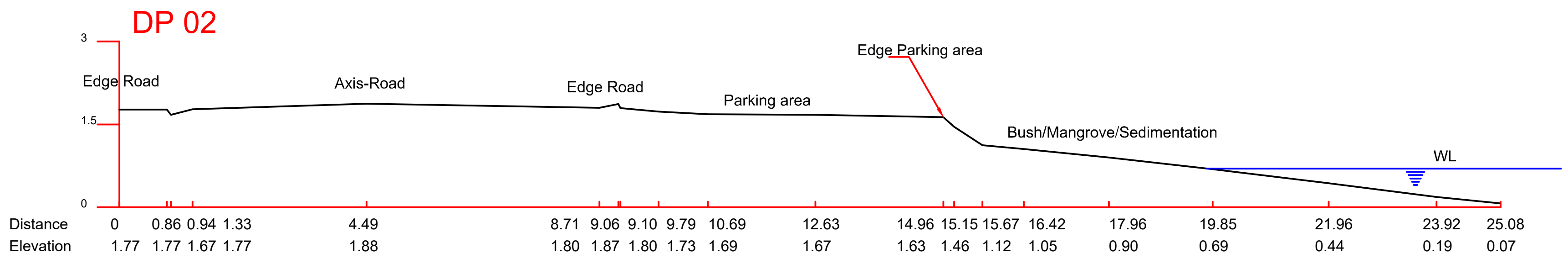
nr.	discription	drawn by	date
6			
5			
4			
3			
2	**Overview/Situation**	**MD**	**18-6-2018**
1	Basic drawing	MD	17-04-2018
0	basic drawing	MJ	12-12-2017

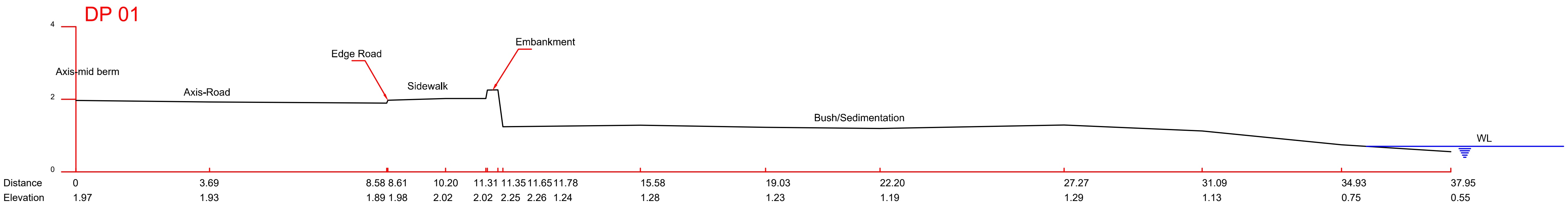
checked: AM/RPA
approved: RPA
Project number: IS-331
Status: Draft
Drawing Code: KNF-OV-01

Format: A3 | Scale: see scale bar | Page number: 1









REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

Client:
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ADAPTATION STUDY PARAMARIBO

PRELEMINAIRY DESIGN FLOOD WALL WATERKANT
CROSS SECTIONS- EXISTING SITUATION

nr.	discription	drawn by	date
6			
5			
4			
3			
2	Cross Section	MD	18-6-2018
1	Basic drawing	MD	17-04-2018
0	basic drawing	MJ	12-12-2017

checked: AM/RPA
approved: RPA
Project number: IS-331
Status: Draft
Drawing Code: KNF-DW-01

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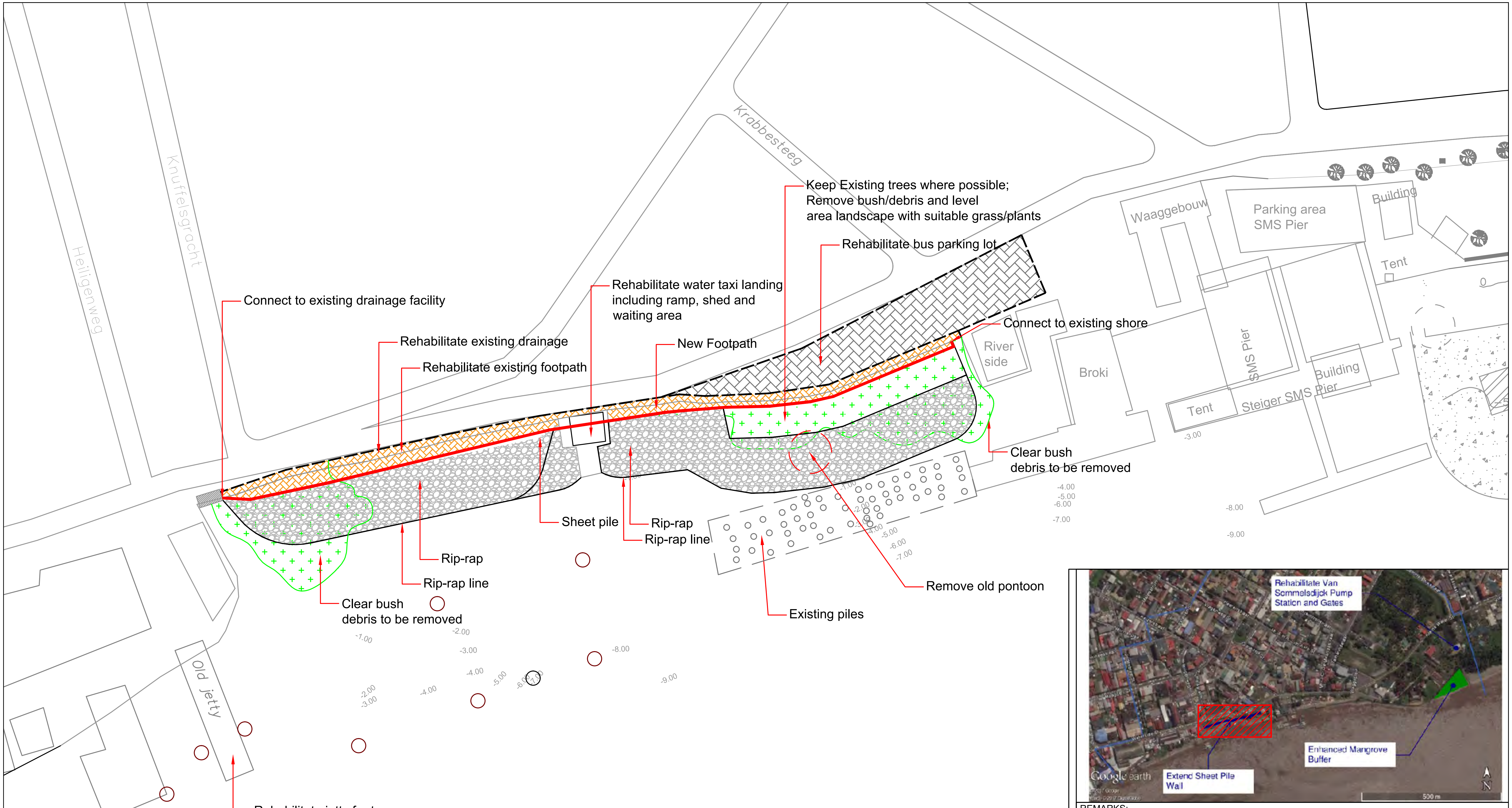

0 50 100M

SCHAAL 1:1000

LEGEND

- Sheet pile
- 50m section line
- -2 Depth in m -NSP
- Existing parking lot
- Bush
- Footpath
- Rip-rap 10-60kg
- Existing mooring pile
- Existing pile

REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE INMETERS NSP (NATIONAL DATUM)

Client:
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ADAPTATION STUDY PARAMARIBO

PRELEMINAIRY DESIGN
OVERVIEW- PLAN FLOOD WALL WATERKANT

nr	discription	drawn by	date
6			
5			
4			
3			
2	Overview/plan	MD	18-6-2018
1	Basic drawing	MD	17-04-2018
0	basic drawing	MJ	12-12-2017

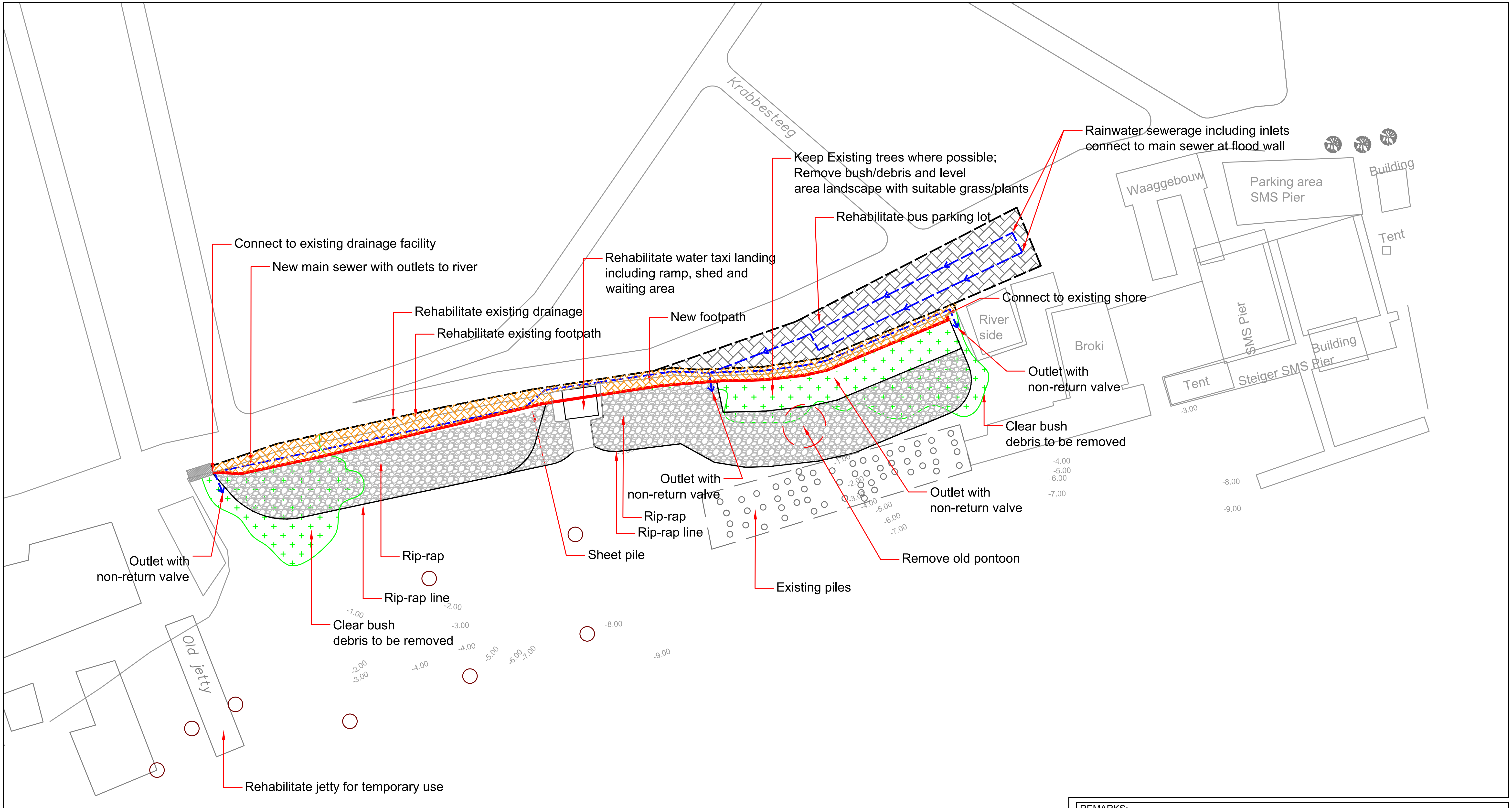
checked: AM/RPA

approved: RPA | Project number: IS-331

Status: Draft

Drawing Code:
KNF-OV-02

Format: A3 | Scale: see scale bar | Page number: 2



0 50 100M

SCHAAL 1:1000

LEGEND

- Sheet pile
- Rainwater sewerage
- -2 Depth in m -NSP
- Existing parking lot
- Bush
- Footpath
- Rip-rap 10-60kg
- Existing mooring pile
- Existing pile

REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE INMETERS NSP (NATIONAL DATUM)

Client:
ERM

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ADAPTATION STUDY PARAMARIBO

PRELEMINAIRY DESIGN
OVERVIEW- SEWERAGE FLOOD WALL WATERKANT

nr	discription	drawn by	date
6			
5			
4			
3			
2	Overview/plan	MD	18-6-2018
1	Basic drawing	MD	17-04-2018
0	basic drawing	MJ	12-12-2017

checked: AM/RPA

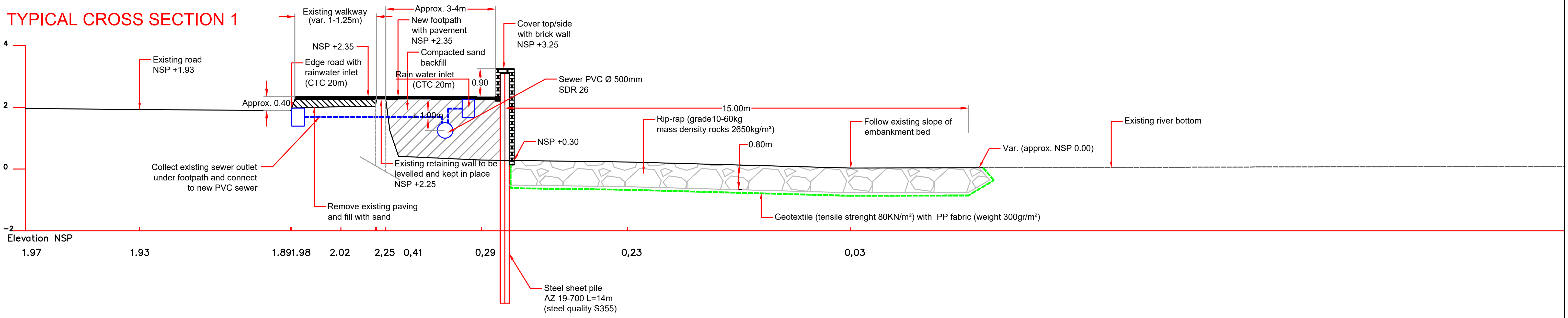
approved: RPA | Project number: IS-331

Status: Draft

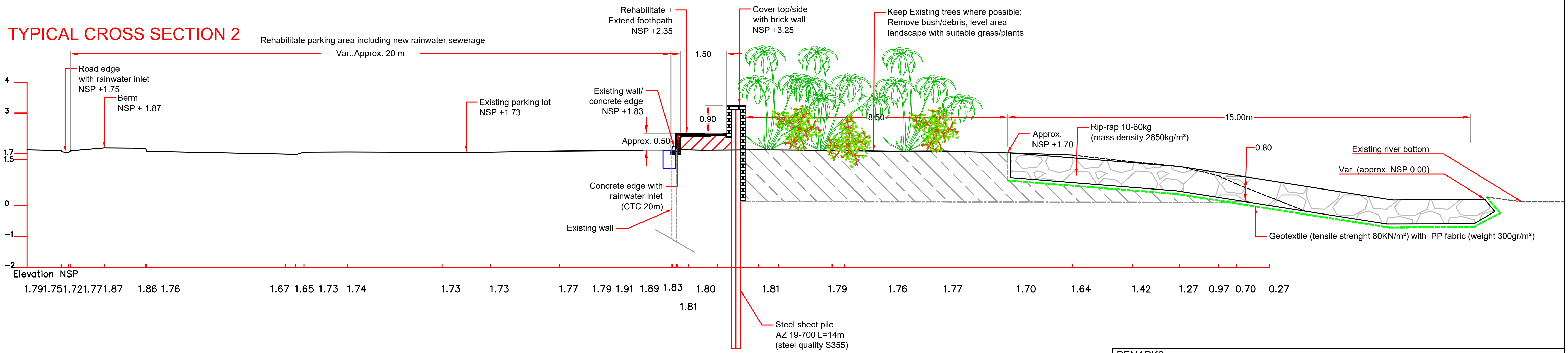
Drawing Code:
KNF-OV-03

Format: A3 | Scale: see scale bar | Page number: 3

TYPICAL CROSS SECTION 1



TYPICAL CROSS SECTION 2



NOTE:
- Grade/quality Rip-Rap according to Rock Manual

REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

Client:
ERM

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ILACO

ADAPTATION STUDY PARAMARIBO

PRELEMINAIRY DESIGN FLOOD WALL WATERKANT
TYPICAL CROSS SECTIONS

nr	discription	drawn by	date
6			
5			
4			
3			
2	Cross Section	MD	18-6-2018
1	Basic drawing	MD	17-04-2018
0	basic drawing	MJ	12-12-2017

checked: AM/RPA
approved: RPA
Project number: IS-331
Status: Draft
Drawing Code: KNF-DW-02

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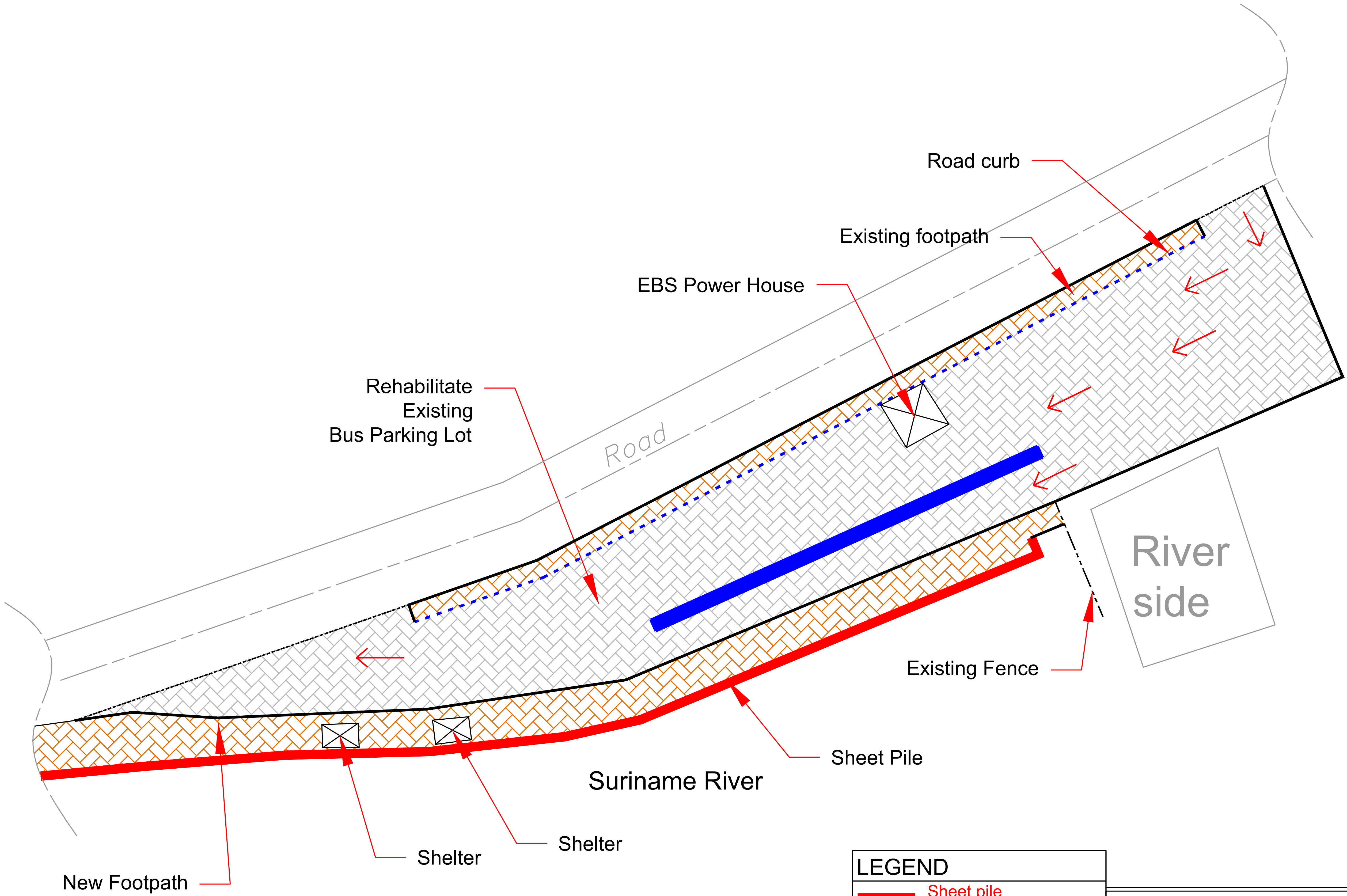

LEGEND

- Sheet pile
- Existing parking lot
- Footpath
- Existing Fence
- Direction
- Road Curb
- Curb/ Pathway

Client:
ERM

Ingenieursbureau:
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ADAPTATION STUDY PARAMARIBO

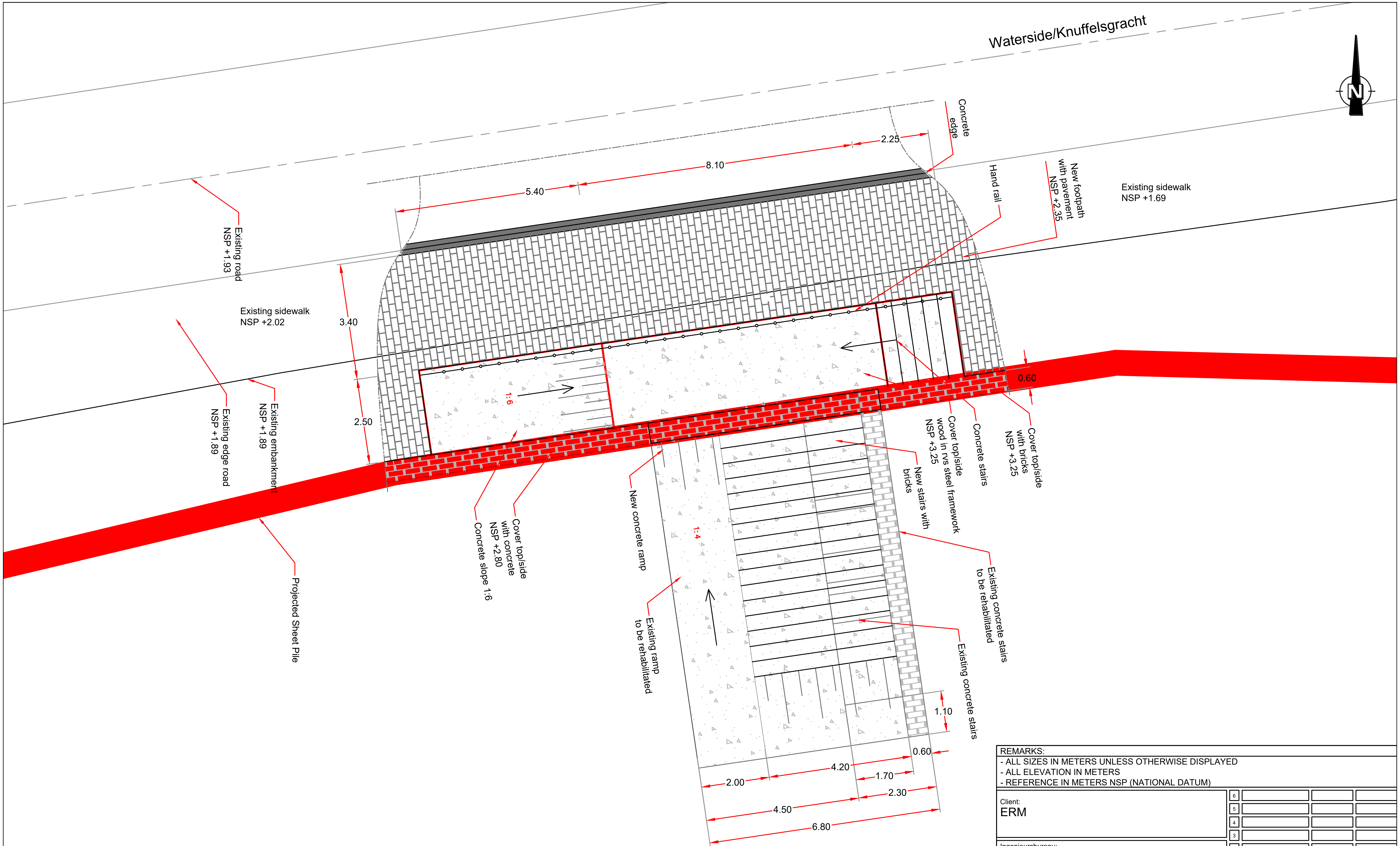
PRELEMINAIRY DESIGN
OVERVIEW- BUS PARKING LOT WATERKANT

nr.	discription	drawn by	date
6			
5			
4			
3			
2	Overview/plan	MD	18-6-2018
1	Basic drawing	MD	17-04-2018
0	basic drawing	MJ	12-12-2017

checked: AM/RPA
approved: RPA
Project number: IS-331
Status: Draft

Format: A3 | Scale: | Page number: 9

Drawing Code:
KNF-OV-07



REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

Client:
ERM

Ingenieursbureau:
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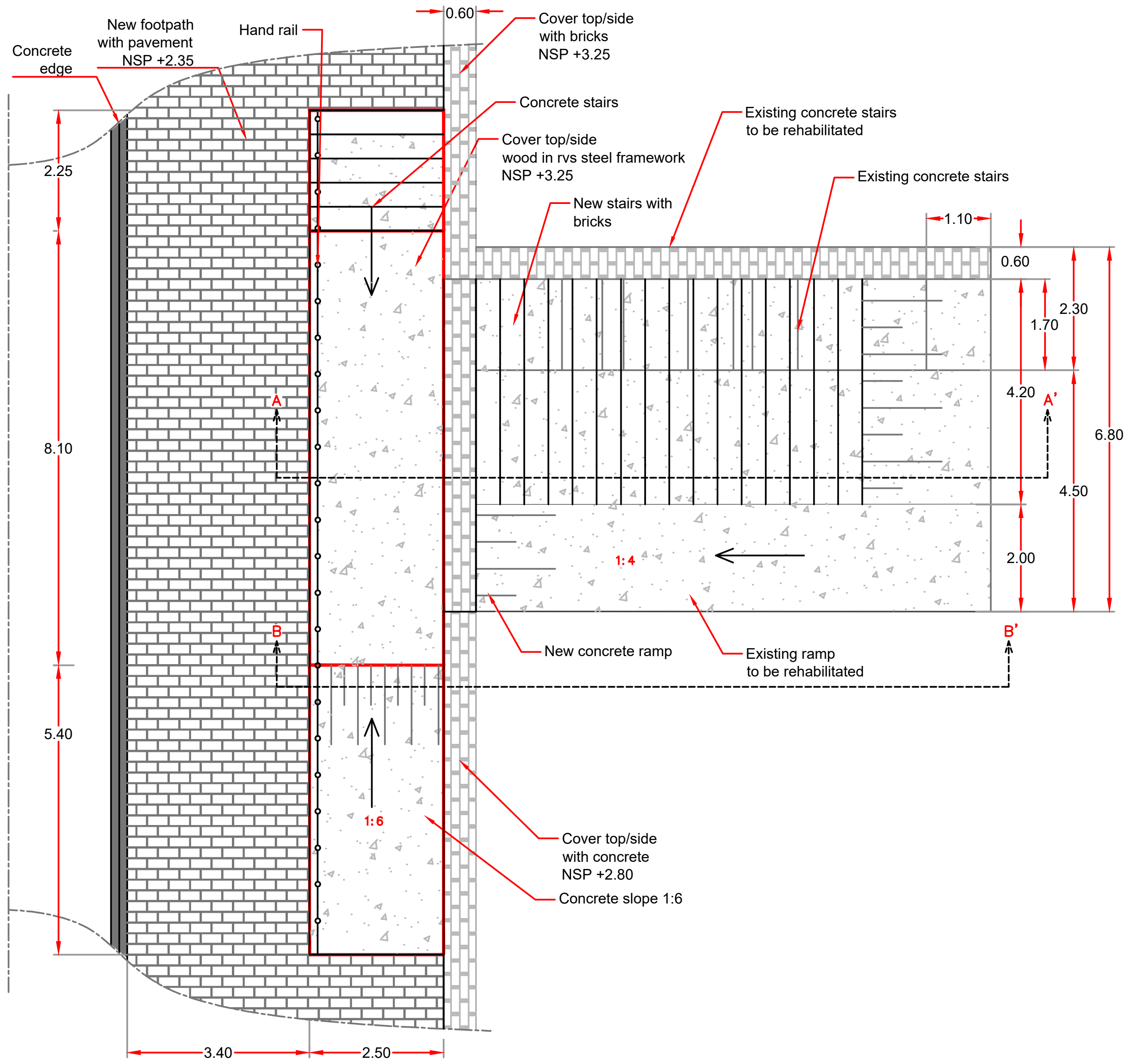
ADAPTATION STUDY PARAMARIBO

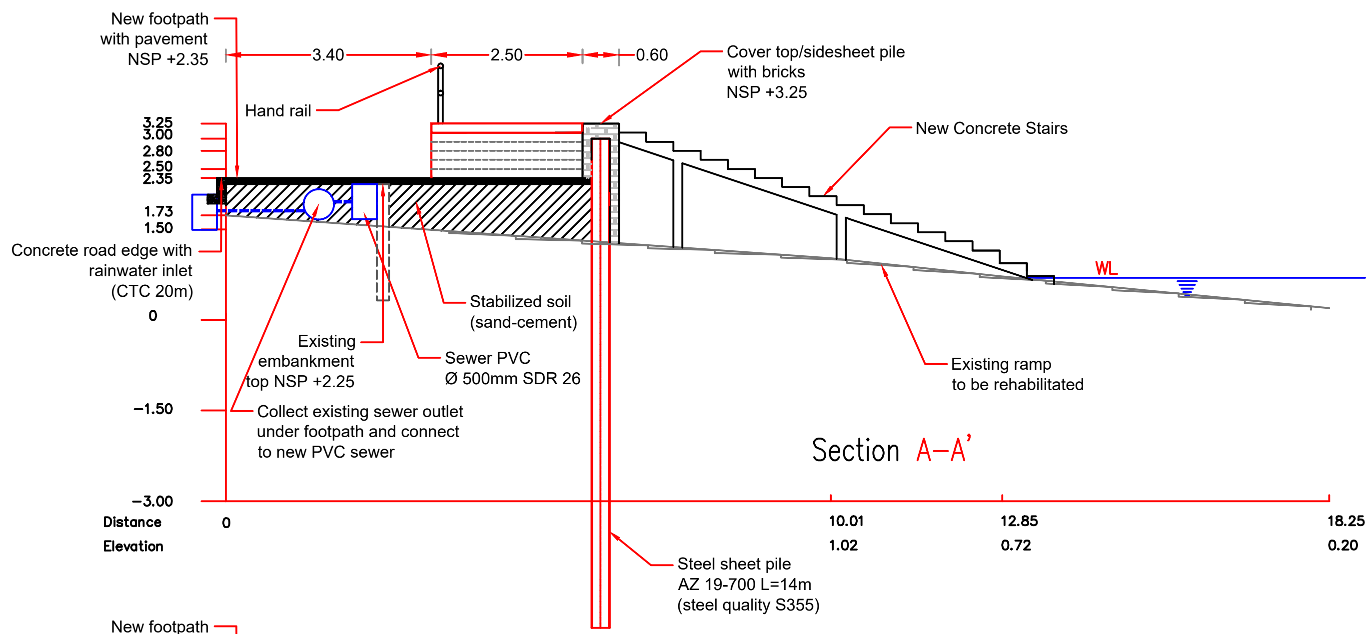
PRELEMINAIRY DESIGN PLAN- FLOOD WALL WATERKANT
Entrance to Water Taxi Landing Waterkant

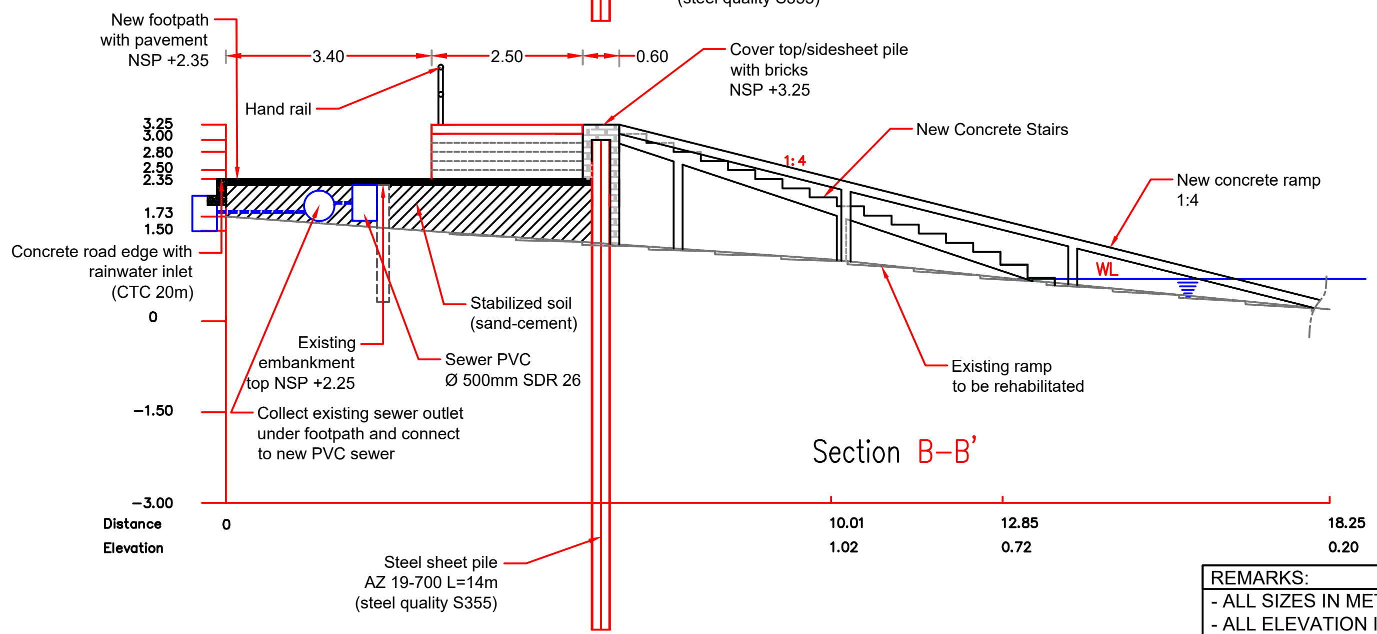
nr.	discription	drawn by	date
6			
5			
4			
3			
2	Plan	MD	04-07-2018
1	Plan	MD	18-6-2018
0	basic drawing	MD	21-12-2017

checked: AM/RPA
approved: RPA
Project number: IS-331
Status: Draft
Drawing Code: KNF-OV-04

Format: A3 | Scale: 10:1 | Page number: 6







REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

NOTE:
- Concrete quality C25
- Reinforcement FeB400
- Brick pavement (fck=7 N/mm²)

Client:
ERM

Ingenieursbureau:
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nr.	discription	drawn by	date
6			
5			
4			
3			
2	Overview/ Pre- design	MD	04-07-2018
1	Overview/ Pre- design	MD	18-6-2018
0	basic drawing	MD	21-12-2017

checked: AM/RPA
approved: RPA
Project number: IS-331
Status: Draft

ADAPTATION STUDY PARAMARIBO

PRELEMINAIRY DESIGN FLOOD WALL WATERKANT
Entrance to Water Taxi Landing Waterkant
Alternative 1

Format: A3 | Scale: 10:1 | Page number: 7

Drawing Code:
KNF-OV-05

MEMO

To	:	ERM
From	:	ILACO Suriname NV
File	:	IS-331
Project	:	Adaptation Study Paramaribo
Subject	:	Rehabilitation sluice/pumping station Sommelsdijckse kreek- Preliminary Design
Version:		final
Date	:	11 July 2018

Contents

Appendices:
I Preliminary Design Drawings (4x)

1. General introduction

The project component at the discharge point of Van Sommelsdijck Creek (canal) consists of 2 sections, namely:

- Rehabilitation of the sluice and pumping station Van Sommelsdijckse Creek (Section A);
- Rehabilitation of the mangrove area at the outflow section of the pumping station and behind Hotel Royal Torarica (Section B). This section is presented in a separate document.

2. Rehabilitation of the sluice and pumping station Van Sommelsdijckse Creek

2.1 General

The catchment area of the Van Sommelsdijckse kreek (Canal) is about 700 hectares, and consists of mostly urban and semi-urban area. The rainfall run off and overflow of mostly domestic wastewater is collected through the main canal via side branches and conveyed to the sluice and pumping station. The water management system is designed as a so-called "polder" due to the flat catchment area and the relative low land levels (avg. NSP +1.7 m to+2.0 m) in comparison to the high water levels in the river, which can reach higher than the land levels. This means that excessive run off is first retained in the canals, drains and retention basin and then gradually released to the receiving tidal river periodically.

The sluice/pumping station is to discharge water from the Van Sommelsdijckse Creek, collected in the water retention basin, to the Suriname River by gravity (2 sluices) and/or pumping (3 pumps).

The rehabilitation of the sluice/pumping station Van Sommelsdijck consists of 3 main parts:
- improvement of the water basin;
- rehabilitation of sluice gates and pumping station;
- improvement of the outflow.

2.2 Improvement of Water basin

The water basin has an area of approximately 1800 m2. At the moment the basin bottom is too shallow to store enough water for regular operation of the installation. The improvement activities include increase of the storage volume (by excavation) and protect the embankments/ side slopes against erosion.

Proposed rehabilitation works include:
- basin to be excavated / dredged to the preferred depth; (see drawing)
- the embankment slope has to be profiled to the preferred shape (for stability)
- restore top of embankment with grass protection.

To enable the excavation, the following method is proposed:

- First the sediment barrier in front of the pumps inlet has to be removed by an excavator/ hydraulic crane. This is to allow proper functioning of the 2 working pumps, while the excavation is being executed (sluice gates operation may be reduced during excavation period).
- The inflow from the Sommelsdijckse kreek must be temporary closed at the bridge/culvert in the Kleine Waterstraat. This means that excavation works should be mainly in the dry seasons (August-November and January-March)
- Then the pumps can be utilized to empty the water basin as and when required
- Using a long arm excavator the basin can be excavated from the sides
- The excavated material can be loaded into sealed dump boxes of trucks to be transported to an approved sludge drying bed/ area (to be appointed by the government)
- The sludge dry out area must be closed off by a seal (waterproof membrane) to prevent leakage of polluted water to the ground water levels.
- After drying out, the dried material can be used for landfill of low lying areas.

2.3 Outflow

The outflow channel, between Pumping Station and river, is currently filled with sediment from the river. The outflow channel needs to be dredged/ excavated to ensure sufficient discharge capacity from the gravity sluices.
Measures using wooden piles are proposed to protect the mangrove trees along the outflow channel: see Mangrove enhancement proposal.
The dredged sediment can be used to fill the area behind the wooden (walaba) piles and enhance growth of the mangrove trees.

2.4 Sluice/Pumping station

2.4.1 General

The pumping station with sluice was built early 1980's and overhauled at the end of the 1990's. The building was renovated in 2011.

Technical data:

Type	**Pumping station with sluice**
Year of construction	1982 - 1983
Service area	691 ha
No of pumps	3
Capacity of each pump	4.66 m3/s
RPM	350/1780 rpm
Level control	none
Start level	0.90/1.10/1.30+ NSP
Stop level	0.50/0.70/0.90+ NSP
Preferred level	-
Minimal level	-
Pump manufacturer, type	KSB, PEZ 1200 - 1170, vertical screw pump
Motor manufacturer, type	HEMAF, UK 315MGT -4
Motor	220 kW
Voltage	440 V
Frequency	60 Hz
Amperage	347 A
Sluices	2 vertical doors and 1 set of swinging doors each sluice channel
Width of sluice channel	3 m
Operation	Manual / electrical / hydraulically

Note: the normal operation of the pumps is: 2 working and 1 standby. All pumps should operate alternating to allow for similar operating hours and maintenance sequence

2.4.2 Current situation

The current situation: 1 sluice channel and 2 pumps are operational (estimated at 70% capacity); the control system is not operational. Sluices and pumps are operated manually.
The lubrication system is not fully operational.
The hydraulic system is faulty and leaking.
The monitoring system and switches are not operational.

Several parts have to be repaired.

Pump #1 has been removed from its pedestal. The interior is corroded. This pump need full refurbishment/overhauling.

The electrical motor has been brought elsewhere for repair.

Due to the low water level in the basin, pumps can only operate for 20 minutes.

Overhead crane
The overhead crane in the building is operational, but the lack of maintenance is showing. The manual hoist operation is too slow to use for regular maintenance tasks.

The pump cellar (basin)
The pump cellar cannot be kept dry: a small discharge pump has to be installed.
Pump parts and connections are corroded on the outside.

The butterfly valves are not operating correctly.
When pumping is started the butterfly valves are kept in the open position by mechanically fixing the valves in the open position.

2.4.3 Proposed pump/sluice rehabilitation works

The minimum works necessary to ensure adequate operation of the pumping station and sluice gates are:

Pumps:
- complete revision of the butterfly valve control system
- complete installation of an up to date electrical installation and cabling
- complete inspection of the existing automatic lubrication system and make operational
- complete refurbishment /overhaul of pump #1 (the casing may still be good, but all internal mechanical parts need replacement)
- inspection of butterfly valve #1 and revision if necessary
- when pump #1 is brought to 100% working condition, an inspection is to be done on pump #2.

Depending on the results of this inspection, critical parts of pump #2 shall be repaired. This way the operation of the pumping part of the installation is guaranteed.
Pump #3 must also be inspected and repaired.

Sluices:
- cleaning of the sluice bottom area within the building
- complete renewal of the 4 vertical lift sluice doors (gates) and hydraulic system
- ensure that the steel lock doors within the sluice box are in full open position (these doors are not used anymore)

Overhead crane:
- inspection and repairs
- install an electrical motor for hoist operation

In general:
Ensure an adequate maintenance regime to keep the installation in good working order.
This also requires an adequate supply of spare parts and all the necessary tools and know how.

Note:
The pumps and sluice gates are prone to salt water intrusion, salty air and untreated wastewater. All steel parts / bolts shall be corrosive resistant as per relevant EN/DIN/ASTM specifications.
Pump impellers and other steel parts shall be cast iron/stainless steel as per manufacturers specifications.
All specifications must be checked and approved by Client prior to supply and installation.

2.5 Civil works

The overall state of the building is good. Locally, in the pump cellar, a few places of concrete reinforcement can be seen. These deteriorated spots shall be repaired using high quality material and/or liners. Concrete to be used shall be minimum C25 (25 MPa) quality and ribbed reinforcement shall have yield strength of 400 MPa (FeB 400).

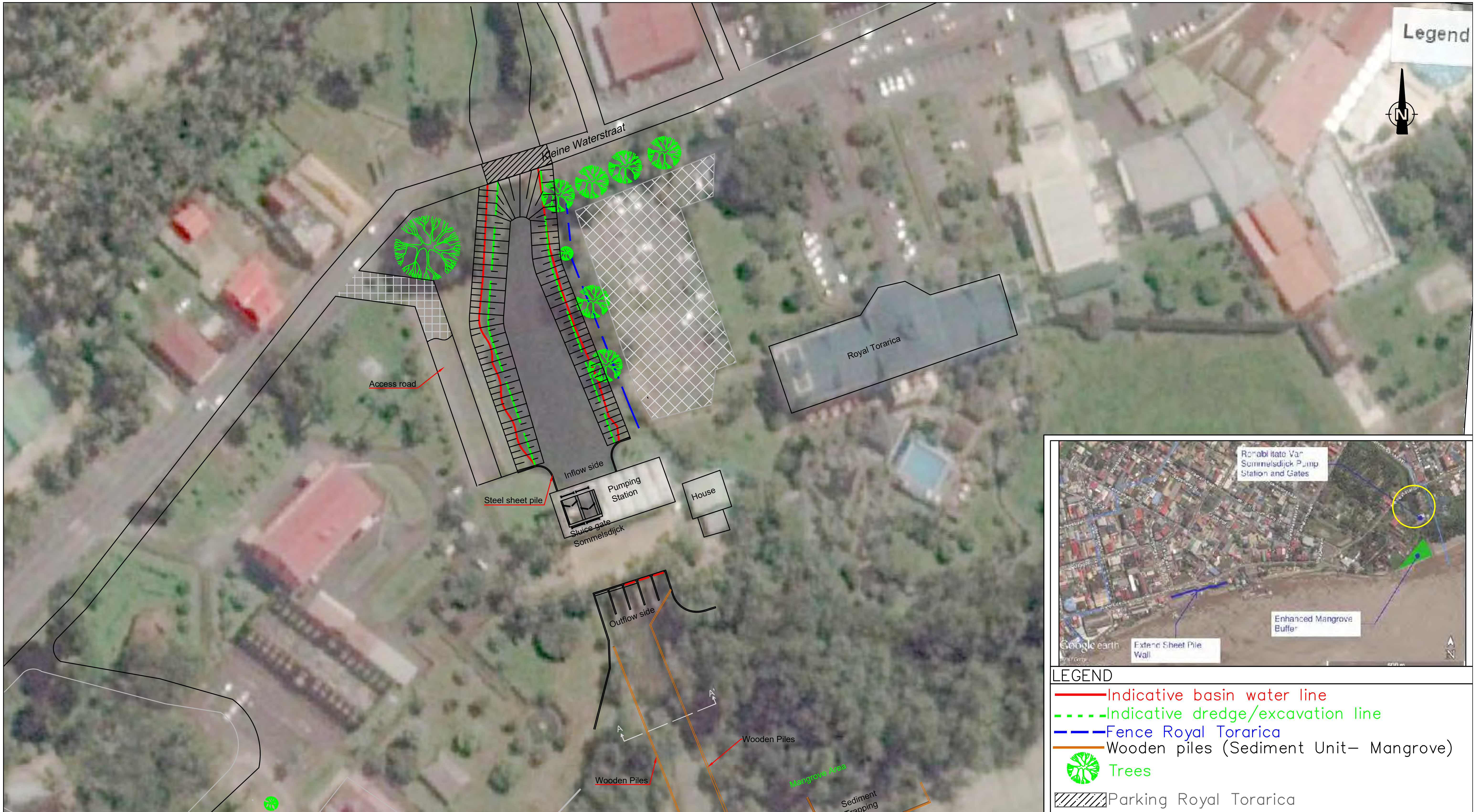
It is recommended to put a roof over the lock area, as the hydraulic lines and other parts are subject to the outdoor conditions (optional).
Alternatively, the roll up door between the roofed and open area can be repaired.

It is also advisable to move the steel doors (not in operation) to a position where their impact on the water flow in the sluice channel is minimal.

2.6 Electrical & Instrumentation

The electrical installation and cabling has to be upgraded. Also the control system has to be made up to date. All electrical installations must comply with the standards and requirements of EBS (Suriname Power Company).
New instruments need to be installed to measure water levels (in and outflow side), including software and devices to send data remotely (GSM).

Appendices: Preliminary Design Drawings (4x)



Client:
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Tel. (597)431270/431290
Telefax. (597)431294

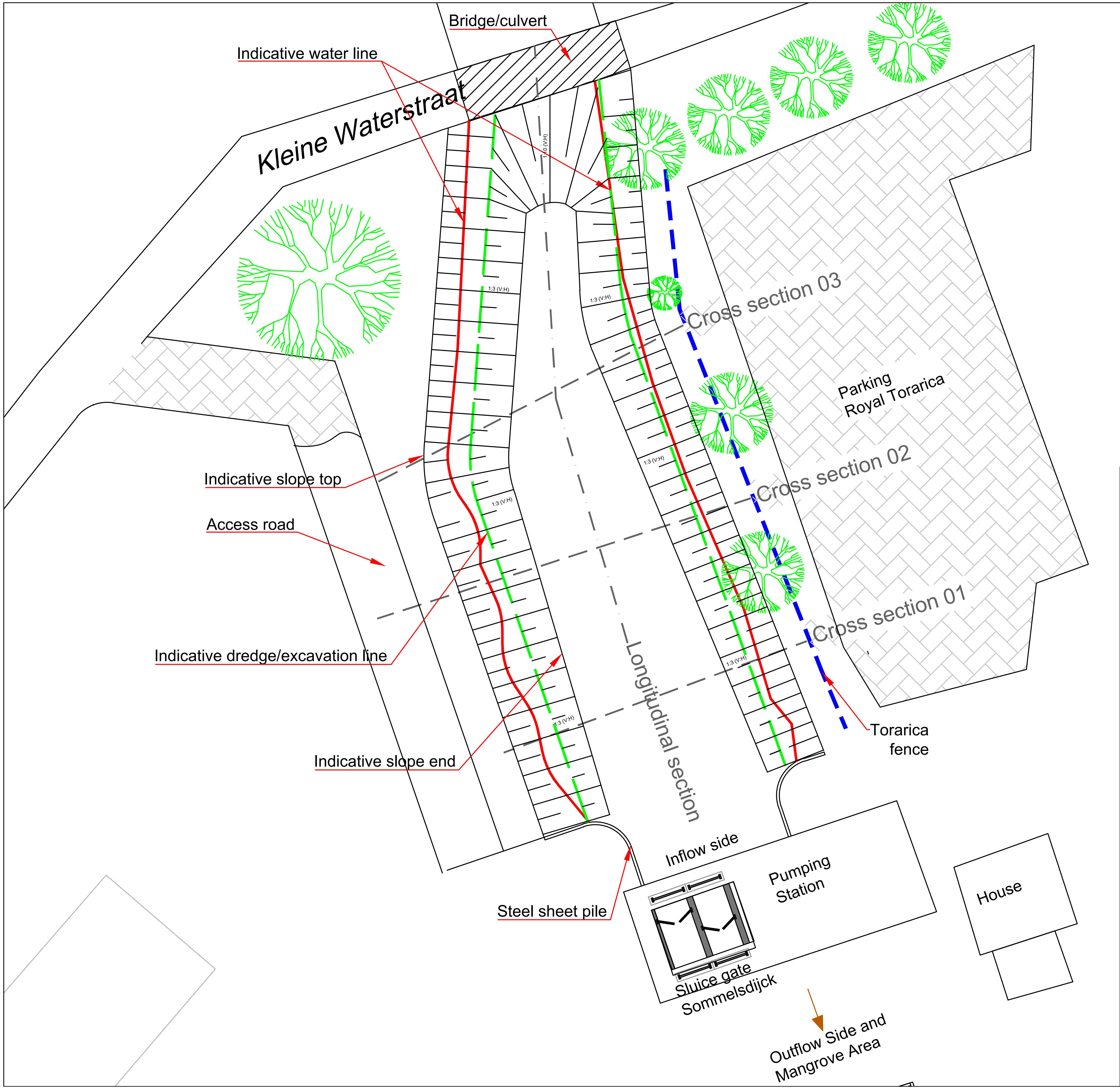
ADAPTATION STUDY PARAMARIBO

PRELIMINARY DESIGN
OVERVIEW–VAN SOMMELSDIJCKSE KREEK

Format: A3 | Scale: see scale bar | Page number: 1

nr.	discription	drawn by	date
6			
5			
4			
3			
2			
1	Overview/Situation	MD	18–6–2018
0	basic drawing	MJ	12–12–2017

checked: AM/RPA
approved: RPA
Project number: IS–331
Status: Draft
Drawing Code:
SOMM–OV–01



LEGEND

- Indicative basin water line
- Indicative dredge/excavation line
- Fence Royal Torarica
- Trees
- Parking Royal Torarica

Client:
ERM

Ingenieursbureau:
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ILACO

ADAPTATION STUDY PARAMARIBO

PRELIMINARY DESIGN PS/SLUICE GATE VAN SOMMELSDIJCK
OVERVIEW–PLAN

Format: A3 | Scale: 1:500 | Page number: 2

nr.	discription	drawn by	date
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5			
4			
3			
2			
1	Overview	MD	18–6–2018
0	basic drawing	MJ	12–12–2017

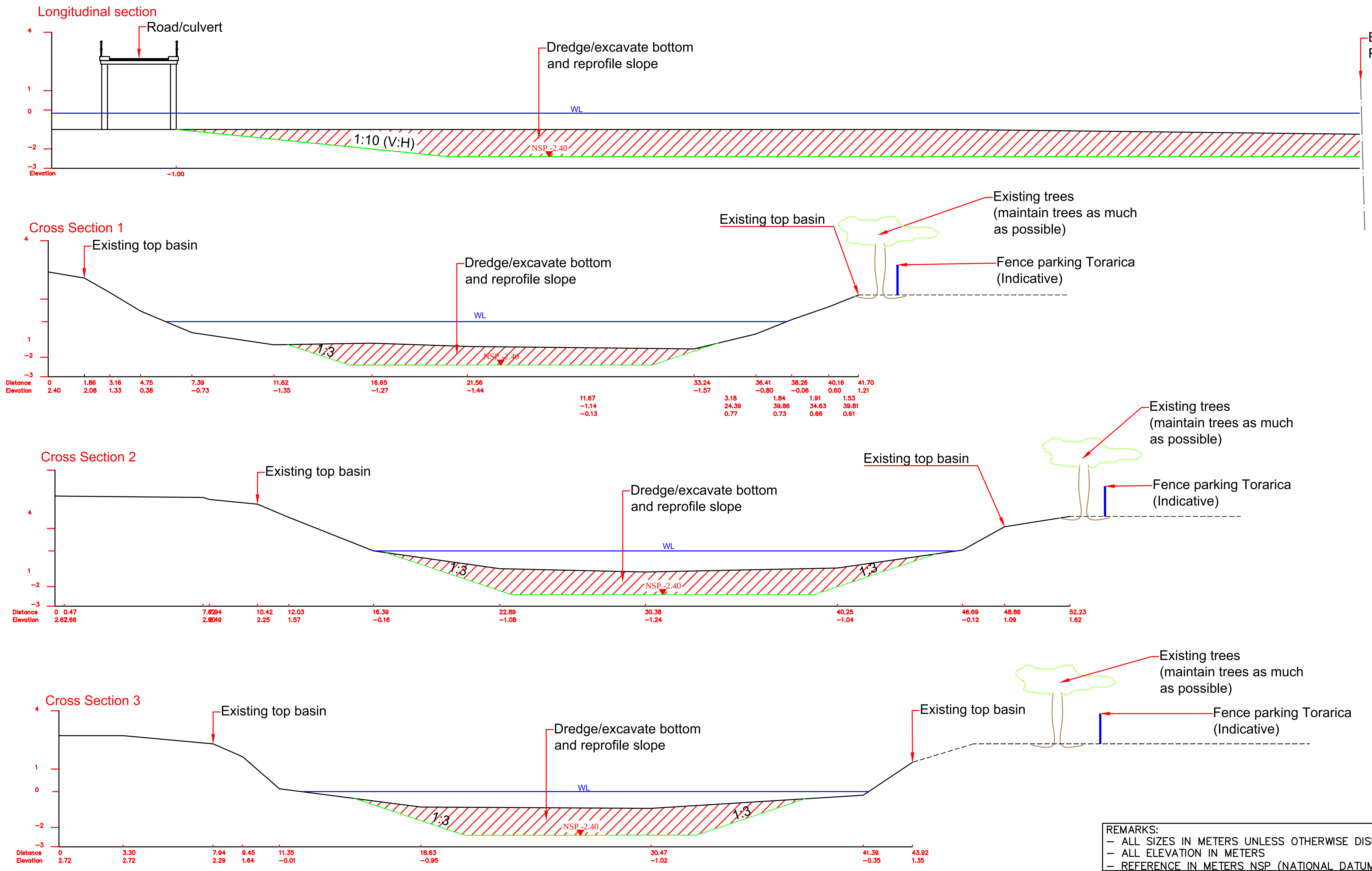
checked: AM/RPA

approved: RPA

Project number: IS–331

Status: Draft

Drawing Code:
SOMM–OV–02



Note:
Discharge sludge to approved sludge drying bed

REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

Client:
ERM

Ingenieursbureau:
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ADAPTATION STUDY PARAMARIBO

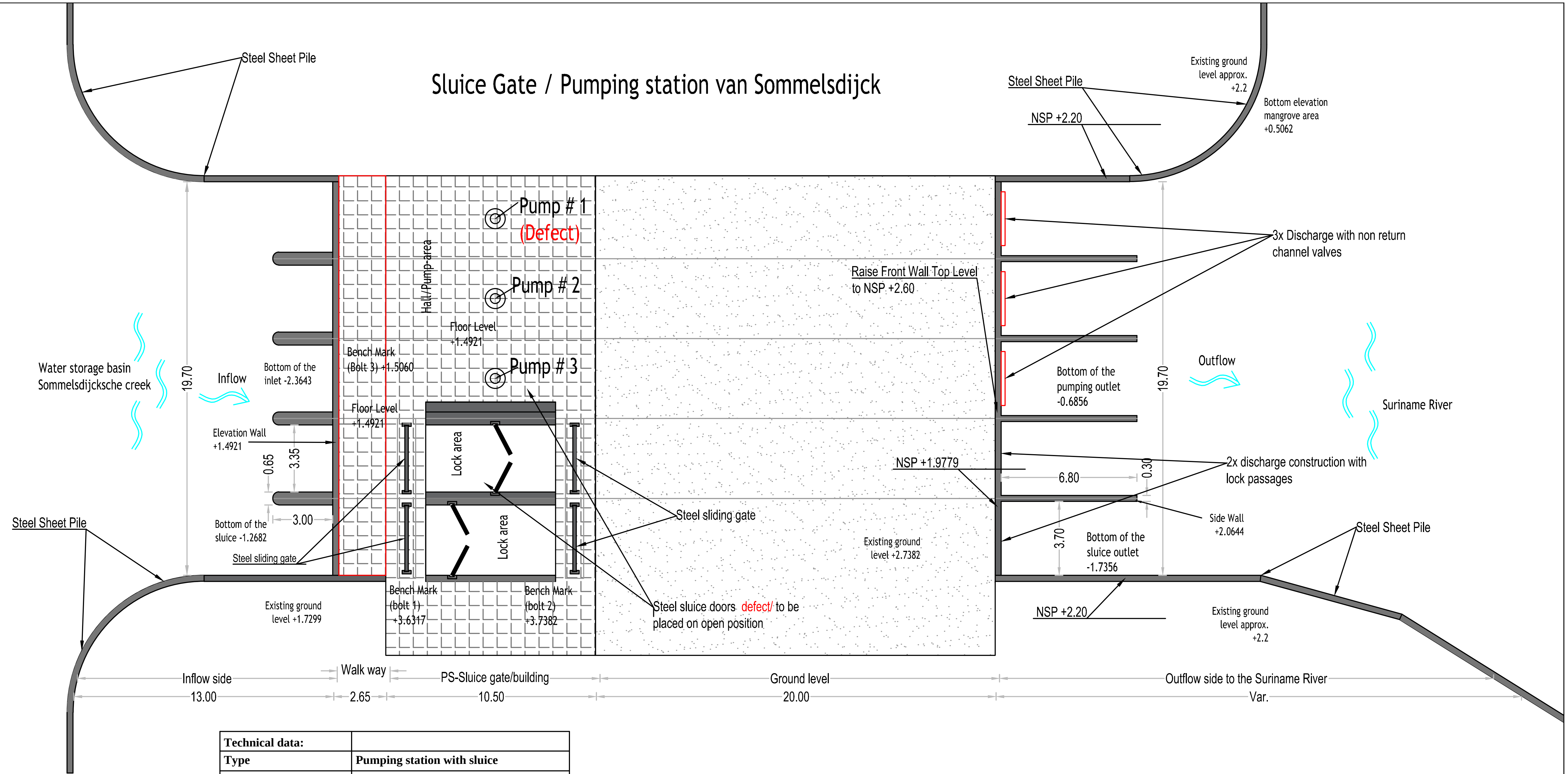
PRELIMINARY DESIGN
CROSS SECTIONS PS/SLUICE GATE VAN SOMMELSDIJCK

nr.	discription	drawn by	date
6			
5			
4			
3			
2			
1	Cross Sections	MD	18-6-2018
0	basic drawing	MJ	12-12-2017

checked: AM/RPA
approved: RPA
Project number: IS-331
Status: Draft
Drawing Code: SOMM-DW-01

Format: A3 | Scale: N\A | Page number: 3

Sluice Gate / Pumping station van Sommelsdijck



Technical data:	
Type	**Pumping station with sluice**
Year of construction	1982-1983
Service area	691 ha
No of pumps	3
Capacity of each pump	4.66 m3/s
RPM	350/1780 rpm
Level control	none
Startlevel	0.90/1.10/1.30 +NSP
Stoplevel	0.50/0.70/0.90 +NSP
Preferred level	-
Minimal level	-
Pump manufacturer, type	KSB, PEZ 1200 - 1170, vertical pump
Motor manufacturer, type	HEMAF, UK 315 MGT - 4
Motor	220 kW
Voltage	440 V
Frequency	60 Hz
Amperage	347 A
Sluices	2 vertical doors and 1 set of swinging doors each sluice channel
Width of sluice channel	3 m
Operation	Manual/ electrical/ hydraulical

Rehabiltation works / activities:

1	Rehabilitation pump # 1
2	Inspection and repair pump #2
3	Inspection and repair pump #3
4	Complete overhaul lubrication system
5	Complete new cabling
6	Complete new switches etc.
7	Complete new instrumentation
8	Complete overhaul hydraulics
9	Renewal of 4 steel sluice gates including hydraulics
10	Raise Frontwall top

REMARKS:
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- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

Client:
ERM

Ingenieursbureau:
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ADAPTATION STUDY PARAMARIBO

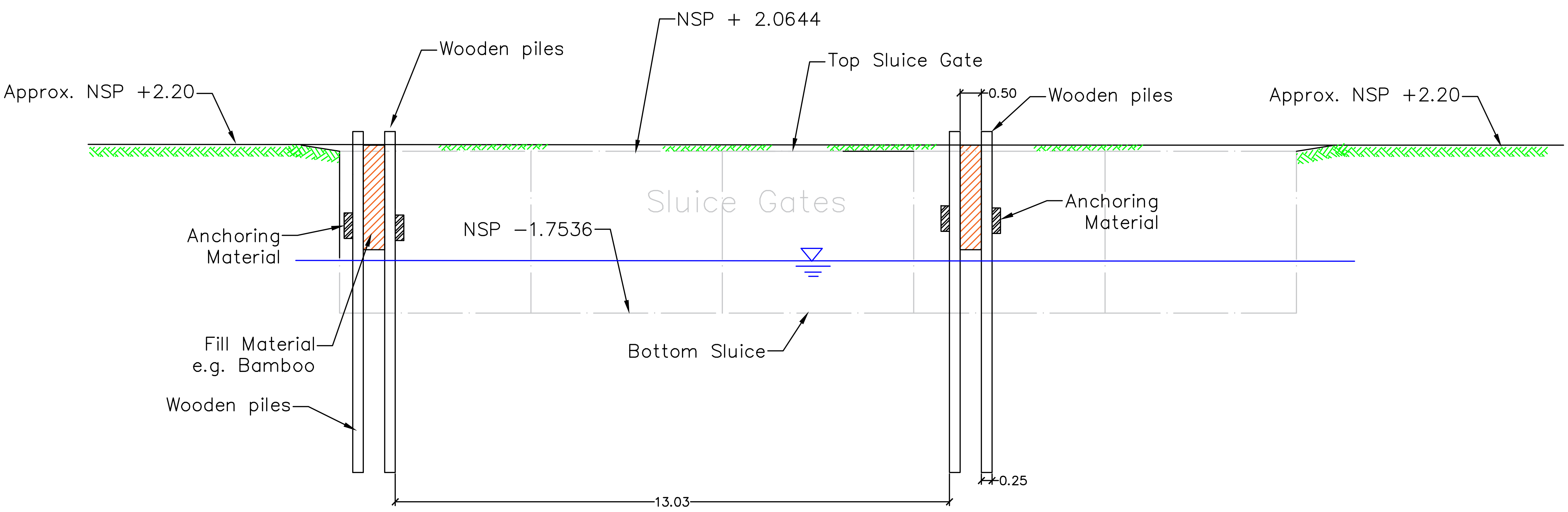
PRELIMINARY DESIGN
OVERVIEW PUMPING STATION

nr.	discription	drawn by	date
6			
5			
4			
3			
2			
1	Overview Pumping Station	MD	18-6-2018
0	basic drawing	MD	13-12-2017

checked: AM/RPA
approved: RPA | Project number: IS-331
Status: Draft
Drawing Code: SOMM-OV-03

Format: A3 | Scale: 1:250 | Page number: 4

Cross Section A–A'



REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

Client:
ERM

Ingenieursbureau:
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ADAPTATION STUDY PARAMARIBO

PRELIMINARY DESIGN
Cross Section Outflow Area

nr.	discription	drawn by	date
6			
5			
4			
3			
2			
1	Cross Section	MB	18–6–2018
0	basic drawing	MJ	12–12–2017

checked: AM
approved: RPA
Project number: IS–331
Status: Draft
Drawing Code: SOMM–DW–02

Format: A3 | Scale: 1:500 | Page number: 5

MEMO

To	: ERM
From	: ILACO Suriname NV
File	: IS-331
Project	: Adaptation Study Paramaribo
Subject	: Enhancement Mangrove Area Van Sommelsdijckse Creek- Preliminary Design
Version	: final
Date	: 11 July 2018

Contents

Appendices:
I Preliminary Design Drawings

1. General introduction

The project component at the discharge point of Van Sommelsdijck Creek (canal) consists of 2 sections, namely:

- Rehabilitation of the sluice and pumping station Van Sommelsdijckse Creek (Section A); This section is presented in a separate document.
- Rehabilitation of the mangrove area at the outflow section of the pumping station and behind Hotel Royal Torarica (Section B).

2. Mangrove

2.1. Introduction

For this part of the report, the focus is the rehabilitation and enhancement of mangrove in sub-area **A** and sub-area **B** as projected on the image below.

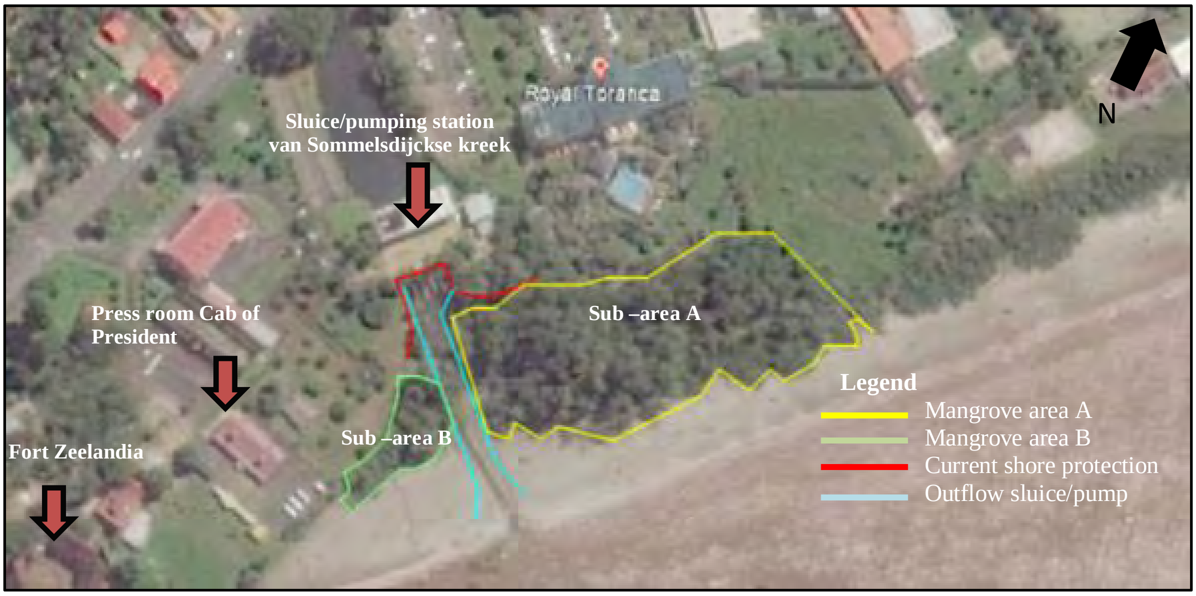

Image 1: Overview mangrove project area in Google Earth (Google Earth, 2017)

The concerned area contains a natural area with mangrove trees and a mix of flora and fauna, including bird breeding during the period April-August. Also noted is that the river embankment shows a net amount of sedimentation in the past years. The mangrove area is divided in two sub-areas, namely:

- Sub-area **A**: A mangrove area behind Royal Torarica with a net amount of sediment depositioning, which can stimulate the natural growth of mangrove trees. It is understood that Royal Torarica has chosen to keep and improve the mangrove area behind the hotel, in line with their eco and green enhancement development objectives.
- Sub-area **B**: A smaller mangrove area in comparison to sub-area A. In sub-area B there is also a net amount of sediment depositioning that could increase the natural growth of mangrove trees if the right conditions are created.

This document contains a design of sediment trapping units and natural structures to protect and stimulate the natural growth of mangrove trees in sub-area **A** and sub-area **B**. The designs are based on experiences along embankment of the Commewijne River and at the coastal shore line north of Paramaribo.

2.2. Mangrove

Mangrove trees protect embankment and coastal lines, because the roots of the mangrove ensure that the waves not only lose their strength, but also their velocity before reaching land. Mangrove trees mostly grow in saline or brackish waters in areas with subtropical and tropical climates. The net amount of sediment depositioning plays an important role in the maturation of mangrove trees. The absence of mangrove trees along the embankment or shoreline could disrupt the balance between sediment growth and erosion, because more sediment is taken away then being deposited. This leads to problems, such as erosion. Mangrove areas also create a good habitat for different species.

There are typically three different types of mangrove trees within the coastal area of Paramaribo:
a. black mangroves;
b. red mangroves;
c. white mangroves or parwa.

The biggest difference between the red mangrove and the black mangrove lies in the structure of their roots. The roots of the black mangroves are long, while the roots of the red mangroves are props. Unlike the visible roots of both the black and red mangrove, the white mangrove has no visible aerial roots.

Image 2: Red mangrove

Image 3: Black mangrove

Image 4: White mangrove

2.3. Development of Mangrove areas

Image 5: Sub-area A 2003

Image 6 : Sub- area A 2013

Image 7 : Sub-area A 2017

As can be seen on the images above and below, the mangrove area in sub- area **A** and B enlarged during the past years.

Image 8: Mangrove area B 2003

Image 9: Mangrove area B 2013

Image 10 : Mangrove area B 2017

Mangrove area	2003	2013	2017
Mangrove area A	7700 m^2	9500 m^2	9700 m^2
Mangrove area B	100 m^2	1000 m^2	1300 m^2

Table 1: Increase of mangrove areas during the past years

In sub-area **A** and **B** there is a variation of both red and white mangroves. In both of the areas mangrove grew naturally.

Image 11 : Mangrove in project area

Image 12 : Mangrove in project area

2.4. Sediment depositioning

The amount of sediment depositioning in the project area is only seen during low water level. In the same areas there is an net positive amount of sediment depositioning with no cultivation of mangrove.

Image 13: sediment depositioning 2009

Image 14: sediment depositioning 2016

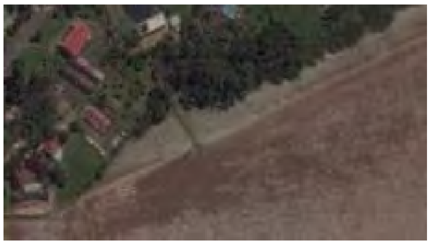

Image 15: sediment depositioning 2017

In 2009 there was approxiametly10 meter sediment depositioning from the waterline to the mangrove line. In 2017 the 10 meter area was increased with another 20 meter sediment depositioning. By creating a specific barrier, the current mangrove will be protected and at the same time create better conditions for the mangrove to grow.

Behind the sluice/pumping station there are sheet piles of steel that protect the area behind the mangrove against high waters. Hotel Royal Torarica does not have any high water protection barrier, except for an elevated earth/clay dam along the river embankment, between the mangrove and land. They have a large area of Mangrove to protect against erosion. So far no complaints of major water flooding have been reported at Royal Torarica premises.

Image16: Sheet piles of steel

Image 17: Royal Torarica with no high water barrier

2.5. Solutions

In order to create a better environment for mangrove trees to grow, the net sediment depositioning has to be much larger than the amount of sediment that is being washed away by the river. By creating a permeable structure of local wood materials the right conditions can be created for the mangrove trees to grow in. This permeable structure promotes the depositioning of sediments and also reduces that wave height/forces on the young trees, which plays an important factor in creating the right conditions for the mangrove trees to grow.

2.5.1. Sediment Trapping Units (STU's)

Sediment Trapping Units are permeable structures that partly dissipate the energy of the waves, while water with lots of sediments is being "sieved". This way the sediment settles inside the structure. When enough sediment is settled and well consolidated, natural mangrove growth can take place. For the permeable construction, we propose wooden piles (for e.g. local walaba piles) with a distance of 0.5-0.75 meter from each other. The empty area between the piles is filled with wood materials such as bamboo. There are also three types of tests that have to been during detailed design and done prior to construction:
Topographic measurements, Sediment transport measurements and Wave measurements.

Image 18: Overview project area with solution

2.5.2. Sub-area A

By creating a permeable structure out of wooden piles with a length of 4 a 5 meter, a protrusion length of max.0.75 meter and a distance of 0.5 meter from each other, sediment depositioning can be stimulated in the area with no mangrove vegetation. The total area in which mangrove will be stimulated has a length of 60 meter and a width between 5-10 meter. In that area two permeable structure or sediment trapping unit (STU) can be created.

2.5.3. Sub-area B

Sub-area **B** is smaller in comparison to sub-area **A**. The area in which mangrove can be stimulated has a length of 50 meter and width of 20 meter. In that area two permeable structure or sediment trapping unit (STU) can be created. As seen on the image below, the STU is created with wooden piles with a length of 4 meter and a protrusion length of max.0.75 meter and a distance of 0.5 meter from each other. In order to solely reduce the wave velocity, an extra row of wooden piles is needed. These piles have a protrusion length of 0.4 meter.

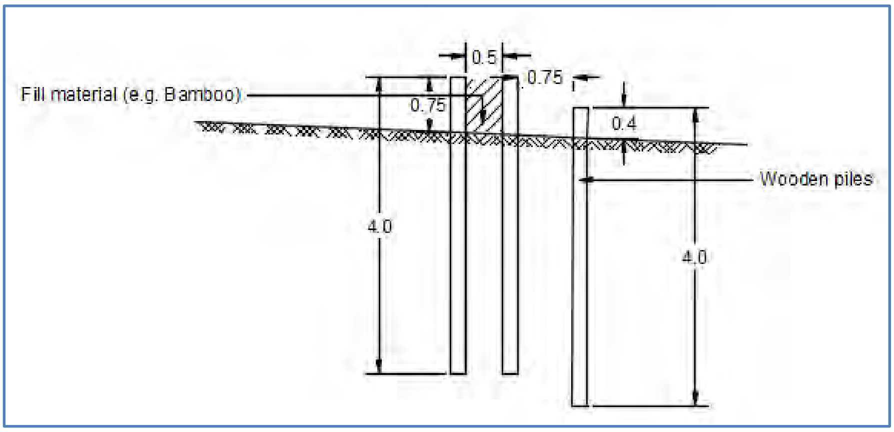

Image 19 : Section drawing STU sub-area B

By implementing STU structures in the project area, the net amount of sediment depositioning and mangrove growth is expected to increase significantly.

Mangrove area	Mangrove in 2017	Maximum increase mangrove	Expected (%)
Mangrove area A	9700 m^2	720 m^2	10420 m^2 (7%)
Mangrove area B	1300 m^2	1000 m^2	2300 m^2 (43%)

Table 2: Expected mangrove growth

As can be observed, the largest increase is anticipated in Sub-area B.

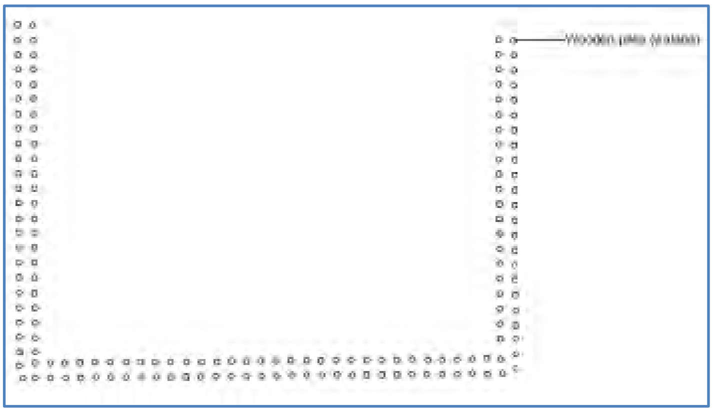

Image 20 : Topview STU sub-area A

2.6. Outflow sluice/pumping station protection

At the moment there is no protection of the mangrove tress in the outflow section of the sluice/pumping system. During excessive discharges, erosion may take place at the roots of the trees, resulting in losses of the mangrove area.

The minimum width of the outflow canal for discharges is kept at 10 meters. This width is considered sufficient for normal operations during rainy seasons. In case of excessive discharge and high water levels, the area behind the wooden piles will also contribute to discharging the water to the river.

We propose a protection barrier of wooden piles with a center to center distance of 0.5 meter. In the outflow section there is currently a lot of sediment deposits mostly coming from the river. To create a better outflow it is necessary to dredge/excavate this section. The excavated sediment material can be placed in the mangrove area behind the wooden piles.

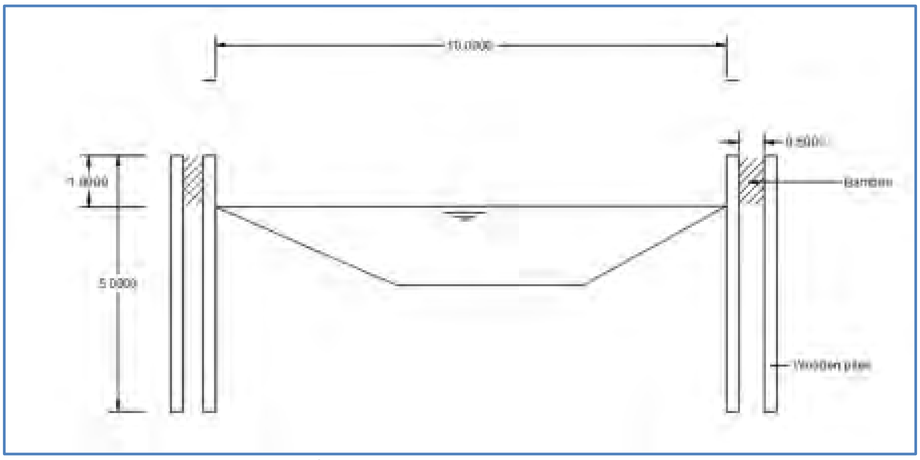

Image 21 : Section drawing outflow protection

2.7. Other technical aspects

The construction activities should not take place between April and August, as this period is important for bird breeding.
The following surveys/tests during detailed designs and pre-construction are required to optimize the designs: Topographic measurements, Sediment transport measurements and Wave measurements.

After construction, some monitoring (6-8 months) and modifications may be need to adjust the STUs as required for better performance.

It is recommended to collect these and other experiences and discuss with the Government and Private parties to implement similar structures along other sections of the rivers in Suriname.

Appendices: Preliminary Design Drawings

LEGEND

- Indicative basin water line
- Indicative dredge/excavation line
- Fence Royal Torarica
- Wooden piles (Sediment Unit– Mangrove)
- Trees
- Parking Royal Torarica

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ERM

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ADAPTATION STUDY PARAMARIBO

PRELIMINARY DESIGN
OVERVIEW–VAN SOMMELSDIJCKSE KREEK

nr.	discription	drawn by	date
6			
5			
4			
3			
2			
1	Overview/Situation	MD	18–6–2018
0	basic drawing	MJ	12–12–2017

checked: AM/RPA

approved: RPA

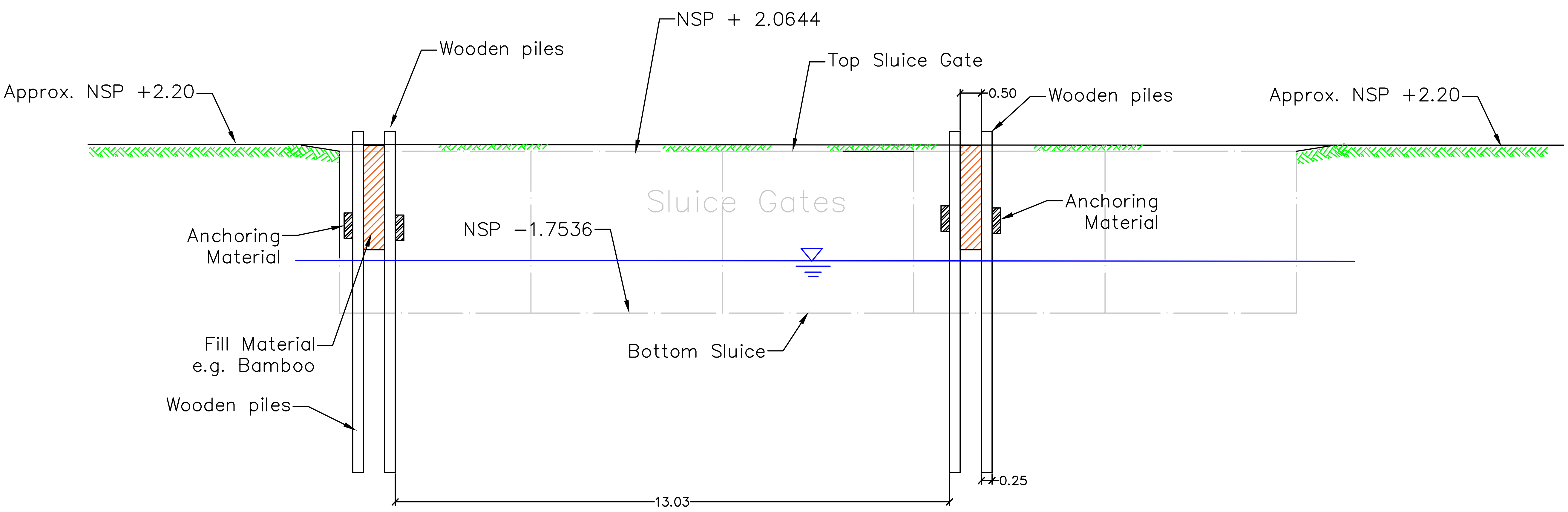
Project number: IS–331

Status: Draft

Drawing Code: SOMM–OV–01

Format: A3 | Scale: see scale bar | Page number: 1

Cross Section A–A'



REMARKS:
- ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
- ALL ELEVATION IN METERS
- REFERENCE IN METERS NSP (NATIONAL DATUM)

Client:
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ADAPTATION STUDY PARAMARIBO

PRELIMINARY DESIGN
Cross Section Outflow Area

nr.	discription	drawn by	date
6			
5			
4			
3			
2			
1	Cross Section	MB	18–6–2018
0	basic drawing	MJ	12–12–2017

checked: AM

approved: RPA

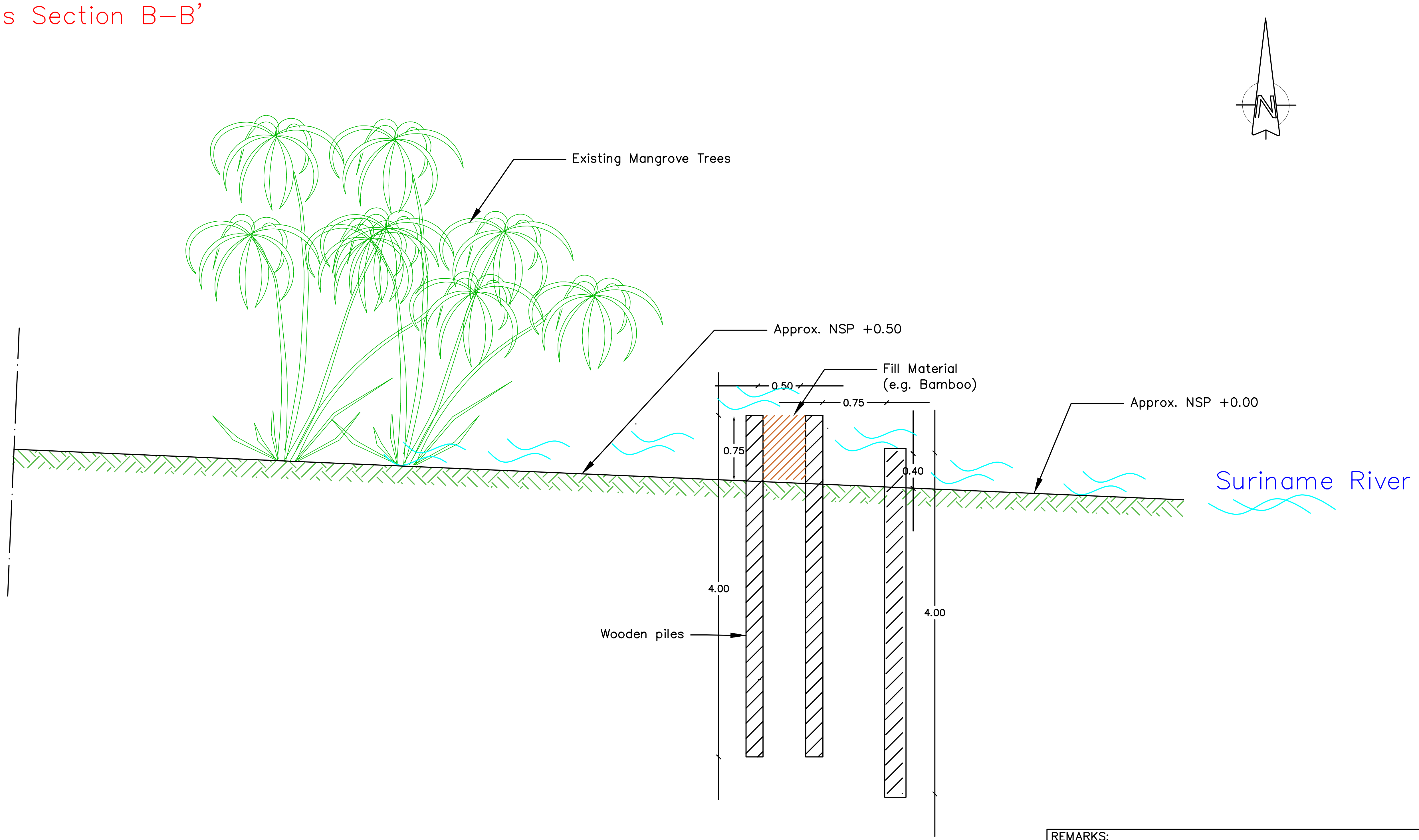
Project number: IS–331

Status: Draft

Drawing Code: SOMM–DW–02

Format: A3 | Scale: 1:500 | Page number: 5

Cross Section B–B'



REMARKS:
– ALL SIZES IN METERS UNLESS OTHERWISE DISPLAYED
– ALL ELEVATION IN METERS
– REFERENCE IN METERS NSP (NATIONAL DATUM)

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ILACO

ADAPTATION STUDY PARAMARIBO

PRELIMINARY DESIGN
Cross Section B–B' Sediment Unit

Format: A3 | Scale: 1:500 | Page number: 6

nr.	discription	drawn by	date
6			
5			
4			
3			
2			
1	Overview Plan	MB	18–6–2018
0	basic drawing	MJ	12–12–2017

checked: AM/RPA

approved: RPA | Project number: IS–331

Status: Draft

Drawing Code:
SOMM–DW–03

Annex E – Environmental and Social Impact Assessment for the Paramaribo Climate Change Adaptation Fund Project

Prepared For:

Inter-American Development Bank

Environmental and Social Impact Assessment for the Paramaribo Climate Change Adaptation Fund Project

July 2018

Inter-American Development Bank
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Prepared for:
Inter-American Development Bank

Environmental and Social Impact Assessment for the Paramaribo Climate Change Adaptation Fund Project

Final

July 2018

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AAL	average annual loss
AF	Adaptation Fund
AoI	Area of Influence
C	Celsius
CBD	Convention on Biological Diversity (United Nations)
CFP	Chance Finds Procedure
CIA	Cumulative Impact Assessment
CO	carbon monoxide
DTM	Digital Terrain Model
ENSO	El Niño -Southern Oscillation
ERM	Environmental Resources Management, Inc.
ESC	Emerging and Sustainable Cities
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
GoS	Government of Suriname (*Republiek Suriname*)
hr	hour
ICOMOS	International Council on Monuments and Sites
IDB	Inter-American Development Bank
IDF	intensity duration frequency
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
km/hr	kilometers per hour
km^2	square kilometers
$L/s/km^2$	liters per second per square kilometers
LVV	Ministry of Agriculture, Animal Husbandry and Fisheries (*Ministerie van Landbouw, Veeteelt en Visserij*)
m	meters
M	Million
m/s	meters per second
m^3/s	cubic meters per second
mg Cl-/L	chloride concentration (milligrams per liter)
mm	millimeters
MARPOL	International Convention for the Prevention of Pollution from Ships (marine pollution)
MAS	Maritime Authority Suriname (*Maritieme Autoriteit Suriname*)
MINOWC	Ministry of Education, Science, and Culture (*Ministerie van Onderwijs, Wetenschap en Cultuur*)
NCCR	National Coordination Centre for Disaster Management (*Nationaal Coördinatiecentrum voor Rampenbeheersing*)
NIMOS	National Institute for Environment and Development in Suriname (*Nationaal Instituut voor Milieu en Ontwikieling in Suriname*)

NO_2	nitrogen dioxide
OWTC	Ministry of Public Works, Transportation and Communication (*Openbare Werken, Transport en Communicatie*)
PS	Performance Standard
PURP	Paramaribo Urban Rehabilitation Program
PWHSMP	Paramaribo World Heritage Site Management Plan
RCIA	rapid CIA
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
ROGB	Ministry of Spatial Planning, Land and Forest Management (*Ministerie van Ruimtelijke, Ordening, Grond en Bosbeheer*)
SBHF	Suriname Built Heritage Foundation (*Stichting Gebouwd Erfgoed Suriname*)
SGES	Foundation Built Heritage (*Stichting Gebouwd Erfgoed Suriname*)
SLR	sea level rise
SMS	SMS Pier
SO_2	sulfur dioxide
SRD	Surinamese Dollar
SRES	Special Report on Emissions Scenarios
STINASU	Foundation for Nature Conservation in Suriname (*Stichting Natuurbehoud Suriname*)
Tr	Ten-year return
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USD	United States Dollars
VECs	Valued Environmental and Social Components
VGZ	Ministry of Health (*Ministerie van Volksgezondheid*)
VOC	volatile organic compounds
WHC	World Heritage Committee
WHS	World Heritage Site
WRI	World Risk Index

EXECUTIVE SUMMARY

The Inter-American Development Bank (IDB) launched the Emerging and Sustainable Cities (ESC) Program (SU-T1081) and the Paramaribo Urban Rehabilitation Program (SU-L1046) (PURP) in Paramaribo, Suriname in 2016. These programs identified that climate risk is a critical concern to Paramaribo and, in particular, the urban area is highly vulnerable to floods due to rising sea levels, increasing intensity of precipitation, and eroding coastal and riverbanks.

Based on this determination, the Government of Suriname (GoS), in consultation with the Housing and Urban Development (HUD) team at IDB, prepared and submitted a concept note proposal to the Adaptation Fund[1] (AF) for funding to deliver an adaptation project in downtown Paramaribo. In March 2017, the AF agreed to endorse the project concept and enclosed a list of required feasibility and related studies to be included in the full application. The IDB has contracted Environmental Resources Management, Inc. (ERM) to prepare the full application, including the enclosed Environmental and Social Impact Assessment (ESIA).

The proposed adaptation Project comprises several components (adaptation measures) that have been selected to address the flood-risks of the Paramaribo waterfront area as Follows and as shown in Figure ES-1:

- Construction of a new flood protection wall;
- Sommelsdijck Canal pump station and sluice gates rehabilitation; and
- Enhancement of mangroves.

These Project components were selected based on a systematic evaluation of multiple plausible alternatives using a series of engineering, financial, environmental and social criteria, in addition to input from stakeholders. The Project will be developed in accordance with national laws and regulations, in addition to the IDB's environmental and social safeguards, and AF's policies and guidelines.

[1] The Adaptation Fund is an international organization that that finances projects and programs to help vulnerable communities in developing countries adapt to climate change

Figure ES-1: Location of Project Components

The Project components are intended to align with the broader concepts for the Paramaribo waterfront area as envisioned by the City of Paramaribo and IDB's PURP.

The Project is anticipated to deliver benefits given the flood protection and resilience outcomes it will provide, however it is also acknowledged that the Project could also potentially lead to environmental and social impacts. Potential environmental and social impacts resulting from Project-related activities include:

- Emissions and noise from construction vehicles and equipment;
- Loss or disturbance of vegetation and wildlife;
- Wildlife injury or mortality;
- Habitat alteration (mangroves and aquatic);
- Loss of income for transport businesses and workers;
- Loss of view of the water (i.e., visual impacts);
- Disproportionate impacts on vulnerable groups;
- Decreased pedestrian and traffic safety;

- Increased traffic congestion and disruption;
- Decreased access to critical facilities, shopping, bus stops etc., resulting in the decrease of tourism;
- Loss of cultural heritage site authenticity and site value; and
- Damage to undiscovered archaeological sites.

Based on this assessment, none of the abovementioned impacts were determined to be major and would all be reduced to minor or negligible with the implementation of appropriate mitigation measures. An Environmental and Social Management Plan (ESMP) has been developed outlining the measures and actions necessary to further minimize impacts to acceptable levels. In addition, implementation of the Project would result in positive environmental and social impacts as the Project components would address Paramaribo's significant flood and climate-change related risks.

1.0 INTRODUCTION

Previous studies performed in Paramaribo have determined that the urban area of Paramaribo is considered highly vulnerable to floods due to sea level rise, increasing precipitation intensity, and loss of land due to coastal and riverbank erosion. The downtown area of Paramaribo has been designated as a United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Site (WHS) due to its cultural significance, and is legally protected by Suriname law and international treaties. Based on its highly vulnerable determination, the Inter-American Development Bank (IDB), in coordination with the Government of Suriname (GoS), prepared and submitted a concept note proposal to the Adaptation Fund (AF) to apply for grant funds for adaptation proposals in downtown Paramaribo. The AF is an international organization that finances projects and programs to help vulnerable communities in developing countries adapt to climate change.

The concept note proposed four objectives:

1. Implement a group of strategic and cost-effective adaptation hard and soft measures in the historic downtown area of Paramaribo that illustrate the benefits of building climate resilience as part of a long-term planning strategy for the city and its metropolitan area.
2. Establish a framework for managing knowledge and disseminating lessons learned that could be used in future resilience programs for the city of Paramaribo and that could be part of a city-level Adaptation Plan.
3. Build capacity across local communities and GoS stakeholders responsible for decision making in Paramaribo to ensure strong implementation and enforcement of the Adaptation Plan.
4. Ensure that there is a robust plan and implementation structure to allow the Project to be implemented, monitored, evaluated, and lessons-learned disseminated.

In March 2017, the AF Board, at its twenty-ninth meeting in Bonn, Germany, agreed to endorse the Project concept. Along with the endorsement, the Board also included a list of observations that need to be addressed in the full proposal document. Among other comments, AF requested for a comprehensive livelihoods assessment in order to minimize disruption to local businesses and residents during physical works, and for further consultations during the project preparation process. The IDB has contracted Environmental Resources Management, Inc. (ERM) to prepare the full application to the AF. The application builds off the IDB's existing work, namely the Emerging and Sustainable Cities (ESC) Program that is being implemented in Paramaribo (SU-T1081), and the IDB's Paramaribo Urban Rehabilitation Program (PURP) (SU-L1046), both of which have identified climate risk and change as a critical issue.

This Environmental and Social Impact Assessment (ESIA) has been prepared as part of a series of studies and assessments being prepared in support of the AF full application. The ESIA focuses in on the selected group of strategic and cost-effective adaptation hard measures proposed for the downtown area of Paramaribo as part of the AF full application.

1.1 PROJECT BACKGROUND

As part of preparing the full application to the AF, ERM assessed a series of potential adaptation measures that could be implemented along the waterfront (*Waterkant Street*) area of the historic urban center of Paramaribo, which is the core zone of the WHS and where flooding is known to be an issue (see Figure 1-1). Adaptation measures considered include hard and soft engineering options ranging from constructing floodwalls to planting mangroves that would aid in minimizing erosion and wave energy.

The suite of adaptation measures were assessed using a range of engineering, environmental, social (including consultations), and economic criteria with a view to selecting a preferred option (or options) that would form the basis of the AF application. The result of this identification, screening, and prioritization of adaptation measures represents the "Project" or "Project components" referenced throughout this document, and it is these that are the focus of this ESIA. Please see Section 3.2 on Alternatives Analysis for additional commentary.

Source: ERM 2017

Figure 1-1: Project Location in Downtown Paramaribo (Blue Boundary indicates the area of focus for this Assessment)

1.2 PURPOSE AND NEED FOR THE PROJECT

Floods in Paramaribo principally occur because large parts of the city were built on low-lying lands in very close proximity to the Suriname River, the city has a poor stormwater drainage infrastructure system relative to the current population size and urban growth. Furthermore, limited maintenance of the drainage infrastructure creates further problems including waste and debris blocking existing drainage channels. A flood protection wall has already been constructed in the area; however, flooding continues to be an issue. The Suriname River is tidally influenced, and when the river's high water level is combined with runoff from impermeable areas, flooding affects the properties along the waterfront and along the canals. These issues will be exacerbated with climate change and flooding in the downtown area of Paramaribo is expected to get worse.

Successful Project implementation would lead to decreased flooding in downtown Paramaribo, which in turn would help with the sustainability and protection of this WHS as well as decreased risk to the health and safety of the people who live and work in the area. The "No Project" alternative would provide no protection to the Project area and could eventually lead to irreversible harm to the WHS (see Section 3. 2, Alternatives Analysis).

1.3 OBJECTIVES AND SCOPE OF THE ESIA

The objective of this ESIA is to assess the Project's environmental and social impacts and its alignment with IDB and AF policy requirements. While it is anticipated that the Project would have a benefit to the community, the potential exists for environmental and social impacts to occur. This document describes the potential positive and negative effects of the Project and recommends an environmental and social management system to be put in place to augment positive effects and mitigate, manage, and monitor potential adverse impacts and risks for the life of the Project.

This ESIA has the following main objectives:

- Identify positive and/or negative changes in the human and natural environment that may affect the quality of life, as well as current and future options for sustainable social and economic development in the Project's Area of Influence (AoI), also referred to in this ESIA as the Project Area.
- Identify measures to minimize negative impacts and enhance positive impacts of the Project, following the mitigation hierarchy.[2]

---

[2] The mitigation hierarchy includes the following steps to manage potential adverse impacts of a proposed activity: avoid, reduce/minimize, remedy/restore and offset.

- Analyze alternatives and recommendations for the best course of action inclusive of any relevant prevention or mitigation measures.

The ESIA process included the following activities:

- Establishment of an environmental and social baseline through the following:
  - A document review including the documentation and information ERM is collating for the Paramaribo Emerging and Sustainable Cities (ESC) program study in addition to other documentation from the GoS and other sources.
  - A site reconnaissance including visual observation of the relevant areas directly and indirectly affected by the Project, meetings with relevant individual/groups/ organizations, and data and information collection.
  - Selected data collection such as through stakeholder engagement activities.
  - Census and Socio-Economic Survey of the Livelihood Restoration Plan (LRP). For details, see Appendix D.
- Evaluation of the legal and regulatory framework applicable to the Project (particularly related to the management of the WHS), including IDB and AF policy requirements.
- Assessment of the potential environmental, social, cultural, health, safety, and labor impacts and risks associated with the Project
- Recommendations for mitigation, management, and monitoring required for the Project in an Environmental and Social Management Plan (ESMP).

A meaningful public consultation with affected parties (following IDB's OP-703 B6) is being carried out to review the main contents and proposals included in this document. Its main comments and conclusions will be reviewed and addressed in the final version of this assessment. For details, see Appendix A (Stakeholder Engagement Plan and Stakeholder Meeting Reports) It should be noted that this ESIA has been prepared to principally address the IDB and AF policy requirements only. While the ESIA does also consider the local regulatory requirements, it has not been formally submitted through the GoS as part of the process to gain GoS approval and/or permits/licenses for works to progress. Any such process and requirements will be implemented if the application to the AF is successful and the Project is actively progressed.

1.4 SCOPING PROCESS AND RESOURCES CONSIDERED IN THIS ESIA

Due to the nature of the type of activities involved with this Project, this ESIA focuses on the relevant existing physical, biological, socioeconomic and sociocultural environments within the Project Area. Because Project activities would be located in previously developed areas within the highly urbanized area of downtown Paramaribo, the baseline conditions for the following resources are described in general for the entire downtown: biodiversity, air quality, noise, and natural hazards. The socioeconomic and cultural baseline, although based largely on previous studies conducted as part of the IDB's ESC and PURP programs, has been updated and tailored to the areas specific to the Project activities.

2.0 *POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK*

This section evaluates the existing institutional and regulatory frameworks including IDB Safeguard Polices applicable to the Project, including a review of applicable legislation and institutions on the management of the WHS.

2.1 *LEGAL AND ADMINISTRATIVE FRAMEWORK*

2.1.1 *National Legislation*

Suriname's national legislation is exercised through Laws or Acts of Parliament (Wet, also called Verordening and Landsverordening prior to 1975), Decrees (Decreet)1, Government Decree (Staatsbesluit), Presidential Decree (Resolutie), Presidential Orders (Presidentieel Besluit) or Ministerial Orders (Ministeriële Beschikking) targeting various sectors including industry, tourism, nature conservation, etc. Suriname has had legislation on the historic environment since the 1950s. A legal Assessment and Gap Analysis of national technical standards, coastal management regulations, and building codes was prepared and is included in Appendix I. This section provides a summary of relevant regulations, including those specifically addressing the WHS:

- The 2002 Environmental Act: This draft act, as it has not yet been passed by Parliament, defines the rules for environmental conservation, management, and protection while promoting sustainable development. The provisions of the Act provide guidance for conducting an ESIA in Suriname, including the principles of access to information, participation and legal protection for stakeholders.
- The Hindrance Act (Hinderwet 1930, 1944, and 1972): This act defines the permit requirements to control noise and air pollution for industrial development projects. The permits are issued and enforced by local District Commissioners (Buursink 2005; SRK Consulting 2007).
- The Nature Conservation Act (Natuurbeschermingswet 1954): This act defines the procedures to establish and manage conservation areas and protect wildlife.
- The Monuments Act (1963, revised 2002): This was the first legislation that focused on the protection of built heritage that includes unique monuments and archaeological assets. This Act was revised in 2002. In the revision, the Act established the Monuments Committee. It also provides general guidance to maintain both designated historic monuments as well as city and town views. The International Council on Monuments and Sites (ICOMOS), Suriname Built Heritage Foundation (SBHF), and the Monuments Committee are collaborating on providing proposed revisions to the Act to accommodate the Paramaribo WHS.

- The Building Act (1958): This act oversees licenses for new construction and residential areas in Suriname.
- The Building Code (1956, revised in 2002): This Code provides the rules for new construction and requires that construction be done in accordance with land use plans.
- The Roads Authority Act (1995): This Act establishes the requirements for managing roads and bridges and gives the Roads Authority the responsibility of providing guidance for construction, rehabilitation and maintenance of primary roads and bridges (as determined by the State Order on Primary Roads of 2001).
- The Harbours Act (1981): This Act establishes rules and regulations for the harbor, prohibiting discharges of waste, oil, oil-contaminated water and unauthorized goods into public waters. According to Art. 11, a permit is needed from the Harbour Master to install any kind of jetty or mooring structure.
- The Town Planning Act (1972): The Act established that the Ministry of Public Works (Openbare Werken, Transport en Communicatie, OWTC) that is responsible for the execution of spatial planning and development of urban areas.
- The Planning Act (1973): The Act established that the Ministry of Planning and Development Cooperation is responsible for a comprehensive and sustainable policy for spatial, ecological, and socioeconomic issues.
- The Monuments List of Paramaribo: This list includes monuments that the Ministerial Resolution of Paramaribo has designated as protected.
- The State Resolution for Monuments Registration (2000): This Resolution registered all designated monuments as officially protected. The Monuments Committee maintains the register.
- The State Resolution for establishing an Aesthetic Building Committee (2001): This Resolution formally designated the Historic Inner City of Paramaribo as a conservation zone with two buffer zones. It also created the Building Committee, which supervises building plans. The Committee has the authority to evaluate building plans according to a special set of building criteria (building codes), which were published in 2003 to control new construction within the WHS and buffer areas.
- State Resolution on the implementation of Article 4, Section 2 of the Building Code of 1956: This Resolution was approved by the President of the Republic of Suriname in 2011 (S.B. 31 October 2011 No. 74). The resolution established an Expert Building Committee (Special Advisory Committee) to review new building plans within the site according to aesthetic criteria for modern architecture, which were published in the Gazette.

- The Government Declaration (Regeringsverklaring 2016-2020) (GoS 2015): This declaration mandates an efficient and effective approach to environmental management and includes governmental goals to establish sustainable development practices.
- The Multi-Annual Development Plan (MOP): An MOP is drafted every five years and submitted to Parliament for approval; and the current plan is for 2017-2021. It is a government policy that includes a national development strategy for sustainable development and use of biological resources.
- The National Biodiversity Strategy (NBS): The NBS establishes goals and strategic directions to be pursued in order to conserve and sustainably use Suriname's biodiversity and biological resources.

2.1.2 National Institutions

Several government institutions are responsible for legal guidance of the Paramaribo WHS and have responsibilities in its management. This section provides a brief breakdown of the relevant ministries and agencies and their responsibilities for the management of the WHS and the Project components comprising the Application.

2.1.2.1 Ministry of Public Works, Transport and Communication

The Project will be led by the OWTC (the Project proponent), which is responsible for planning, building, and constructing road and walkway infrastructure, public transportation including the placement of bus stops, parking, drainage, sewage, waste management, green zones, park development, the development of tourism, bridges, sea walls, and dikes in the Paramaribo WHS. The OWTC is also responsible for maintaining all state-owned buildings, including listed monuments. An Expert Building Committee within this Ministry is appointed by the Minister of Public Works. The Expert Building Committee is responsible for new buildings in the preserved area of the Paramaribo WHS and its buffers.

2.1.2.2 Ministry of Education, Science, and Culture

The Ministry of Education, Science, and Culture (MINOWC) is responsible for the development of policies to enhance the protection of the Historic Site and its monuments. The Department of Culture within the Ministry is responsible for maintaining the historic Garden of Palms and the Fort Zeelandia within the Paramaribo WHS.

The SBHF was established in 1997 within the MINOWC by the Ministry of Education and People's Development, the predecessor of MINOWC. Its responsibilities include setting up an infrastructure to preserve and manage the historical built heritage in Suriname. Further, SBHF is responsible for implementing the Paramaribo World Heritage Site Management Plan 2011-2015 (PWHSMP), which was developed in response to the UNESCO designation of

Paramaribo as a WHS. SBHF is a not-for-profit organization composed of different economic groups (banks, companies) whose mandate is to purchase heritage buildings, restore them, and then sell or rent them to new tenants. The foundation has completed these activities for two buildings and is currently working on several others.

The Monuments Committee is another advisory board within the MINOWC. It is responsible for monitoring the implementation of laws, formulating policies, and administering the Monuments Register. The Commission, in turn, appoints a Site Administrator, whose role is to follow up, verify, document, and manage the actions and performance of the different institutions and actors under the regulations and parameters established in the PWHSMP. To maintain the WHS designation, the GoS also established a Special Committee of Construction Experts, whose mandate is to provide guidance to the OWTC regarding approvals for new development, restoration, public works, urban design, and other programs of a similar nature within the boundaries of the Paramaribo WHS and its buffer zones.

2.1.2.3 Ministry of Regional Development – District Commissioner

Paramaribo is administratively divided into two geographic regions, which are each headed by a District Commissioner: Paramaribo North–East and Paramaribo South–West. The Paramaribo District is further subdivided into 12 resorts. The District Commissioner is responsible for issuing licenses to all resort users including, but not limited to, shops, parking, businesses, cultural activities, and advertisements on public spaces. The District Commissioner is also responsible for monitoring the effects of licenses and is responsible for applying sanctions.

2.1.3 Environmental Management

Suriname is governed according to the 1987 Constitution of the Republic of Suriname. Suriname does not have a single comprehensive environmental policy and there is no legislation dealing specifically with environmental management. However, environmental legislation is currently being developed. As previously mentioned, the National Institute for Environment and Development in Suriname[3] (NIMOS) released guidelines for environmental and social impact assessments. These guidelines have been updated in the recent Guidance Note NIMOS Environmental Assessment Process (2017), effective January 2018. Based upon the current scope of this Project, this Project will likely be categorized as a Category B[4] project; however, it is up to NIMOS to screen the project and determine the level of ESIA required. If AF funding is secured and the Project

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[3] *Nationaal Instituut voor Milieu en Ontwikieling in Suriname*

[4] Projects whose impact depends on the sensitivity of the location, scale and predictability

proceeds, NIMOS will be consulted (by the Ministry of Works as the Project proponent) to determine the level of environmental assessment required.

Responsibility for environmental and natural resource management at the national level in Suriname is divided among different government institutions in as described in various pieces of legislation.

In the environmental field, responsibilities are spread among a number of government organizations. Environmental management and protection are the responsibility of the National Council for the Environment and the NIMOS. NIMOS is an executing arm of the National Council for the Environment (President's Office). Under the Draft Environmental Act, the objectives for NIMOS are to act as the main governing body responsible for enforcing environmental laws and regulations, as well as managing and effecting new laws and developing subsidiary legislation. The mission of NIMOS is to initiate the development of a national legal and institutional framework for environmental policy and management in the interest of sustainable development through the Office of Environmental and Social Assessment. The Cabinet of the President, Security, and Environment (formerly the National Council for the Environment), is an advisory body of the GoS, established by Presidential Decree in 1997, which supports NIMOS in the area of policy and advice.

In addition, a number of agencies and departments are responsible for environmental protection, such as enforcing existing environmental regulations and contributing to environmental planning activities, as summarized in Table 2-1.

Table 2-1: Legal Framework for National Environmental Management in Suriname

Government Stakeholder	**Role**
Cabinet of the President: Security and Environment (*veiligheid en milieu Linscheer*) (Formerly the National Council for the Environment)	Environmental management and protection. Preparation of environmental policy at the national level and exercise of control in its implementation.
National Institute for Environment and Development in Suriname (*Nationaal Instituut voor Milieu en Ontwikieling in Suriname* [NIMOS])	Environmental management and protection. Main governing body responsible for enforcing environmental laws and regulations as well as managing and effecting new laws and developing subsidiary legislation.
Ministry of Natural Resources (*Ministerie van Natuurlijke Hulpbronnen*)	Responsible for policy direction, legislation, issuance of permits, budget allocation and inter-ministerial coordination, and for all matters relating to natural resources (not fisheries).
Nature Conservation Division (*Natuurbeheer*) of the Suriname Forest Service	Manages natural reserves and parks (not Brownsberg Nature Park). Supports ROGB (below) in management and law enforcement regarding conservation, nature reserves, and wildlife.
Foundation for Nature Conservation in Suriname (*Stichting Natuurbehoud Suriname* [STINASU])	A non-governmental organization that assists the Forest Service in managing nature reserves. Manages Brownsberg Nature Park and others

Government Stakeholder	Role
	Responsible for nature tourism and promoting public environmental awareness campaigns.
Ministry of Spatial Planning, Land and Forest Management (*Ministerie van Ruimtelijke, Ordening, Grond en Bosbeheer* [ROGB])	Performs land use planning. Manages and enforces laws regarding conservation, nature reserves, and wildlife.
Ministry of Agriculture, Animal Husbandry and Fisheries (*Ministerie van Landbouw, Veeteelt en Visserij* [LVV])	Manages land and water used for agricultural purposes; manages fish resources; controls water quality.
Sub-directorate of Fisheries (*Onder Direkteur van de Visserij Dienst*)	Manages fish resources. Enforces Fish Protection Act and Sea Fisheries Decree.
Ministry of Health (*Ministerie van Volksgezondheid* [VGZ])	Manages environmental health (infectious diseases, food quality, water quality, industrial waste disposal, water-soil-air quality standards vis-à-vis human health).
Maritime Authority Suriname (*Maritieme Autoriteit Suriname* [MAS])	Manages maritime traffic.
National Coordination Centre for Disaster Management (*Nationaal Coördinatiecentrum voor Rampenbeheersing* [NCCR])	A Division of the Ministry of Defense. Develops national policies on disaster management through coordination and prevention of potential threats and disasters.

Source: CSA 2015

The Draft Environmental Act of 2002 is a framework law that was prepared as a result of the Rio Declaration of 1992 in order to introduce international legal requirements into Suriname's environmental legislative scheme. This Draft Act establishes an Environmental Authority, a Supervisory Board, an Environmental Fund, and an Inter-Ministerial Advisory Committee. It also states the need for an ESIA for all new economic activities that might have an adverse impact on the environment. The ESIA must include tools for pollution control. It also requires permits for waste management and contingency plans for potential accidents that may cause environmental pollution. An important step in the Draft Act is the granting of public participation in the decision making process related to projects that may have an adverse effect on the environment.

The Planning Act of Suriname, which originated in 1973, establishes procedures for national and regional land use planning and provides guidelines for drafting land use plans. This Act also empowers the GoS to establish protected areas other than nature reserves such as special management areas. Laws on the issuance of state-owned lands provide for the issuance of long-term leases for management of public lands including environmental management.

2.1.4 Applicable International Conventions and Agreements

The GoS has also ratified and complied with the terms of several international treaties and accords. These have been designed to formalize cooperation on regional and global environmental protection strategies. In this regard, Suriname has signed Agenda 21 and is party to the following conventions and agreements:

- United Nations Convention on Biological Diversity (CBD)
- The Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (Western Hemisphere Convention)
- The Ramsar Convention (The Convention on Wetlands of International Importance)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora
- Amazon Cooperation Treaty
- United Nations Convention on the Law of the Sea
- International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
- International Covenant on Civil and Political Rights
- International Covenant on Economic, Social and Cultural Rights
- American Convention on Human Rights
- United Nations Framework Convention on Climate Change
- World Heritage Convention, including the associated United Nations Educational, Scientific and Cultural Organization (UNESCO) guidelines[5]
- Other relevant international conventions

2.2 *INTERAMERICAN DEVELOPMENT BANK SAFEGUARDS AND COMPLIANCE*

The IDB has established its own policies and safeguards to ensure that projects financed by the IDB group are sustainable (see Table 2-2). These environmental and social policies are guided by international best practices, and are relatively consistent with widely used International Finance Corporation (IFC) guidelines regarding environmental, health, and social management.

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[5] The UNESCO guidelines provide operational guidance for the implementation of the World Heritage Convention by setting forth a procedure for: the inscription of properties on the World Heritage List and the List of World Heritage in Danger, the protection and conservation of World Heritage properties, the granting of international assistance under the World Heritage Fund, and the mobilization of national and international support in favor of the World Heritage Convention.

Table 2-2: IDB Policies

IDB Policies	Policy Description
OP-703 – Environmental and Safeguards Compliance Policy	The Policy has three specific objectives: (i) To enhance long-term development benefits by integrating environmental sustainability outcomes in all Bank operations and activities and strengthening environmental management capacities in its borrowing member countries (ii) To ensure that all Bank operations and activities are environmentally sustainable (iii) To foster corporate environmental responsibility within the Bank The Policy has two sets of directives, as follows: • *Environmental Mainstreaming (Directives A.1 through A.7),* which refer to the concept of mainstreaming environmental issues and upstreaming them early on during the project cycle. • *Safeguarding Directives (Directives B.1 through B.16)* – allow the Bank to adopt a more effective and efficient risk management framework. Safeguards are applied throughout the project cycle to ensure the environmental sustainability of all Bank-financed operations. The Environmental Safeguards Directives are: B.1 Bank Policies; B.2 Country Laws and Regulations; B.3 Screening and Classification; B.4 Other Risk Factors; B.5 Environmental Assessment Requirements; B.6 Consultations; B.7 Supervision and Compliance; B.8 Transboundary Impacts; B.9 Natural Habitats and Cultural Sites; B.10 Hazardous Materials; B.11 Pollution Prevention and Abatement; B.12 Project Under Construction; B.13 Noninvestment Lending and Flexible Lending Instruments; B.14 Multiple Phase and Repeat Loans; B.15 Co-financing Operations; B.16 In-country Systems; B.17 Procurement.
OP-710 Involuntary Resettlement Policy	This document presents the principles and strategies to be followed in the case of Bank-financed development projects that result in involuntary relocation and includes specific guidelines on preparing resettlement plans. The guidelines are meant to assist the Bank and borrowers in mitigating the negative impacts of compulsory relocation on individuals and communities, and in assisting the affected populations to establish a sustainable society and economy.
OP-761 Gender Equality in Development	This Policy integrates a gender perspective that seeks equal conditions and opportunities for women and men to reach their social, economic, political, and cultural potential by providing specific mechanisms for ensuring the effective implementation of the Policy and the evaluation of its results.
OP-765 Indigenous Peoples Policy	The objectives of this policy in the context of the social and environmental quality review of its projects is to strengthen *standards and guidelines* on sociocultural relevance and feasibility in order to avoid, mitigate, compensate, or offset adverse impacts and safeguard indigenous peoples' legitimate interests and rights. Such standards and guidelines will take into account the points of view of indigenous peoples, and will be incorporated into the Bank's safeguards and environmental procedures using specific operational guides approved by Management's Programming Committee.
OP-704 – Natural and Unexpected Disasters Policy	The Policy has two interrelated specific objectives: i) To strengthen the Bank's effectiveness in supporting its borrowers to systematically manage risks related to natural hazards by identifying these risks, reducing vulnerability, and preventing and mitigating related disasters before they occur ii) To facilitate rapid and appropriate assistance by the Bank to its borrowing member countries in response to disasters in an effort to efficiently revitalize their development efforts and avoid rebuilding vulnerability
OP-102 Access to Information Policy	This Policy is based on the principle that information concerning the Bank and its activities must be made available to the public in the absence of a

IDB Policies	Policy Description
	compelling reason for confidentiality. Information provided to the public must be made available in a form and at a time that enhances the transparency and therefore the quality of Bank activities.

Regarding environmental and social issues, the Project triggers the following directives of the Environment Safeguard Policy (OP-703):

- B.1, Bank Policies: The Bank will only finance operations and activities that comply with the directives of this policy and are consistent with the relevant provisions of other Bank policies. This policy ensured the borrower/executing agency has legislation in place that promotes environmental management, training, and environmental governance, and also promotes conservation and sustainable use of natural resources.
- B.2, Country Laws and Regulations: Project activities must comply with all Suriname laws and regulations, including the preparation of an ESIA if the AF approves the Project and the grant is given to the GoS. Applicability will be determined once the Project funding is approved and activities are clearly defined.
- B.3, Screening and Classification: The Project will have impacts on the environment and the community. The Project is classified as Category "B". In accordance with OP-703, Category B projects "are likely to cause mostly local and short-term negative" impacts, for which "effective mitigation measures are readily available". These will be further discussed in this ESIA as well as the Project's ESMP.
- B.4, Other Risk Factors: The Project's executing agency needs to comply with the ESIA and ESMP requirements. Therefore, the executing agency and relevant third parties will be required to develop appropriate measures for managing the identified risks, such as a LRP for economic displacement of Affected Persons (Appendix D).
- B.5, Environmental Assessment Requirements: This ESIA addresses the IDB's requirement for environmental assessment for the Project.
- B.6, Consultations: An initial public consultation was conducted on 8 November 2017 to discuss possible alternatives and receive initial stakeholder feedback. Consistent with the IDB's Access to Information Policy (OP-102) and this policy (OP-703), the Draft ESIA was made available to the public and further meaningful consultation with affected parties was carried out in three separate engagements between 04 and 06 July 2018. The report on these final public consultations is available as an Appendix of this ESIA. In addition, consistent with the IDB's Involuntary Resettlement Policy (OP-710) and OP-703 (for economic displacement), specific public consultations will be conducted with potentially affected stakeholders in the immediate Project to present and discuss the LRP included as an Appendix of this ESIA.

- B.7, Supervision and Compliance: A monitoring plan will be implemented for the Project as part of the Project's ESMP.
- B.9, Natural Habitats and Cultural Sites: The Project is located in downtown Paramaribo, which is a WHS. This directive requires the development of mitigation and monitoring measures to mitigate impacts addressed in this ESIA and the ESMP.
- B.11, Pollution Prevention and Abatement: Project activities have a risk of pollution, specifically during the construction phase. Pollution prevention is addressed in the Project's ESMP (see Section 6.0).
- B17. Contractor clause for implementation of ESMP

Additionally, the Project triggers the IDB's Access to Information Policy (OP-102), the Gender Equality in Development Policy (OP-761), Diasaster Risk Management Policy (OP-704), Involuntary Resettlement Policy (OP-710), and the Indigenous Peoples Policy (OP-765). When it comes to financing projects, it is the Bank's intent to be as clear and transparent as possible and, through clear stakeholder communication, to improve the quality of its operations.

2.3 ADAPTATION FUND POLICIES AND GUIDELINES

The AF finances climate adaptation projects in developing countries that are parties to the Kyoto Protocol and the Climate Change Convention, ratified by Suriname in 2006 and 1997, respectively. The Adaptation Fund Board has created Strategic Priorities, Policies and Guidelines in order to ensure the appropriate implementation of its funds. Of particular importance to this Project are the AF's Environmental and Social Policy (ESP) and Gender Policy. These policies are to be applied throughout all of the Project's implementation phases, including design, execution, monitoring, and evaluation.

The AF's ESP ensures that projects supported by the AF promote positive environmental and social benefits and mitigate or avoid adverse environmental and social risks and impacts. The AF's ESP contains 15 principles, as presented in Table 2-3 below.

In order to be approved for funding, the Implementing Entity needs to demonstrate its capacity to screen and assess risks, avoid adverse impacts where possible, develop an ESMP, and monitor the work done by the Executing Entity.

Table 2-3: AF Principles

Principle	**Requirements for Funding**
1 - Compliance with the Law	Projects shall be in compliance with all applicable domestic and international law.

Principle	Requirements for Funding
2 - Access and Equity	Projects shall provide fair and equitable access to benefits in a manner that is inclusive and does not impede access to basic health services, clean water and sanitation, energy, education, housing, safe and decent working conditions, and land rights.
3 - Marginalized and Vulnerable Groups	Projects shall avoid imposing any disproportionate adverse impacts on marginalized and vulnerable groups.
4 - Human Rights	Projects shall respect and where applicable promote international human rights.
5 - Gender Equality and Women's Empowerment	Projects shall be designed and implemented in such a way that both women and men 1) have equal opportunities to participate as per the Fund gender policy; 2) receive comparable social and economic benefits; and 3) do not suffer disproportionate adverse effects during the development process.
6 - Core Labor Rights	Projects shall meet the core labor standards as identified by the International Labor Organization.
7 - Indigenous Peoples	Projects shall be consistent with the rights and responsibilities set forth in the UN Declaration on the Rights of Indigenous Peoples and other applicable international instruments relating to indigenous peoples.
8 - Involuntary Resettlement	Projects shall be designed and implemented in a way that avoids or minimizes the need for involuntary resettlement.
9 - Protection of Natural Habitats	The Fund shall not support projects that would involve unjustified conversion or degradation of critical natural habitats.
10 - Conservation of Biological Diversity	Projects shall be designed and implemented in a way that avoids any significant or unjustified reduction or loss of biological diversity or the introduction of known invasive species.
11 - Climate Change	Projects shall not result in any significant or unjustified increase in greenhouse gas emissions (GHGs) or other drivers of climate change.
12 - Pollution Prevention and Resource Efficiency	Projects shall be designed and implemented in a way that meets applicable international standards for maximizing energy efficiency and minimizing material resource use, the production of wastes, and the release of pollutants.
13 - Public Health	Projects shall be designed and implemented in a way that avoids potentially significant negative impacts on public health.
14 - Physical and Cultural Heritage	Projects shall be designed and implemented in a way that avoids the alteration, damage, or removal of any physical cultural resources, cultural sites, and sites with unique natural values recognized as such at the community, national or international level.
15 - Lands and Soil Conservation	Projects shall be designed and implemented in a way that promotes soil conservation and avoids degradation or conversion of productive lands or land that provides valuable ecosystem services.

Based on the Environmental and Social screening performed for AF Programme Proposal, the Project is Categorized as a Category B Project: Projects/programmes with potential adverse impacts that are less adverse than Category A projects/programmes, because for example they are fewer in number, smaller in scale, less widespread, reversible or easily mitigated.

A technical review of the Programme Proposal was carried out by the AF Board Secretariat (January 2017). According to the Proposal review, the Principles deemed most necessary for further assessment and management for the Project were:

- 2. Access & Equity;
- 3. Marginalized and Vulnerable Groups;
- Human Rights;
- Gender Equity and Women's Empowerment: to be assessed through this ESIA;
- 9. Protection of Natural Habitats; and
- 14. Physical and cultural heritage.

These Principles are further assessed throughout out this ESIA and the ESMPs.

3.0 DESCRIPTION OF THE PROPOSED PROJECT

The Project consists of several components (adaptation measures) that have been selected to address the flood-risks of the Paramaribo waterfront area. The adaption measures include floodwall, green infrastructure, and drainage system improvements as discussed in Section 3.1 below. The Project components are intended to align with the broader concepts for the Paramaribo waterfront area as envisioned by the City of Paramaribo and IDB's PURP.

3.1 SELECTED PROJECT COMPONENTS

After a thorough selection process (see Section 3.2), the following three components were selected as the preferred alternatives which will comprise the Project:

- Construction of a new flood protection wall;
- Sommelsdijck Canal pump station and sluice gates rehabilitation; and
- Enhancement of mangroves.

Figure 3-1 depicts the location of these components within downtown Paramaribo and the following sections describe each component in more detail.

Figure 3-1: Location of Project Components

3.1.1 Construction of a New Flood Protection Wall

The existing shore protection consists of a brick retaining wall, which has collapsed in several areas, mainly because of erosion and wear and tear over time (see Figure 3-2 below). Although the exact date of construction for the wall is unknown, it was present in historic photographs dating back to the 1940's. As part of this Project, this historic flood wall on the south side of Waterkant Street will be replaced with a modern sheet pile wall extending approximately 250 meters from Knuffelsgracht Street to the SMS Pier along the south side of *Waterkant* Street (see Figures 3-3 and 3-4).

Figure 3-2: Existing Historic Flood Protection Wall – Note Extensive Disrepair

The proposed sheet piles will be coated to protect them against corrosion. The steel sheet pile wall will be reinforced along the river side with locally available riprap/stone and finished with a concrete/brick cap. The rip-rap provides erosion controls and sufficient passive pressure to keep the steel sheet piles stable. The rip-rap will be designed with a slope not steeper than 1 vertical (V): 3 horizontal (H). On the river side of the current wall, the existing shore level is high due to silt sedimentation, so a portion of the shoreline will be excavated to enable the placement of the rip-rap.

The existing sidewalk along the new flood protection wall will also be rehabilitated and extended to meet the new wall location (new flood wall will be located approximately 2-3 m from the existing brick retaining wall). Similarly, a new stormwater drainage system will be installed along the flood wall, under the new sidewalk, connected to the existing stormwater inlets. The drainage will then discharge collected stormwater to the river through two outlets with check valves (non-return) to protect the area from inflow during high water levels in the river.

The existing landing for water taxis (small boats), including its roof, will be rehabilitated, and the entrance will be made suitable for use by the water taxis after construction of the new and taller flood protection wall. Additionally, the existing standards of these facilities will be improved to ensure enhanced accessibility for patrons with disabilities. As part of stakeholder interviews held in May 2018 with representatives from the water taxis, temporarily relocating the water taxi landing to the “old steel jetty” 100 meters east of their existing location was discussed, and stakeholders were satisfied with the proposal, emphasizing its feasibility in view of its temporary nature and the fact that safe and proper facilities would be put in place at the temporary location in advance. This will be further discussed as part of future engagements.

Part of the nearby existing parking area for public transportation (see Figure 3-3) will be used during construction of the flood protection wall and rehabilitated after. As part of early engagements with representatives from the buses in May 2018, temporarily relocating buses to the parking in the general area along Riverside/Broki and along the main road in close cooperation with the Traffic Police was discussed and was considered the preferred option by those consulted. This will also be further discussed as part of future engagements.

Figure 3-3: Aerial View of Waterfront (Along Waterkant Street)

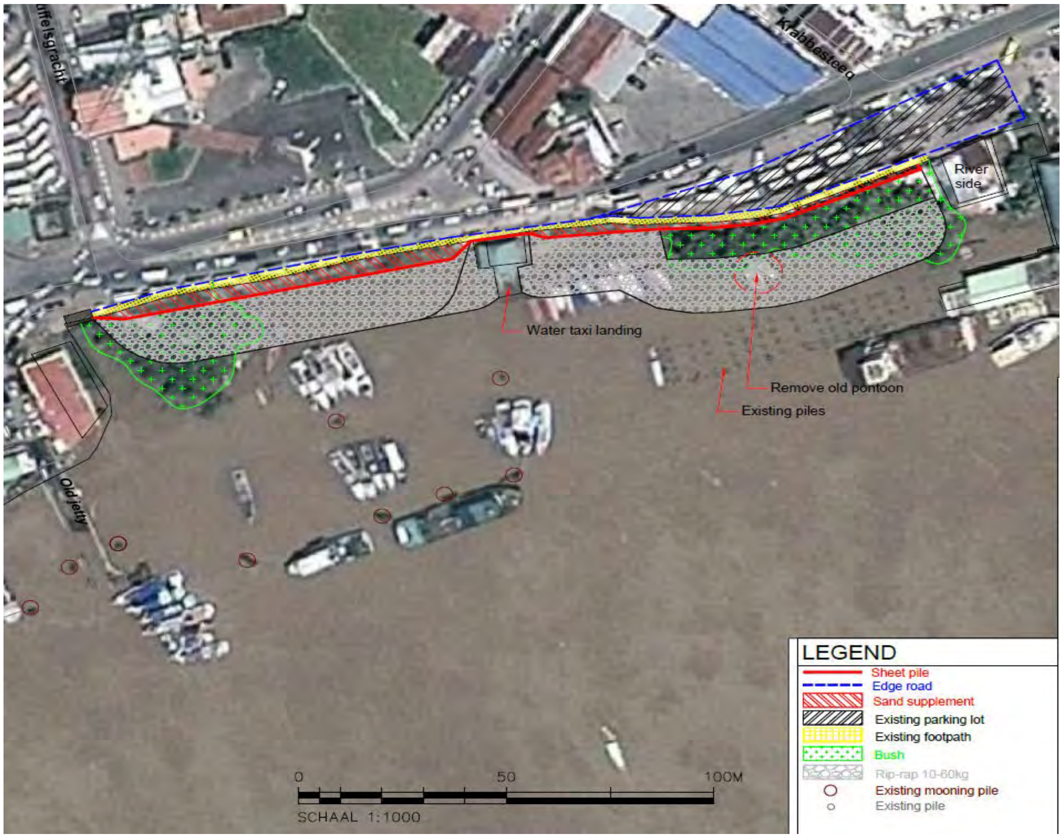


Figure 3-4: Concept for the New Flood Wall

3.1.2 Sommelsdijck Canal Pump Station and Sluice Gates Rehabilitation

The catchment area of the Van Sommelsdijck creek (Canal) is about 700 hectares, and consists of mostly urban and semi-urban area. The rainfall run off and overflow of mostly domestic wastewater is collected through the main canal via side branches and conveyed to a basin up-gradient to the sluice and pumping station. The sluice/pumping station discharges water collected in the water basin to the Suriname River periodically by gravity (sluice gates) and/or pumping (pumps).

The rehabilitation of the sluice/pumping station Van Sommelsdijck consists of 3 main activities, as shown on Figure 3-5 and listed below:

- Improvement of the water basin;
- Rehabilitation of sluice gates and pumping station;
- Improvement of the outflow.

Figure 3-5: Rehabilitation Components of Sluice/Pumping Station at Van Sommelsdijck Canal

a. Improvement of the water basin: The water basin consists of an area of approximately 1800 m^2. Currently, the basin bottom is too shallow to store enough water for regular operation due to sedimentation and plant/weed growth (see Figure 3-6). Improvement activities include excavation of the basin to approximately 1.5 meter depth to increase the volume of storage. The side slope of the basin will be graded to 1V:3H, and the top of the embankment will be restored with grass protection.

Figure 3-6: Existing Condition of Water Basin

b. Rehabilitation of sluice gates and pumping station: Currently, only one sluice gate and two pumps (out of three pumps) are operational, however the supporting control system is not operational (see Figure 3-7). The hydraulic system is faulty and the monitoring switches are not in operation. The sluice gate and pumps are operated manually. The proposed rehabilitation of the sluice gates and pumping station mainly includes the following activities:
   - Rehabilitation of the valve control system, installation of a new electrical control system, rehabilitation of the electrical and instrumentation systems, and the rehabilitation of the automatic lubrication system.
   - Complete overhaul of pump #1. Once pump #1 is rehabilitated, an inspection of pump #2 will be conducted, and depending on the results of this inspection, critical parts of pump #2 will be repaired. Similarly, pump #3 will also be inspected and repaired if needed.
   - Rehabilitation of four vertical lift sluice doors and the hydraulics system.

Figure 3-7: Existing Pump House

c. Improvement of the outflow: The outflow channel is currently filled with sediment from the river (see Figure 3-8). The outflow channel will be dredged/excavated to ensure sufficient discharge from the gravity sluices.

Figure 3-8: Existing Condition of Outflow Area

3.1.3 Enhancement of Mangroves

Mangrove trees protect the embankments and coastal lines because the roots of the mangrove not only dissipate wave strength, but also the water velocity before reaching land. The net amount of sediment deposition plays an important role in the maturation of mangrove trees. The absence of mangrove trees along the embankment or shoreline can disrupt the balance between sediment deposition and erosion, leading to problems such as sediment erosion. Mangrove areas also create a good habitat for different animal species.

An existing mangrove forest is immediately downstream of Sommelsdijck Canal pump station at the confluence of the canal and the Suriname River as shown in Figure 3-9. In order to create a better environment for mangrove trees to grow, the net sediment deposition has to be much larger than the amount of sediment that is being washed away by the river. The existing mangrove area will be slightly expanded and enhanced to facilitate growth, sediment entrapment, and protection against erosion. The OWTC is currently working with Professor Sieuwnath Naipal of the Anton de Kom Universiteit van Suriname, and other entities to design and construct green solutions along the coasts of Suriname to help with rising sea levels and to protect against erosion. Professor Naipal was consulted on the design and implementation of green solutions and the design proposed below was based on local experience and expert knowledge.

Figure 3-9: Mangroves North and South of the Canal Confluence

The enhancements will include constructing sediment trapping units (STU's). STU's are permeable structures that partly dissipate the energy of the waves, while water with lots of sediments is being "sieved". This way the sediment settles inside the structure. When enough sediment is settled and well consolidated, natural mangrove growth can take place.

The proposed STU's consist of wooden piles installed at specific distances along the shoreline. The space between the piles is filled with wood materials (such as bamboo) to trap sediments behind the STUs. A typical detail of an STU is shown on Figure 3-10.

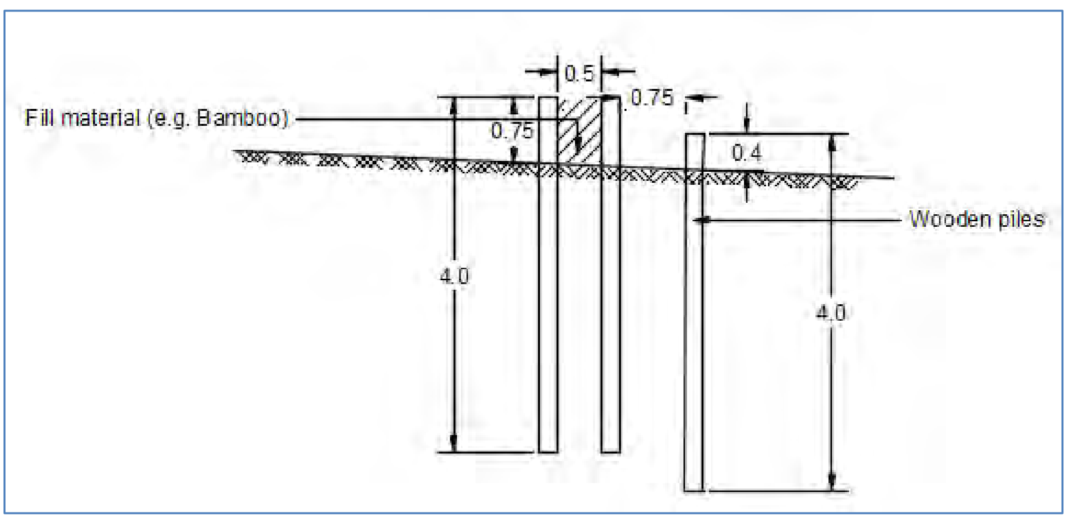


Figure 3-10: Typical Detail of Sediment Trapping Unit.

Based on the size and location, the mangrove enhancement areas are divided into two sub-areas, depicted in Figure 3-11 below. By implementing STU structures in the project area, the net amount of sediment deposition and mangrove growth is expected to increase significantly. The increased mangrove vegetation prevents erosion of the area.

Currently, there is no protection at the outflow section of the pumping station which runs through the mangrove area (See Figure 3-11). A protection STUs will be installed along the either side of the outflow channels to prevent siltation of the outflow channel. During high flow periods silts and sediments carried by the flow will be deposited behind the STUs installed along the outflow channel.

Figure 3-11 Mangroves Enhancement Areas

3.2 ALTERNATIVES ANALYSIS

The Project components were selected based on a systematic evaluation of several plausible alternatives. The process involved identifying, evaluating, and selectively reducing the number of alternatives that could potentially meet the overall objective of addressing flooding in the Paramaribo waterfront area. This section describes the process of selecting the Project components.

3.2.1 Alternatives Considered

Adaptation measures considered for this Project included either applicable engineering technologies or general methods that fall under the following categories:

- Regulation and Policies: Policy, zoning, and land use options
- New Flood Protection Wall: Construct previously proposed floodwall extension
- Rehabilitation
  - Existing retaining wall: Reinforce existing retaining wall with steel sheet piles, riprap, increase dike height, etc.

- Existing Flood Control Mechanisms: Increase pumping capacity, replace non-functioning pumps/sluicegates, improve sluice gates, automate functions, etc.
- Drainage System: Improve existing canal, new/improved culverts, drains, road structures, etc.

• Shoreline Erosion Protection/Stabilization: Install or improve riprap/gabions/articulated concrete blocks along shoreline, mangrove buffers, etc.

• Stormwater Retention and Release: Implement stormwater management facilities with storage capacity such as swales, ponds, raingardens, permeable pavers, etc.

3.2.2 *Project Components Selection Process*

The process of selecting Project components involved a screening exercise of a broad universe of potential adaptation measures or alternatives, including floodwall, green infrastructure, and drainage system improvements that could function separately or as integrated solutions.

The estimated order-of-magnitude costs and the relative merits (based on the evaluation criteria below) of each potential component were used as a means of reducing the alternatives to those that could be implemented within the budgetary limitations and required standards for the Project.

The screening resulted in 14 targeted site-specific alternatives being identified, which represent viable options while preserving the concept to mitigate climate change issues considering both inland and coastal flooding. These 14 alternatives are summarized in the Table 3-1 and shown in Figure 3-12.

Table 3-1: Site-Specific Alternative Description

Technology/Alternatives	Site-Specific Alternative
Regulations and Policies	Alternative 1: Government policy, zoning, and land use options
New Flood Protection Wall	Alternative 2: New flood protection wall from Knuffelsgracht Street to SMS Pier
Rehabilitate Existing Old Retaining Wall	Alternative 3: Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal
Rehabilitation –Existing Flood Control Mechanicals	Alternative 4: Rehabilitate Van Sommelsdijck pumping station and sluice gates
	Alternative 5: Rehabilitate sluice gate and pumping station at Knuffelsgracht Street
	Alternative 6: Rehabilitate Jodenbree Street sluice gate near Central Market

Technology/Alternatives	Site-Specific Alternative
Rehabilitate Drainage System	Alternative 7: Rehabilitate Van Sommelsdijck Canal
	Alternative 8: Rehabilitate drainage system along Waterfront between Knuffelsgracht and SMS Pier
	Alternative 9: Improve Viotte Kreek drainage system
Shoreline Erosion Protection/ Stabilization	Alternative 10: Riprap/gabions/ articulated concrete blocks along shoreline
	Alternative 11: Create buffer with enhanced mangrove plantings
Stormwater Retention and Release	Alternative 12: Install underground stormwater retention system
	Alternative 13: Construct aboveground stormwater retention and release system
	Alternative 14: Construct permeable pavements or similar alternatives to impervious surfaces

Figure 3-12: Alternatives Map

3.2.3 Technical Screening

A comparison matrix was used to screen all alternatives by quantifying evaluation criteria and ranking them based on their scores. Evaluation criteria used for the alternatives were broadly classified into the following four main categories:

- Technical achievement (weight of up to 35 points);
- Socio-political achievement (weight of up to 25 points);
- Environmental achievement (weight of up to 25 points); and
- Programmatic achievement (weight of up to 15 points).

Each potential alternative was scored against the evaluation criteria based on the component's ability/likelihood to meet that specific criterion. A numerical value was first assigned to each evaluation criteria such that the sum of all numerical points (values) totaled 100. Higher numerical points (value) were assigned to those criteria considered more important. Numerical scoring was employed to provide a mechanism to quantitatively rank alternatives relative to their ability to achieve the evaluation criteria in a simple and straight-forward manner. The numerical scoring exercise is relative, i.e., in the numeric scoring exercise, higher % weight simply indicate that an alternative would meet the evaluation criteria comparatively more successfully than the lower scored alternatives. The allocation of percentage weight increases with the increase in ability/likelihood of the alternative to meet the criteria based on the following scale:

If an alternative:

- Meets and/or has significant/numerous positive impact toward the criterion = 100 percent of the total points for that criterion
- Meets and/or has marginal/minor positive impact towards the criterion = 75 percent of the total points for that criterion
- Meets and/or has mixed impacts towards the criterion = 50 percent of the total points for that criterion
- Does not meet and/or marginally deviates from the criterion = 25 percent of the total points for that criterion
- Does not meet and/or has several negative impacts towards the criterion = 0 percent of the total points for that criterion

Significantly meet, marginally meet, mixed, marginally deviates, does not meet are relative in terms of how close they are likely to meet a certain evaluation criteria. In the definition " an alternative meets and/or has significant/numerous positive impact towards the evaluation criteria", the word "significant" is used to define the concept that the alternatives meeting this criterion has relatively numerous positive effects (as compared to other alternatives) towards the criterion. Similarly, if an alternative meets the evaluation criteria with marginal positive impacts, it is intended that the alternative, in a relative term, has minor positive effects towards the criterion. A weighted sum score was calculated for each alternative. The alternatives that scored above 70 were considered a preferred adaptation measure, as identified in Table 3-2.

Table 3-2: High Ranked Site-Specific Alternatives

Site-Specific Alternatives		**Scores**
Alternative 2	New flood protection wall from Knuffelsgracht Street to SMS Pier	73.25
Alternative 3	Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal	78.25
Alternative 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	70
Alternative 5	Rehabilitate sluice gate and pumping station at Knuffelsgracht Street	70
Alternative 7	Rehabilitate Van Sommelsdijck Canal	73.5
Alternative 8	Rehabilitate drainage system along the waterfront on Waterkant Street between Knuffelsgracht and SMS Pier	70.5
Alternative 11	Create buffer with enhanced mangrove plantings	76.5

Recognising the potential available grant budget from the AF for implementation, the proposed individual adaptation measures, the seven highest-ranked alternatives (alternatives 2, 3, 4 5, 7, 8, and 11) were assembled into three groups that represent implementation options for further analysis. These three groups are presented in Table 3-3.

Table 3-3: Alternative Groups

<table>
<tr><th>Group</th><th>Alternative</th><th>Alternative Description</th><th>Benefits</th><th>Drawbacks</th></tr>
<tr><td rowspan="3">Group A</td><td>Alt 2</td><td>New flood protection wall from Knuffelsgracht Street to SMS Pier</td><td rowspan="3">• Strong measure for coastal flood protection
• Adaptive to future by increasing wall height
• Addresses critical flood area
• Address both coastal and inland flooding</td><td rowspan="3">• May temporarily obstruct view
• Inland flood control requires operation of pump and gates
• Flood wall overlaps with existing water taxi business and may have impacts on livelihoods
• Management of potentially impacted sediment
• Resolution of historic land concession required</td></tr>
<tr><td>Alt 4</td><td>Rehabilitate Van Sommelsdijck pumping station and sluice gates</td></tr>
<tr><td>Alt 11</td><td>Create buffer with enhanced mangrove plantings</td></tr>
<tr><td rowspan="2">Group B</td><td>Alt 3</td><td>Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal</td><td rowspan="2">• Minimal construction disturbance to</td><td rowspan="2"></td></tr>
<tr><td>Alt 4</td><td>Rehabilitate Van Sommelsdijck pumping station and sluice gates</td></tr>
</table>

	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)	rehabilitate existing wall • Added functionality along canal for walkways • Address both costal flood and limited (reduced segment of canal improvement)	• Critical flood area not addressed • Only portion of canal is rehabilitated • Inland flood control requires pump and gates operation • Management of potentially impacted sediment
	Alt 11	Create buffer with enhanced mangrove plantings		
Group C	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	• No view obstruction • Added functionality along canal for walkways • Address both coastal flood and limited (reduced segment of canal improvement)	• Critical flood area partially addressed by new pump station (PS) – Alt 5 • Construction disturbance at new PS – Alt 5 • Inland flood control requires pump and gates operation
	Alt 5	Rehabilitate sluice gate and pumping station at Knuffelsgracht Street		
	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)		
	Alt 11	Create buffer with enhanced mangrove		

3.2.4 *Benefit Cost Analysis*

Taking the three groups above, a Benefit Cost Analysis (BCA) was also performed for the three Alternative Groups. This BCA included looking at the economic benefits, economic costs, economic returns, as well as sensitivity analysis over a 72 year timeframe (useful design life of the Project) based on the Monte Carlo Model using a 12% discount rate (a simulation used to quantify the impact of uncertainty on the estimated economic returns for each of the three groups). Benefits were principally measured as the reduction in total damages from floods with the projects compared to the damages that would occur without the projects, under the scenario where climate change increases the frequency and severity of floods over time. Costs included both capital and operating costs. The primary approach for measuring benefits of the alternatives was a standard analysis of the avoided costs.

The results of the BCA showed that Group A was the most favorable. It showed that the estimated net present value of benefits for Group A are $24.1 million and the sensitivity analysis shows that there is 99 percent probability that net benefits are positive. For Group B, the net present value of benefits are $6.6 million with a 94 percent probability of positive benefits. Group C has estimated value of $-1.6 million and there is only a 24 percent probability that net benefits will be positive.

3.2.5 *Stakeholder Engagement*

To supplement the technical screening and BCA, stakeholder engagement has been carried out throughout the conceptual development of the Project and this ESIA.

As defined by the IDB's Environment and Safeguards Compliance Policy, B.6 Consultation, engagement is considered appropriate when interacting with a Project's stakeholders, while consultation is required in order to interact and incorporate the viewpoints of Affected Parties. The objectives of stakeholder engagement are to:

- Identify Project stakeholders and Affected Parties, and understand their interests, concerns and influence in relation to Project activities.
- Promote the development of respectful and open relationships between stakeholders and the Project.
- Provide stakeholders with timely information about the Project, in ways that are appropriate to their interests and needs, and also appropriate to the level of potential adverse impacts.
- Record and resolve any grievances that may arise from Project.

A stakeholder is defined by the IDB as:

…Individuals, groups, or institutions that have a stake, or an interest, in the project: They may be affected by it (either positively or negatively), or they may have an interest in it and be in a position to influence its outcomes.

Under IDB policies, this Project is categorized as a Category B Project and is required to engage stakeholders over the life of the Project.

A Stakeholder Engagement and Communications Plan has been developed for the Project and this details the identified stakeholders and engagement activities (Appendix A).

In order to meet the requirements of the IDB's Consultation Policy, several activities have taken place to further identify and inform the Project's possible stakeholders. A stakeholder meeting was held on the November 8, 2017 with key identified stakeholders to present the set of potential adaptation measures, to inquire about additional stakeholders that could potentially be affected, and to receive suggestions and concerns with regards to the ESIA and the adaptation measure options being evaluated. Additionally, supplemental information was gathered through in-person interviews and phone consultations with individual stakeholders and stakeholder groups throughout November 2017 to May 2018. Three meaningful consultation meetings were carried out between 04 and 06 July 2018. These meetings served as an opportunity of two-way exchange to present specific information regarding the Project, findings of this ESIA, and the ESMP, and to solicit further inputs, especially with regard to the planned mitigation measures to ensure these take into account stakeholders specific views on measures relevant to them. This consisted of one meeting for the general public and two separate meetings with key directly affected stakeholders (bus transportation providers and water taxi transportation providers). Appendix B contains the Stakeholder Meeting Reports, to date.

A summary of the stakeholder's main concerns is provided below, both in general (for all groups) as well as per stakeholder group with relation to all groups of alternatives.

- General stakeholder feedback:
  - Stakeholders indicated that they are not opposed to the proposed adaptation measures because they are aware of increasing climate change risks and the need to reduce downtown flooding and improve infrastructure. Stakeholders in the Waterkant/Knuffelsgracht area value the historic city and the importance of preservation and conservation and are concerned about its neglect and lack of maintenance. Stakeholders expressed the hope that in addition to the basic infrastructure works, other issues would be addressed (lack of public restrooms, bad smell, and waste) to enhance attractiveness of the area.
  - Stakeholders are skeptical about the possible construction activities along the waterfront because of frequent consultations without follow-up actions and because of ambiguity about land ownership. Among the concerns was that the Adaptation Fund cannot pay for construction work on privately owned land. Alignment and coordination between development plans of different parties was also identified as a primary concern.
  - All stakeholders stressed the need for timely and transparent communication about Project activities and sharing of Project updates and reports. In addition, concerns were expressed about obstacles and delays in the planning process due to preparations for the 2020 elections. Stakeholder fatigue was observed and some interviewees conveyed that they only wanted to be contacted again if new, concrete information was available.
  - Stakeholders also expressed concern about the vibrations cause by pile driving. Pile driving in the area poses a risk to the older buildings in the area.
- Main concerns per stakeholder group:
  - Restaurants, bar, and small business owners emphasized the importance to conduct construction works from the river side, rather than the street side, to minimize nuisance and loss of local business. Stakeholders emphasized that revitalization of the Paramaribo Historic Center and promoting tourism must also address the security situation, specifically the presence of homeless people, drug dealing, and petty crime. Another concern is that vibration related to piling could damage the delicate structure of the historic buildings. Various restaurants, bars, and enterprise owners indicated that they did not feel represented by the Waterfront Management Board (Beheersraad Waterkant) and criticized its lack of visibility and action.

  - Owners and/or drivers of the commuter boats reported that they are not opposed to temporary relocation to the old ferry landing; however, safe and proper facilities must be created at the temporary location, in line with the needs of the boat passengers. It was emphasized that the relocation must be temporary. The Platte Brug was suggested as a possible alternative location for the duration of construction. Information about when, how, and how long construction will take place, must be obtained well ahead of time. During the November stakeholder consultation prior to knowing Project details, boat owners and drivers expressed that they expect a loss of revenue as a result of the construction, as some clients may opt to take the bus, which is cheaper (SRD 0.85) than the boat commute. The main concern expressed during the July stakeholder consultation was instead with regards to the safety of using the existing jetty as an alternative mooring location. According the drivers, when the water level is deep and choppy, it is difficult to keep the moored boats still at that location and there is the risk of someone falling into the water. As a mitigation measure, there should be a passenger boardwalk with railings to hold on to. This risk can also be reduced if they are relocated during the months of April-June when conditions are better.

- The main concern for owners and drivers of bus transport PG and LIJN 4 is that they will not be able to return to their present location and they would lose income if they have to park at another location. They suggested that moving the busses slightly towards the street could alleviate this concern, depending on the exact location of construction activities.
- Land owner and large business owner, Cactus NV, presented its development plans for the area. The construction costs of the Adaptation Fund plan for this area can possibly be partly incorporated in the plans of the property owner. Communication between Project management and the property/business owner is essential to ensure that the various development plans are in line with and complement one another. Cactus NV reportedly offered to repair the old ferry boat landing to have as an alternative for the bridge and the commuter boats, but this idea was declined by the government.
- Stichting Gebouwd Erfgoed Suriname (SGES) emphasized that the Platte Brug (concrete jetty for the water taxis) is an important historical object. Even though it is not a historic monument, it is on the listing of protected cultural and historic heritage sites. Therefore, construction and rehabilitation must be carried out following UNESCO guidelines. Furthermore, the consulted SGES representative advised that development plans and designs be tested to determine if they meet the cultural and historic Paramaribo heritage site guidelines.
- District government requested that relevant information be shared with resort representatives and responsible government parties in the Project Area well in advance of commencement of activities. The representative of the District Commissioners' office also emphasized the importance of the phase after completion of construction in that plans and funds must be in place for maintenance to avoid neglect of the site, as well as pollution. Other concerns related to traffic disruptions, especially during busy times in the year prior to the elections, and the need for public engagement.

3.2.6 Alternatives Analysis Conclusion

The review of these benefits and drawbacks, including a comparative analysis of these groups and input from stakeholders, concluded that alternatives within Group A were the preferred adaptation measures to form the components of the Project. The following points were considered for recommending Group A:

1. Group A addresses the critical flood area (proposed new wall location). It manages current and future climate-change-induced flooding. Modelling indicates that the new flood wall prevents coastal flooding in the most flood prone area for the 50-year return period (baseline condition) and for the 25 year return period for 2020 climate change conditions. Beyond 2020 and higher return periods, the flooding is reduced as compared to non-existence of the wall. The model flooding results are based on a wall elevation equivalent to the elevation of the recently constructed flood wall (+3.25 NSP). Flood Wall (+3.25 NSP) is based on a 50 years return period for High Water Level, increased with sea level rise for 50 years, expected wave height and free board. Currently there are no national design standards for flooding. The flood depths and corresponding hazard rankings for different return periods and climate change conditions are presented in the modelling results report.

2. Group A integrates different forms of alternatives; the floodwall to address river front flooding, inland drainage system improvements to address inland flooding, and green infrastructure for shoreline erosion protection and stabilization.

3. These alternatives are spread out and not concentrated in one specific area. The alternatives address both coastal and inland flooding.

4. The Van Sommelsdijck Canal and pumping station is one of the major inland drainage systems in the targeted study area. Improving the operational capacity of this system will have a large impact on inland flooding.

4.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

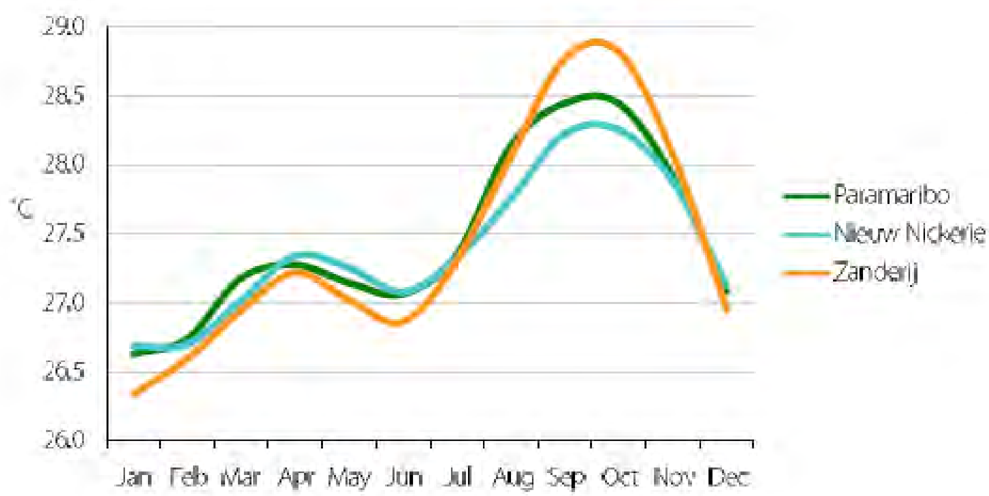
4.1 PHYSICAL RESOURCES

4.1.1 Climate

Even though Suriname is located outside the hurricane area, hurricane effects are often experienced in the form of heavy rainfall. Sibibusies's (Sibi= sweep, busie= forest), Inter Tropical Convergence Zone (ITCZ) and the El Niño phenomenon are climate systems that influence meteorological conditions in Suriname (CIS 2014).

- Sibibusies are heavy winds events that occur during heavy precipitation with speeds between 70 kilometers per hour (km/hr) and 100 km/hr.
- ITCZ is an area close to the equator, where the northeast and southeast trade winds meet.
- The El Niño phenomenon usually occurs every 2 to 7 years lasting 12 to 18 months, but it can occur any time. Generally, El Niño conditions in Suriname are dryer than normal.

The Project is located within the urban footprint of downtown Paramaribo, which has an average daily temperature of approximately 27.4° Celsius (C), with daily variations of 5°C (MLTDE 2013). Figure 4-1 shows the average monthly temperature for Paramaribo indicating that there is only a small variation in air temperature throughout the year. The coldest month of the year in Paramaribo is January and the warmest month of the year is October.



Source: MLTDE 2013

Figure 4-1: Average Monthly Temperatures for Paramaribo

Paramaribo has two wet and two dry seasons with an annual average precipitation of 2,210 millimeters (mm):

- The short wet season occurs from December to February and the long wet season occurs between May and August, with an average monthly precipitation of approximately 200 mm for both wet seasons.
- The short dry season occurs between February and April and the long dry season occurs from August to December, with an average monthly precipitation of 100 mm for both dry seasons.

Classification of these four seasons is based on precipitation records from the Cultuurtuin meteorological station located in Paramaribo, immediately north of the Project Site (Amatali 2007; MLTDE 2013).

Precipitation intensity depends on the duration of the storm and return period. The precipitation intensity decreases when the duration of the storm decreases (Amatali 2007). Figure 4-2 shows the precipitation intensity duration frequency (IDF) curves for different return periods for the Cultuurtuin station based on historical precipitation records for 1981 to 2015.

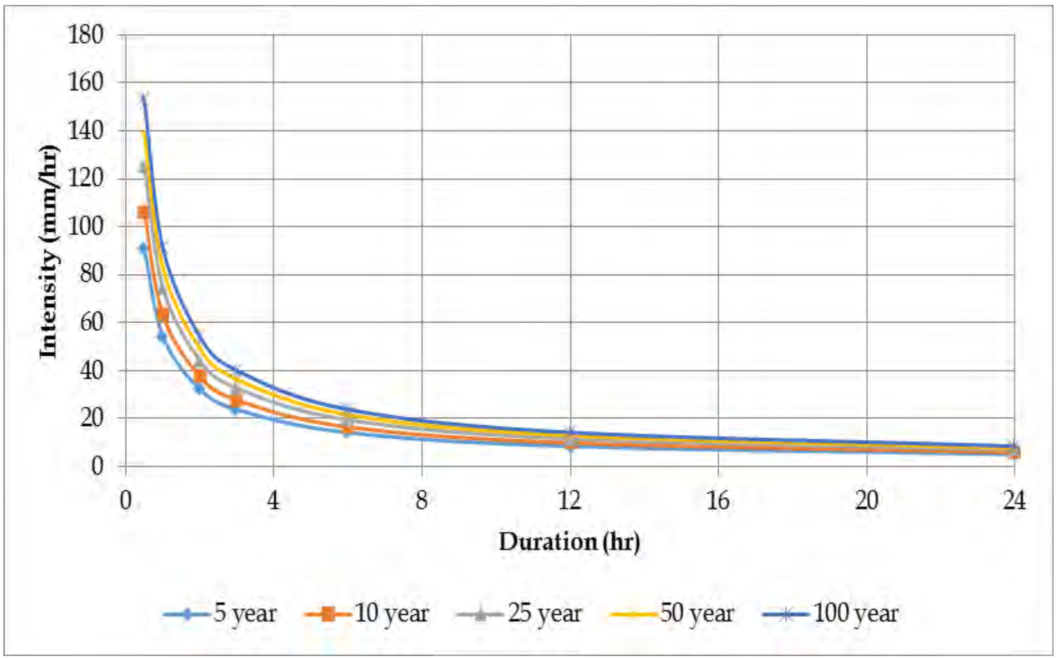


Figure 4-2: Intensity Duration Frequency (IDF) Curves for Cultuurtuin Station (1981-2015)

4.1.2 Air Quality

Air quality baseline data (gaseous pollutants and dust) are currently not available in the Project Area. There are no major industrial sources of emissions in the area so it can be presumed that average air quality is low-to-medium due to the roadway and boat traffic associated with commercial and tourism activities, particularly in areas close to the central market, bus terminal, and the waterfront. Most of the roads are paved, which results in low dust generation. The major air pollutants likely to be present in the air in downtown Paramaribo include inhalable particulate matter (mostly associated with smoking in public places), and combustion/exhaust emissions such as carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and volatile organic compounds (VOC).

The most significant existing air pollution sources in the Project Area are likely to include:

- Vehicles on Waterkant Street and the surrounding streets (Dr. Sophie Redmond Street, Jodenbree Street, Heiligenweg, Knuffelsgracht Street, Watermolen Street, Keizer Street, Kromme-Elleboog Street, Mr. J.C. De Miranda Street, and Flags Square [*Vlaggenplein*]) including public buses
- Commercial boats by the waterfront at Platte Brug and port in De Waag
- Tobacco smoking in public places (indoor and outdoor)

Considering the dispersion of air pollutants (i.e., potential to disperse kilometers away from the source origin), all persons within the Project Area are considered susceptible to changes in air quality.

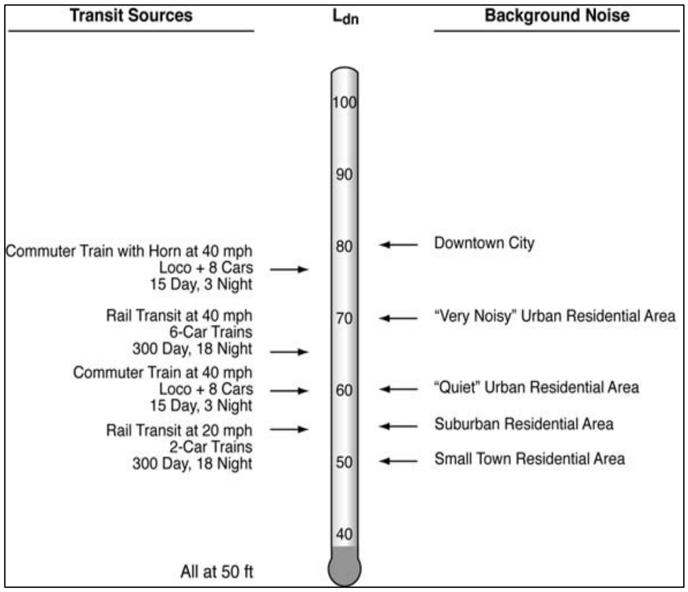
4.1.3 Noise

Noise baseline data are currently not available in the Project Area. The Project Area presents no industrial noise generating sources; however, it can be presumed that the average noise level in the Project Area is medium and typical of an urban environment. The most significant existing sources of noise pollution in the Project Area are likely to include:

- Vehicles on Waterkant Street and the surrounding streets (Dr. Sophie Redmond Street, Jodenbree Street, Heiligenweg, Knuffelsgracht Street, Watermolen Street, Keizer Street, Kromme-Elleboog Street, Mr. J.C. De Miranda Street, and Flags Square [*Vlaggenplein*]) including buses
- Commercial boats by the waterfront at Platte Brug and port in De Waag
- High tourist activity, highlife music, and street dogs between Market Hall and De Waag
- Occasional sporting events at Fort Zealandia (cultural/preserved area)
- Operation of the sluice gates and pumps on the southwest of the Project Area

Receptors sensitive to in-air noise within the Project Area include nearby residents, tourists (particularly near the waterfront), Suriname Museum, churches (e.g., Center Church [*Centrumkerk*] and Saint Peter and Paul Cathedral [*Saint Petrus en Paulas Katedraal*]), and some hotels and restaurants.

Figure 4-3 shows typical day-night sound levels for different land uses and transit sources.



Source: FTA 2006

Figure 4-3: Typical Day-Night Sound Levels

4.1.4 Natural Hazards

The Project Area is prone to flooding during rain events and other natural hazards such as storms, erosion, salt intrusion, and high winds (see Table 4-1 below, for floods in Paramaribo). These natural hazards may pose risk to the implementation and sustainability of the adaptation measures, the surrounding population, and the environment. Details of the natural risks for the Project Area are described in the following sections. Other natural risks such as drought may occur at the regional level but are not described in this ESIA due to the lack of nexus to the Project.

Disaster risk is defined as the combination of the probability of an event and its negative consequences (UN 2014). The risks for the Project, people, and environment include the following components:

- Exposure (probability and intensity of natural disasters and the number of people exposed or threatened by these disasters)
- Vulnerability (considering susceptibility, coping capacity, and adaptive capacity)

According to the World Risk Index (UN 2014), Suriname is ranked 49 of 174 countries in the world in terms of vulnerability with a WRI of 8.42 percent (exposure and vulnerability risk where 0.08-3.46 is considered very low risk, 3.47 to 5.46 is low, 5.47 to 7.30 is medium, 7.31-10.39 is high and 10.40-36.72 is very high risk). Suriname is especially vulnerable to natural hazards for the following reasons:

- Population concentrations in low-lying, hazard prone areas
- Weak institutional capacity to prepare for, and respond to, natural disasters

- High levels of poverty that limit the population's ability to respond to natural disasters

Table 4-1 provides a summary of the types of natural disasters and the population affected in Suriname between 2000 and 2016. The United Nations Development Program (UNDP) includes Suriname in the list of the ten most vulnerable countries with low-lying coastal plains that are threatened by sea level rise (SLR) in this century.

Table 4-1: Types of Natural Disasters and Population Affected 2000-2016 in Suriname

Date	Natural Disaster	Affected Areas	Population Affected
5/28/2000	Flood due to excessive rainfall	Sipaliwini, Northern Marowijne, Tapanahony River, Lawa, and Curuni	5,000 people
9/7/2004	Floods associated with rainfall from Hurricane Ivan	Not specified	Unknown
6/5/2006	Flood due to excessive rainfall	Gran Rio and Pikin Rio rivers, Paramacaans on the Marowijne River, upper Marowijne, Tapanhony and Lawa, (Mofina) Suriname and Sipaliwini River	25,000 people
June 2006	Floods due to heavy rainfall	Villages along the upper Marowijne river and the upper Suriname River	20,000 people
2006/2007	Flood	Coropina triangle, Vier Kinderen, La Prosperite and Republiek	500 people
4/20/2007	Floods due to continuous rainfall	Paramaribo	Unknown
6/8/2008	Flood due excessive rainfall	Southern part of the interior: Djumu, Asidonhopo, Semoisi, Awaradam	Unknown
1/10/2009	Flood due to excessive rainfall	Paramaribo	Unknown
2/4/2009	Flood due to excessive rainfall	Paramaribo	Unknown
10/3/2009	Flood due to excessive rainfall	Paramaribo	Unknown
5/3/2009	Flood due to excessive rainfall	Paramaribo	Unknown
2009/2010	Drought	National level	Unknown
7/14/2010	Coastal flooding as a result of dam fail	Saramaca: La poule, Peperhol, north part of Wayambo	Unknown
4/24/2010	Flood due to excessive rainfall	Paramaribo	Unknown
4/16/2010	Flood due to excessive rainfall	Paramaribo: Margarethalaan	Unknown
4/22/2010	Flood due to excessive rainfall	Paramaribo: Poelepantje	Unknown
6/1/2012	Storm	Nickerie: Nieuw Nickerie	55 houses
6/20/2012	Storm	Paramaribo, Marowijne: Galibi and Albina	35 people

Date	Natural Disaster	Affected Areas	Population Affected
5/17/2013	Flood due to excessive rainfall	Saramacca: Misgusnst Commewijne: Frederikdorp Para, Paramaribo, Marowijne (Cottica)	Unknown
6/20/2013	Tail of a heavy tropical storm/flooding (heavy rainfall)	Paramaribo, Wanica, Saramacca, Marowijne (Galibi). Roof were torn away (30 houses), trees uprooted and damaged power poles, advertising signs and street lighting	300 people
12/27/2013	Flood due to excessive rainfall	Paramaribo, Wanica, Saramacca	Unknown
7/6/2014	Storm	National: Paramaribo, Coronie, Commewijne, Saramacca en Nickerie Nickerie: Nieuw Nickerie	150+ people
5/2/2015	Flood	Marowijne: Alale Kondre	Unknown
5/18/2015	Persistent rainfall	Wanica: Hanna's Lust	Unknown
6/21/2015	Storm	Paramaribo: Zorg en Hoop	1 injured and 35 homes affected
6/28/2015	Storm	Paramaribo	1 (death)
7/27/2015	Flood	Saramacca	Unknown
1/16/2016	Hailstorm	Paramaribo and surroundings	Unknown

Source: Adapted from CIS 2014 and NCCR 2017. Detailed data not readily available after January 2016.

4.1.4.1 Flooding

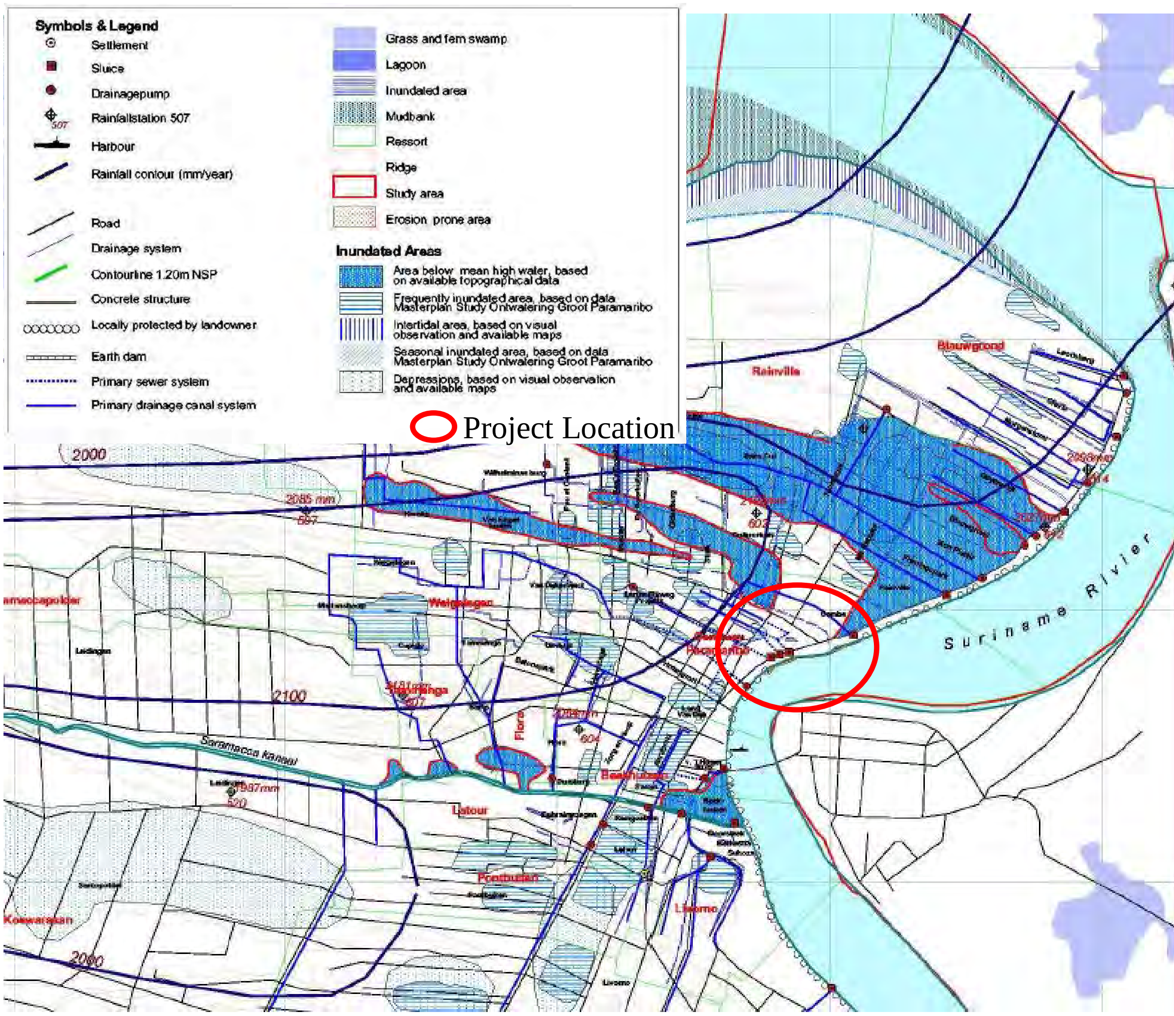
Suriname experiences frequent floods in its coastal plain and rivers. Inland and coastal flooding in urban areas of Paramaribo is produced from the high volume of precipitation, poor drainage due to the outdated and insufficient drainage system, and rising sea and river water levels.

The Project is located in downtown Paramaribo on the left bank of the Suriname River. Besides Paramaribo, other settlements are along the left bank of the river, including Domburg and Paranam. New Amsterdam is on the right bank of the river (Amatali and Naipal 1999). The urban area of Paramaribo (including downtown, the location of the Site) is considered highly vulnerable to flooding due to sea level rise and the increasing intensity of precipitation; loss of land due to coastal and riverbank erosion; longer and frequent severe dry periods; and uncontrolled urbanization in Paramaribo and areas north of downtown (Noordam 2007). The Suriname River borders Paramaribo to the east, which is a tidally-influenced river with a catchment area of 16,500 square kilometers (km^2). Its waters discharge into the Atlantic Ocean and its flow has been regulated by the hydropower Afobaka Dam (Prof. van Blommenstein reservoir) since 1964, which is located approximately 194 km upstream of Paramaribo.

According to a study on disaster management in Suriname, before May 2006, natural disasters were infrequent in Suriname (Karijokromo 2011). Some historical normal floods were produced by an outdated drainage system in different areas of Paramaribo City (Karijokromo 2011). The impacts of these normal floods were not as damaging as the first major flood that occurred on

2006. The Preventionweb reports that flooding represents an average annual loss (AAL) of USD $53.81M for Suriname (Prevention Web 2014).

According to a masterplan prepared by the OWTC, approximately 13 percent of the total urban area of Paramaribo was affected by this hazard, causing economic damage and health conditions associated with stagnant water (MOGP 2001). The most recent severe floods in Paramaribo occurred in 2006 and 2008, but no records of economic or life losses were available. Floods principally occur because large parts of the city were built on low-lying lands and the city lacks an updated stormwater drainage system (see Figures 4-4, 4-5, and 4-6). The Project area is prone to floods because it is located at low-lying lands and it is part of the left bank of the Suriname River (the area of the proposed wall extension floods every time there are heavy rains). This river is tidally- influenced and when the high water level of the Suriname River is combined with runoff from impermeable areas, it produces floods affecting properties within the Project area.



Source: Taken from Amatali 2007

Figure 4-4: Frequent and Seasonal Inundated Areas in Paramaribo based on Data from Masterplan Study Ontwatering Groot Paramaribo

Source: IDB staff

Figure 4-5: Inland Flooding in Downtown Paramaribo in March 2015 (North of the Project Site)

Source: YouTube 2010

Figure 4-6: Inland Flooding in Urban Paramaribo in October 2009

Coastal and Suriname River banks are at risk for flooding due to higher water levels. According to a study on climate change for Suriname, over 2,000 km² of coastal zones of Suriname are at risk for flooding (CCCRA 2012). Historical sea level rise is affecting the city and sometimes existing natural and artificial protections are insufficient. Portions of the Suriname River's left bank (e.g., Anton Dragtengwe, Paramaribo North) are overtopped during high water (MOGP 2001).

Most of the floods in the Project area occur during spring tide. Breaching or overtopping defensive structures results in tidal flooding by saline or brackish water (Noordam 2007). At the mouth of the Suriname River, the mean tidal range is 1.8 m between neap tide and spring tide. A slightly positive increase of +0.6 mm/year on water levels in the Suriname River has been observed based on historical annual water level measured at Paramaribo station located at km 52 in the Suriname River (Amatali 2012). The inhabited areas along the Suriname River banks, the land level is lower than the 10-year return (Tr) water level (see Table 4-2) producing potential risk for inundation from the river.

Table 4-2: High Water Level in the Suriname River

Station	**Annual HHW in cm NSP**			
	Tr = 10-years	**Tr = 25-years**	**Tr = 50-years**	**Tr = 100-years**
Geleidelicht	185	198	207	216
New Amsterdam	193	203	210	217
Paramaribo	201	211	219	226
Domburg	198	203	207	212
Paranam	155	175	190	204

cm= centimeters; HHW= Higher High Water; NSP= Normaal Surinaamse Peil; Tr= Return period
Source: Adapted from Amatali 2012

4.1.4.2 Riverine Erosion

Erosion takes place along the coastline and at some sections along the Suriname River. The main drivers for erosion at the Suriname River are from high tide floods and human activities such as the removal of mangrove areas and the navigation of shipping barges. River bank erosion and deposition can affect Suriname River navigation and impact residential areas and zones with light industry (Noordam 2007). It can also cause damage and increase the vulnerability of waterfront property to storm surge, as well as threaten natural resources.

According to the River Bank Protection Waterside Paramaribo, SMS Pier Project (*Technische Programma van Eisen Oeverbescherming Waterkant te Paramaribo, SMS Pier-Knuffelsgracht*) prepared by the OWTC, the Suriname River's left bank indicates signs of erosion. The main objectives of this project were to stabilize the river bank and protect the shoreline from high tide, and to construct public mooring facilities. Figure 4-8 shows the location of cross sections along the Suriname River that are prone to river erosion and where the Suriname River Bank Protection Waterside Paramaribo, SMS Pier Project was conducted. The area already presents poor conditions and protection measures are required to prevent further bank erosion, which can lead to instability and increased flood risk during high tide.

Source: MOGP 2001

Figure 4-7: Suriname River Bank Protection Project

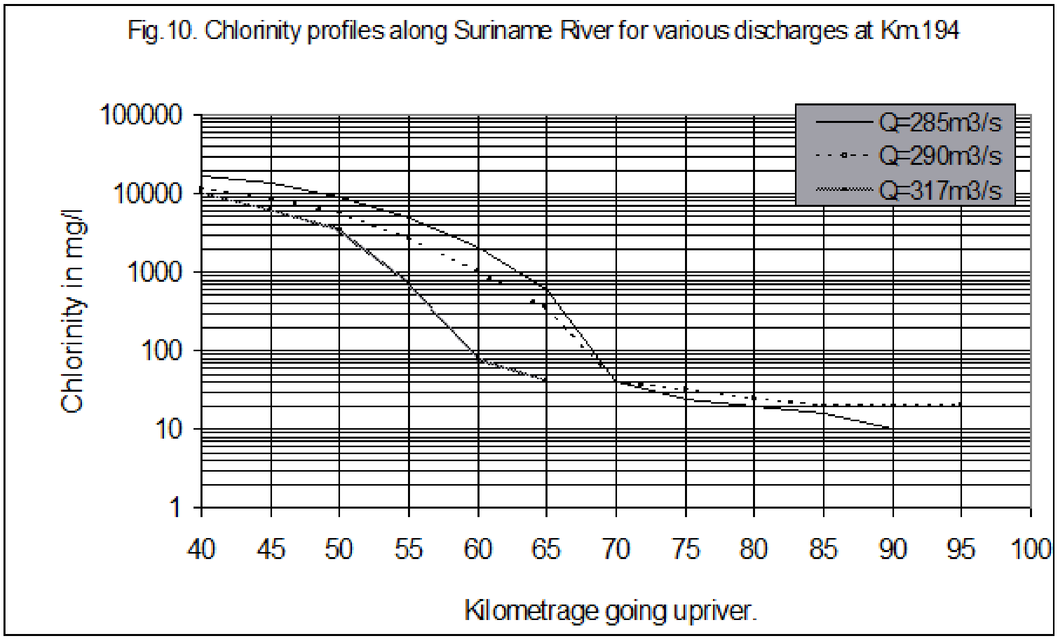
Source: ERM 2016

Figure 4-8: Existing Barriers along the Left Bank of Suriname River

4.1.4.3 Salt Intrusion

The Suriname River is considered one of the main freshwater sources in Suriname with a mean discharge at its mouth of approximately 426 cubic meters per second (m^3/s) and specific discharge of 25.8 liters per second per square kilometers ($L/s/km^2$). The Suriname River near the Paramaribo urban area is not appropriate for drinking water purposes due to its brackish characteristics. The salt wedge (300 mg Cl^-/L limit) along the Suriname River was identified near Domburg (approximately 10 km upstream of Paramaribo) during the dry season and near Doorsteek during the wet season (Amatali 2007). Figure 4-10 shows the estimated location of the salt wedge along the Suriname River. The salt wedge can be further upstream than Paramaribo (km 52) and reach Paranam at km 88 (Amatali and Naipal 1999).

The levels of salinity along the Suriname River were considered when deciding on the types of infrastructure or adaptation measures to be considered for the Project. High levels of salinity can have the potential to damage and reduce the life of infrastructure such as roads or buildings. It can also impact vegetation along the riverbank.

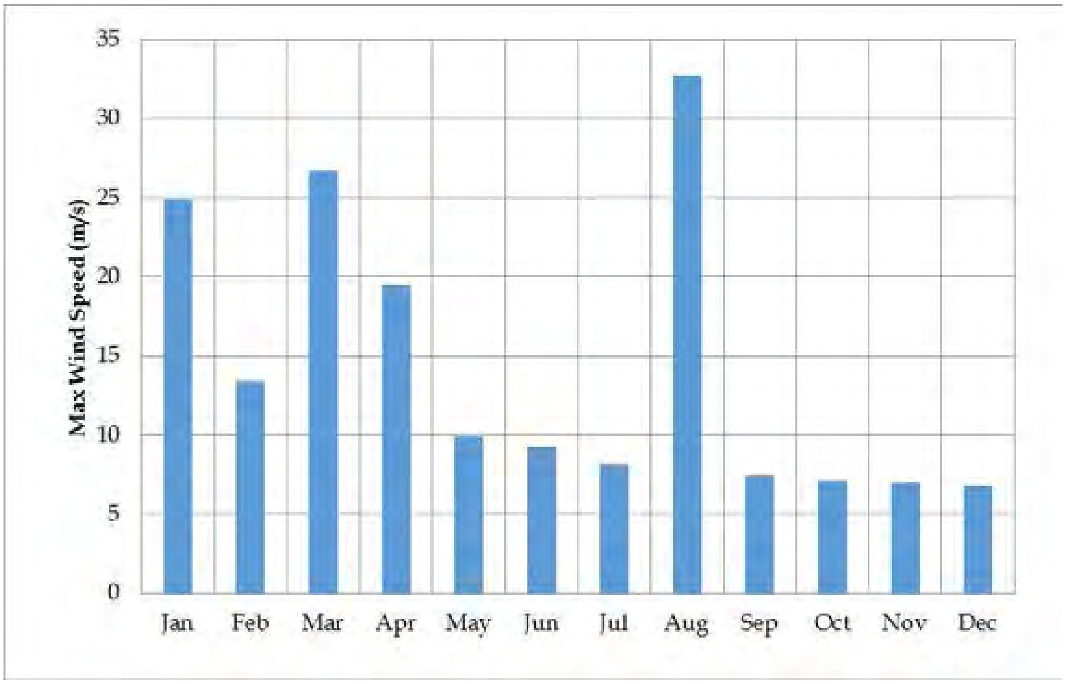


Source: Amatali and Naipal 1999

Figure 4-9: Chloride Concentrations along Suriname River for Different Discharges

4.1.4.4 Extreme Wind

According to the Environmental Statistics published by Conservation International Suriname and conversations with local specialists (Sukarni Sallons Mitro, Meteorological Service Suriname, personal communication), Paramaribo has recently experienced severe weather conditions including high intensity wind or Sibibusies (CIS 2014). These extreme wind conditions have caused partial destruction of Paramaribo's infrastructure. The Sibibusies occur during heavy rains and can present wind speeds between 20 meters per second (m/s) and 30 m/s. It is expected that with the projected increase in temperature, the energy in the atmosphere will increase as well as the maximum wind velocity (Amatali 2007). Extreme winds have toppled trees, blown off roofs, and snapped light poles. The National Coordination Center for Disaster Management (NCCR) has provided help to people under extreme wind events at more than 35 places around Paramaribo (Hokstam 2012). Figure 4-11 shows maximum wind speeds recorded at the Cultuurtuin Climatological Station for the last 2 years (February 2015 to August 2016).



Source: ERM (data provided by the Meteorological Service)

Figure 4-10: Maximum Wind Speed (m/s) Recorded at Cultuurtuin Climatological Station for 2015-2016 Period

4.2 BIODIVERSITY

Due to the urban focus of the Project, few biodiversity resources occur in the immediate Project Area—none of which are listed on the IUCN red list as threatened or endangered.

4.2.1 The Sommelsdijck Canal Heronry

The Sommelsdijck Canal heronry (a colony of breeding herons, egrets, and other waterbirds) occupies the end of the canal on the eastern bank of the Suriname River between the Royal Torarica Hotel and the Cabinet of the President. The heronry supports several hundred breeding pairs of cattle egret (*Bubulcus ibis*) with smaller numbers of snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), tricolored heron (*Egretta tricolor*), and more recently black-crowned night heron (*Nycticorax nycticorax*) (circa 2000) and boat-billed heron (*Cochlearius cochlearius*) (circa 2011). These colonially nesting species occupy the mangrove forest at the convergence of the canal with the Suriname River during the April to September breeding season (Briggs 2015). The presence of a large mixed-species heronry in such an urban location is somewhat uncommon, particularly the regular breeding presence of the boat-billed heron - a typically reclusive species. The area is closed to the public, which facilitates its sustainability as an active heronry since the species that inhabit this area are sensitive to human disturbance, especially during the breeding season (none of the heronry species are listed as endangered).

The canal is heavily polluted with trash and organic matter, including raw sewage, and the birds that breed in this heronry do not regularly forage in the canal but rather further afield in higher quality habitats associated with the Suriname River and other waterbodies.

4.2.2 The Garden of Palms

The Garden of Palms is located between the Small Water Street (*Kleine Waterstraat*) and Great Combe Road (*Grote Combeweg*). This garden, approximately 4 hectares in size, is a managed landscape within a public park that is vegetated primarily with planted royal palms. The garden provides habitat for common tropical bird species and occasionally tufted capuchin monkeys (*Cebus apella*) occur in the garden.

4.2.3 Shoreline Habitats Along the Suriname River

The shoreline along the Suriname River in the Project Area is largely developed and the limited natural habitats in the area are significantly fragmented and degraded. A well-managed seawall extends from Fort Zeelandia Road along the Suriname River. The shoreline is largely developed, including a waterfront park with a playground and a marina. Beyond the marina, the seawall is dilapidated and/or not present, allowing for establishment of a small salt marsh. Culverts along the seawall direct stormwater from the downtown area into the Suriname River.

Further west along the Suriname River, areas of riprap extend along the river behind the Riverside Restaurant. A narrow band of forest extends between the Riverside Restaurant and a local boat launch. Between the boat launch and the Cactus N.V. building along Waterkant Street is another salt marsh area that has established along the dilapidated seawall. This area is vegetated with low-lying herbaceous tidal vegetation with patches of arrowhead plant and seedling cecropia plants and is polluted with plastics and other garbage.

4.3 SOCIOECONOMIC AND CULTURAL BASELINE

4.3.1 Social Context and Area of Influence

The Project components are concentrated in two areas as shown in Figure 3-1.

The first area, where the floodwall extension is planned, is along the waterfront on Knuffelsgracht Street. This is congested given it includes the bus terminal, a water taxi landing, and several restaurants/shops; and also because it is in close proximity to historical monuments, e.g., Van de Gevallenen and Revo and allows a view of the water. It has heavy commuter and pedestrian traffic on weekdays, especially during "rush hour," i.e., 6:30 am to 9:00 am and 12:00 pm to 3:00 pm; with similar congestion on weekends and during the evening.

The Project Area on Waterkant Street includes the following stakeholders and potentially Affected Parties (Figure 4-11):

- 38 water taxis that operate from the current area of the proposed floodwall new build;
- 103 bus owners and operators of PG and LIJN 4, two Paramaribo service providers;
- Eight taxicab drivers; and
- One small business—Riverside Bar and Terrace.[6]

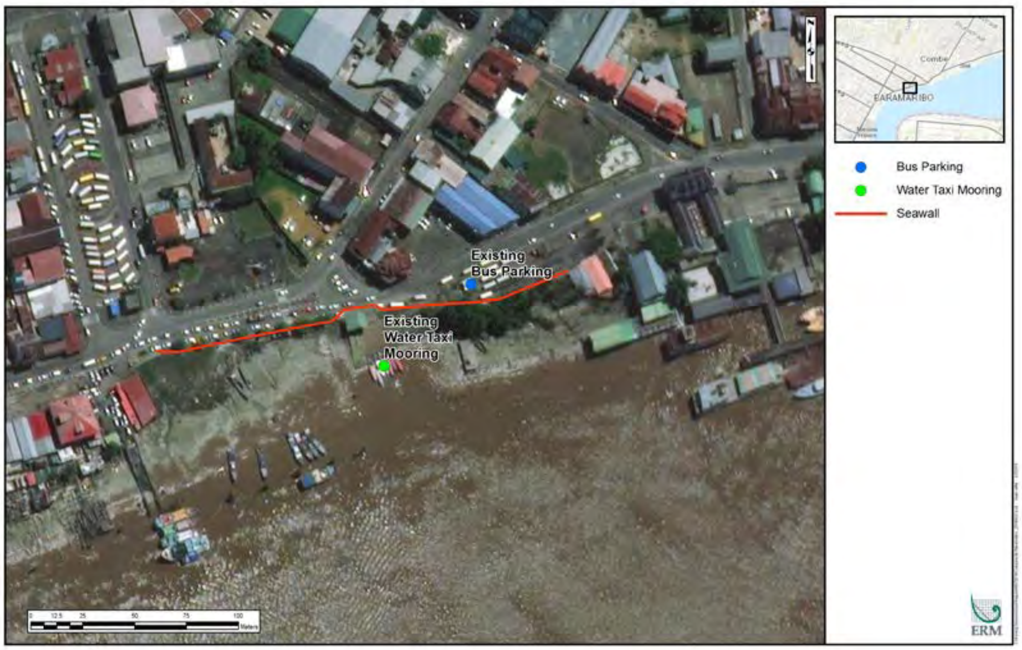


Figure 4-11: Stakeholders in relation to the floodwall extension Project component

The above stakeholders participated in a detailed census in accordance with IDB safeguards and, where possible[7], socio-economic data was collected and is presented below.

The Project Area for components associated with the Van Sommelsdijck pumping station and sluice gates and mangroves enhancement is managed by the GoS, specifically the Cabinet of the President. It includes the Presidential Palace, the National Assembly, the Suriname Museum, and the Queens Hotel and Casino. The work associated with these Project components is self-contained.

[6] There are other businesses in the larger Project Area; however, they are not expected to be impacted by the Project in any way.

[7] In some cases, stakeholders were unwilling to participate in the socio-economic survey or the interviewers were unable to make contact.

4.3.2 *Population and Demographics*

Of the 151 stakeholders included in the census, demographical and socio-economic data was collected for 115 of them. Some stakeholders were unwilling to participate in the socio-economic survey or the interviewers were unable to make contact with them for the duration of the census. An overview of demographical information is provided in Table 4-3 below.

The majority of these potentially Affected Persons are male (98.3 percent), while only two of them are female (1.7 percent)—with the average age of 44.7 years old, and outliers at 22 to 73.

Educational attainment is low for all potentially Affected Persons. More than half of potentially Affected Persons had no more than primary education. One of every five potentially Affected Persons had completed lower vocational education after primary school (19.6 percent), and a similar share had completed middle school (18.6 percent). Approximately 7 percent of potentially Affected Persons attained an education beyond middle school, and none had been to college or university.

Despite the relatively low levels of formal education, the majority of potentially Affected Persons are fluent in the Dutch language (92.1 percent)—and those who are not fluent could understand it. All potentially Affected Persons are fluent in the Suriname creole language, Sranantongo.

Two-thirds of potentially Affected Persons are of Hindustani, persons of East Indian migrant descent. The next largest ethnic groups are Javanese (14.8 percent), persons of Indonesian migrants from the island of Java descent, and Creoles (10.4 percent), persons of mixed-African heritage. Fewer individuals are Maroons (2.6 percent), descendants of run-away African slaves, or Indigenous (0.9 percent). Approximately 4.3 percent of potentially Affected Persons self-identified as mixed ethnic heritage.

Those individuals who self-identified as Maroons and Indigenous in the Project Area were interviewed. They speak Dutch, had a similar educational attainment as other identified stakeholders, and do not live in or occupy a culturally significant role. They are in the immediate Project Area solely because of employment opportunities occupied by Indigenous and non-Indigenous People alike.

Table 4-3: Population and Demographical Data

Stakeholder Group	Gender	Age (Mean)	Educational Attainment	Ethnicity
All (N=115)	98.3% Male 1.7% Female	44.7 (22-73)	No formal education, 15.7% Primary school, 39.2% Lower vocational ed., 19.6% Middle school, 18.6% High school, 5.9% Higher vocational, 1% (Valid N=102)	Hindustani, 67% Javanese, 14.8% Creole, 10.4% Mix, 4.3% Maroon, 2.6% Indigenous, 0.9%

Additional baseline studies were conducted to identify patrons of Project Area businesses, including those in the transportation sector, and determine other vulnerabilities. This overview is provided below in Section 4.3.5.

4.3.3 *Employment and Income*

Potentially Affected Persons in the Project Area are primarily associated with the transport industry (i.e., water taxis, buses, and taxicabs). The daily income of the persons in the transport industry vary considerable (Table 4-4), which is further exacerbated considering that some individual are license owners (i.e., owner of a bus), license owners and drivers, and drivers. The incomes listed in Table 4-4 were self-reported as part of the census/socio-economic survey.

Table 4-4: Estimated Average Daily Income by Stakeholder Group

		Buses (N=67) **	Ferry boats (N=30)	Taxicabs (N=8)
License Owners / Owners	SRD	170	80	79
	USD	23	11	11
Only drivers	SRD	112	67	N/A
	USD	15	9	
All (N=105)	SRD	120		
	USD	16		

For the purposes of this baseline, annual incomes for the transport industry were calculated by deducting annual estimated costs from annualizing daily incomes. Costs vary by transport group and are captured in Table 4-5 below.

Table 4-5: Annual Average Estimated Costs (USD)

Item	Buses (N=40) **	Ferry boats (N=26)	Taxicabs (N=8)
Gasoline	3,930	5,785	2,306
Maintenance	1,179	893	228
Labor expenses	1,566	10	N/A
Insurance	141	N/A	79
Taxes	119	48	17
Other expenses, (e.g., payment to government, inspection fee)	291	40	17
Total annual costs	9,211	6,577	2,622

Estimated annual incomes for the different stakeholders in the transport industry, distinguishing between license owners (including persons who both have a license and drive the vehicle) and persons who are only drivers, are presented in Table 4-6. On average, these persons earn between USD 2,000 and USD 3,500 annually. Some of the estimated annual incomes are at or less than Suriname's hourly minimum wage (SRD 6.14/USD 0.82; USD 1,705.60 per year).

Table 4-6: Estimated Average Annual Income by Stakeholder Group (USD)

	Buses	Ferry boats	Taxicabs (N=8)
License owners / owners	1,962 (N=24)	2,241 (N=22)	2,670
Only drivers	3,388 (N=30)	2,704 (N=5)	N/A
All (N=89)	2,617		

In addition, there are less than 20 people that are employed by the tourist/hospitality industry in the immediate Project Area as a result of employment at Riverside Bar/Terrace or Cactus Gold Shop. Formally, there was another restaurant in the Project Area (i.e., Broki), but it has since closed.
Housing

There are no identified residences in the Project Area.

4.3.4 Tourism and Hospitality

As shown in Figure 4-12, the larger Project Area is congested given its proximity to historical monuments and other tourists and shopping attractions, including:

- Fort Zeelandia- Historic fortress;
- Suriname Museum- Museum;
- Onafhankelijkheidsplein- Historic town square;
- Numismatic Museum- Museum;
- Magic Island Casino- Privately-owned casino;
- Golden Dragon Casino- Privately-owned casino;
- Vaillantsplein- Historic city center;
- Simon Bolivar Monument- Historical monument;
- Centrumkerk- Church;
- Cactus Gold Shop- Privately held business;
- Broki; and
- Riverside Bar and Terrace.

Figure 4-12: Tourist and Hospitality Receptors

4.3.5 Transportation

As identified above, there are several public and private modes of transportation in the Project Area including:

- Water taxis;
- Buses; and
- Taxicabs.

Baseline studies were conducted on 3 and 4 of July 2018 to identify the demographics of each modes' patrons, and determine vulnerabilities.

Table 4-7: Public/Private Transportation Modes

Mode	Male	Female
Water Taxis	38.9 percent (627 patrons)	61.1 percent (983 patrons)
PG Buses	34.3 percent (465 patrons)	65.7 percent (890 patrons)
LIJN Buses	40 percent (250 patrons)	60 percent (375 patrons)
TOTAL	**37.4 percent (1,342 patrons)**	**62.6 percent (2,248 patrons)**

In general, women are slightly more likely than men to take all forms of transportation assessed. Patrons across all modes primarily commute to

Paramaribo for work or school, and ranged in socio-economic status. There was only one patron identified with a physical disability (walking with crutches).

Paramaribo's road transportation system is characterized by a dense rectilinear network of streets and roads. Locally-oriented streets are clustered around and between larger roads that connect the capital to the rest of the region. Henck Arron Street/Kwattaweg Street and Jaggernath Lachmon Street are the primary east–west roads in the city, while Zwartenhoven Bridge Street is the primary north–south road. A single bridge, the Jules Wijdenbosch Bridge, carries the East-West Connector Road (*Oost-West Verbinding*) across the Suriname River.

Waterkant Street runs along the Suriname River shoreline and is the main road that is near the Project area. Waterkant Street is paved with a width of about 8 m, sufficient for two lanes of traffic. Curbs and bollards typically separate pedestrian areas from vehicle travel areas. A limited number of traffic signals are present at major intersections.

The GoS has not published traffic volume data for Paramaribo. Observations within the Project area indicate generally heavy automobile and bus traffic congestion, and parking demand that exceeds supply. The most significant existing sources of traffic congestion in the Project area is found along Waterkant Street.

Pedestrian traffic is relatively heavy throughout the Project area. Heavy vehicular traffic and limited traffic controls (i.e., signals) create pedestrian safety concerns, particularly at crossings of major thoroughfares.

Commercial vessel traffic includes large commercial vessels bound to and from port facilities in and around Paramaribo, as well as smaller vessels using docking facilities at Platte Brug and De Waag.

4.3.6 Cultural Heritage

A number of built heritages and archaeological and living heritage resources occur within the Project Area. The following sections provide a summary of the information on cultural heritage resources within the Project Area with a focus on those resources near the Project components.

4.3.6.1 Built Heritage

The Project would include a series of adaptation components within the Historic Inner City of Paramaribo, which was inscribed as a UNESCO World Heritage Site (WHS) on 29 June 2002. According to the nomination form, seven "Essential" listed monuments are inside the site's Designated Conservation Zone (Figure 4-11):

- Fort Zeelandia complex, which consists of Fort Zeelandia (operated as a museum), four former officer houses (used as office buildings), two former commander houses, a former guardhouse, a former military prison, and the ruins of "Gebouw 1790" (a former barracks);

- Presidential Palace;
- Ministry of Finance;
- St. Peter and Paul Cathedral (*St. Petrus en Paulus Kathedraal*), Roman Catholic;
- "Corner House";
- "De Waag" (1824); and
- Center Church (*Centrumkerk*), Dutch Reformed.

In addition, two Essential-listed monuments are outside the site's Designated Conservation Zone, but within buffer zones:

- Lutheran Church; and
- "Neve Shalom" Synagogue (Ashkenazi Jewish Community).

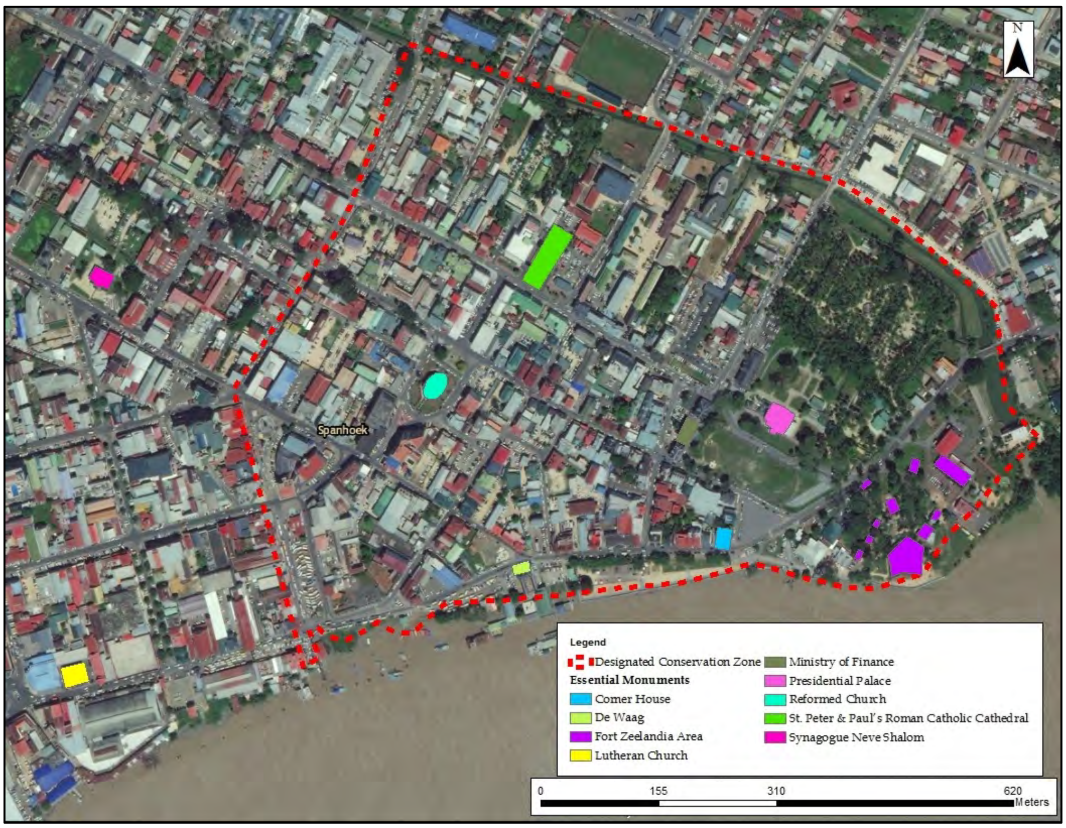


Figure 4-13: Paramaribo UNESCO WHS Essential Monuments

At the time of nomination, the WHS consisted of 244 formally protected monuments (Figure 4-12). Approximately 50 percent of these monuments are located within the Designated Conservation Zone, and approximately 15 percent are located in the two buffer zones. The Designated Conservation Zone and buffer zones comprise an area of approximately 90 hectares.

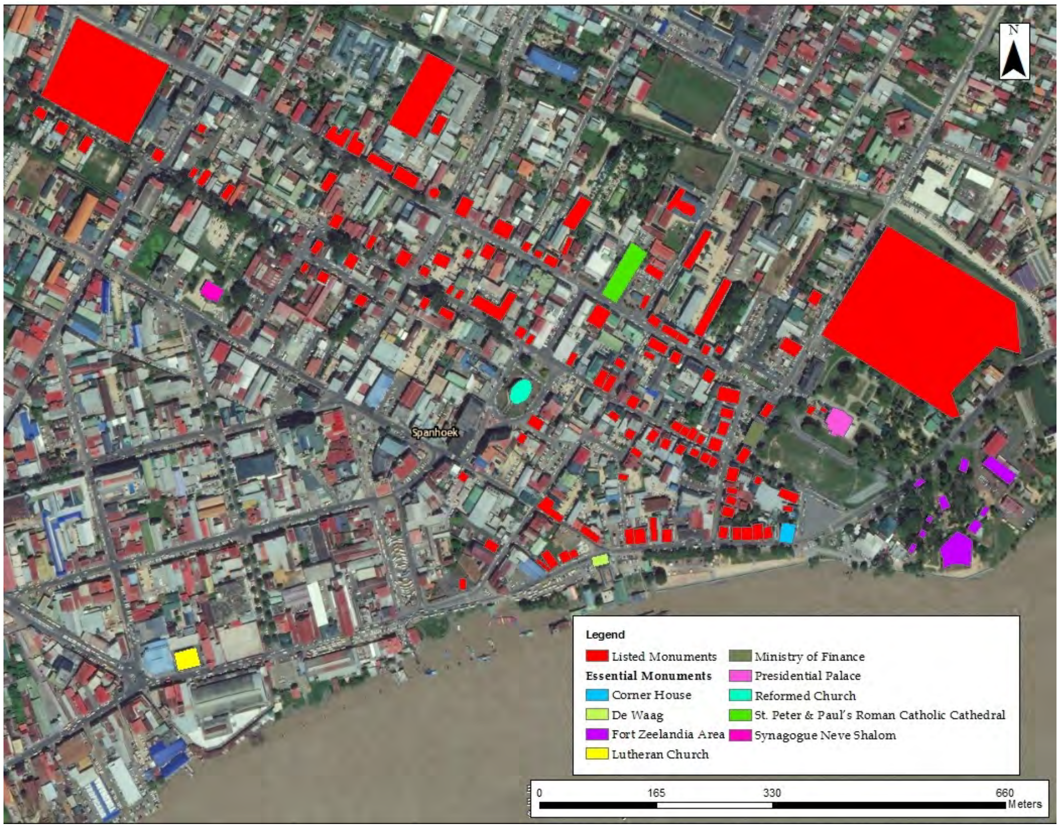


Figure 4-11: Paramaribo Listed and Essential Monuments

According to UNESCO's webpage on the Historic Inner City of Paramaribo (UNESCO 2017), there are currently 291 listed monuments in Paramaribo. Protection of approximately 250 of these monuments was initially guaranteed by the 1963 Monuments Act, which was replaced in 2002 by a new Monuments Bill (S.B. 5 September 2002 No. 72). The latter provides for the designation of protected historic quarters with controls over interventions and provision for subsidies to owners for conservation works. Additional monuments were added to the monuments list in 2007 (1 monument), 2010 (1 monument), and 2011 (25 monuments).

The Project components are located within 150 m of nine listed monuments, including three monuments listed in the UNESCO WHS (Figure 4-13):

- New Flood Protection Wall: The new flood protection wall would be within 150 m of seven listed monuments including the Monument of the Revolution listed monument and the UNESCO WHS-listed De Waag Building. The flood wall would be visible from all seven structures.
- Rehabilitation of the Sommelsdijck Canal Pump Station and Sluice Gates and enhancement of mangroves: The pump station is adjacent to two listed monuments: the UNESCO WHS-listed Fort Zeelandia complex and the Garden of Palms listed monument.

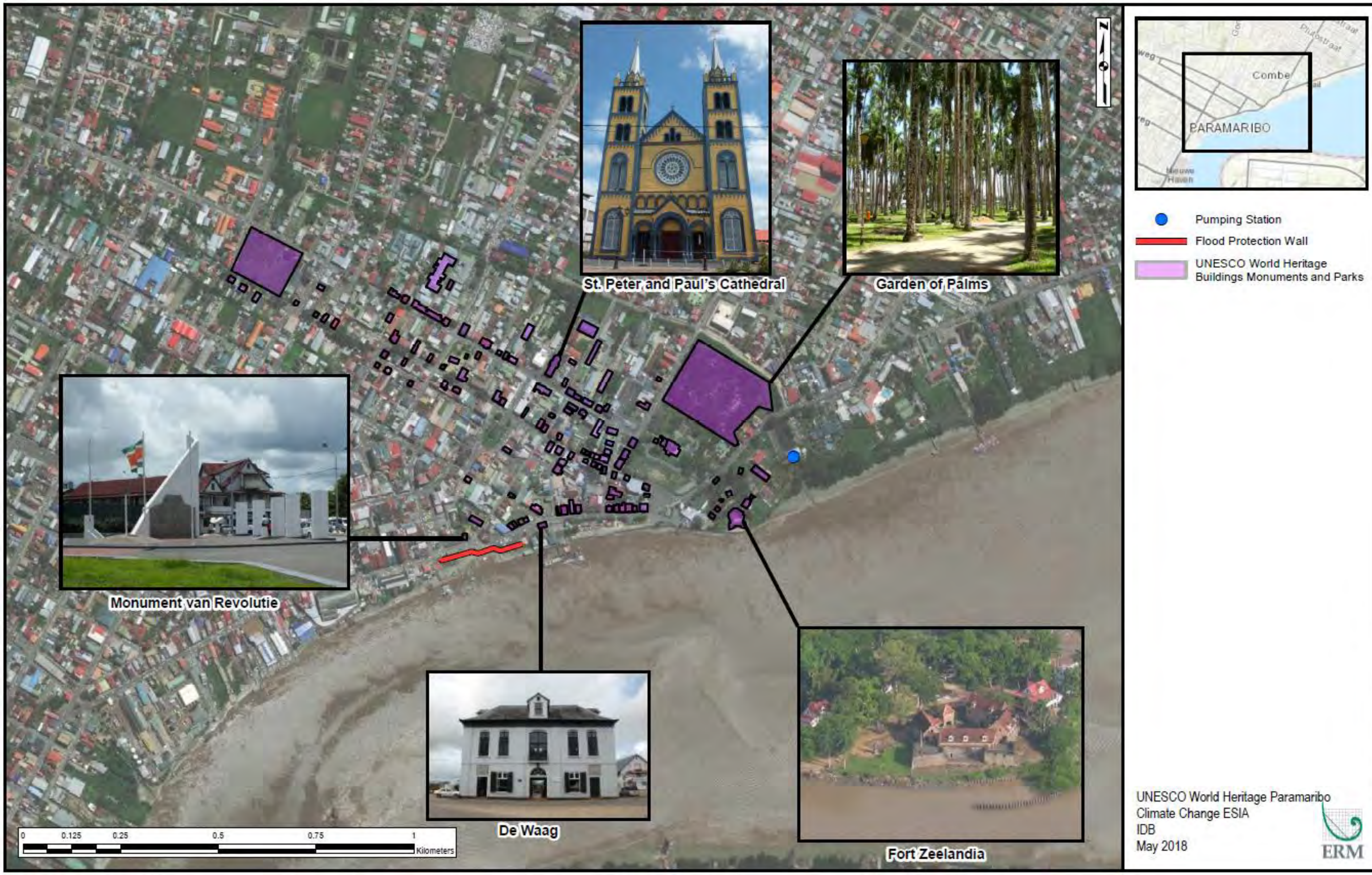


Figure 4-12: Listed Monuments and Proposed Project Components

4.3.6.2 Archaeological

According to the PWHSMP, archaeological research in Suriname is predominantly focused on the pre-Columbian period. According to the PWHSMP, approximately 400 known pre-Columbian archaeological sites are in Suriname. Of these, only a few are located in and around Paramaribo. Within the Paramaribo WHS, the only known pre-Columbian archaeological resources are at the waterfront. Additional resources are located at Kwatta, Charlesburg, and Blauwgrond, approximately 5 to 10 kilometers (km) from the inner city.

Archaeology of the colonial period is mainly practiced by amateur archaeologists. Urban archaeological resources can be found at construction sites within the historic inner city, and consists mostly of clay pipes, bottles, coins, brick foundations, and brick water cellars. Archeological resources preserved within standing historic structures include the remains of a fountain or pound under the floor of the St. Peter and Paul Cathedral, which dates back to the Jewish Theater building "The Resurrected Phoenix," brick foundations of an earlier building constructed at Great Combe Road (*Grote Combéweg*) #2, and brick foundations of houses destroyed during the city fires of 1821 and 1832 (e.g., Waterfront 12). Several historic brick wells, cellars, and ovens have also been documented by the SBHF in Paramaribo.

As noted in the PWHSMP, there is the potential to find additional archaeological remains in the Paramaribo WHS associated with the first European inhabitants of Paramaribo, as well as the Indigenous settlement near the Garden of Palms. Due to the presence of Pre-Columbian and historic European archaeological resources within Paramaribo, any Project ground disturbing activities have the potential for uncovering previously undiscovered archaeological resources.

4.3.6.3 Living Heritage

Living heritage sites are locations, buildings, landscape features, and other tangible cultural heritage resources that are part of a living cultural tradition. Examples of living heritage sites commonly found in urban environments include places of religious worship (churches, synagogues, mosques, etc.), shrines, cemeteries, and commemorative monuments. Living heritage sites located within the Project Area include the St. Peter and Paul Cathedral and the Dutch Reformed Center Church (*Centrumkerk*). Both of these resources are also UNESCO WHS-listed monuments. The Dutch Reformed Center Church is located over 250 m from the new flood protection wall and is not visible from the church. The St. Peter and Paul Cathedral is located approximately 150 m south of the Sommelsdijck Canal Pump Station.

5.0 *IMPACT ASSESSMENT*

5.1 *GENERAL METHODOLOGY*

The primary purpose of an ESIA is to predict the impacts resulting from the proposed project. Impacts can be direct, indirect, or induced, as defined in Table 5-1.

Table 5-1: Impact Designation Definitions

Designation	Definition
Direct	Impacts that result from a direct interaction between the Project and a resource/receptor (e.g., between disturbance of a plot of land and the habitats on that plot of land that are affected).
Indirect	Impacts that follow from the direct interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g., viability of a species population resulting from loss of part of a habitat as a result of the Project occupying a plot of land).
Induced	Impacts that result from other activities (which are not part of the Project) that happen as a consequence of the Project (e.g., influx of camp followers resulting from the presence of a large Project workforce).

The assessment of impacts proceeds through an iterative process that considers four questions as illustrated in Figure 5-1.

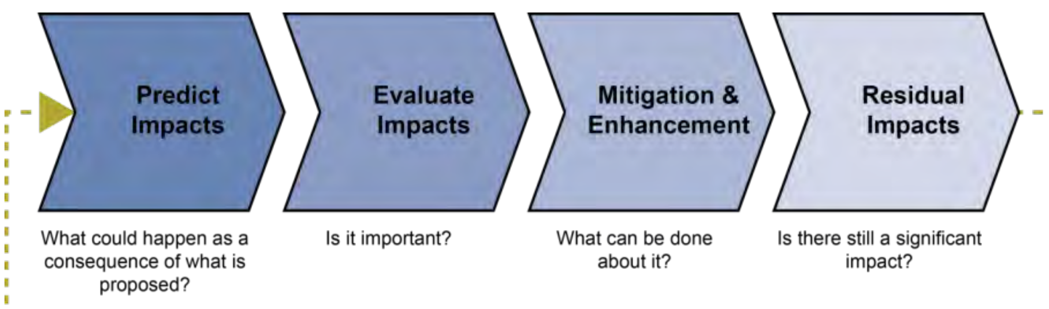


Figure 5-1: Impact Prediction and Evaluation Process

These questions are expanded in Steps 1 through 4 below.

5.1.1 *Step 1: Predict Impacts*

An ESIA evaluates potential project impacts by predicting and quantifying to the extent possible the magnitude of impacts on resources (e.g., water and air) or receptors (e.g., people, communities, wildlife species, habitats). Magnitude is a function of the following impact characteristics:

- Type of impact (i.e., direct, indirect, induced)
- Nature of the change (what is affected and how)
- Size, scale, or intensity

- Geographical extent and distribution (e.g., local, regional, international)
- Duration and/or frequency (e.g., temporary, short term, long term, permanent)

Magnitude describes the actual change that is predicted to occur in the resource or receptor. The magnitude of an impact takes into account all the various dimensions of a particular impact in order to make a determination as to where the impact falls on the spectrum (in the case of adverse impacts) from *Negligible* to *Large*. Some impacts can result in changes to the environment that may be immeasurable, undetectable, or within the range of normal natural variation. Such changes can be regarded as essentially having no impact, and are thus characterized as having a *Negligible* magnitude. In determining the magnitude of impacts on resources and receptors, embedded controls (i.e., physical or procedural controls that are planned as part of the project design) are taken into consideration (e.g., the magnitude of impacts on stream water quality from construction take into consideration the effectiveness of proposed sediment and erosion control measures).

In addition to characterizing the magnitude of impact, the sensitivity/ vulnerability/importance of the impacted resource/receptor is characterized. A range of factors is taken into account when defining the sensitivity/ vulnerability/importance of the resource/receptor. Where the resource is physical (e.g., a waterbody), its sensitivity (to change) and importance (on a local, national, and international scale) are considered. Where the resource/receptor is biological or cultural (e.g., the marine environment or a coral reef), its importance (e.g., its local, regional, national, or international importance) and its sensitivity to the specific type of impact are considered. Where the receptor is human, the vulnerability of the individual, community, or wider societal group is considered. Other factors may also be considered when characterizing sensitivity/vulnerability/importance, such as legal protection, government policy, stakeholder views, and economic value.

As in the case of magnitude, the sensitivity/vulnerability/importance designations themselves are universally consistent (i.e., *Low*, *Medium*, and *High*), but the definitions for these designations would vary on a resource/receptor basis.

5.1.2 Step 2: Evaluate Impacts

An ESIA evaluates the significance of a potential project impact by considering, in combination, the magnitude of the impact and the sensitivity/vulnerability/importance of the impacted resource or receptor. The assignment of a significance rating facilitates decision-makers and stakeholders to understand how much weight should be given to the issue in their process. In the case of positive impacts, the significance is assigned as *Positive*.

Significance was assigned for each impact using the matrix shown in Table 5-2. This matrix applies universally to all resources/receptors.

Table 5-2: Evaluation of Significance of Impacts

Impact Significance Matrix		**Sensitivity/Vulnerability/Importance of Resource/Receptor**		
		Low	**Medium**	**High**
Negative Impacts				
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major
Positive Impacts				
Magnitude of Impact	NA	Positive	Positive	Positive

In terms of what the various significance designations represent, the following considerations are provided:

- An impact of *Negligible* significance is one where a resource/receptor (including people) would not be affected by a particular activity, or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background variations.
- An impact of *Minor* significance is one where a resource/receptor would experience a noticeable effect, but the impact magnitude is sufficiently *Small* (with or without mitigation) and/or the resource/receptor is of *Low* sensitivity/vulnerability/importance. In either case, the magnitude should be well within applicable standards.
- An impact of *Moderate* significance has an impact magnitude that is within applicable standards but falls somewhere in the range from a threshold below which the impact is *Minor*, up to a level that might be just short of breaching a legal limit. To design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for *Moderate* impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable. This does not necessarily mean that impacts of *Moderate* significance have to be reduced to *Minor*, but rather that *Moderate* impacts are being managed effectively and efficiently.
- An impact of *Major* significance is one where an accepted limit or standard may be exceeded, or *Large* magnitude impacts occur to highly valued/sensitive resources/receptors.
- An impact of *Positive* significance is one that has been identified as having a positive effect on the receptor/resource. Generally, this ESIA does not attempt to characterize magnitude for positive impacts.

A goal of an impact assessment is to get to a position where a project does not have any *Major* residual impacts (i.e., after mitigation measures are considered), certainly not ones that would endure into the long term or extend over a large area. However, for some aspects, there may be *Major* residual impacts after all practicable mitigation options have been exhausted. An example might be the visual impact of a facility. It is then the function of the decision-makers and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on a project.

5.1.3 Step 3: Mitigation and Enhancement

An ESIA process aims to ensure that project decisions are made in full knowledge of their likely impacts on the environment and society. A vital step within the ESIA process is therefore the identification of measures that could be taken to mitigate potential impacts of the project being assessed.

This process involves identifying where potentially significant impacts could occur and identifying ways of mitigating those impacts as far as reasonably possible. The mitigation hierarchy was used for this ESIA, in which preference was given to trying to avoid or minimize the impact before considering other types of mitigation (i.e., remedy, compensate, offset):

- Avoid —remove the source of the impact
- Minimize —reduce the magnitude of the impact
- Mitigate—"repair" the results of the impact after it has occurred
- Compensate/offset—address the loss or change to a resource by replacing the loss/change in kind or with a different resource of equal value

5.1.4 Step 4: Residual Impacts

Once mitigation measures are determined, the next step in the impact assessment process is to determine the residual impact significance. Residual impacts are the impacts that are predicted to remain after both embedded controls and committed mitigation has been taken into consideration. In most cases, the sensitivity/vulnerability/importance of a receptor is unaffected by proposed mitigation measures: the mitigation measure is typically intended to reduce the magnitude of a predicted impact, thereby reducing its overall significance.

5.2 PHYSICAL RESOURCES IMPACT ASSESSMENT

5.2.1 Natural Disasters and Climate Change

5.2.1.1 Natural Hazards

According to a Global Assessment Report on Disaster Risk Reduction prepared by the United Nations, a hazard is a dangerous phenomenon, human activity, or condition that may cause loss of life, injury, or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR 2009). A disaster is defined as a serious disruption of the functioning of a community or a society involving widespread, human, material, economic, or environmental losses and impacts that exceeds the ability of the affected community or society to cope using its own resources.

The Project itself would be highly exposed to natural events such as floods, erosion, and salt intrusion, which could affect it during both construction and operations. For example:

- Construction Phase: Tropical storms and storm surges could significantly impact construction and result in damage to Project components (e.g., damage to facilities and construction equipment) and worsen impacts to the environment (e.g., increased risk of erosion, and sedimentation because of construction activities).
- Operation Phase: Natural events could damage the waterfront through floods, erosion, and salt intrusion affecting facilities and population.

It should be noted that the Project itself has been designed to offer localized protection against natural disasters, namely flooding.

5.2.1.2 Climate Change Projections

Climatological conditions in Suriname are affected by El Niño -Southern Oscillation (ENSO) that occurs once every 2 to 7 years. Prior studies indicate that El Niño events may reduce precipitation in Suriname (Amatali 2012). Historically, El Niño events in South America have led to excess precipitation on the west coast, while Suriname has presented dryer conditions (MLTDE 2013).

Air temperatures in Suriname have increased during the last 47 to 50 years based on historical records from Cultuurtuin and Nickerie Airport meteorological stations. These stations have shown increasing trends on annual mean air temperatures of +0.016 °C/year and +0.008 °C/year, respectively while the Zanderij station has shown trends of annual mean air temperature of +0.004 °C/year (Amatali 2012; MLTDE 2013).

Precipitation records from Cultuurtuin climatological stations have shown a decreasing trend on annual mean precipitation and maximum daily precipitation of -1.147 mm/year and -0.0247 mm/year, respectively. Dry seasons recorded at Cultuurtuin station show increasing dry seasons (3 weeks) when the last 30 years are compared with the first 30 years of data from the previous century (Amatali 2012).

The Second National Communication to the United Nations Framework Convention on Climate Change presented climate change scenarios and projections for Suriname (MLTDE 2013). These projections include sea level rise (SLR), changes on precipitation, changes in temperature, and possible changes in extreme events including wind speeds. All these projections are based on scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) and adapted for Suriname to describe how future conditions may develop considering the driving forces and key relationships. Elements of A2 and B2 scenarios, specific data for the country, and data of extreme events and variations were used to develop the adapted projections for Suriname. Table 5-3 shows the mean climate change projections for Suriname.

Table 5-3: Climate Change Projections for Suriname based on A2 and B2 IPCC Scenarios

Parameters	Value	Year	Source
Air temperature overall annual mean	+2 °C to +3 °C	2100	IPCC Fourth Assessment Report Second National Communication to the United Nations Framework Convention on Climate Change
Precipitation	-10%	2100	IPCC Fourth Assessment Second National Communication to the United Nations Framework Convention on Climate Change
Weather extremes, including wind, intensity	+27% Dec-Jan- Feb +18% March- Apr-May	2100	IPCC Fourth Assessment
Average significant wave height	+2.5% compared with the current magnitude	2099	Technical paper Future profile. Second National Communication. Sector Water Resources
Sea level rise	+1.0 meter	2100	Technical paper Future profile. Second National Communication. Sector Water Resources

Source: MLTDE 2013, CCCRA 2012

However, the projected changes in precipitation for 2050 and 2080 were obtained from the CARIBSAVE climate change report (CCCRA 2012). This report provided seasonally varying extreme precipitation data for the SRES Scenario A2 (Equivalent to RCP 8.5) computed from RCM models ECHAM4 and HadAM3 and is shown in Table 5-4 and graphically illustrated in Figure 5-2. The monthly climate change projection of extreme precipitation was used along with baseline historical time-series precipitation data to develop IDF curves for future years of 2050 and 2080 (baseline year of 2006).

Table 5-4: Monthly Extreme Precipitation Climate Change Projection for the Years 2050 and 2080

% Change in Precipitation for Scenario A2 (≈ RCP 8.5)		
Month	**2050**	**2080**
Jan	10	8
Feb	10	8
Mar	9	13
Apr	9	13
May	7	13
Jun	7	16
Jul	7	16
Aug	7	16
Sep	21	24
Oct	21	24
Nov	21	24
Dec	10	8

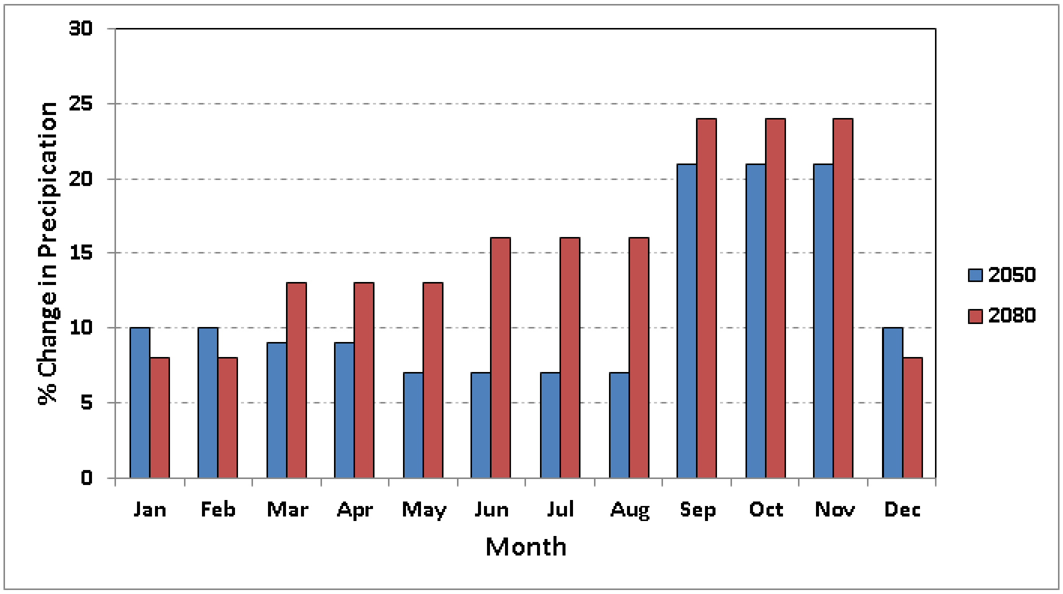
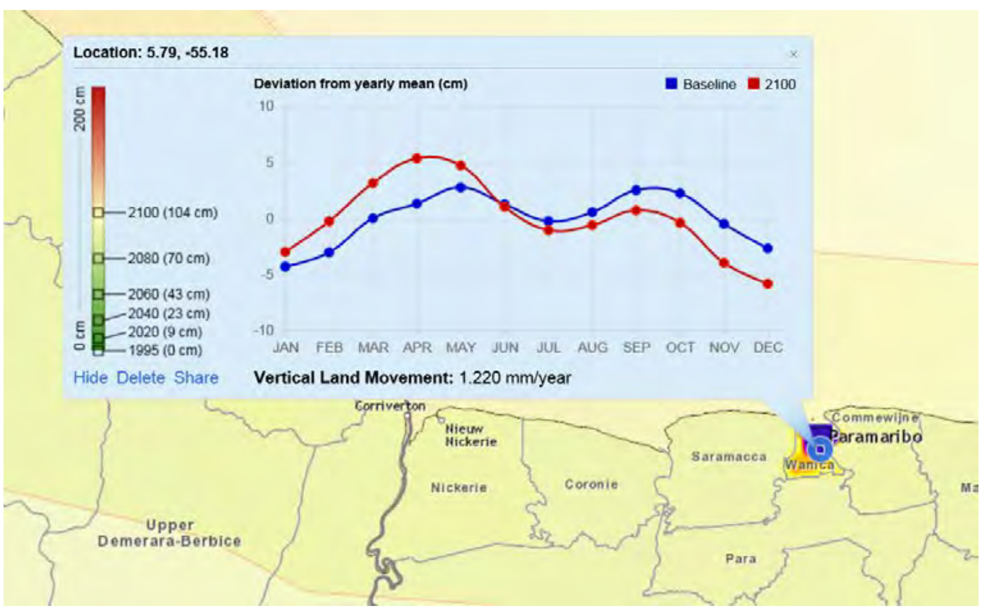


Figure 5-2: Monthly Variation of Extreme Precipitation Climate Change Projection for the Years 2050 and 2080

Similarly, SLR was evaluated from various sources that include CARIBSAVE report and CLIMSystems online sea-level rise tool. CARIBSAVE report provides SLR projection for 2100 and not for any other years. So, SLR data for every 2 decades was obtained from CLIMsystems online tool (www.climsystems.com) and is shown in Figure 5-3. A regression analysis was performed to obtain yearly variation as shown in Figure 5-4 so that data for the years 2050 and 2080 can be estimated correctly.



Source. http://www.climsystems.com/slr-cities-app/

Figure 5-3: SLR for the City of Paramaribo

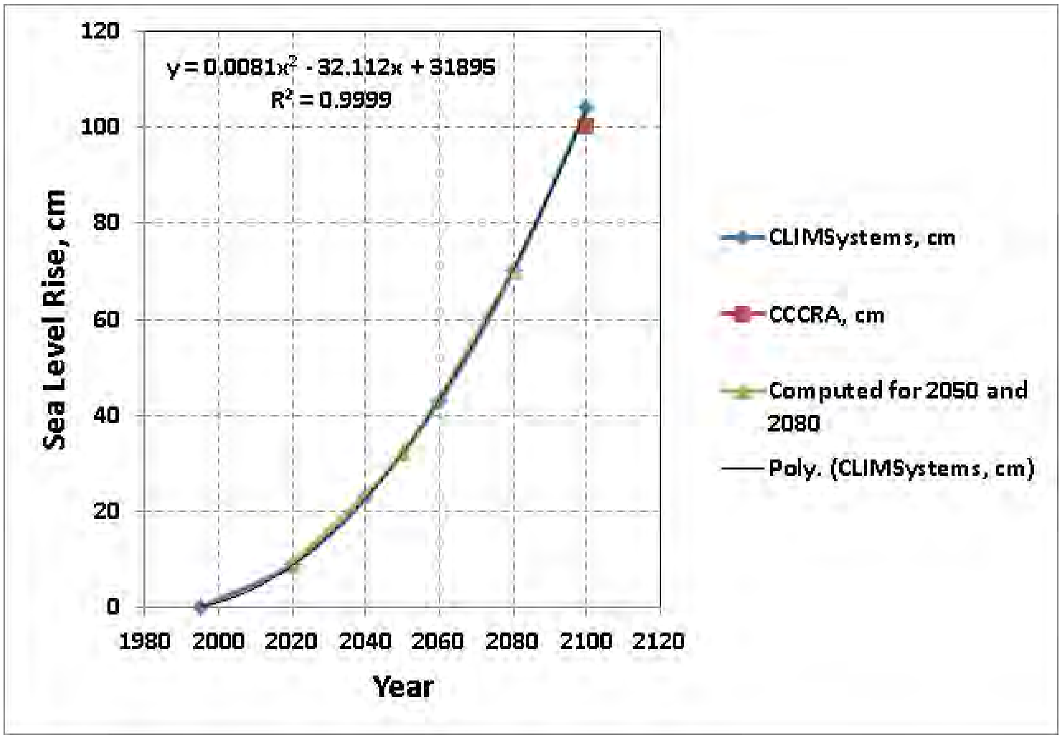


Figure 5-4: Regression Analysis for SLR Variation with Year

Both the modified IDFs and SLR obtained for the climate change years 2050 and 2080 were then used to evaluate associated flood inundation and risk maps for subsequent impact assessment.

5.2.1.3 Impact Assessment

Relevant climate change projections illustrate a dynamic system with anticipated changes that could pose changes in the hazard and risk profiles. To evaluate flood hazards and risks in the Project Area, ERM has considered the baseline and projection data and performed a series of additional analyses that includes the following steps:

- Developed flooding hazard profiles;
- Assessed vulnerability (exposed buildings and population);
- Estimated losses; and
- Developed risk analysis framework.

These analyses are documented in a separate report prepared by ERM (Site-Specific Risk Analysis for the Paramaribo Climate Change Adaptation Fund Project, 2018, see summary in Appendix G). It should be noted that these studies have been undertaken to assess appropriate flood protection and adaptation options when considering climate change and natural disasters. As a consequence, the selected Project components provide protection in part against these phenomena.

It should however be noted that the Project in isolation will not ensure complete protection of the downtown Paramaribo area against flooding and future natural hazards. The Project is part of a progressive series of steps towards building climate resilience to this part of Paramaribo. The general objective of the proposed Project is to contribute towards increasing the adaptive capacity of communities living in Paramaribo to cope with observed and anticipated impacts of climate change on floods and sea level rise. The Project components form part of a broader framework that will be implemented using the AF grant monies comprising the following:

- Downtown Adaptation Measures: Implement a group of strategic and cost-effective adaptation hard measures in the historic downtown area of Paramaribo that illustrate the benefits of building climate resilience as part of a long-term planning strategy for the city and its metropolitan area (the Project components that are the focus of this ESIA);
- City Adaptation Framework and Plan: Establish a framework for managing knowledge and disseminating lessons learned that could be used in future resilience programs for the city of Paramaribo and that could be part of a city-level Adaptation Plan;
- Capacity Building: Build capacity across local communities and GoS stakeholders responsible for decision making in Paramaribo to ensure strong implementation and enforcement of the Adaptation Plan; and
- Monitoring and Evaluation: Ensure there is a robust plan and implementation structure to allow the Proposed Project to be implemented, monitored, evaluated and lessons learned disseminated.

Therefore, implementation of the Project would have a positive impact with respect to climate change and natural hazards, by minimizing potential risks.

5.2.2 Air Quality

Construction-related air pollution associated with the selected Project components would result from operating heavy construction equipment and increased vehicle traffic in the Project Area. Of the Project components, the new flood protection wall is expected to generate the most air emissions, as it involves the most construction activities (the flood protection wall construction itself and roadside drainage improvements).

The remaining Project components are mostly related to improving existing facilities or infrastructure with minimal use of heavy construction equipment. These components involve rehabilitating the existing canal basin, sluice gates, and pump stations, and are expected to occur over a shorter duration compared to the new flood protection wall.

Considering that construction and rehabilitation activities would be localized, intermittent, and occur over a short-term (a few weeks), the air quality effects of all four alternatives on the nearest receptors is expected to be minimal.

The air quality impacts associated with all four alternatives could be minimized using the following measures:

- Maintain all construction equipment in accordance with manufacturer's specifications.
- Suppress dust as need in unpaved areas.
- Avoid burning non-vegetative wastes (refuse, etc.) at construction sites.
- Avoid unnecessary idling of construction equipment or delivery trucks when not in use.

After construction, ambient air quality is expected to return to pre-construction levels. Therefore, implementation of the Project would have no impact on the surrounding air quality.

5.2.3 Noise

Construction-related noise pollution associated with the selected Project components would result from operating heavy construction equipment and increased vehicle traffic in the Project Area. Of the components, the new flood protection wall is expected to generate the most noise, as it involves the most construction activities (the flood protection wall construction itself, sheet piling, roadside drainage improvements, etc.). Aside from airborne noise impacts on nearby human receptors, the new flood protection wall also involves shore-based activities such as sheet piling, which would generate underwater sound, and possibly impact aquatic resources close to the shore.

The remaining Project components are mostly related to improving existing facilities or infrastructures with minimal use of heavy construction equipment. These components involve rehabilitating the existing canal basin, sluice gates, and pump stations, and are expected to occur over a shorter duration compared to the new flood protection wall.

Considering that construction and rehabilitation activities would be localized, intermittent, and occur over a short-term (a few weeks), the noise effects of the Project components on the nearest receptors are expected to be minimal.

The noise impacts associated with the Project components could be minimized using the following measures:

- Maintain all construction equipment in accordance with manufacturer's specifications.
- Schedule construction and rehabilitation work during daylight hours when increased noise levels are more tolerable.
- Schedule construction and rehabilitation work to minimize activity during peak periods of tourism and recreation (weekends, holidays, etc.).
- Develop and implement a Construction Communications Plan to inform adjacent receptors (e.g., commercial businesses, churches, and tourists) of construction activities.

- Use vibratory or press-in piling instead of impact piling during shore-based construction activities to avoid generating impulsive noise and vibration that could impact nearby buildings.

After construction, ambient noise levels are expected to return to pre-construction levels. Therefore, implementation of the Project components would have no impact on the surrounding noise environment.

5.2.4 Waste

Waste associated with the Project includes both general construction waste as well as dredge material. General construction waste generated on-site will be collected in waste bins/receptacles to be hauled offsite by a licensed waste hauler and disposed of accordingly in approved landfills. Construction waste consists of general food and office waste, personal protection equipment, paper, cardboard, plastic, pallets, wood, scrap steel, etc.

Dredge material will be generated from the canal improvement activities in the water basin at the Van Sommelsdijck Pumping Station as well as from the construction of the flood wall. The excavated material will be discharged to a sludge drying area previously approved by the Government prior to disposal. All removed and excavated sediment material will be disposed by the Contractor at a Government approved disposal site. The GoS decides on a case by case basis where the Contractors can dispose the sludge. As with the canal maintenance work already takes place yearly, the Contractors propose a sludge drying and disposal area to the GoS for approval prior to beginning the work. Sludge/dredge material is generally disposed of in open private land available within 10-20 km outside the city perimeter. Contractors may also dispose the material in their own land. There is no permit required to dispose sludge in an open land area; however, the Contractor must comply with the general Hindrance Act, which limits the amount of disturbance to neighborhoods (hours and number of operating trucks).

Considering that construction activities would be intermittent, and occur over a short-term (a few weeks), and the amount of waste to be generated is expected to be low, the impacts related to waste generation and disposal of the Project are expected to be minimal.

5.3 BIODIVERSITY IMPACT ASSESSMENT

The small footprint and degraded natural habitat conditions in the Project Area limit the significance of the Project's impacts on biodiversity. Overall, impacts to biodiversity related to implementation of the Project during the construction phase would be minor and temporary and easily managed through implementation of standard mitigation measures and construction good practice. Ultimately, implementation of the Project components would benefit biodiversity through an improvement of water flow and quality in the Sommelsdijck Canal as a result of the flood control improvements and improved habitat conditions in the mangrove as a result of the mangrove restoration activities. These improvements would positively affect terrestrial and aquatic biodiversity in the in the canal and the associated mangrove, including the Sommelsdijck Canal heronry. The potential impacts to biodiversity from implementation of the Project include:

- Loss or degradation of vegetation;
- Wildlife injury or mortality;
- Wildlife disturbance and displacement; and
- Habitat improvements in Sommelsdijck Canal and mangrove.

5.3.1 Loss or Degradation of Vegetation

Limited vegetation clearing would likely occur in the immediate vicinity of the Canal improvements but the exact location and extent of vegetation clearing cannot be determined until more specific designs and construction procedures are developed. With the exception of the mangrove forest at the end of the Canal which is relatively undisturbed, the vegetation community in and along the edges of the Canal is of low quality due to the low species diversity, proximity of human activity, polluted water in the Canal, and presence of invasive vegetative species. Minor loss and disturbance of this vegetation community would be temporary during construction and disturbed areas would revegetate quickly. Minimization of the construction footprint and avoidance of vegetation disturbance to the extent possible would minimize the impacts to vegetation to a negligible level.

The mangrove restoration component would improve vegetative conditions in the area once restoration activities are completed.

5.3.2 Wildlife Injury or Mortality

With the exception of the birds occupying the Sommelsdijck Canal heronry and common, disturbance-tolerant aquatic species that inhabit the canal itself, wildlife in the Project Area is very limited and restricted primarily to transient birds and occasional mammals (e.g., Capuchin monkeys) occurring in strips of vegetation along the waterfront and in the Garden of Palms. For the most part, wildlife will move away from work areas during construction, avoiding injury or mortality from Project activities, and return to the area once construction activities are complete. Increases in vehicular and heavy equipment traffic would pose risks to wildlife but limiting work to daylight hours, effectively managing the construction workforce, and limiting vegetative clearing to distinct zones will reduce the significance of these impacts. Together, the mitigation and construction management measures described in the ESMP will help ensure that the Project has negligible impacts on terrestrial biodiversity.

Slow moving or aquatic invertebrates and other slow moving species could be injured or crushed by heavy equipment or during dredging required for the Sommelsdijck sluice gate/pump station rehabilitation activity. Potentially impacted species are common in the region and would not be impacted at the population level. Populations of these species would be expected to return to pre-construction conditions in a year or less following completion of construction works. Populations of these and other species could increase over time as habitat conditions in the canal improve due to improved water management in the canal as a result of the sluice gate and pump station rehabilitation. Off-site disposal of the dredge material from the Canal will limit exposure of aquatic and terrestrial wildlife to contaminated sediments that are removed from the Canal during sluice gate and pump station rehabilitation.

5.3.3 Wildlife Disturbance and Displacement

The most significant potential impact of the Project on wildlife is the disturbance and displacement of the waterbirds that nest in the Sommelsdijck Canal heronry between April and September. There are several hundred breeding pairs of waterbirds in this heronry including charismatic species such as the boat-billed heron and this heronry is a locally important birding spot for recreationists. Colonial waterbird breeding colonies are particularly vulnerable to disturbance, and human activity can cause desertion of the nesting colony. Many studies throughout the world have documented that increased noise, light, human, and vessel activity all have the capacity to cause disturbance and displacement of colonially nesting birds. Where displacement occurs, it can result in the functional loss of habitat, decreased carrying capacity of habitats, and increased energy expenditure of affected individuals (Platteeuw and Henkens 1997). The degree of disturbance and displacement experienced by birds depends on the season and life stage when the impact occurs, as well as the sensitivities of individuals and species to disturbance impacts.

Colonial nesting birds are most susceptible to disturbance just before and during the nesting period and direct and indirect nesting site disturbance can lead to temporary or permanent nesting site abandonment, direct mortality of eggs and/or young, and reduced breeding success (Ruddock and Whitfield 2007). Studies in Florida identified differences in the sensitivity of different types of waterbird colonies to disturbance and concluded that breeding colonies of herons and storks (including some of the species that inhabit the Sommelsdijck Canal heronry) were more susceptible to disturbance than colonies of other waterbird species such as terns and skimmers. Disturbance as close as 200 meters to a nesting colony of herons and storks can result in temporary abandonment of nests by adults and related egg and chick mortality (Rodgers and Smith 1995). If construction-related disturbance and human activity were to occur in the Project Area during the nesting period from April through September, this could cause abandonment of the heronry for the breeding season. Depending on the stage of nesting (early, mid-, or late-nesting), individuals may not re-nest elsewhere, resulting in the loss of a brood year. Avoidance of construction activities during the nesting period would avoid or minimize disturbance to colonial waterbirds and other bird species that occur in the mangrove and Canal.

5.3.4 Habitat Improvements in Sommelsdijck Canal Basin and Mangrove

Enlarging the Canal Basin to improve flow and mangrove restoration would improve habitat conditions for aquatic and terrestrial biodiversity over the long term.

5.3.5 Mitigation/Enhancement Measures and Residual Impacts

Mitigation measures to minimize the potential impacts of the Project on biodiversity include:

- When designing and planning work elements, minimize temporary and permanent construction footprints
- Demarcate work area with fencing to minimize disturbance or removal of natural vegetation
- Proper disposal of dredged material to avoid wildlife exposure
- Conducting canal- and mangrove-related works outside the waterbird breeding season (April – September)
- Minimize lighting in and around construction sites
- Implement noise and air emission abatement measures measures
- Implement sediment control procedures during in-water works to minimize the release of fine sediments to downstream waterways, particularly the Suriname River

Implementation of these measures would reduce the significance of the impacts to biodiversity to Negligible or Positive when considering the benefits of the mangrove restoration and Canal expansion/water management.

5.4 SOCIOECONOMIC AND CULTURAL HERITAGE IMPACT ASSESSMENT

5.4.1 Social [8]

Potential impacts on social receptors from the Project include the following:

- Loss of income for businesses in the transport industry in the Project Area during construction;
- Loss of view of the water (i.e., visual impacts);
- Loss of tourism;
- Adverse and disproportionate impacts on vulnerable groups;
- Negative health and safety consequences;
- Reduced flooding; and
- Job creation.

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[8] Please refer to Section 5.2.3 for social impacts related to noise.

As described above in Section 5.1, the significance of potential social impacts were evaluated by determining the magnitude of each change, including considerations of the type (direct, indirect, induced, or cumulative), nature of change, extent and scale (size of the change), and duration (temporary, short term, long term, or permanent) of each potential impact, and the sensitivity of the social receptor

5.4.1.1 Loss of Income for Transportation Businesses

The construction of a new flood protection wall, which is expected to last between 4 to 8 months, could directly impact businesses in the transport and hospitality industries as described in Section 4.0 in the Project Area. Although Waterside Street will remain opened, land-based transportation businesses limited to the two bus lines—PG and LIJN—and taxicabs would not be able to continue loading/unloading/parking immediately in front of the existing flood protection wall due to safety concerns during construction. Similarly, water-based transportation businesses (i.e., water taxis) would not be able to continue loading/unloading/docking at their current dock due to the same safety concerns. Riverside Bar/Terrace, the only identified restaurant in the hospitality industry in the Project Area, would be able to remain open and operational. Given the concentration of and the short duration of the potential impact, the magnitude has been determined to be small to medium

A small portion of the potentially Affected Persons identified in the census/socio-economic survey whose income could be impacted have low annual income levels (e.g., water taxis), an attribute associated with medium to high vulnerability. However, other Affected Persons far exceed the minimum wage in Suriname and have low vulnerability.

Mitigation/Enhancement Measures and Residual Impacts

This impact's significance is determined to be moderate to major and wholly dependent on the vulnerability of the Affected Person. In order to minimize the impacts to minor to moderate, the mitigations that follow below are recommended. It is important to note that these mitigations measures were developed taking into account the results of the stakeholder engagement activities carried out from November 2017 to May 2018 (See section 3.2.5). They were further consulted in three meaningful stakeholder engagement conducted in July 2018, after the Draft ESIA became available, to engage in two-way exchange on specific Project information and the planned mitigation measures.

- The majority of construction activities are executed from the water side (please note this mitigation measure would reduce impacts on land-based businesses only).
- Buses that park along Waterkant Street remain in the larger Project Area and be temporarily relocated to the Bus Terminal, which is expected to remain open, 200 meters west of their existing location and 100 to 200 meters east and west along Knuffelsgracht Street (Figure 5-5).

- Water taxis remain in the larger Project Area and be temporarily relocated to the "old steel jetty" 100 meters east of their existing location, and the old pier's current condition be improved in order to be of equal or better quality than their existing location (Figure 5-6).
- A Traffic Management Plan is developed and implemented to help facilitate busing routes and alternative stops in the immediate study area as appropriate.
- A LRP is developed and implemented for any stakeholder that is potentially impacted during construction in order to make them whole, although this is not expected after implementing the other mitigation measures.

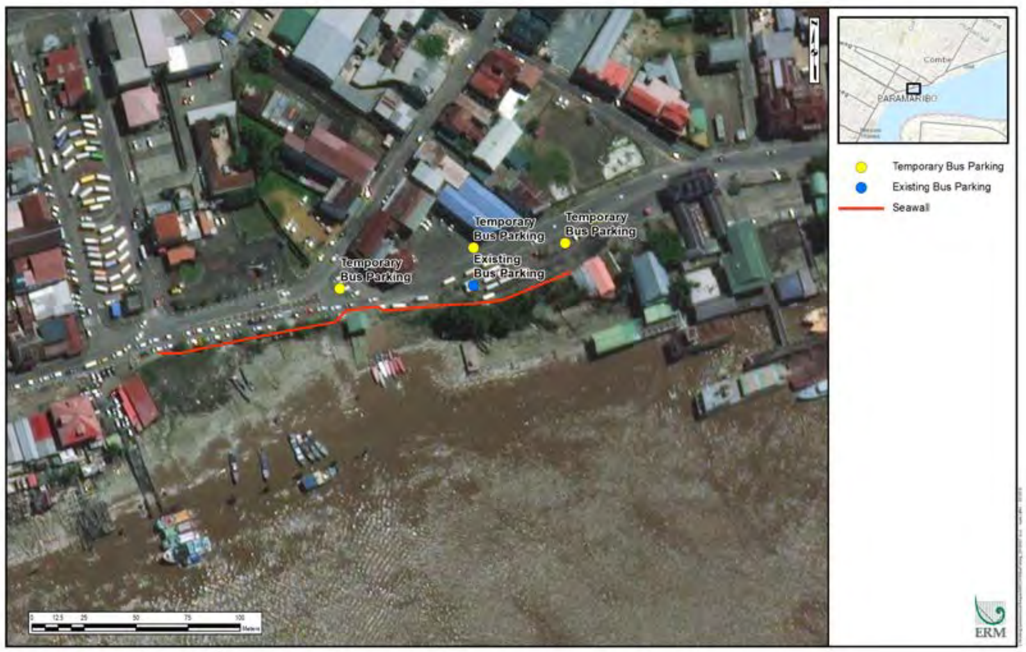

Figure 5-5: Temporary Relocation of Buses

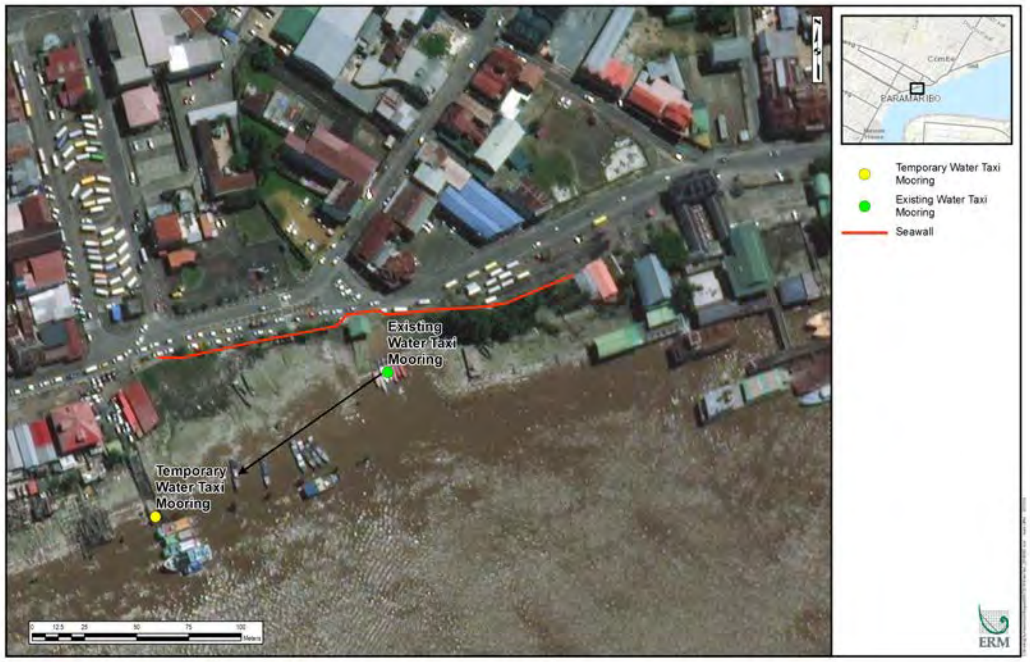

Figure 5-6: Temporary Relocation of Water Taxis

In addition, a Stakeholder Engagement and Communication Plan (Appendix A) has been developed and will continue to be implemented, in addition to a Grievance Mechanism. This mechanism is designed to receive, facilitate investigation, and respond to grievances from Project stakeholders and Affected Persons; and it will be managed by a designated personnel (e.g., Community andSocial Coordinator for the OWTC).

After construction, both land- and water-based businesses in the transport industry are expected to return to their preconstruction locations as proposed by each respective stakeholder group.

5.4.1.2 Loss of Waterview

The new flood protection wall along Waterkant Street may temporary obstruct residents and tourists' view of the water during construction as a result of equipment, vehicles and construction fencing. This impact is concentrated between Knuffelsgracht Street and SMS Pier along Waterkant Street and there will remain water views outside of this small area. The disruption will be temporary in duration (i.e., 4 to 8 months); therefore, the magnitude has been determined to be negligible. This impact would equally and undiscriminatorily affect residents and tourists of ranging vulnerabilities.

After construction, and based on engineering plans, the new flood protection wall will be comparable to the existing flood protection wall north of the Site; and it will not impede residents or tourists' view. The location of the floodwall extension is also at a lower elevation than its surroundings, hence the reason for continual flooding.
Mitigation/Enhancement Measures and Residual Impacts

This impact is determined to be negligible and no mitigations are necessary; however, as a good practice and related to this potential impact, a Stakeholder Engagement and Communications Plan has been drafted for the Project to inform stakeholders of construction activities.

In addition, residents and tourists will be able to access a water view 100 meters east and west of Project construction.

5.4.1.3 Vulnerable Groups

As part of the census, a total of four individuals self-identified as Maroon or Indigenous, both of which can be labeled as Indigenous People in accordance with OP-765. These Indigenous People are fully integrated into urban life in Paramaribo, Suriname as identified in the baseline. Their employment in the transportation industry is not of any cultural significance and their status as Indigenous People does not have any bearing on their employment. The Project does not disproportionately impact them as a result of their identity, exclude them from participation, impede on their rights or claims to territorial or culturally significant lands, or prevent them from fulfilling traditional ways of life. As such, it is expected they will enjoy equal access to the Project's overall benefits, and that the Project's mitigation measures and ESMP will extend to them without discrimination, covering any impacts they may incur as with any other PAP.[9]

Similarly, only two women were identified in the census and occupy roles in the transport industry similar to men. However, with relation to transport patrons, at a ratio of approximately 3:2, more women than men take water taxis and buses in the Project Area. It is important to highlight that women will not be disproportionately adversely impacted. Finally, only one patron in the Project Area was identified as having a physical disability at the time of baseline studies, but he had physical mobility and could load/offload the water taxis without assistance. Despite not expecting disproportionate impacts for these groups, the Project will

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[9] An additional consultation was carried out on 16 July 2018 with the person who self-identified as Indigenous during the census. The purpose of the consultation was to ensure that this person had the opportunity to voice any particular concerns that he may have had as a result of his Indigenous identity vis-à-vis the Project. The person did not feel that the Project would generate any particular negative impacts due to his identity, as he was born in Paramaribo and does not live in community with his indigenous community or speak the language. He further affirmed to understand the Project, its nature, duration and mitigations, and stated to have no comments or concerns and did not believe the Project would affect his livelihood in anyway.

include the following measures to ensure that any potential risks are fully mitigated:

- Proper lighting in the Project Area for early-morning and late-evening commuting;
- Adequate ground surfaces to ensure patrons have ease of mobility (e.g., high heels or crutches); and
- Gender Awareness Training for contractors and their staff.

Mitigation/Enhancement Measures and Residual Impacts

No additional mitigations are necessary. Vulnerable groups will have equal access to the Project and associated safeguards (e.g., entitlements as part of the LRP, grievance mechanism as defined in the Stakeholder Engagement and Communications Plan).

5.4.1.4 Reduced Flooding

Presently, flooding is a severe problem during rainfall and high tide in the Project Area, especially near and around Knuffelsgracht Street. The Project, as a result of the three selected components will reduce flooding, thereby improving hygiene, safety, and accessibility. This is consequently a positive impact.

5.4.1.5 Job Creation

Construction activities for all three components will likely provide jobs to local construction companies and workers, and the Project would likely source some materials from the local economy. This would have a positive impact on the Suriname economy.

The positive impact could be enhanced in the following ways:

- Adopt preferential contracting for local companies with capacity.
- Require international contractors to partner with local engineering firms.
- Require contractors to source locally where possible.

It is estimated that the construction of the project will utilize approximately 12 local laborers on average day, and approximately 20 local laborers on peak periods.

5.4.2 Cultural Heritage

Potential negative impacts on cultural heritage from the Project include the following:

- Reconstruction and/or construction of structures that may diminish the authenticity of the site, without due consultation with UNESCO and its advisory bodies

- Construction of structures that diminish the view of, or from, historic buildings (i.e., visual impacts), and therefore their value to stakeholders
- Changes to the historic landscape that affect the context of individual historic buildings and/or the WHS as a whole, and thus their value to stakeholders
- Direct physical damage to undiscovered archaeological resources during construction of Project components.

The Project components were evaluated in light of these potential impacts to cultural heritage. The severity of these impacts were assessed based on the magnitude of each change, including considerations of the type (direct, indirect, induced, or cumulative), extent and scale (size of the change), and duration (temporary, short term, long term, or permanent) of each impact and the sensitivity of the cultural heritage resources that would be impacted.

5.4.2.1 Loss of Cultural Heritage Site Authenticity due to Construction of Project Components

Construction of Project components would result in increased noise, dust, and other temporary changes to the visual landscape of the WHS. Completion of these components would add permanent additional, modern structural elements to the historic core of the WHS. The extent of these permanent additions is relatively low compared to the size of the Paramaribo WHS. In addition, similar modern structures are already present within the Paramaribo WHS. Therefore, the addition of these Project components would result in negligible changes to the character of the Paramaribo WHS and the severity of the loss of cultural site authenticity due to construction of the Project components is negligible. The disruption to the visual and auditory environment during construction would be of relatively short duration. The extent of the potential changes to the WHS through the addition of modern structures and features is small relative to the size of the WHS. The scale of the impacts is also negligible as most of the additional components would be underground, under water, or not visible (drainage and sewer system, new flood wall, pump station improvements); those that are above ground (walkways, parking areas, riprap embankments) would cause very localized changes; numerous similar structures are already present in the WHS. The implementation of the Project would also contribute a positive benefit in terms of minimizing the flooding to the southern part of the WHS,

Mitigation/Enhancement Measures and Residual Impacts

Construction of Project components would have negligible impacts to a high sensitivity resource resulting in unmitigated impacts of negligible significance. The Project components would result, however negligible, in impacts to a UNESCO WHS. To mitigate potential impacts to the Paramaribo WHS listing, the Project will consult with the following cultural heritage stakeholders:

- UNESCO WHC
- ICOMOS

- Expert Building Committee or Special Advisory Committee
- Suriname Department of Culture
- The SBHF formed to implement the PWHSMP

These consultations should focus on developing management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS. Implementation of approved plans would result in residual impacts of negligible significance.

5.4.2.2 Loss of Cultural Heritage Site Value due to Project Components Diminishing the View from Historic Buildings

The Project components are near a number of registered monuments (historic structures) that are part of the Paramaribo WHS:

- New flood protection wall is near five listed monuments including the Monument of the Revolution (*Monument van de Revolutie*) listed monument and the UNESCP WHS-listed De Waag building.
- Sommelsdijck Canal Basin rehabilitation is near two listed monuments, the Garden of Palms monument and the UNESCP WHS-listed Fort Zeelandia.
- Pump Station and Sluice Gates Upgrades/Rehabilitation is near Monument of the Revolution and Garden of Palms listed monuments and the UNESCP WHS-listed Fort Zeelandia.

Construction of these elements would temporarily change the view from these listed monuments due to the presence of active/open construction areas, equipment, and construction vehicles. Completion of the new flood protection wall and the Sommelsdijck Canal Basin rehabilitation would permanently change the views from seven listed monuments including the Garden of Palms and Monument van de Revolutie as well as the WHS-listed De Wagg Building and Fort Zeelandia complex. Based on the limited extent of the construction, with much of it installed underground, and the presence of similar modern structures near the listed monuments, the changes to the views from historic structures have been assessed as small magnitude impacts.

The De Wagg Building, Fort Zeelandia complex, Garden of Palms, and the other listed monuments near Project components are formally protected monuments within the Paramaribo WHS and are protected under Suriname law. These resources are considered significant under Suriname law and the UNESCO WHS listing as individual resources as examples of a distinct architectural style resulting from early contacts between Europeans and South Americans. As a result, all the monuments are Critical Cultural Heritage under B.9 of the IDB's OP-703. However, due to their setting in an environment containing structures from multiple periods (historic through modern), the cultural value of the individual resources stems mostly from their aesthetic, historical, and architectural characteristics as individual resources and not from their location in an area dominated by historic structures. As a result, the resources are considered to be of moderate sensitivity to changes to their surroundings through the addition of minor, modern structures.

Construction of the Project components would result in impacts of minor severity due to the loss of site value from changes in the view from historic structures. The WHS listing criteria for the monuments within the WHS attributes their cultural significance is a result of their individual characteristics representing a distinct architectural style, suggesting the individual characteristics of the resources are more significant than their setting. In addition, the listed monuments are located in areas with a mix of historic and modern structures and, as a result, the views from each individual resource already contain numerous modern elements. The addition of the Project above ground elements (walkways, parking areas, new drains, riprap) would result in small magnitude changes to the historic views from the buildings of limited spatial extent and minimal scale. The small magnitude of the changes to these moderate sensitivity resources would result in unmitigated impacts of minor severity.

Mitigation/Enhancement Measures and Residual Impacts

Construction of the Project components would result in minor severity impacts to medium sensitivity resources resulting in unmitigated impacts of negligible significance. The Project components would, however, result in impacts to a UNESCO WHS. To mitigate impacts to the WHS, the Project will consult with the cultural heritage stakeholders to develop management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS. Implementation of approved plans would result in residual impacts of negligible significance.

5.4.2.3 Loss of Cultural Heritage Site Value due to Project Components Changing the Historic Landscape of the Paramaribo WHS

Construction of the Project components would permanently change the historic landscape of the Paramaribo WHS Conservation Core through the addition of modern infrastructure. The mixed architectural character of the Paramaribo WHS, however, contains a large number of modern buildings, infrastructure, and structures. Also, the extents of the changes to the historic landscape are relatively small compared to the size of the WHS. The scale of the impacts is further reduced because a number of the components would be underground, underwater, or not visible when completed. As a result, construction of the Project components would result in negative impacts of negligible magnitude to the Paramaribo WHS historic landscape.

The magnitude of the changes to the historic landscape would be negligible due to the small scale and extent of the Project components and the existing mixture of modern and historic structures within the WHS.

Mitigation/Enhancement Measures and Residual Impacts

The Project will consult with the cultural heritage stakeholders to develop management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS. Implementation of approved plans would result in residual impacts of negligible significance.

5.4.2.4 Damage to Undiscovered Archaeological Sites due to Construction of Subsurface Project Components

Ground disturbing activities associated with the new flood wall construction, storm water and sewer drainage system improvements, and Sommelsdijck Canal Basin rehabilitation/expansion could damage undiscovered, subsurface archaeological resources. The magnitude of any impacts to undiscovered sites would depend on the extent of the impacts relative to the size of the resource. If construction impacts a small portion of the site, the magnitude of the impacts would be small. If, however, a significant portion or all of a resource is removed or damaged, the magnitude of the impact would be large.

The cultural heritage baseline suggests very little is understood about the prehistoric and historic archaeology of Paramaribo. A small number of prehistoric archaeological resources have been found at the waterfront, and historic archaeological sites have been found at scattered building sites within historic Paramaribo. The sensitivity of any undiscovered archaeological sites could range from negligible to high depending on the integrity of the resource (i.e., level of previous disturbance), if the resource is relatively unique for the period it represents.

The severity of any impacts to undiscovered archaeological resources would depend on the extent of direct physical damage to the resource and its sensitivity based on the integrity and uniqueness of the resource. Based on a combination of impact magnitude and resource sensitivity, Project impacts to undiscovered archaeological resources could range from negligible to major.

Mitigation/Enhancement Measures and Residual Impacts

Potential impacts to undiscovered archaeological sites can be mitigated through the implementation of a Project Chance Finds Procedure (CFP) during all Project ground work. PS 8 defines a CFP as "a project-specific procedure that outlines the actions to be taken if previously unknown cultural heritage is encountered." According to the IFC Guidance Note 8, the CFP should:

> …include record keeping and expert verification procedures, chain of custody instructions for movable finds, and clear criteria for potential temporary work stoppages that could be required for rapid disposition of issues related to the finds. It is important that this procedure outlines the roles and responsibilities and the response times required from both project staff, and any relevant heritage authority, as well as any agreed consultation procedures. The procedure should be incorporated into the Management

Program and implemented through the client's Environmental and Social Management System.

Implementation of a CFP would significantly reduce the severity of potential impacts to undiscovered archaeological resources.

5.4.3 *Traffic*

Construction of the Project would require frequent large vehicle trips into and out of the Project area, carrying construction materials and supplies to and from individual construction sites. A limited number of heavy equipment movements would also be required. This ESIA assumes that construction employees would arrive at construction sites via automobile, foot, or public bus (i.e., no Project-specific employee busing). The number and type of construction truck trips are not known. Depending on the extent and methodology of construction, traffic may be disrupted along Waterkant Street and other roads adjacent to construction sites due to temporary road closures and changing traffic patterns.

Overall, Project construction would result in increased traffic volumes, as well as concentration of non-Project traffic along alternative routes. This would increase the potential for traffic congestion and disruption. Project construction would also further worsen pedestrian safety issues, which in turn could hinder access to public and community facilities.

Mitigation/Enhancement Measures and Residual Impacts

These impacts will be minimized through the development and implementation of a Traffic Management Plan and an Access Management Plan to be prepared by the Project contractor following the guidance of the Traffic And Pedestrian Management Plan provided in Appendix H. The Traffic Management Plan would include early notification of road closures, detour signage, and safety programs and measures for pedestrians and bicyclists, especially for the most vulnerable populations. Parking and traffic management should be reviewed in an integrated manner to discourage car and motorcycle parking on sidewalks, as well as a review of public transportation systems. The plan should suggest accommodations/improvement to bus routes, stops, and terminals. The Access Management Plan would maintain continuous access for critical community facilities for pedestrians through careful staging and sequencing of construction activities and provision of alternative pedestrian crossings and facilities, where needed.

Operation of the Project would require no regular vehicular, pedestrian, or vessel traffic. Traffic volumes and circulation patterns would return to pre-construction conditions. Therefore, operation of the Project would have no impact on traffic and transportation.

5.4.4 *Health and Safety*

All Project components pose some health and safety risks to area residents, pedestrians and tourists, as does any construction activity. To mitigate this risk, a

Health and Safety Plan will be developed and implemented by the Project Proponent and its contractor in general alignment with ISO45001 (or its predecessor OHSAS18001).

5.5 *CUMULATIVE IMPACTS ASSESSMENT*

This chapter focuses on potential cumulative impacts from the Project. Cumulative impacts are defined as the successive, incremental, and/or combined effects of a Project or activity, accumulated with other Projects or activities. Given that the Project is complying with the IDB's policies, which are very similar to the IFC PSs, potential cumulative impacts are evaluated pursuant to IFC's Cumulative Impact Assessment (CIA) guidance - *Good Practice Handbook - Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets* (IFC 2013).

A CIA focuses on environmental and social components rated as "critical" by the affected communities and the scientific community (Valued Environmental and Social Components [VECs]), which are cumulatively impacted by the Project, other projects, and sources of external pressure (IFC 2013). The development of a CIA requires the identification of VECs on the basis of the AoI of the Project; other existing, planned, and future projects; sources of external social and environmental pressure; and the results of consultation with stakeholders.

For this Project, a rapid CIA (RCIA) was conducted following the approach summarized and illustrated below in alignment with the IFC's Good Practice Handbook (Figure 5-5). First, VECs are identified and their baseline conditions in the AoI are considered. Next, other projects and external pressures are identified that could influence the VECs in the future. The RCIA then identifies and assesses the future status of the VEC considering other projects, without considering the development of the Project. Finally, the difference between the future condition and that same future condition adding the Project is evaluated.

This RCIA was based on information gathered through consultation with our local partners on this ESIA - Social Solutions and ILCAO, baseline information generated in the ESIA, information available in the public domain, and information gathered during the consultation process.

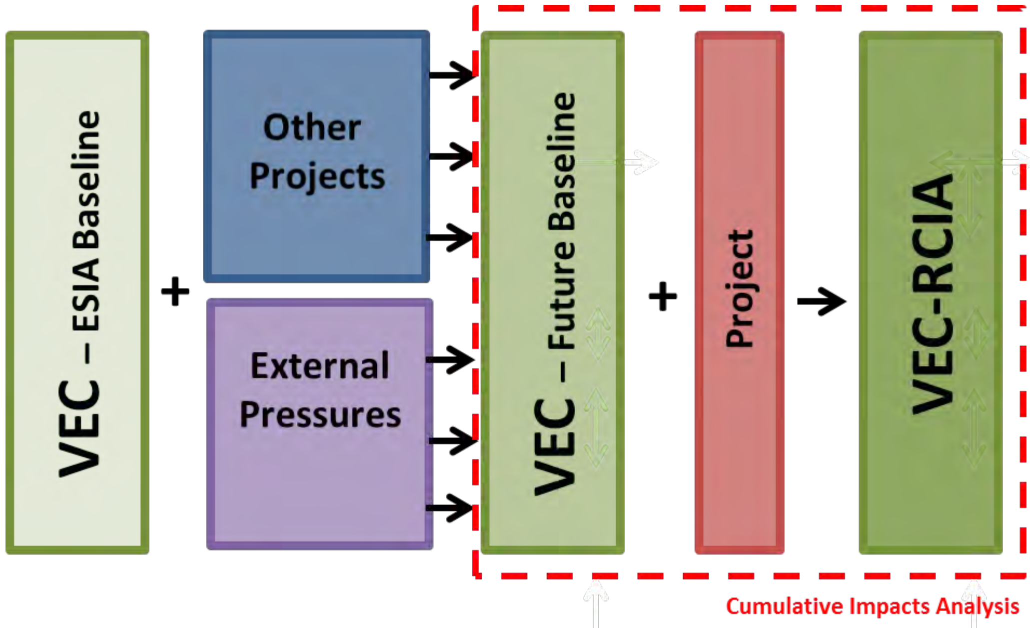

Figure 5-7: Rapid Cumulative Impact Analysis Scheme

5.5.1 VECs

The identification of VECs for this assessment was based on social and environmental receptors identified in the assessment of impacts of the ESIA, other known activities in the Project Area, supplemented with information obtained during the baseline survey, and the consultation process of this ESIA through interviews and meetings with various stakeholders.

This ESIA concluded that most of the resources affected by the Project (e.g., air quality, noise, biodiversity, social, traffic, cultural resources) would incur *Minor* or *Negligible* impacts that would be localized in extent and duration. Taking into consideration the impacts of the Project and the location and nature of other projects and external pressures, the identified VECs for this RCIA are:

- Project-affected people
- Cultural resources of the Paramaribo WHS
- Biodiversity

Chapters 4 and 5 of this ESIA describe the baseline condition and impacts of the Project on these VECs, respectively. In summary, the Project Area in downtown Paramaribo is urban in nature, although it is recognized as a WHS and contains numerous cultural sites of international importance. Biodiversity resources are minimal in the downtown area but a large heronry which is recognized as locally important bird area occurs in the mangrove at the confluence of the Sommelsdijck Canal and the Suriname River. Some of the Project works occur along or in the immediate vicinity of the Suriname River, the most important aquatic and terrestrial biodiversity resource in and around Paramaribo.

5.5.2 *Other Projects and External Pressures*

A review of available information on past, existing, or future projects and external pressures within the AoI was conducted. The Project Area is in a highly urbanized location within downtown Paramaribo. Interviews with the GoS indicated that no government funded projects are currently planned or taking place inside the AoI. Other projects that have been identified within the AoI are listed below.

- The Paramaribo Urban Rehabilitation Program, being implemented by the IDB, will invest in a series of projects that include:
  - improvement of public and green spaces;
  - rehabilitation of historic buildings;
  - provision of new opportunities for civil society participation;
  - integration and economic development;
  - improvements to mobility and parking; and
  - institutional strengthening.

  These Projects have not yet been defined and their specific locations are unknown.
- The Flood Risk Management in Greater Paramaribo Area project, launched in April 2016 and implemented under a grant by the World Bank, developed a strategic flood risk assessment in the Greater Paramaribo area to support the GoS in prioritizing targeted flood risk reduction investments that may be funded by the World Bank. According to the OWTC, projects currently under consideration by this program concern the Saramacca Canal, which is not in this Project's AoI.

The primary external pressure affecting VECs in the AoI is expanding urbanization. Ongoing flooding of the downtown area adversely impacts all VECs through inconvenience, reduced safety, decreased access to local businesses, adverse impacts to water quality and hygiene, etc.

5.5.3 *Potential Cumulative Impacts*

As stated above, cumulative impacts include the successive, incremental, and/or combined effects of a Project or activity that accumulate with other Projects or activities (IFC 2013). The potentially cumulative impacts created by Project activities are all related to construction and include:

- increased traffic due to construction equipment and alternate traffic patterns
- temporary closure of roads and walkways
- temporary access limitation to certain economic activities
- temporary decrease or loss of livelihood, for example if certain roads and walkways lead to the temporary closure of shops; and
- increased dust and noise.

6.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

6.1 INTRODUCTION

This ESIA has identified a range of potential environmental, socioeconomic, and cultural impacts related to implementation of the Project components, as described in Chapter 5.0 Impact Assessment. As part of the environmental and social management requirements established by IDB and according to industry good practice, an ESMP must be developed and implemented for the Project.

This ESMP describes the approach that the Project proponent and other involved parties (e.g., local contractors) would follow to manage, mitigate, and monitor the potential impacts of the Project. It includes the Project commitments and mitigation measures as identified in Chapter 5.0, Impact Assessment.

6.2 ESMP GUIDING PRINCIPLES

6.2.1 Plan, Do, Check, Review

Industry good practice follows the general principles of the "Plan, Do, Check, Review" cycle as described below, and outlined in Figure 6-1.

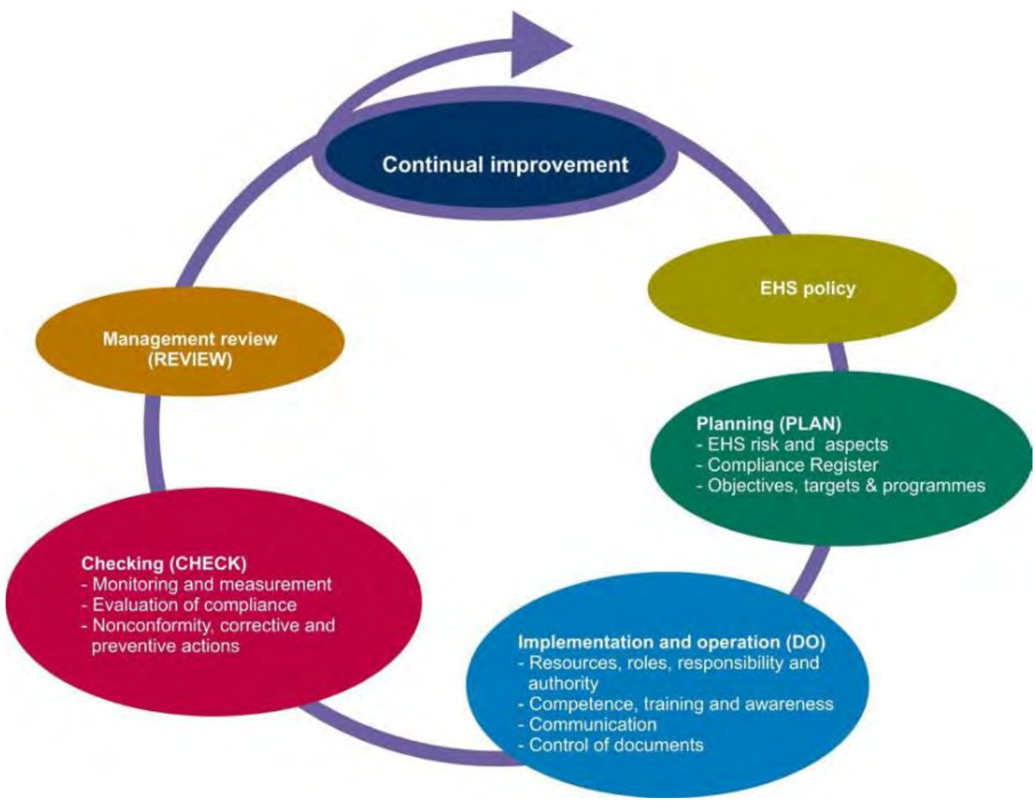

Figure 6-1: Plan, Do, Check, Review Cycle

Plan

- Define policies and objectives for environmental and social performance.

- Identify environmental and social impacts and risks of the operations.
- Develop mitigations and operational controls to address impacts and risks.
- Develop a management plan to achieve these objectives.

Do

- Implement a management plan.
- Implement mitigation and operational controls.

Check

- Monitor performance against policies and objectives.
- Check that mitigation and operational controls are effective.

Review

- Make corrections to plans, mitigation, or controls in response to performance monitoring or out of control events.

6.2.2 *Mechanism for Auditing, Adjustments, and Reporting*

Auditing and adjustment is an essential part of a successful ESMP. Auditing systems include inspections and monitoring to confirm proper implementation of the ESMP, as well as effectiveness of mitigation measures. Corrective actions include response to out-of-control situations, non-compliances, and non-conformances. Actions also include those intended to improve performance.

The parties involved in overseeing the day to day activities of Project implementation will conduct continuous monitoring to ensure that all Project personnel (contractors) are fulfilling their obligations under this ESMP.

Monitoring will be conducted to ensure compliance with ESIA commitments and to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. Project monitoring activities are presented in Section 6.4.

The Project proponent will keep relevant authorities informed of the Project performance with respect to environmental and social matters and implementation of this ESMP by way of written status reports and/or face-to-face meetings. Contractors will also be required to provide EHS performance reporting as relevant based on the contractor's responsibilities. The Project proponent will continue the stakeholder engagement efforts described in Section 4.3.2 and communicate with stakeholder groups regarding Project activities and the results of environmental and social monitoring.

6.2.3 *Training*

All Project personnel will be qualified to the particular job that they are performing and undergo further training to meet the needs of the working environment, as required. All personnel, regardless of position, will be given specific job oriented

EHS training prior to starting work and as necessary thereafter. All personnel will be trained on general awareness of environmental and social issues and specific procedures aimed at the avoidance of environmental damage as well as human health and safety. New staff, contractors, and visitors will be given basic induction training and follow Project EHS procedures.

6.3 ORGANIZATIONAL CAPACITY AND POLICIES

The Ministry of Works, as the Project proponent, will be responsible for leading the Project through implementation, and therefore will also be responsible for the implementation of the ESMP. Given the scale and nature of this project, as a minimum the following roles will be required to support ESMP implementation:

Environmental coordinator – part-time resource (maximum of 20 hours a week) to ensure that the works are implemented according to applicable national laws, regulations, and rules, as well as international standards – mainly IDB standards – as defined in Section 2 of this ESIA and follow applicable good industry practice (e.g., *ISO 9001 Quality Standards, ISO 14001 Environmental Standards*, and *OHSAS 18001 Occupational Health and Safety Standards*). The role will also need to ensure that the relevant management plans described herein are being implemented by the selected contractor, including the associated mitigation measures, so that noise, air quality, water, traffic and biodiversity issues are appropriately managed. Requirements for this role will be a degree in environmental management or engineering (or equivalent) and at least 5 years' experience of environmental management on construction sites.

Community and Social Coordinator – full time resource (40 hours a week) to manage the implementation of the Stakeholder Engagement and Communication Plan, the LRP and also liaise with the Environmental Coordinator on aspects of the Construction Environmental Plan and Traffic and Pedestrian Management Plan. Requirements for this role will be a degree in social sciences (or equivalent) and at least 10 years' experience of stakeholder engagement and livelihood restoration, including to international standards.

6.4 ESMP

Table 6-1 summarizes the approach that the Project proponent and other involved parties (e.g., local contractors) would follow to manage, mitigate, and monitor the potential impacts of the Project. It includes the Project commitments and mitigation measures as identified in Chapter 5.0 *Impact Assessment*. And also references a series of relevant management pans that have been prepared and are contained in the appendices.

Table 6-1: ESMP Measures and Related Management Plan and Monitoring Recommendations

Resource/ Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
Air Quality					
Emissions from construction vehicles and equipment	Construction	See Appendix C for a Construction Environmental Management Plan, which includes the following: • Maintain all construction equipment in accordance with manufacturer's specifications. • Suppress dust as needed in unpaved areas. • Avoid burning non-vegetative wastes (refuse, etc.) at construction sites. • Avoid unnecessary idling of construction equipment or delivery trucks when not in use.	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Noise					
Noise generated by construction equipment and activities	Construction	See Appendix C for a Construction Environmental Management Plan, which includes the following: • Maintain all construction equipment in accordance with manufacturer's specifications. • Schedule construction and rehabilitation work during daylight hours and to minimize activity during peak periods of tourism and recreation (weekends, holidays, etc.). • Develop and implement a Construction Communications Plan to inform adjacent receptors (e.g., commercial businesses, churches, and tourists) of construction activities. • Use vibratory or press-in piling instead of impact piling during shore-based construction to avoid generating impulsive noise and vibrations. • Limit construction noise levels to applicable standards such as BS 5228-1:2009+a1:2014 (British Standards Institution 2014), or FTA-VA-90-1003-06 (U.S. Federal Transportation Authority (FTA))	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Waste					
Waste generated by construction activities	Construction	See Appendix C for a Construction Environmental Management Plan, which includes the following: • Provide appropriate waste bins, type, volume and service frequency to accommodate anticipated waste streams. • All loads arriving or leaving the site will be appropriately secured.	Construction contractor	Site inspection during construction	Monthly progress reports during construction

Resource/ Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
		• Provide information regarding waste management in site specific inductions, including waste separation and importance of securing vehicle loads. • Ensure licensed contractors are used to collect controlled wastes			
Biodiversity					
Biodiversity management in general including the items below	Construction	See Appendix C for a Construction Environmental Management Plan, which includes the mitigation measures below.	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Loss or disturbance of vegetation	Construction	• When designing and planning work elements, minimize temporary and permanent construction footprints • Demarcate work area with fencing to minimize disturbance or removal of natural vegetation	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Wildlife injury or mortality	Construction	Proper disposal of dredged material to avoid wildlife exposure	Construction contractor	Site inspection during construction	Monthly progress reports during construction
Disturbance and/or displacement of wildlife	Construction	• Conducting canal- and mangrove-related works outside the waterbird breeding season (April – Sept) • Minimize lighting • Implement above measures to minimize noise and air pollution	Construction contractor	Site inspection and interview of construction contractor	Monthly progress reports during construction
Habitat alteration - mangroves	Construction Operation	Seasonal restriction (work to be done outside of bird breeding season which occurs from April-September)	Construction contractor	Site inspection	Monthly progress reports during construction
Habitat alteration - aquatic	Construction Operation	Implement sediment control procedures during in-water works to minimize the release of fine sediments to downstream waterways, particularly the Suriname River	Construction contractor	Site inspection	Monthly progress reports during construction
Social					
Loss of income for transport businesses	Construction	• Execute construction activities from the water side to reduce impacts on land-based businesses. • Temporarily relocate land and water-based businesses to adjacent locations in the immediate Project Area. • Develop and implement a Traffic and Pedestrian Management Plan (Appendix H).	Construction Contractor - Community Liaison Officer	Interviews with construction contractor and affected parties	Monthly progress reports during construction

Resource/ Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
		• Develop and implement a Livelihood Restoration Plan (see Appendix D) for potentially Affected Persons. • Continue stakeholder engagement through Project implementation through the use of the Stakeholder Engagement and Communications Plan (see Appendix A). • Implement a Grievance Mechanims to receive and respond to grievances (see in Appendix A). •			
Loss of water view	Construction	• See mitigations for "loss of income for transport businesses." No additional mitigations are necessary.	Construction Contractor - Community Liaison Officer	Interviews with construction contractor and affected parties	Monthly progress reports during construction
Loss of tourism	Construction	• See mitigations for "loss of income for transport businesses." No additional mitigations are necessary.	Construction Contractor - Community Liaison Officer	Interviews with construction contractor and affected parties	Monthly progress reports during construction
Provision of construction jobs to local companies and materials sourced from the local economy	Construction	Implement job quotas for local employment and sourcing requirements for construction contractors based on the size and scope of the Project	Construction contractor	Records review and interview of construction contractor	Monthly progress reports
Potential vulnerable groups (gender or disability related)	Construction Operation	• Install proper lighting in the Project Area for early-morning and late-evening commuting; • Ensure adequate ground surfaces and associated infrastructure (such as ramps) for patron mobility (e.g., high heels and crutches) at both the temporary unloading dock and the rehabilitated location post construction; and • Conduct Gender Awareness Training for contractors and their staff.	Construction contractor	Records review and interview of construction contractor	Monthly progress reports
Traffic					
Decreased pedestrian and traffic safety	Construction	Implement Traffic and Pedestrian Management Plan to include early notification of road closures, detour signage, and safety programs and measures for pedestrians and bicyclists (Appendix H).	Construction contractor	Site inspection during construction	Monthly progress reports
Increased traffic congestion and disruption	Construction	Incorporate public transportation alternatives (e.g., pedestrian and bus) into Traffic and Pedestrian Management Plan (Appendix H)	Construction contractor	Site inspection during construction	Monthly progress reports

Resource/ Receptor and Impact	Project Phase	Mitigation Measures	Execution Responsibility	Means of Verification	Monitoring and Reporting
Decreased access to critical facilities, shopping, bus stops etc.	Construction	Implement Traffic and Pedestrian Management Plan to maintain continuous access through careful staging and sequencing of construction activities and provision of alternatives where needed (Appendix H)	Construction contractor	Site inspection during construction	Monthly progress reports
Cultural Resources					
Loss of cultural heritage site authenticity due to Project implementation	Construction Operation	Consult with the relevant cultural heritage stakeholders and develop and implement Cultural Heritage Management Plan (see Appendix F) to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS.	Construction contractor	Interviews with relevant stakeholders, site inspection	Monthly progress reports
Loss of cultural heritage site value due to Project changing the historic landscape of the Paramaribo WHS and diminished site view from historic buildings	Construction Operation	Consult with the relevant cultural heritage stakeholders and develop management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS (see Cultural Heritage Management Plan in Appendix F).	Construction contractor	Interviews with relevant stakeholders, site inspection	Monthly progress reports
Damage to undiscovered archaeological sites due to construction of subsurface Project components	Construction	Implement a Project Chance Finds Procedure (CFP) during all Project ground work (see Cultural Heritage Management Plan in Appendix F).	Construction contractor	Interviews with construction workers, site inspection	Monthly progress reports
Health and Safety					
Management of health and safety of both construction workers and the public	Construction	Develop and implement a Construction Health and Safety Plan (see Appendix E)	Construction contractor	Records review and interview of construction contractor	Monthly progress reports
Climate Change and Natural Hazards					
Climate change and natural hazards	Construction Operation	Implement a Construction Environmental Management Plan and a Health and Safety Plan	Construction contractor	Interviews with construction workers, site inspection	Monthly progress reports

7.0 CONCLUSIONS

7.1 IMPACT ASSESSMENT OVERVIEW

Table 7-1 summarizes the key impacts of the Project on the resources assessed in this ESIA. The table summarizes each key impact identified in the ESIA and their pre-mitigation impact significance rating, the associated mitigation measure(s), and the post-mitigation impact significance rating, as developed through the impact assessment process defined in Section 5.1 of this ESIA.

In summary, the ESIA determined that the Project would likely result in some environmental and social impacts, but these impacts could be readily mitigated and managed, and the Project should comply with the relevant IDB Environment Safeguard Policies as long as the actions identified in the ESMP are effectively implemented (see Section 7.2 for further details on Project conformance with IDB and AF policies). In addition to implementing measures to minimize or avoid the potential adverse impacts of the Project, measures to enhance the positive effects of Project activities, as described in the ESMP, could be implemented (e.g., maximizing local construction jobs, increased intergovernmental coordination and institutional strengthening, etc.) to maximize the short- and long-term benefits of the Project. Ultimately, implementation of the Project would result in positive environmental and social outcomes because the Project components would address the significant flood and climate-change related risks that the historic city of Paramaribo and its residents face and this, in turn, would improve environmental and social conditions in the area.

Table 7-1: ESIA Summary - Paramaribo Climate Change Adaptation Fund Project

Impact Significant Ratings

Negligible
Minor
Moderate
Major
Positive

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Air Quality				
Emissions from construction vehicles and equipment	Construction	Minor	• Maintain all construction equipment in accordance with manufacturer's specifications. • Suppress dust as needed in unpaved areas. • Avoid burning non-vegetative wastes (refuse, etc.) at construction sites. • Avoid unnecessary idling of construction equipment or delivery trucks when not in use.	Negligible
Noise				
Noise generated by construction equipment and activities	Construction	Minor	• Maintain all construction equipment in accordance with manufacturer's specifications. • Schedule construction and rehabilitation work during daylight hours when increased noise levels are more tolerable. • Schedule construction and rehabilitation work to minimize activity during peak periods of tourism and recreation (weekends, holidays, etc.). • Develop and implement a Construction Communications Plan to inform adjacent receptors (e.g., commercial businesses, churches, and tourists) of construction activities. • Use vibratory or press-in piling instead of impact piling during shore-based construction activities to avoid generating impulsive noise and vibrations.	Negligible

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Waste				
Waste generated by construction equipment and activities	Construction	Minor	• Provide appropriate waste bins, type, volume and service frequency to accommodate anticipated waste streams. • All loads arriving or leaving the site will be appropriately secured. • Provide information regarding waste management in site specific inductions, including waste separation and importance of securing vehicle loads. • Ensure licensed contractors are used to collect controlled wastes	Negligible
Biodiversity				
Loss or disturbance of vegetation	Construction	Minor	• When designing and planning work elements, minimize temporary and permanent construction footprints • Demarcate work area with fencing to minimize disturbance or removal of natural vegetation	Negligible
Wildlife injury or mortality	Construction	Minor	• Proper disposal of dredged material to avoid wildlife exposure	Negligible
Disturbance and/or displacement of wildlife	Construction	Moderate	• Conducting canal- and mangrove-related works outside the waterbird breeding season (April – Sept) • Minimize lighting • Implement above measures to minimize noise and air pollution	Negligible
Habitat alteration – mangroves	Construction Operation	Positive	Seasonal restriction (work to be done outside of bird breeding season which occurs from April-September)	Positive
Habitat alteration – aquatic	Construction Operation	Positive	Implement sediment control procedures during in-water works to minimize the release of fine sediments to downstream waterways, particularly the Suriname River	Positive
Social				
Loss of income for transport businesses.	Construction	Moderate	• Execute construction activities from the water side to reduce impacts on land-based businesses. • Temporarily relocate land and water-based businesses to adjacent locations in the immediate Project Area.	Minor

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
			• Develop and implement a Traffic Management Plant. • Develop and implement a Livelihood Restoration Plan (see Appendix D) for potentially Affected Persons. • Continue stakeholder engagement through Project implementation through the use of the Stakeholder Engagement and Communications Plan (see Appendix A). • Implement a Grievance Mechanims to receive and respond to grievances (see Appendix A). •	
Loss of view of the water (i.e., visual impacts)	Construction	Negligible	• Develop and implement a Stakeholder Engagement and Communications Plan to keep stakeholders informed of Project-related activities (see Appenix A).	Negligible
Loss of tourism	Construction	Negligible	• Develop and implement a Stakeholder Engagement and Communications Plan to keep stakeholders informed of Project-related activities (see Appenix A).	Negligible
Impacts on Vulnerable groups, including women patrons and a disabled patron	Construction	Negligible	• Implement a Grievance Mechanims to receive and respond to grievances (see Appendix A). • Install proper lighting in the Project Area for early-morning and late-evening commuting; • Ensure safe conditions for mooring, including boardwalk with railings; Ensure adequate ground surfaces and associated infrastructure (such as ramps) for patron mobility (e.g., high heels and crutches) at both the temporary unloading dock and the rehabilitated location post construction; and • Conduct Gender Awareness Training for contractors and their staff.	Negligible
Boost to the local economy through provision of jobs to local companies and workers and locally sourced	Construction	Positive	Implement job quotas for local employment and sourcing requirements for construction contractors based on the size and scope of the Project	Positive

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
materials				
Traffic				
Decreased pedestrian and traffic safety	Construction	Minor	Implement Traffic Management Plan to include early notification of road closures, detour signage, and safety programs and measures for pedestrians and bicyclists.	Negligible
Increased traffic congestion and disruption	Construction	Minor	Incorporate public transportation alternatives (e.g., pedestrian and bus) into Traffic Management Plan	Negligible
Decreased access to critical facilities, shopping, bus stops etc.	Construction	Minor	Implement Access Management Plan to maintain continuous access through careful staging and sequencing of construction activities and provision of alternatives where needed	Negligible
Cultural Resources				
Loss of cultural heritage site authenticity due to construction of Project	Construction Operation	Minor	Consult with the relevant cultural heritage stakeholders and develop management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS.	Negligible
Loss of cultural heritage site value due to Project components changing the historic landscape of the Paramaribo WHS and diminished site view from historic buildings	Construction Operation	Minor	Consult with the relevant cultural heritage stakeholders and develop management plans and measures to avoid or minimize short-term and permanent Project impacts to the Paramaribo WHS.	Negligible
Damage to undiscovered archaeological sites due to construction of subsurface Project components	Construction	Minor	Implement a Project Chance Finds Procedure during all Project ground work.	Negligible
Health and Safety				
Impacts on health and safety of workers and public	Construction	Minor	Develop and implement a Construction Health and Safety Plan (see Appendix E)	Negligible
Disaster Risk				

Resource/ Receptor and Impact	Project Phase	Pre-Mitigation Impact Significance	Mitigation Measures	Residual Impact Significance
Flood risk due to current layout of locality and also projections for future changes in climate	Operation	Moderate	Implementation of the Project itself.	Positive

7.2 CONFORMANCE WITH IDB SAFEGUARDS

Numerous IDB policies and environmental and social safeguards apply to this Project. As stated above, the Project would likely result in some environmental and social impacts, but these impacts could be readily mitigated and managed, and the Project should comply with all relevant IDB policies and safeguards, as summarized in Table 7-2, and the AF's policies in Table 7-3.

Table 7-2: Project Compliance with Applicable IDB Policies and Safeguards

IDB Policy	Applicability	Project Conformance with Policy/Safeguard
OP-703 – Environmental and Safeguards Compliance Policy		
B.1, Bank Policies	Operations will only be financed if they comply with the directives of this policy and are consistent with the relevant provisions of other Bank policies.	This ESIA demonstrates that the Project can be implemented in full conformance with all applicable IDB policies.
B.2, Country Laws and Regulations	Project activities must comply with all Suriname laws and regulations, including the preparation of an ESIA.	An ESIA that is compliant with Surinamese regulatory requirements will be prepared if the AF is approved.
B.3, Screening and Classification	The Project is classified as Category "B". In accordance with OP-703, Category B projects "are likely to cause mostly local and short-term negative" impacts, for which "effective mitigation measures are readily available".	This Project would likely cause mostly local and short-term negative impacts which would be mitigated via the mitigation measures presented in the ESMP. Ultimately, the Project would benefit environmental and social conditions and no residual negative impacts would occur.
B.4, Other Risk Factors	The Project's executing agency must comply with the ESIA and ESMP requirements. Therefore, the executing agency and relevant third parties will be required to develop appropriate measures for managing the identified risks, such as a LRP for economic displacement of Affected Persons.	The Bank will engage with the executing agency and relevant third parties to develop appropriate measures for managing the identified risks as presented in the ESMP (see Section 6.0). This includes the implementation of a LRP to address the potential impact of temporary economic displacement (Appendix D).
B.5, Environmental Assessment Requirements	The Bank will require compliance with specified standards for Environmental Impact Assessments and Environmental and Social Management Plan (ESMP), and as a minimum must include: screening and scoping for impacts; timely and adequate consultation and information dissemination process; examination of alternatives including a no project scenario.	This ESIA addresses the IDB's requirement for environmental assessment for the Project. An ESIA compliant with Surinamese regulatory requirements will be prepared if the AF is approved.
B.6, Consultations	As part of the environmental assessment process, Category B operations require consultation of affected parties at least once.	A meaningful stakeholder consultation, consistent with OP-703 and OP-102, was conducted on 06 July 2018 to present the ESIA findings. The Draft ESIA was made available prior to the consultation.
B.7, Supervision and Compliance	Monitoring must be conducted for the Project to ensure that applicable commitments, requirements, policies, and safeguards are effectively implemented.	A monitoring plan would be implemented for the Project as part of the Project's ESMP (see Section 6.0).

IDB Policy	Applicability	Project Conformance with Policy/Safeguard
B.9, Natural Habitats and Cultural Sites	This directive requires the development of mitigation and monitoring measures to mitigate impacts related to natural habitats and cultural sites.	The Project is located in downtown Paramaribo, which is a WHS, and would temporarily impact some natural habitats. These impacts are addressed in this ESIA and relevant mitigation measures are included the ESMP (see Section 6.0).
B.11, Pollution Prevention and Abatement	Bank-financed operations require measures to prevent, reduce or eliminate pollution emanating from their activities.	Project activities have a risk of pollution, specifically during the construction phase. Pollution prevention is addressed in the Project's ESMP (see Section 6.0).
B.17, Procurement	Bank-financed operations require measures to ensure sustainable and ethical procurement.	Ensure responsibility for implementing ESMP is stipulated in construction contracts.
OP-761 Gender Equality in Development	Bank-financed operations require measures and strategies to promote gender equality in accordance with international agreements on the topic of this policy.	The Project does not have adverse or disproportionate impacts on gender and a Grievance mechanism will be implemented.
OP-765 Indigenous Peoples Policy	Not applicable. Projects whose activities adversely affect indigenous people must ensure compliance with this policy.	The Project does not have adverse or disproportionate impacts on indigenous peoples and a grievance mechanism will be implemented.
OP-704 – Disaster Risk Management Policy	Bank operations must identify and manage risks related to natural hazards by identifying these risks, reducing vulnerability and by preventing and mitigating related disasters before they occur.	Natural hazards are discussed in detail in Sections 4 and 5 of this ESIA. The Project itself is aimed at alleviating risk from natural hazards including flooding. Mitigation measures are included in the ESMP.
OP-102 Access to Information Policy	Projects funded by the IDB must be transparent in all aspects of its operations and must provide clear and easy access to the information it produces.	A meaningful stakeholder consultation, consistent with OP-703 and OP-102, was be conducted in July 2018 to present this ESIA. The Draft ESIA was made available prior to the consultation.

Table 7-3: Project Compliance with Applicable AF Policies and Safeguards

Principle	Requirements for Funding	Applicability to the Paramaribo Project
1 - Compliance with the Law	Projects shall be in compliance with all applicable domestic and international law.	This Project would be conducted in compliance with all applicable local Surinamese regulations, international agreements, and IDB safeguards and policies as discussed previously in this Section.
2 - Access and Equity	Projects shall provide fair and equitable access to benefits in a manner that is inclusive and does not impede access to basic health services, clean water and sanitation, energy, education, housing, safe and decent working conditions, and land rights.	This Project is an infrastructure project designed to protect and enhance downtown Paramaribo by reducing flood risk and vulnerability to climate change. Its benefits are distributed across all users of the area equally and once construction activities are finalized, it would not negatively impact any of the stakeholders in the Area of Influence (see Sections 5 of this ESIA).
3 - Marginalized and Vulnerable Groups	Projects shall avoid imposing any disproportionate adverse impacts on marginalized and vulnerable groups.	This ESIA analyzes Project-related impacts in relations to Indigenous People, women and people with disabilities; however, none of these groups are expected to be disproportionately impacted in any way due to the magnitude of impacts. Preventative measures have been proposed to address any issues (e.g. specific preventative measures for gender and disability related issues and a Grievance Mechanism) as part of the Project's ESMP (see Section 6).
4 - Human Rights	Projects shall respect and where applicable promote international human rights.	This Project is an infrastructure project designed to protect and enhance downtown Paramaribo by reducing flood risk and vulnerability to climate change. Human rights issues are not anticipated as a result of this Project.
5 - Gender Equality and Women's Empowerment	Projects shall be designed and implemented in such a way that both women and men 1) have equal opportunities to participate as per the Fund gender policy; 2) receive comparable social and economic benefits; and 3) do not suffer disproportionate adverse effects during the development process.	This ESIA analyzes Project-related impacts in relations to Indigenous People and women; however, neither group is expected to be disproportionately impacted in any way due to the magnitude of impacts. Preventative measures have been proposed to address any issues (e.g., Grievance Mechanism and gender-related measures) as part of the Project's ESMP (see Section 6).
6 - Core Labor Rights	Projects shall meet the core labor standards as identified by the International Labor Organization.	ILO's Core Conventions deal with freedom of association and right of collective bargaining (No. 87 and 98), forced labor (No. 29 and 105), child labor (No. 138 and 182), and equal remuneration (No. 100 and 111). Suriname has ratified all of these Conventions (as stated in Section 2) and has domestic laws to uphold such labor principles. The Project will incorporate contractual language to ensure Contractors meet this requirements and this will be monitored.
7 - Indigenous Peoples	Projects shall be consistent with the rights and responsibilities set forth in the UN Declaration on the Rights of Indigenous Peoples and other applicable international instruments relating to indigenous peoples.	This ESIA analyzes Project-related impacts in relations to Indigenous People; however, Indigenous peoplesare notexpected to be disproportionately impacted in any way due to the magnitude of impacts. Preventative measures have been proposed to address any issues (e.g., Grievance Mechanism) as part of the Project's ESMP (see Section 6).

Principle	Requirements for Funding	Applicability to the Paramaribo Project
8 - Involuntary Resettlement	Projects shall be designed and implemented in a way that avoids or minimizes the need for involuntary resettlement.	No involuntary physcial resettlement would occur as a result of the implementation of this Project. The Project could result in economic displament of those in the transport and hospitality industries in the immediate Project Area; however, this risk has been mitigated by the Project's ESMP and related Livelihood Restoration Plan.
9 - Protection of Natural Habitats	The Fund shall not support projects that would involve unjustified conversion or degradation of critical natural habitats.	There are no critical natural habitats in the Area of Influence of the Project. Biological resources impacts and mitigation measures are discussed in Sections 5 and 6 of this ESIA.
10 - Conservation of Biological Diversity	Projects shall be designed and implemented in a way that avoids any significant or unjustified reduction or loss of biological diversity or the introduction of known invasive species.	No significant adverse impact to biodiversity would occur as a result of implementation of this Project, as discussed in Sections 5 and 6 of this ESIA.
11 - Climate Change	Projects shall not result in any significant or unjustified increase in greenhouse gas emissions (GHGs) or other drivers of climate change.	Project activities are only expected to result in insignificant increases to GHGs during the construction phase. Relevant mitigation measures are discussed in Sections 5 and 6 of this ESIA.
12 - Pollution Prevention and Resource Efficiency	Projects shall be designed and implemented in a way that meets applicable international standards for maximizing energy efficiency and minimizing material resource use, the production of wastes, and the release of pollutants.	The Project's ESMP and related Construction Management Plan provide mechanisms to ensure Project conformance with this policy. (see Section 6 of this ESIA).
13 - Public Health	Projects shall be designed and implemented in a way that avoids potentially significant negative impacts on public health.	As with Policy 2 above, this Project is an infrastructure project designed to protect and enhance downtown Paramaribo and once construction activities are finalized, would not negatively impact any of the stakeholders in the Area of nfluence (see Sections 5 and 6 of this ESIA).
14 - Physical and Cultural Heritage	Projects shall be designed and implemented in a way that avoids the alteration, damage, or removal of any physical cultural resources, cultural sites, and sites with unique natural values recognized as such at the community, national or international level.	Because downtown Paramaribo is a WHS, Cultural Heritage is thoroughly discussed in Sections 4 and 5 of the ESIA. Mitigation measures relative to cultural resources are presented in Section 6 of this ESIA.
15 - Lands and Soil Conservation	Projects shall be designed and implemented in a way that promotes soil conservation and avoids degradation or conversion of productive lands or land that provides valuable ecosystem services.	This Project will take place in the highly developed landscape of downtown Suriname. Soil conservation and land conservation are not applicable to this Project.

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APPENDIX A:

Stakeholder Engagement and Communications Plan

This Stakeholder Engagement and Communications Plan captures the stakeholder engagement activities undertaken to date. As the Project progresses, the Project Proponent will update and own this plan through the subsequent project stages. Text in red are sections which the Contractor needs to complete.

1. Introduction

1.1. Overview

This document is the Stakeholder Engagement and Communications Planfor the Adaptation Fund for Urban Investments for the Resilience Program (the "Project"), a Category B Project, that focuses on the Paramaribo waterfront area and comprises three components:

- Construction of a new flood protection wall;
- Sommelsdijck Canal pump station and sluice gates rehabilitation; and
- Enhancement of mangroves.

This plan sets out the approach that the Project Proponent (i.e., the Government of Suriname, GoS, and its partner, the Inter-American Development Bank, IDB) will follow in order to engage and communicate with stakeholders over the life of the Project.

As defined by the IDB's Environment and Safeguards Compliance Policy, *B.6 Consultation*, engagement is considered appropriate when interacting with a Project's stakeholders[x], while consultation is required in order to interact and incorporate the viewpoints of Affected Parties[xi]. Given the nature of the Project, and as stipulated in OP-710 on Involuntary Resettlement, special consideration will be given to vulnerable groups, including with relation to engagement and consultative activities.

The Stakeholder Engagement and Communications Plan builds on the larger engagement efforts of the Project Proponent as part of the Emerging and Sustainable Cities (ESC) Program and should be considered as such. It is a 'living' document and is being developed progressively, with updates issued as the Project is defined and implemented.

This plan is organized as follows:

- Section 1 introduces the Stakeholder Engagement and Communications Plan and outlines the objectives of stakeholder engagement;

x The IDB defines a stakeholder as "… individuals, groups, or institutions that have a stake, or an interest, in the project: They may be affected by it (either positively or negatively), or they may have an interest in it and be in a position to influence its outcomes."

xi The IDB defines an an affected party as "…individuals, group of individuals or communities who may be directly impacted by a Bank-financed operation. Such impacts may be positive or negative. Affected parties may designate representatives as part of the consultation process."

- Section 2 introduces the Stakeholder Engagement Plan and related methods, in addition to previous and future activities;
- Section 3 introduces the Communication Plan and outlines its goals and objectives;
- Section 4 describes roles and responsibilities for stakeholder engagement;
- Section 5 explains the ways in which stakeholders can contact the Project Proponent, including the grievance mechanism for the Project; and
- Section 6 describes the monitoring and reporting of stakeholder engagement activities.

1.2. Objectives of Stakeholder Engagement

The activities of engagement are guided by good international industry practice, as well as all applicable laws and regulations in Suriname. The objectives of stakeholder engagement, outlined in this plan, are to:

- Promote the development of respectful and open relationships between stakeholders and the Project proponent and other relevant parties in the pre-construction and future phases;
- Identify Project stakeholders and understand their interests, concerns and influence in relation to Project activities, particularly during the construction phase;
- Provide stakeholders with timely information about the Project, in ways that are appropriate to their interests and needs, and also appropriate to the level of expected risk and potential adverse impacts;
- Support alignment with financing standards and guidelines for stakeholder engagement, as necessary in the pre-construction phase; and
- Record and resolve any grievances that may arise from Project-related activities through a Grievance Mechanism.

2. *Stakeholder Engagement Plan*

2.1. Stakeholder Analysis

Stakeholders and Affected Parties of the Project were identified based on the following information:

- The stakeholder list provided in the livelihoods study conducted by Culturecom (2016);
- Stakeholders in attendance at the public stakeholder consultation meeting held on 8 November 2017;
- Subsequent census and stakeholder interviews held in May 2018;
- Observations made during study site visits;
- Census surveys and discussions held with stakeholders during May 2018; and
- A final round of Public Consultation (three separate meetings) in July 2018 with stakeholders after the Draft ESIA was publicly available.

The following stakeholders and Affected Parties were identified based on the location of the individual Project components.

Construction of the Floodwall

This Project components would take place along Waterkant Street, adjacent to the water taxi landing ramp. Stakeholders include:

- Owners and/or drivers of the commuter boats and fishing boats;
- Bus owners/ drivers;
- Small and large business owners;
- Government institutions/representatives;
- Land owners (also some business owners;)
- District Commissioner's Office Paramaribo North East; and
- Foundation Stadsherstel (Stichting Stadsherstel), a part of the Foundation Built Heritage (Stichting Gebouwd Erfgoed Suriname [SGES]).

Sommelsdijck Pump Station and Sluice Gates Upgrades

These Project components would take place within the Sommelsdijck Pump Station building and within its basin. There are no residents or businesses in this area, and the main stakeholder would be the Ministry of Public Works (OWTC) who operates the station. Depending on actual construction activities, nearby stakeholders could include:

- The Royal Torarica; and
- Flower stands in front of Hotel Torarica.

Enhancement of Mangroves

These Project components are located downstream of the Sommelsdijck Canal and isolated. There are no residents or business in the area.

Cultural Resources Stakeholders

It is also recognized that the proposed Project components are located in the vicinity of the downtown area of Paramaribo which has been designated as a World Heritage Site (WHS) by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) due to its cultural significance, and is legally protected by Suriname law and international treaties. Cultural resource-specific stakeholders are also important and these comprise:

- Suriname Cultural Directorate;
- Suriname Center for Archaeology;
- UNESCO World Heritage Committee;
- International Council on Monuments and Sites (ICOMOS), which is an advisory body that offers advice to UNESCO on World Heritage Sites; and

- Suriname Built Heritage Foundation (SBHF), which was formed to implement the PWHSMP.

It is understood that the UNESCO World Heritage Committee and/or its advisory body (ICOMOS) do not necessarily provide approval and/or non-objection for development projects in World Heritage sites; however, the Project proponent is encouraged to maintain an open channel of dialogue with these entities and give them with an opportunity to provide input on the design.

2.2. Stakeholder Engagement Methods and Materials

The engagement process encourages meaningful participation by stakeholders. The Project Proponent will employ a range of methods and channels for disclosing information in order to tailor disclosure to the interests and needs of the various stakeholder groups and will also produce materials appropriate for specific stakeholders and types of engagement. This may include typical disclosure and engagement methods, such as:

- Local Newspaper Articles, Radio, Television Pieces, or Digital Media – Used to convey information to local audiences about proposed Project activities and progress (particularly relevant for any future offshore construction work).
- Internet/Website - Used to promote information or invite stakeholder queries and comments via email.
- Grievance Mechanism - Used by the public to obtain information, ask questions or report and get responses to grievances.
- Public Education, Outreach - use the general public and media outreach efforts as described in Section 4 to raise awareness on key issues of the Project, specifically.

The stakeholder engagement process includes two-way targeted engagement related to specific potential Project impacts. The environment and social impact assessment report prepared has assessed the majority of the residual environmental and social operational impacts of the Project to be of low or negligible. However, engagement activities will continue to be organized around specific topics of interest and known concerns of stakeholders.

Feedback mechanisms are adapted to suit the needs and preferences of different stakeholders and their physical locations. A Grievance Mechanism will be established to provide a dedicated mechanism for interested stakeholders to provide Project-related feedback (discussed in Section 7).

2.3. Completed Stakeholder Engagement

In order to meet the requirements of the IDB's Consultation Policy, several activities have taken place to further identify and inform the Project's stakeholders and Affected Parties. The Project Proponent has been engaging stakeholders since September 2016 as part of IDB's ESC Program and as outlined in its respective Environmental and Social Management Plan (ESMP). This previous engagement was designed to gain an understanding of stakeholders' general views about conditions in Paramaribo and receive concerns in order to steer the overall ESC Program.

There were four workshops with stakeholders, specifically government ministries and targeted privately-owned companies, as part of the ESC Program:

- Workshop 1, March 2016- During this workshop, the IDB introduced the ESC Program and its Consultant;
- Workshop 2, April 2016- The IDB's Consultant discussed required inputs to complete the feasibility studies for the ESC Program and met with individual stakeholders;
- Workshop 3, July 2016- The IDB's Consultant presented preliminary results of the feasibility studies and discussed data gaps; and
- Workshop 4, October 2016- The IDB's Consultant presented the final results of the feasibility studies.

Specific to this Project, a stakeholder meeting was held on the November 8, 2017 with the above listed stakeholders (Section 2) to present the set of potential adaptation measures, to inquire about additional stakeholders that could potentially be affected, and to receive suggestions and concerns with regards to the adaptation measure options being evaluated.

Additionally, supplemental information was gathered through in-person interviews and phone consultations with individual stakeholders and stakeholder groups after the November 8th stakeholder meeting.

I in May 2018, the Project Proponent conducted a socio-economic survey and census in the immediate study area in order to gain more accurate and timely information from stakeholders and potentially Affected Parties.

After the Draft ESIA was made publicly available, additional consultations with all stakeholders (meaningful consultation in accordance with IDB requirements) were held on 04 and 06 July 2018 to present the Draft ESIA. This stakeholder consultation was divided into a general consultation for all stakeholders, and two separate specific meetings with just the stakeholders which would be most directly impacted by the Project –transportation providers and water taxis transportation providers. These consultations served to share specific information on the adaptation measures selected for the Project, validate data relevant to the LRP with PAPs, and engage in a two-way exchange on the feasibility of the planned mitigation measures so that these can be best suited to respond to PAPs concerns. Appendix B of this report contains the Stakeholder Meeting Reports as well as the presentation provided during the meetings.

2.4. *Overview of Future Activities*

The Project Proponent will continue engaging with stakeholders on issues related to the Project. As part of the current consultation processes which have focused on pre-construction planning and design, the Project Proponent has scheduled a public stakeholder meeting for July 2018 to present the ESIA and provide updated information on the Project and its schedule.

If the Project secures the required funding and progresses forward, future key stages will include the following:

Project Stage	Engagement Activities Required
Funding secured	This will allow the Project governance and delivery structure to be established. This may bring additional stakeholders into play, in terms of Government agencies and/or other interested entities such as the Adaptation Fund. Consultations with these stakeholders will be initiated at this stage.
Design and build tender for construction works awarded	The construction firm appointed to undertake the Project design and build will revisit all stakeholder engagement activities to date, and in conjunction with the OWTC (as the Project proponent) will update this plan to align with its schedule of works.
Finalisation of design and construction activities	Once the construction firm finalizes its intended design and construction activities, consultations with identified stakeholders will be required where material changes are being proposed compared to what has been presented in the ESIA. Furthermore, consultations will also be required to update stakeholders on the schedule and sequencing of construction activities.
Construction phase	During construction, appropriate communications and engagement activities will be undertaken to keep stakeholders informed of progress.
Project completion	Once the works are completed, a final engagement exercise will be undertaken to ensure no remaining concerns or issues remain.

3. *Communications Plan*

The Communications Plan defines the communications goals and methods that the Project Proponent (the Government of Suriname, GoS) and the selected construction firm will pursue in order to communicate with stakeholders throughout the life of the Project. This plan sets out a framework to ensure consistent, efficient project communication throughout the Project planning and implementation process. As this ESIA and its management plans form part of an application to the Adaptation Fund, and the construction firm has not yet been selected, some elements are not yet possible to define. As such, the CP should be considered a 'living' document, and should be developed and refined progressively, with updates incorporated as the Project is further defined and implemented.

3.1. Objectives

It is important that communication with the public about the Project is consistent and easily understood by diverse audiences. Interest and knowledge levels will vary greatly – from highly-engaged individuals and organizations, to members of the general public that have limited familiarity and/or information about climate adaptation projects. Regardless of the interest and knowledge level of any individual, the objective is to provide easily digestible and practical information for the public to augment a smooth Project implementation process.

3.2. Communication Goals

The specific goals of this CP is to provide a strategic guide to:

- Proactively engage stakeholders with up-to-date information regarding Project development, construction timeline, and any changes in scope or delays

- Promote the benefits and importance of the Project to Paramaribo's resilience in the face of climate change

- Stress the Project's commitment to minimal disruptions to daily life in Paramaribo and adherence to Project construction timeline

- Establish public trust through credible, consistent, and open communication

- Provide a variety of information tools and points of contact to satisfy a diverse public audience

3.3. Key Messages

This section will include key Project messages. Messages should address the following themes and/or categories:

- Project benefits for the city and its future resilience

- Public involvement opportunities

- Key actors (OWTC, IDB, Construction Firm)

- Other TBC

Key messages should be developed internally and socialized with all Project staff as required for the audiences they might encounter such as upper management and Project Spokespersons, to construction site supervisors and social outreach team members.

3.4. Communication Methods

Communication methods should be developed to convey information to target audiences and the public at large, maintain consistent messaging, and provide the public with the opportunity to offer feedback.

Potential platforms and materials include:

Informational Materials

Clear, accurate, and comprehensive informational materials for use with stakeholders during formal consultation events and informal interactions will be produced. These materials will be updated as the Project evolves and supplemented with additional materials and can include:

- Project fact sheet with infographics
- Frequently Asked Questions
- Advertisements for public meetings
- Project maps
- Handouts/flyers
- Physical signs near sites of Project components with visualizations and key information (purpose and dates for completion)

All materials should include a link to the project website where further information can be obtained as well as a point of contact for questions or concerns (as described below).

Project Contact Vehicles

To give stakeholders easy and convenient access to the Project, the following contact vehicles will be put in place:

- Toll-free number for general Project inquiries, the Project may wish to consider SMS capabilities to provide easier access;
- General e-mail address; and
- Mailing address and physical office location.

The contact vehicles will be monitored regularly and response protocols should be developed to ensure all inquiries are tracked for reporting purposes and that responses are provided. Monitoring will also allow for modifications or ramping up of certain contact vehicles should one method prove more effective than others.

Stakeholder Point of Contact

A community and social coordinator for the Project should be established as a single point of contact for stakeholders. This person will be tasked with providing information and responding to questions, or should they not be able to adequately address enquiries, forwarding the question to a relevant authority.

Information and Communications with Specific Stakeholders

As Project development advances and specific construction plans are in place, the community and social coordinator should be responsible for conducting specific outreach with key stakeholders. The primary purpose of this outreach is to share information, answer questions and obtain stakeholders input on issues and concerns that need to be addressed. These meetings will also help to identify any new stakeholders to include in future outreach activities. Meetings can take place in many formats, from one-on-one casual conversations to small focused industry-specific meetings.

The waterfront area is a key area of focus for this outreach, as it is the area that has the most human and traffic presence and will be moderately affected by construction of the new flood protection wall. The community and social coordinator will lead a process of conducting outreach in the waterfront area to give specific information to shops, restaurants and transportation providers regarding traffic rerouting, construction implements and closures. Particular attention should be given to conducting such outreach on multiple days to ensure contact with all transportation providers to inform them well in advance of when they will need to use the alternative dock and parking sites, expected duration and any other logistical information they may need to smoothly continue their operations during the construction period.

Public Information and Communications

Beyond specific stakeholders, the public at large should be informed of the Project, its purpose, and key information that may affect daily life in the city. The key messages should always be reiterated during such efforts, in addition to addressing logistical Project updates. Formats for public information and communications should include:

- Public Meetings

- Media engagements especially via most-used media sources (radio, local television, etc.)
- Presentations to key stakeholder groups
- Community event attendance—i.e., booth at local fairs or celebrations
- OpEds and Project milestone press releases to local media
- Project website with up-to-date information
- Updated information on social media

4. *Roles and Responsibilities*

The Project Proponent and the construction firm selected will allocate sufficient resources devoted to managing and implementing the Stakeholder Engagement and Communications Plan, including a community and social coordinator. The process will be led by the OWTC as the Project Proponent, and supported by the construction firm.

5. *Contact with Project Proponent (Grievance Mechanism)*

5.1. Feedback Process

Stakeholders will be able to contact the Project Proponent at any time by letter, phone, fax, or email. Contact information will be made available through a website and also on external publications and communications (including newspapers, reports, leaflets, letters, emails, etc.). Communications with the Project Proponent will be possible through all locally used languages.

Stakeholders are invited to provide feedback and report grievances about the Project, including those related the economic displacement. This will allow the Project Proponent to monitor how the Project is doing, and will help to identify areas of improvement. The Project Proponent will treat all types of feedback with professional consideration and respect, and base its responses on open and honest communication. Feedback and grievances, where appropriate and necessary, will be investigated and closed out, and stakeholders will be informed of resulting decisions.

5.2. Grievance Mechanism

The Project Proponent will establish prior to construction a Grievance Mechanism (GM) to address any feedback and grievances associated with Project activities in good faith through a transparent and impartial process.

Specific objectives of the Grievance Mechanism are to:

- Help identify issues and concerns early, so that they can be addressed quickly and proactively;
- Continuously improve Project performance; and
- Demonstrate the Project Proponent's commitment to meaningful stakeholder engagement, and respect for local opinions and concerns.

The GM provides opportunities for the receipt, investigation, and resolution of complaints at the Project level during the pre-construction through operations phases. Stakeholders will be notified about the GM in external publications and communications (including newspapers, reports, leaflets, letters, emails, etc.), and contact details associated with the GM will be placed at the entrances to construction worksites. A dedicated telephone number and email option for public enquiries and feedback will also be shared.

The Project Proponent will use the GM as a component of the broader stakeholder engagement activities, including monitoring and reporting. A named individual will be assigned as the person in charge (PIC) of managing the GM, including the internal processes for grievance resolution.

5.3. Grievance Mechanism Structure and Process

The following structure and process will be integrated into the GM.

Timeframe

The Project Proponent will seek to close out feedback within 30 days of receipt. The following timeline will be used as a general guideline:

- Record and assess the feedback within 3 working days of receiving it;
- Acknowledge the feedback within 3 working days of recording it;
- Assign the feedback to a responsible party and investigate it within approximately 15 days;
- Resolve the feedback immediately upon investigation;
- Respond to the feedback submitter within 6 days of resolution; and
- Provide an opportunity for submitter's feedback or appeal if they are not satisfied with the outcome.

Depending on the feedback, its severity and the investigative process, the process might take more than 30 days.

Recording and Assessing Feedback

All feedback is forwarded on to the named PIC. She/he will file the feedback in the Feedback Management System (comprising a Feedback Intake Form and Feedback Log, see below) and determine the feedback's initial categorization and severity. If the feedback is about the PIC, it will be escalated to the Project proponent's Project Manager, who will manage the issue.

Severity levels for prioritization of feedback are as follows:

- Level 1 – Low Priority: Isolated or 'one-off' feedback (within a reporting period of one year) and essentially local in nature;
- Level 2 – Medium Priority: A feedback which is widespread and repeated e.g. dust or noise from construction vehicles; and
- Level 3 – High Priority: A feedback that has resulted in a serious breach of national laws, has led to or has the potential to lead to negative media coverage and/or is in breach of the Project proponent's own policies and procedures e.g. serious accident, pollution incident. A Level 3 feedback will be referred to the Project proponent's Project Manager.

Acknowledging Receipt of Feedback

Upon recording the feedback, the PIC will contact the submitter to notify him / her that their feedback was viewed and recorded (see Table 1), and will now be investigated. It will also provide information on the overall process and contact numbers. In the case of confidential feedback, the staff member dealing with the issues will be the only point of contact during the period that the feedback is being dealt with, unless in exceptional circumstances, and with authorization from the submitter, it is escalated.

Assigning the Feedback to a Responsible Party

The PIC will investigate the feedback or assign it to a qualified party in order to investigate it and seek resolution (if necessary). The investigative process can include (but is not limited to) site visits, face-to-face meetings, and interviews. All such activities will be documented.

Resolving the Feedback

After investigating the feedback, a resolution will be adopted. In some cases, the Project Proponent's team can immediately address the feedback, while in other cases the feedback might need to be elevated to senior management.

Responding to the Feedback's Submitter

Upon resolution, the PIC or responsible party will report out to the feedback submitter. The submitter will then be invited to provide additional feedback about the resolution process and outcome. The entire record will be preserved in the Feedback Management System.

Monitoring and Evaluating the Grievance Process

The PIC will be responsible for monitoring and evaluating the overall Grievance Mechanism and process. Using and maintaining the Feedback Log (see Table 2), she / he will quarterly review the feedback process to assess that key milestones are met and feedback are closed out within 30 days of receipt.

The system will allow for aggregation of data including:

- Number of feedbacks received;
- Types of feedback raised;
- Who / what caused the issue;
- Number of feedback events assigned to each Project department / office;
- Average resolution times; and
- Feedback from complainants regarding satisfaction of the resolution.

Monitoring these indicators will allow the PIC to identify trends evaluate the effectiveness of the mechanism and identify areas for improvement. It may also allow for the identification of recurring issues that could warrant discussion and action by the Project proponent's team.

Table 1: Feedback Intake Form

FEEDBACK RECORD			
FEEDBACK REFERENCE NUMBER:	***DATE / TIME RECEIVED:***		***TARGET DATE FOR RESOLUTION:***
NAME OF SUBMITTER:		***ADDRESS AND CONTACT DETAILS:***	
FEEDBACK RECEIVED BY:		***NAME OF PERSON IN CHARGE (PIC) / EMPLOYEE DEALING WITH THE GRIEVANCE:***	
CONFIDENTIALITY LEVEL (TICK RELEVANT BOX)	***NOT CONFIDENTIAL***	***CONFIDENTIAL***	***NOTE: IF CONFIDENTIAL THE PIC/PERSON DEALING WITH THE ISSUE WILL NOT DISCLOSE INFORMATION REGARDING THE COMPLAINANT UNLESS IN EXCEPTIONAL CIRCUMSTANCES WITH AUTHORIZATION FROM THE COMPLAINANT.***
TYPE OF ISSUE/ TOPIC (E.G. NOISE, LAND, POLLUTION, VERBAL ABUSE ETC.):	***DESCRIPTION OF FEEDBACK (INCLUDE DETAILS ON WHO / WHAT CAUSED THE ISSUE AND LOCATION OF ISSUE):***		
ASSESSMENT OF FEEDBACK PRIORITY LEVEL (TICK RELEVANT BOX)	***HIGH PRIORITY***	***MEDIUM PRIORITY***	***LOW PRIORITY***
SIGNATURE AND ROLE OF EMPLOYEE			***DATE:***
ACTIONS TO RESOLVE FEEDBACK			
DELEGATION TO:			
ACTION	***WHO***	***WHEN***	***COMPLETED Y/N/DATE***
RESPONSE/RESOLUTION:			
STRATEGY TO COMMUNICATE RESPONSE:			
SIGN-OFF:			
DATE:			
CONCLUSION			
IS SUBMITTER SATISFIED? (Y/N)		***COMMENTS FROM /EMPLOYEE DEALING WITH THE FEEDBACK:***	
SUBMITTER COMMENTS REGARDING RESOLUTION:			

FEEDBACK CLOSED?	***Y/N***	***FEEDBACK RESUBMITTED?***	***Y/N***
SIGNATURE AND ROLE:		***DATE:***	
DATE:		***NEW FEEDBACK NUMBER:***	

Table 2: Feedback Log

Details of Feedback								
Feedback Reference Number	**Date Received**	**Time Received**	**Name of Submitter (if not anonymous)**	**Address of Submitter**	**Contact Details of Submitter**	**Confidentiality Level**	**Priority Level**	**Name of staff member that received the feedback**

Issue Raised		**Reporting and Acknowledgement**				**Grievance Management**		
Type of Issue (e.g. Noise, Land, Pollution Verbal Abuse etc.)	**Description of Feedback (include details on who / what caused the issue and location of issue)**	**Communication Channel Used (e.g. Telephone, Email)**	**Has the issue been documented in a grievance form? (Y/N)**	**Has an acknowledgement been submitted to the submitter with a redress date? (Yes / No) if so what date?**	**Name of Staff Member that Submitted the Acknowledgement to the Submitter**	**Has the feedback been re-assigned to a different person/ department?**	**Name of Staff Member Managing the Feedback**	**Expected Resolution Date**

Actions to Resolve Feedback and Conclusion								
Description of Response / Resolution	**Has the resolution been communicated to the submitter?**	**Method of Communication to the Submitter**	**Date Resolution Communicated to the Submitter**	**Is the submitter satisfied with the resolution? (Yes / No)**	**If not, what additional action is being taken?**	**Name of Staff Member Assigned to Additional Action**	**Revised Resolution, if Applicable**	**Grievance Status (i.e., Not Started / Pending / Resolved)**

6. *Monitoring and Reporting*

6.1. Monitoring

It is important to monitor stakeholder engagement and communication to ensure that consultation and disclosure efforts are effective, in particular that stakeholders have been meaningfully consulted throughout the process.

Monitoring will cover:

- Consultation activities conducted with government authorities and non-governmental stakeholders;
- The effectiveness of the engagement processes by tracking feedback received from engagement activities; and
- Any grievances received.

6.2. Tracking Stakeholder Engagement Activities

Future tracking of stakeholder engagement will be used to assess the effectiveness of the Project's stakeholder engagement activities. Indicators for tracking will include, among others:

- Place and time of formal engagement events and level of participation including by specific stakeholder categories and groups (e.g. women);
- Number of comments by topic and type of stakeholder, and details of feedback provided through the GM or other means (office visits, emails, phone calls etc.);
- Numbers and types of grievances and the nature and timing of their resolution;
- Recording and tracking commitments made to stakeholders; and
- Community attitudes and perceptions of the Project's activities pertaining to the Project based on media reports and stakeholder feedback.

6.3. Project Reporting

Internal Reporting

Reports on stakeholder engagement efforts will summarize all activity for the period and provide a summary of issues raised and how they have been addressed. Potential issues include timeliness of responses and mitigation and measures taken to address grievances, and analysis of trends in key performance indicators (KPIs). These may include:

- Total numbers of stakeholders engaged according to stakeholder category;
- Numbers of comments and queries received according to topic and responses;
- Issues raised and levels of support for and opposition to the Project; and
- Numbers of grievances lodged.

The Stakeholder Engagement and Communications Plan will be reviewed on a regular basis and revised as needed to reflect completed engagement activities and future engagement plans.

External Reporting

The Project Proponent will provide information to stakeholders that will focus on non-routine activities, after an unplanned event or incident (if one occurs), or if there is any change to company structure or practice.

APPENDIX B:

Stakeholder Meeting Reports

REPORT

STAKEHOLDER MEETING

'Adaptation Fund Study'

By Rachelle Bong A Jan and Karin Lachmising
Location: Waaggebouw, Waterkant 5
Date: November 8th, 2017
Time: 8.30-12.00 hrs

Contents

1. Introduction

Previous studies performed in Paramaribo have determined that the urban area of Paramaribo is considered highly vulnerable to floods due to sea level rise, increasing precipitation intensity, and loss of land due to coastal and riverbank erosion. Based on this determination, the Inter-American Development Bank (IDB), on behalf of the Government of Suriname (GoS), prepared and submitted a concept note proposal for Paramaribo to the Adaptation Fund, an international organization that finances projects and programs to help vulnerable communities in developing countries adapt to climate change.

This project application is additional to the Paramaribo Urban Rehabilitation Program (PURP), a rehabilitation program with the aim of revitalization and to increase the attractiveness of the historical center through restoration of heritage buildings and improvement of public space and mobility. The application has targeted measures for the protection of the Paramaribo Center against negative influences of climate change , in this case high tide and exuberant rain evacuation. In particular attention is given to the UNESCO World Heritage Sites, including the riverside(waterkant) and connecting parts with the Sommelsdijkse kreek.

Two public stakeholder meetings have been planned. The goal of the stakeholders meeting held on the 8th of November was to inform a wider audience about this program and to present a set of potential alternatives / measures to be taken and get response and suggestions concerning the set-up of the study and the several presented options and ideas for adaptation measures.

2. Stakeholders

The next groups of stakeholders were present:

Aurora Architects	Enterprise construction
KDV architects	Enterprise construction
Prosco Industrial NV	Enterprise construction
TBS consulting	Enterprise construction
Cactus NV	Enterprise large
NV EBS	Enterprise large
Telesur	Enterprise large
NV Guimar	Enterprise medium
CT consultants	Enterprise small
Stichting Waaggebouw	Enterprise small
Brandweer	Government
Buurtmanager Paramaribo Centrum	Government
Centrale Bank van Suriname	Government

DC Paramaribo Noord Oost	Government
DNA	Government
Kabinet van de Vice president	Government
Ministerie RO	Government
Ministerie van Financien	Government
Ministerie van Handel en Industrie	Government
Ministerie van Justitie en politie	Government
Ministerie van OWTC	Government
Ministerie van ROGB	Government
Rekenkamer van Suriname	Government
Staatsraad	Government
Stichting gebouwd erfgoed	Government
Riverside Terras	Horeca
Restaurant Broki	Horeca
Uitbater waaggebouw	Horeca
VSB	Representatives Enterprise
Beheersraad Waterkant	Representatives Enterprise
Vereniging Boothouders	Representatives water transport
management VSH apartments	Tourism
Shata	Tourism
Stichting Toerisme	Tourism

A total of 55 persons participated, who represented a diverse group of stakeholders, directly involved stakeholders and knowledge persons. Absent were people from the craft stalls and some other small enterprises with businesses in the area.
(see Annex 1 for the listing of all persons participated during the stakeholders meeting).
A summary of the main concerns and suggestions brought forward by the stakeholders during the questions and answers sessions are listed in table 1.

Table 1. Summary concerns and suggestions stakeholders

Subject	Concerns /issues	Suggestions
World heritage site/ Built heritage/ private owners	General elections, replacement of government/different people/ new decisions.	Tax reduction for private owners of historic buildings, with regard to maintenance costs
Maintenance	How sustainable is the adaptation? Mostly lack of	Payment systems, contribution by the people

	maintenance.	
Pollution		Waste management: Develop a waste management plan for the inner city. Air pollution: incorporate data collected and identify possible effects during and after construction Traffic Noise: Make use of the plan(s) for noise reduction – made by the DC of Paramaribo North East
Plans made by other departments/ studies that have been done already	How to bring together the different projects.	Take into consideration and discuss options and plans and incorporate these studies/ ideas and suggestions if valuable or relevant. e.g. Waterkant study Anton Dragtenweg -Business plan by association of ferry boat owners - water taxies -EBS energy (construction) plans funded by IDB e.g. carbon footprint project.
Knowledge		Make use of DC information /assistance Share the process with the other DCs of the different districts of Suriname Make use of landscape designers for this project /esthetic aspects important Synergy with other plans
Finance	Safeguards funding with regards to inflation, economic /social	Include local finance institutes

	situation of the country	for funding Toll charge e.g. Wijdenbosch bridge to finance ferry dock IDB plans- co finance by other IDB plans
Health		Incorporate health in all plans
Technical/construction	Construction companies: control system not to damage historic buildings/ archeology or other subjects of historic-cultural value that should be preserved Poor Drainage system OW	Use of local knowledge historically and culturally with regards to construction. OW construction plans: coordination with OW plans of construction
Traffic	Influence from other traffic areas outside central Paramaribo/ heavy traffic south north	Cameras to control and monitor.
Energy	Flooding: risks energy supply during construction phase High complex ratio	Room for energy needs and efficiency and placement of electricity infrastructure
Greening/ landscape/ river view	Air pollution Accessibility Suriname river Increase of built-up area caused declined water storage	Trees in the city, landscaping Look for modern methods Be innovative, apply modern methods/systems
Land ownership	Private owners take independent measures against flooding, rainfall etc. Area behind Waag gebouw: Land and water area granted by the	Cooperation also with private owners on measures concerning flooding/rainfall etc. Transparency, Laws en regulation (monitoring) that

	government to a private company makes it impossible to take measures against flooding. The riverside is not accessible because of this ownership. Market stalls/stand on public domain Land tenure/landownership dynamic is complicated; situation changes in short amount of time; can cause different project conditions than started with.	makes it possible to prevent public domain becoming private owned land.
Cooperation		Cooperation needed with private owners regarding government/ public domain projects
Information/communication	Transparency regarding land tenure/landownership Construction and OW works Talking but not doing	Intensive communication with actors needed and feedback All ministries should be involved

3. Notes of the meeting

R. Patandin (Ilaco):
-Opening and agenda discussion; project is in the preparation phase. IDB and Government of Suriname (GoS) are working together to carry out the project. The goal of this meeting is to inform a wider audience about this program and to present a set of potential alternatives / measures to be taken.
-Introduction of S. Mohan; short explanation of his role and responsibilities in the project.
-Introduction of S. Fokke- who will present the project in a greater context
-Ilaco will present the application of an additional project attached to the PURP.

S. Mohan (Ministry of Public Works-OW):
-Presented on the topic of climate change, how it is experienced in Suriname and the linkage between climate change and the PURP. Climate change is affecting everyone on earth, also Suriname is being affected. Temperatures will rise, precipitation in total will decrease, however extreme rainfall occurrences will increase. Measurements indicate this trend will continue. Several studies are being

executed to collect data for instance Ministry of LVV is collecting statistics on agriculture. Three studies using modeling /simulations are being done. Results will be in shortly. LVV is doing a part, there is also the REDD+ program in forestry. A strategy for sustainable and green development of the economy of Suriname is being developed. The government is looking towards striking a balance with green measures. Around December we expect to have the results of the Masterplan study Drainage.
-ESC (Emerging Sustainable Cities) is being implemented in Latin-America: approx. 68 cities. The focus is on 2 programs namely PURP (S.Fokke presentation) and ADAPTATION (Ilaco presentation), the reasons for which we are here today. I have to emphasize that the project has not been written yet. The feedback/input of the public in particular the stakeholders, is imperative.
-with regards to the climate change effects and demographic issues a simulation plan will be ready by the end of 2017/ beginning of 2018
R. Patandin added: WMO has noted that 2015 and 2016, most likely also 2017 were the warmest years ever in a hundred years' time, ever since measurements were started.

<u>S. Fokke-SF (see also ppt slides for detail info):</u>
-is the program coordinator of PURP. Implementation has been delegated by the Ministry of Education, Science and Culture to the SGES (Stichting Gebouwd Erfgoed Suriname).
-budget is 20 million USD, however it is not sufficient. With this amount not all problems can be resolved; the funding need is many times larger.
-Area: world heritage site of the UNESCO (2002)
-there are 4 main components which are divided into subcomponents….
[*SF discussed each component indicating the buildings targeted and activities to be executed*]
-The operational services of the parliament shall be transferred to the new buildings that will arise at the Henck Arronstreet (former location of the parliament and the Ministry of Public Affairs). Since the budget is limited, not all properties can be restored. Eligible buildings were selected based on previously defined criteria. [*SF discloses the criteria that were used for building selection*].
-Not the whole of Paramaribo was reviewed, but a smaller part to allow for more effective and efficient use of financial resources.
-regarding traffic mobility: a lot of simulations are used to address this issue.
Comp.2-at the moment owners of monumental buildings don't have access to any financial incentives to carry out maintenance. Therefore a study will commence to determine if and how owners can apply for financial support or subsidy in order to appropriately maintain their properties. At night the center of Paramaribo is desolate since everyone moves out of the center. As such PURP is also looking into transforming the monumental buildings into residences, in order to create housing for locals or to give the buildings a dual purpose of workplace and residence combined into one.
-regarding component 3: management framework; this entails strengthening the capacity of SGES. The Ministry of Trade and Industry is also developing a Tourism Plan.

<u>Q&A session:</u>

-Wilgo Bilkerdijk (Staatsraad): I saw a financing mechanism mentioned. What about providing fiscal incentives?
SF: there was a meeting with the previous Head of the Tax Authority whereby a tax deduction was discussed for the owners of monumental buildings; he was open to the idea, but then he was replaced by someone else when another government won the elections. In foreign countries certain maintenance costs are eligible for tax deductions.

-Audrey Palman (District Commissioner's Office Paramaribo North-East): I haven't seen a maintenance plan mentioned.
SF: That's because an important prerequisite of the program is that government offices cannot be housed in the buildings anymore, after they have been restored. The restored buildings must generate income that will be partially used to carry out maintenance. Also I would like to add, that it is even more important to adhere to a maintenance plan rather than having one which you don't stick to in the end. This is something that occurs all too often.
-Audrey Palman: Waste management is also very important; a waste management plan needs to be incorporated. It doesn't make sense to restore all the buildings while the streets are lined with garbage. Regarding component 1 (traffic nuisance): we have formulated different actions to resolve these problems. We can assist or advise with this.

-Joy Themen (independent consultant-TDS consulting): are safeguards incorporated for the funding of the program, because you had mentioned that the budget is tight. What about inflation etc.? Also, when the timeline for the program was drafted, where you also considering the more busy times of the year? I say this in light of traffic management.
SF: we are currently in the start-up phase of the program, as such, a lot of data is being collected and studies are looking at the best way to do this. So I can't say anything about the points mentioned.

-Joy Themen: Do we have technical expertise available in house in the area of history and monuments? For advise on proper implementation? SF: yes, there are specialists in Suriname and we have a technical advisory group which consists of representatives of different government institutions. If a particular expertise is not in house, then we have alternatives available.

-Joy Themen: what if an archeological discovery is made? How will the situation be monitored? because artifacts have been taken away in the past. SF: a special manual was developed that shows which procedures are to be followed in case a discovery is made. Additionally, for each monument an ESIA must be carried out. The ToR is being drafted for this at the moment.
-Joy: what about the part of contractors and subcontractors...how will this part be monitored? SF: with assistance of the Advisory Groups.

-Joy Themen: I see an opportunity for knowledge transfer between governmental institutions, so I would suggest including the district commissioner's office staff from the other districts in the process.

-R.Patandin: can owners of monumental buildings and business owners participate in the Advisory Group?
SF: no, I already mentioned that the Advisory Group consists of government representatives, however we value their feedback and input and that's why we have planned stakeholder meetings.

-R. Hieralal (CT consult-civil works consultancy): will the traffic study focus solely on the historic center of Paramaribo or will it also relate to traffic flows coming from other areas e.g. traffic going South to North? SF: we will not only look at central Paramaribo, because any measure you take in the center of Paramaribo will have an impact somewhere else. So, yes we will consider the connectivity. Consultants are collecting data and consulting with stakeholders. When we have the results, we will share this with you.

-R. Patandin: emphasized the context of this particular meeting and how all the different projects fit into a larger program, also how they relate to one another. The meeting for today is to discuss a potential addition to the PURP: the Adaptation Fund. Government will do this together with the IDB. Key factor: how can we protect Paramaribo even better? Make it more resilient?
Although the focus is now on the historical center of Paramaribo, we will also look beyond this area. The smaller projects are complementary to the larger PURP.

[coffee break]

<u>Presentation Ilaco (R.Patandin):</u>
-Description of the study area: the area under consideration for the evaluation of the potential adaption measures to be taken in relation to climate change.
-Presentation of the project process: different steps. With regards to 'Criteria' there are 4 main considerations namely technical, social, environment, programmatic.
-The project has already gone through a screening of its feasibility. We are now trying to determine the potential impacts and formulate mitigating measures in case of negative impact such as traffic nuisance or hindrance and relocation of water taxies. All these factors are being considered.
-A lot of infrastructure that is located inside the project area requires repair or restoration, however, we are explicitly looking at measures that will be implemented on public domain, not private domain.
-We've already identified ways to mitigate impacts that may arise for example if work needs to be done at the docking place for water taxies, than we have alternative locations such as the old ferry landing. We are also going to renew the pathways for pedestrians.
-Regarding the restoration of the dyke behind Fort Zeelandia: the intent is to also include measures for the recovery of the Mangrove stand in order to extend the green zones in Paramaribo.
-Explanation of the different restoration measures/alternatives possible for the Sommelsdijck creek e.g. repairing the sluice and pumping engine. There are some challenges identified such as encroachment; the built-up area has expanded thereby impeding the drainage systems.
-There are several options to resolve perceived problems, but not all are a good fit for this project or they can also be carried out in another project or by another organization. In the Adaptation Fund the

maximum amount to apply for is 10 million US dollars (out of which 7-8 Million USD for works) , but it is not enough to fix everything, that's why we need to choose between different options. And the decisions will be made using different criteria.

Q and A session:

-Chiquita Resomardono (NV EBS): adaptation measures in relation to the greening of the area; have you also considered the energy needs and energy efficiency? Also placement of electricity infrastructure: street lights, placement of light poles, also taking care that in case there is flooding, that the energy supply isn't at risk.
R. Patandin: the utility companies will need to take responsibility for their own part; what falls within their scope of work.

-Omzichtig (Riverside Terras): I've deposited stones at the back of my property to protect against flooding. It has helped a bit, but when the water level in the river is extremely high, my place gets flooded. Each business owner must protect his property and needs to maintain it to attract visitors. Government and entrepreneurs must collaborate better. Everyone must contribute, otherwise we cannot make progress. Maintanance is crucial. People must stop talking so much and start doing more.
R. Patandin: the preconditions of the project dictate we should operate on public domain. But there is a possibility that (in the near future) there will be an initiative coming from the private sector. They could join the project. It is a possibility.

-Joy Themen: some suggestions…….1) besides the civil engineering experts, it is also important to include experienced landscape designers; otherwise it can turn out to look messy. Esthetic aspects need to be considered. 2) A while back plans were written for the area Waterkant-Anton Dragtenweg; these plans should be contemplated. 3) Also, try to incorporate modern elements, where relevant and 4) try to establish synergies with projects already in existence for example the utilities companies…try to collaborate and combine efforts; this way you can be cost-effective. Because this program is complex it requires continuous communication and feedback with the stakeholders. All ministries will in some way be influenced by this program and should participate with the meetings.
R. Patandin: the project coordinator will have to consider all the linkages and also the communication with the utilities. Joy: also take care not to damage historic objects.

Palman: how can local financial institutions be involved in the funding of the project? And what actions are taken by the ministry of Public Works to realize better drainage?
Mohan (Ministry of Public Works-OW): maintenance of the drainage system is an on-going process. We continue with our work, even if it isn't adequately done. We have limited resources, so we are looking for different ways to keep on going. Some projects are executed under PURP, others are separate.

Chermaine Felter (Chair-Supreme Audit Institution of Suriname): some suggestions for the Ministry of Public Works: 1) there aren't enough trees in the city. Trees are important for human beings. A greener city is also important for tourism. 2) Can Mr.Mohan present to the Minister of Public Works the idea of a

penalty system to be enforced on those persons that are polluting the environment? Maybe monitoring can take place by using street cameras, in order to identify the offender(s) and impose a fine on them. 3) Is there a way to restore the old ferry connection? Traffic on the Wijdenbosch Bridge is always in a deadlock. Maybe a small contribution (toll charge) can be asked from the citizens in order to finance the repair of the ferry dock. Maybe the IDB can be approached to assist with this.
It is important that our community participates and takes responsibility and not to rely on government only. Any contribution, even a small one by the people themselves could help to find additional funding from the IDB. People should pay for maintenance.

John Pawiroredjo (former director of the Directorate of Culture):
-called attention to the issue of accessibility of the Suriname River; as time progresses, the view of the Suriname River has become more and more obstructed. It is requested that when building plans or civil engineering plans are drafted, the aspect of visibility of the River is incorporated.
-the air quality above Paramaribo is also important, especially in relation to development of the tourism sector. The gold processing activities and car traffic are polluting the air.
-the built-up area in Paramaribo has increased significantly with the consequence that the water storage capacity has declined. Also a lot of open sewers have been replaced with closed drainage systems which aren't sufficient. We need to look for modern methods, apply innovative systems such as water injection into the earth.
R. Patandin: we are contemplating infiltration systems to bring the water back into the soil. But this will only work if the Ministry decides to reorganize the identified location. This option is only viable if it is implemented together with other measures.

Oliver Smith (Foundation Waaggebouw):
We built a sheet pile wall at the back of the Waag property, which now is leaking. It needs to be repaired, but we cannot reach it, because the land has apparently been granted by the government to a private company? We would like to be informed about this matter. Is this true or not?
R. Patandin: The measures we are discussing today are intended to be carried out on public domain. The government is also involved in this project and they need to say whether this is true, because we cannot invest public funds in operations that in the end will not benefit the general public.
Oliver Smith: we want to and are financially able to protect the property Waaggebouw, but we cannot maintain the sheet pile wall, because we can't get to it.

Mr. Nathoe (Association of ferry boat owners-water taxies): we are developing a business plan. Our passenger needs are important to us and we want to keep our clients satisfied. But we did not consider climate change in our plans, so this is something that we will incorporate from now on. When we finish our plan, we would like to present it to you.
R. Patandin: your input is highly valued. And we are standby to discuss with you.
Nathoe: we've included elements like sanitairy facilities and we also incorporated Meerzorg, because we work in both locations.

Roger Tanoewihardjo (Prosco Industrial NV): I have some inquiries .....1) About the sheet piling walls placed at the Dr. S. Redmond street near Dream Café. The activities have quieted down all of a sudden…what is going to happen next? 2) The market stalls/stands that are being erected on public domain, along the creeks in North Paramaribo. What is happening?
Patandin: you are right. I'm not sure if everything will fit; if all measures will be implemented. I can only respond to the technical questions related to this Adaptation Fund Study.
Palman: I just started working at the District Commissioner's Office, so I'm not authorized to speak on the matter of the stalls, but as far as I know, the construction should not be permanently fixed.
Patandin: I want to bring everyone back to the project under discussion....whatever you are planning; the institution in charge of maintenance must under all circumstances have access to the infrastructure to carry out maintenance tasks.

R. Hieralal: was involved in the project 'Ringweg canal': there was a very complicated dynamic going on concerning the land tenure/land ownership of the persons living along the Ringweg and also the kinds of activities that were going on. I strongly advise not to underestimate the dynamics going on in the Sommelsdijck kreek area, because a lot can change in a short amount of time; conditions that are beyond your control.

Chiquita Resomardono (NV EBS): in line with what Oliver Smith brought forward......the IDB always looks closely at issues of land tenure / land ownership…this must be figured out whether it is true that the area behind the Waag is actually in private hands.
Kadirbaks (ROGB): I'm from the Ministry of RGB, but I'm not in charge of regional zoning policy or land ownership. I think something went wrong in the case of Waaggebouw, I consider it as a mistake that happened. We have laws and regulations in place that we can fall back on. If it is in the public interest to make changes and take back the land, than that is a possibility. Maybe policy was different in the past; but in coming years a policy will be enforced that aims to correct things. If Foundation Waaggebouw would like to call attention to some issues that are going on; the Ministry is all ears.

R. Patandin: We will share the selected adaptive measures with the other Ministries in order to have a broad social basis and for better rapport.
Oliver Smith: someone has granted the land behind de Waag. I have a technical question: is RGB only for land or also for water? Maybe I'm talking to the wrong party?
R. Patandin: we will surely take your technical comments into account.

E. Doorson (Broki): You are a representative of the state Mr. Patandin. Patandin: No, I am not, but Mr. Mohan is.
E. Doorson: you applaud Mr. Omzichtig and Foundation Waaggebouw for their efforts and also the water taxi owners, but you're not even aware that 1.1 hectares have been granted to Cactus N.V.? This area in the back of our properties belongs to Cactus N.V. You mustn't encourage Mr.Omzichtig because he is throwing away his money.

R. Patandin: We have put forward this question to the government and let us wait for an answer of the government, whether or not the land and water was granted.

Omzichtig: the government cannot maintain the civil works and other infrastructure for instance if we look at the fountain at Valliantsplein; it is dirty. Who has adopted the fountain to take care of it? Maybe it should be replaced by something else which requires less maintenance. Another example of the inability of the state to maintain its infrastructure is the old ferry dock. It has sunk into the water.

Chiquita Resomardono: EBS is also executing a few IDB funded projects. [*Offers background info about the projects*]. Let's be in touch to discuss how we can combine efforts especially concerning 'green public spaces', because there is overlap in what we are doing and where we are working.
Patandin: we actually do a lot, but it is not always visible to everyone else what it is that we are doing.

R. Hieralal: we are discussing individual projects, but how will we bring together all the different projects?

Joy Themen: reiterates about the importance of having designers involved in the projects and the inclusion of specialists in the area of history and culture.

R.Patandin: explains the timeline for the next phases in the project. If approved by the Adaptation Fund, the project will commence at the end of 2018 or at the beginning of 2019.

R. Olff (Telesur): what if the project isn't approved?
Patandin: other projects will continue on with or without this project and there will be other funding opportunities.

Annex 1. List of participants

Presentielijst
Datum : Woensdag 8 November 2017
Locatie : Waaggebouw (zaal boven)
Tijd : 8.30 am-12.00 u

No.	Instantie/Organisatie	Naam	E-mail adres	Tel.nr	Paraaf
1	Standhouders Waterkant (Belangen Organisatie Waterkant)	Marjon Emanualson			
2	Beheersraad Waterkant	Mw. Kastile Pinas		8928762	
3	Surinaamse Scheepsvaart Maatschappij (afd. PFC)	Dhr. Main			
4	Stichting Waaggebouw	~~Dhr. Azaad~~ O. Smith	OSMITH@FIRMENGINEER[illegible]	[illegible]	
5	Uitbater Waggebouw	Dhr. Azaad	[illegible]	[illegible]	
6	Boothouders Waterkant	Dhr. Michael Nathoe			
7	Stichting Gebouwd Erfgoed Suriname (SGES)	Dhr. S. Fokke	Sges@sr.net	8553014	
8	Juwelier Waterkant	Sunil Oemrawsingh			
9	Centrale Bank van Suriname (CBvS)	Dhr. Satimin			
10	Management VSH Appastementen	Charieta Lie Wan Hing	[illegible]	7107765	
11	Rekenkamer van Suriname	C. Felter	[illegible]	8793016	
12	Ministerie van Onderwijs, Wetenschap & Cultuur	J. Pawiroredjo	[illegible]	0355[illegible]	
13	Staatsraad	Wilgo Bilkerdijk	[illegible]	[illegible]	
14	Ministerie van Ruimtelijke Ordening, grond- en bosbeheer	Kadirbaks	[illegible]	0790212	
15	Ministerie van Ruimtelijke Ordening, grond- en bosbeheer	E.Djojokasiran	[illegible]	8215083	
16	Ministerie van Justitie en Politie (afd. Voorlichting)	M. Ritfeld	[illegible]@gmail.com	8925626	
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18	Buurtmanager Paramaribo- Centrum	J.Colli	jechcol@hotmail.com	7174905	
19	Commandent Brandweer Knuffelsgracht	Aramake			
20	Commandent Brandweer Knuffelsgracht	Mungroep			
21	Ministerie Regionale Ontwikkeling	Fonkel	[illegible]@hotmail.com	8705503	
22	Ministerie van Financien	R. Ramsukul			
23	Ministerie van Financien	Sultan	[illegible]sultan@yahoo.com	471108	
24	Stadsherstel N.V.	Kenneth Woei A Tsoi			
25	CT Consult	R. Hieralal	rhieralal@hotmail.com	8581593	
26	CM Engineering	Robin Van Dijk			
27	Le Grand Baldew- President Commisaris	W. Baldew			
28	Stichting Toerisme Suriname	James	[illegible]	811658	
29	SHATA (Suriname Hospitality and Tourism Association)	Ambel T.	[illegible]@gmail.com	8695727	
30	Stephany van Doom	Stephany van Doorn			

No.	Instantie/Organisatie	Naam	E-mail adres	Tel.nr	Paraaf
31	DNA Jules de Rijp	Jules de Rijp	jderijp@yahoo.com	8540724	
32	DNA	Vivian Pleisner			
33	DNA	Tanya Sewnandan			
34	DNA	Zefenia Telting			
35	Telesur/Corp Comm	Ruth Olff	rolff@telesur.sr	474242	
36	Consultant social solutions	Rachelle Bong A Jan	[illegible]@gmail.com	08980550	
37	Min RO, DC Parbo Noord Oost	Audrey Pawirodimedjo	[illegible]@gmail	825[illegible]	
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	Brandweer Knuffelsgracht	Aramake + Mungroep	[illegible]@.net	8542229	
39	AFIA CACTUS N.V			7190188	
40	KDV Architects	Peggy Bawek	pbawek@kdvarchitects.com	8834991	
	[illegible]	Eda Doorson	[illegible]	8800472	
41	DNA	Tanya Sewnandan	[illegible]@hotmail.com	[illegible]	
42	Centrale Bank v Sur	Satimin Melvin	MSatimin@cbvs.sr	3524572	
43	M. NATHOE BOOTHOUDERS		natmi-@hotmail.com	8070540	
44		[illegible]		4911474	
45	Ministerie van OW en C	Aisha Sno	aishasno@hotmail.com	[illegible]	
46	Min. v. OWTC	Soerdjal Rashna	rashnasoerdjal@gmail.com	8511555	
	[illegible]	[illegible]		0881128	
47	NV EBS	Ch. Reemnarain	chiquita.reemnarain@ebs.sr	8971951	
48	VSB	Cheryl Vroom	vsbsha@sr.net	476788	
49	TDS Consulting	Joy [illegible]	joythewen@gmail.com	8810396	
50	NV. Guimar	Leo Tjon A Njoe	[illegible]@guimar.com	08805340	
51	Aurora Architects	Gallil G.	gumar@aurora-architects.com	866328	
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53	Prosco Industrial NV	Tamoenwhordjo R	[illegible]@prosco industrial.com	8660892[illegible]	
54	Min. Handel Industrie en Toerisme	Fraser Bradley	bradley.fraser@minhi.gov.sr	[illegible]	
55	Hab. VP.	REVINA RAMNANDANLALL	34CONCEPTS@gmail.com	7538775	

Annex 2. Impressions of the stakeholder meeting

Report on Final Public Consultations

1 General Approach

Final public consultations were held on three sessions. One session was held for the general public, and two sessions specifically targeted the most affected stakeholder groups; the bus and ferry boat owners and drivers. The reasons to have separate sessions for these specific stakeholder groups, is that these persons often do not attend formal meetings that are held at a time that may not be convenient to them, and in a location where they feel they have to dress up. By holding separate meetings with these group, we could select the time and location that was most convenient to the target group, as indicated by their spokespersons.

In order to schedule the meetings with the specific stakeholder groups, contact was made with the representatives. The purpose of the meeting was explained, and the representative was asked to suggest a time and place. Both the bus and ferry boat representatives asked to have the meeting in River Side bar, which is usual hang-out for bus and ferry boat people at the Waterkant near their work areas.

Prior to the consultation meetings, the consultant visited the bus parking place and ferry boat landing to invite the boas and boat owners and drivers to the meetings and distribute the invitation letter from the Ministry of OWTC (Annex 4). In addition, the representatives for the Lijn 4 and PG buses and the ferry boats were asked to spread the message among their colleagues. One day prior to the meetings, a reminder was sent to these representatives.

2 Meeting with PG and Lijn 4 bus license holders, owners and drivers

The meeting with bus owners/drivers on Wednesday July 4, at 15h. Eighteen representatives participated in the meeting for the PG and Lijn 4 buses (Annex 1). The meeting started with another brief explanation of the broader Urban rehabilitation project, and the specific construction activities that would be carried out at the Waterkant. It also was explained that the input of the bus license holders/owners/drivers is very important because they have most knowledge about the situation of the buses, may suggest measures to mitigate potential effects, and will be using the rehabilitated area.

Questions, Comments and Answers

Q: Where will the buses park during construction activities?

A: There are different alternatives, incl. the parking lot of the Casino across the street. There also will be discussion with the contractor to arrange that. The parking lot can be rehabilitated in phases, so that not all buses need to move at once

Comment: the empty land of KASIMEX also may be use. From there the buses can drive immediately from keizerstraat to Watermolenstraat.

A: This option can be discussed with KASIMEX

Comment: it would be most convenient to do construction activities during the long summer holidays (mid-August-September) because during this period the buses have fewer passengers. Also, many bus owners use this time to repair or repaint their bus, so there are fewer buses active.

Q: What will the new parking lot look like? How will it be designed?

A: This will be developed in collaboration with the contractor, the ministry of OWTC and the bus owners/drivers.

Comment: Suggested improvements could be garbage bins, a waiting shelter, street lights (now there is a problem with theft from buses at night), a waiting room for drivers, and toilets. It was advised to not build a barrier or separation line in the area for PG buses, only between OG and Lijn 4 bus areas. The separation should serve as a walkway and should not be too high. It is not necessary to indicate parking areas; the bus drivers themselves can organize that.

Q: Will the trees that provide shadow be removed?

A: In order to execute the construction activities, some trees will need to be cut, but not all. New trees will be planted.

Q: How much space will be gained?

A: From the Ferry landing 2-3 m to the front. It will be most practical to decide about the lay out of the new parking lot.

Comment: The lay-out must be discussed prior to construction so that it will not be forgotten.

Q: Will there be a place for the bus drivers to sit?

A: There is a small budget to construct such things.

Q: Can the EBS power station be replaced, as it obstructs driving space?

A: Moving this structure is not a project priority. Such a request needs to be done with EBS, and it will involve additional expenses.

Q: When will the project start?

A:The proposal will be submitted to the IDB by the end of July, but it is a long process. If everything goes well, construction could start by the second half of 2019.

Q: Can a toilet be built to prevent urinating in public?

A: There are already 2 locations where one can use the restroom: the public restroom and the restroom of Riverside Bar. If people do not want to pay for these places now, they will not pay for a public restroom either. Maintenance is a problem. It will be better to use the existing places.

MH: On the basis of interviews, we estimated that a bus driver earns, on average, about 112 SRD/day, after subtraction of gasoline expenses. Is that about correct?

A: People may not provide honest information about their incomes. Bus drivers earn typically between SRD 100 and 125 /day, so that amount seems about right.

MH: We also calculated that bus owners may earn, on average, about 170 SRD/day/bus, after subtraction of gasoline expenses, is that a realist estimate?

A: Yes that seems about right.

Bus representative: There is one women who sometimes drives the Lijn 4 bus, but she could not make it to the meeting.

Participants are thanked for their time and input.

3 MEETING WITH FERRY BOAT OWNERS AND DRIVERS

The meeting with ferry boat owners/drivers was held Friday July 6, at 10:30. Three boat owners participated in the meeting for the ferry boat owners (Annex 2). In addition, thee other boat owners were consulted more informally on Wednesday July 4 (Annex 2). The boat owners at the formal consultation meeting explained that they were only present with a small group because the others were working, but they would distribute the information among the others. Paper copies of the most relevant slides were provided to them.

The formal meeting started with another brief explanation of the broader Urban Rehabilitation Project, and the specific construction activities that would be carried out at the Waterkant. It also was explained that the input of the ferry boat owners/drivers is very important because they have most knowledge about the situation of the buses, may suggest measures to mitigate potential effects, and will be using the rehabilitated area.

Questions, comments and answers

Comment: The large pontoon boat along Waterkant damagers the ferry boats. The boats grind against this vessel when they steer their boat into the landing space. Especially when all boats are active (34), there is not enough space due to this pontoon boat; only 8 to 9 boots can moor at a time. So they remaining ferry boats have to stay out on the water, waiting for a free spot. This is tiring and costly.

Comment: When the water is choppy, it is difficult to moor the boats at the old jetty. You cannot keep the boat still at that location. The water is very deep, and someone may fall in the water. If we moor at the old jetty, there should be a passenger boardwalk with two railings to hold on to. Another option would be to moot at the jetty behind the Central market, but in that case the number of passengers would decline. [Note: during the informal consultations one boat owner also suggested the jetty behind the Central market as an alternative, but others objected to this option, because there are many large stones there, which may damage the boats at low tide.]

A: Safety of the passengers is of great concern to everyone involved, including the ministry and the IDB. When the time of execution of the activities comes nearer, there will be more discussions with the ferry boat owners to design a temporary mooring location that is safe to the boat drivers and the passengers.

Comment: In the months of April-May-June the water is typically less choppy, so that would be the preferred time of the year to moor at the old jetty. In the dry season, September-October, and particularly January-March, there are often hard winds. The wind conditions should be taken into account.

A: That is a useful observation and will be communicated to the Project Executing partners.

Comment: If the ferry boats are to moor at the old jetty, mooring posts need to be placed so that the boats can be kept on a steady location.

MH: We calculated the boat owners earn about SRD 80/day, after subtraction of gasoline expenses, is that about correct?

Boat owners: That estimate appears too low. Boat owners typically earn a minimum 125-150 SRD/day, after subtraction of gasoline expenses.

4 MEETING FOR THE GENERAL PUBLIC

The general public meeting was held on Friday July 6, from 8:30 to 10:30 in the Waaggebouw at Waterkant. Several organizations that were formally invited, including the National Women's Movement (NVB) did not attend.

Questions and answers

Moredjo (SGES): The Waterkant will be extended with 2-3 m in the river. What will happen with the "Platte Brug", which is part of our cultural heritage?

A (ILACO): The Platte Brug is part of the World Heritage Site; it is built heritage but not a monument; it does have a cultural value. The Project will not demolish or tear down anything, only improve existing structures. The Platte Brug will as much as possible remain the same, it only will be tidied up.

Oemrawsingh (Jeweller): We already participated in different sessions of different organisations. A vision would be developed for the larger area, for example, will it be made a car-free zone, will it become a tourist area… At this moment there is so much nuisance from the exhaust of buses; you have to wash the buildings so often, and it is a public health hazard. This project does not resolve these various problems, it only looks at better drainage. Buses would be placed at this location temporarily, but now it looks like the area will be redesigned to make this a permanent bus stop, so their presence is formalised because it is convenient for the buses. But this creates an unsafe situation and does not resolve the traffic problems.

With regard to the Platte Brug, it must be taken into account that Police boats and speedboats (for leisure) also use this jetty. It must remain accessible for boats that come from the street side.

Furthermore, during pile-driving, the entire building shakes. These are very old buildings. There is a risk that these buildings are damaged. Who will compensate that damage? Also, if the government encounters problems with private parties, they can decide to expropriate. We will strongly protest against such procedures. Private property not only has a material value, but also an emotional value.

Patandin (ILACO): The objective of the present Project was never to completely change the existing situation. This Project focuses on drainage. There was a plan to improve the entire situation with the buses, but that is a Project from the Ministry of OWTC.

Mohan (OWTC): There is a Committee from the Ministry, Department of Transportation, which looks at this issue. We started with the districts. He will inform about the status of this Project for Paramaribo.

Patandin: With regard to building a boulevard, the present walk way will be widened and can then be used for different purposes, incl. tourism. The lay-out of the larger area will be the focus of another Project, also financed by IDB. There is a link between these two projects.

With regard to vibration from piling, the engineering advice is to use another technique, namely press-in installation of sheet piling instead of pile driving. This will cause minimal vibration on buildings and nearby areas. Also, prior to start of the work, the status of all nearby buildings will be assessed, with photographs. Contractors are responsible, and typically have an all risk insurance to deal with such issues.

Moredjo (SGES): If the sluices are managed will, mangrove vegetation will grow by itself. There will be no need to plant mangrove.

Patandin (ILACO): The sluice-gates must be repaired. There is a management system, but that must be improved. Sediment trapping also can be used to stimulate natural regeneration of mangrove vegetation.

Natha (MAS): When the jetty is extended, one must take shipping routes into account.

Patandin (ILACO): No new jetty will be built, end the existing jetty will not be extended. The existing jetty only will be tidied up.

SMS pier representative: Where Cactus is, is our property, including the old jetty. SMS is part of Ministry of OWTC.

Patandin (ILACO: The old jetty only will be renovated and tidied up.

Mr Freeman (in name of Mr. Opzichtig, Broki): I worked for 12 years at Waterkant, I have seen a lot. Many things are not working well. In my opinion, the Ministry of OWTC must monthly operate drain suction vehicles for this area. We wanted to build a dam ourselves but it was too expensive. The present situation is not good for tourists. I have little hope that this Project will actually be executed.

Patandin (ILACO): You must not be discouraged. The area is not public land. But your worries will only be resolved in 1 ½ years from now. The Ministry of OWTC is working hard to realise this Project.

ANNEX 1. PARTICIPANTS IN CONSULTATION MEETING FOR BUS LICENSE HOLDERS, OWNERS AND DRIVERS.

Presentielijst

Onderwerp: Waterkant rehabilitatie

Datum: 4-7.18

PG of Lyn 4

Naam	~~Organisatie~~	Contactgegevens (e-mail/ telefoon nr.)	Handtekening
Awadhpersad	PG	7173391	[illegible]
Asraf C.A	P.G	8574869	Asraf
Ramdhan B	PG	8510939	Ramdanis
Ramdin M.S	PG	8630700	~~[illegible]~~ nejal V
nejal V	PG	8607744	nejal V
Kalimos A.	4	8566056	[illegible]
Ramlagan	PG	8509472	Ramlagan
Kalloe	PG.	8591685	[illegible]
Raadnath M.	4	8522129	[illegible]
Mammoeh	S.	8822633	[illegible]
Repine	PG	8773210	[illegible]
Jagdew Sew	P.G	8271970	[illegible]
Toby Roy	P.G	8583250	[illegible]
Jagdew W. G	P.G	8580355	[illegible]
Sarajbeli G.	P.G.	0878116	[illegible]
Reji	PG	7458098	Rp
G Jagdew	4	8327967	[illegible]
LINO	PG	8161831	THE

ANNEX 2 PARTICIPANTS IN CONSULTATION MEETING FOR FERRY BOAT OWNERS AND DRIVERS.

Informal consultation, 4-7-2018

- Henry Debidienm boat owner
- Jaswat Raghoebar, boat owner
- Badri Radj, boat owner

Formal consultation meeting, 6-7-2018

- Anoed Debidin, boat owner
- Michel Nathoe, boat woner and representative of the Ferry Boats association
- Kewalpersad Sital

ANNEX 3. PARTICIPANTS IN PUBLIC CONSULTATION MEETING FOR GENERAL PUBLIC

vr. 6 juli 2018

ORGANISATION/INDIVIDUALS	REPRESENTATIVE	EMAIL
Maritieme Autoriteit Suriname (MAS)	A. Natha	anatha@mas.sr.
Café Broki	geen reacties	
Café Riverside	P. Freeman	/
Casino Magic Island		
Dhr. Oemrawsingh (Juwelier)	S. Oemrawsingh	sunil1@sr.net.
Dhr. Gangaram Panday (arts)	vertegenwoordigd door S. Oemrawsingh	
Winkel Tjoen	Geen nummer	
Nationale Vrouwenbeweging		
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Kabinet vice President (Coord. Milieu)		
N.V. Cactus		
Stichting de Waag		
Nimos		
Stichting gebouwd erfgoed Suriname	Armand Moredjo (HSE specialist)	amoredjo@hotmail.com
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IDACO	DAHLBERG	8808153

ANNEX 4. INVITATION LETTER FOR PUBLIC CONSULTATION MEETINGS, FROM MINISTRY OF PUBLIC WORKS, COMMUNICATION AND TRANSPORTATION.

2620 H

Aan: (vertegenwoordigers van) organisaties met betrekking tot Waterkant (Plattebrug)

Paramaribo, 28 juni 2018

Betreft: *Finale Consultaties ivm projectvoorstel renovatie Waterkant tussen Knuffelsgracht en Riverside*

Geachte Heer/Mevrouw,

Het Ministerie van Openbare Werken, Transport en Communicatie is, met ondersteuning van de Inter-American Development Bank (IDB), bezig aan de voorbereiding van een projectvoorstel voor renovatie van de waterkant tussen Knuffelsgracht en bar/restaurant Riverside.

Ter afronding van dit projectvoorstel worden er thans finale consultaties gehouden met belanghebbenden, die direct of indirect nabij de voorgestelde projectwerkzaamheden activiteiten ontplooien. Het gaat hierbij in het bijzonder om winkeliers, eigenaars van horeca gelegenheden, bushouders, boothouders bij de Plattebrug/Waterkant en eventuele overige organisaties of gebruikers.

De consultatie zal geschieden door het ingenieursbureau ILACO en het onderzoeksbureau Social Solutions.

Het Ministerie nodigt u hierbij uit voor het bijwonen van de finale consultatie op **vrijdag 6 juli 2018 van 8:30 u tot 11:00 u** in het Waaggebouw (Waterkant 5-7).

Bij voorbaat dank voor uw tijd en inzet.

Namens het Ministerie van Openbare Werken, Transport en Communicatie,

Directeur van het
Directeur Civieltechnische Werken,

Dhr. S. Soman BSc.

Maatregelen Klimaatverandering Adaptatie Studie

Paramaribo, Suriname

ILACO ERM

The world's leading sustainability consultancy

Agenda

8:30 u – 8:45 u:	**Inloop/ Registratie**
8:45 u – 8:50 u:	**Welkom/opening**
8:50- 9:00 u:	**Introductie - Dhr. S. Mohan (MOW, T &C)**
9:00- 10:00 u:	**Resultaten Adaptatie Studie:** **Technisch- Dhr. R. Patandin (ILACO/ERM) en** **Sociale analyse- Dr. Marieke Heemskerk (Social Solutions)**
10:00 – 10: 30u:	**Rondvraag/ discussie**
10:30- 10:45 u:	**Vervolg / afsluiting**

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- Adaptation Fund: financiert projecten en programma's om kwetsbare gebieden weerbaar te maken tegen **klimaatveranderingen**.
- "Het Project": zal bestaan uit een combinatie van maatregelen binnen het historische centrum van Paramaribo, om de stad weerbaar te maken en wateroverlast tegen te gaan.

Project Doel en Probleemstelling

Doel

Projectinformatie en betrokkenen (stakeholders) informeren over gekozen maatregelen om wateroverlast te verminderen in Paramaribo.

Probleemstelling

- Paramaribo is gebouwd op laaggelegen land, dichtbij de Surinamerivier en Atlantische Oceaan. Het functioneren van de bestaande ontwateringswerken en hoogwaterbescherming wordt steeds minder.
- Grote delen van Paramaribo, maar in het bijzonder het centrum, zal in toenemende mate gevoelig zijn voor wateroverlast door:
  - Zeespiegelstijging (en stijging rivier water niveaus),
  - Toename regenintensiteit (dus meer heftige regen in kortere tijd), en
  - Schade en landverlies door toenemende oevererosie

Probleemstelling

Hoogwaterbescherming bij plattebrug, maar toch regelmatig overstromingen door:

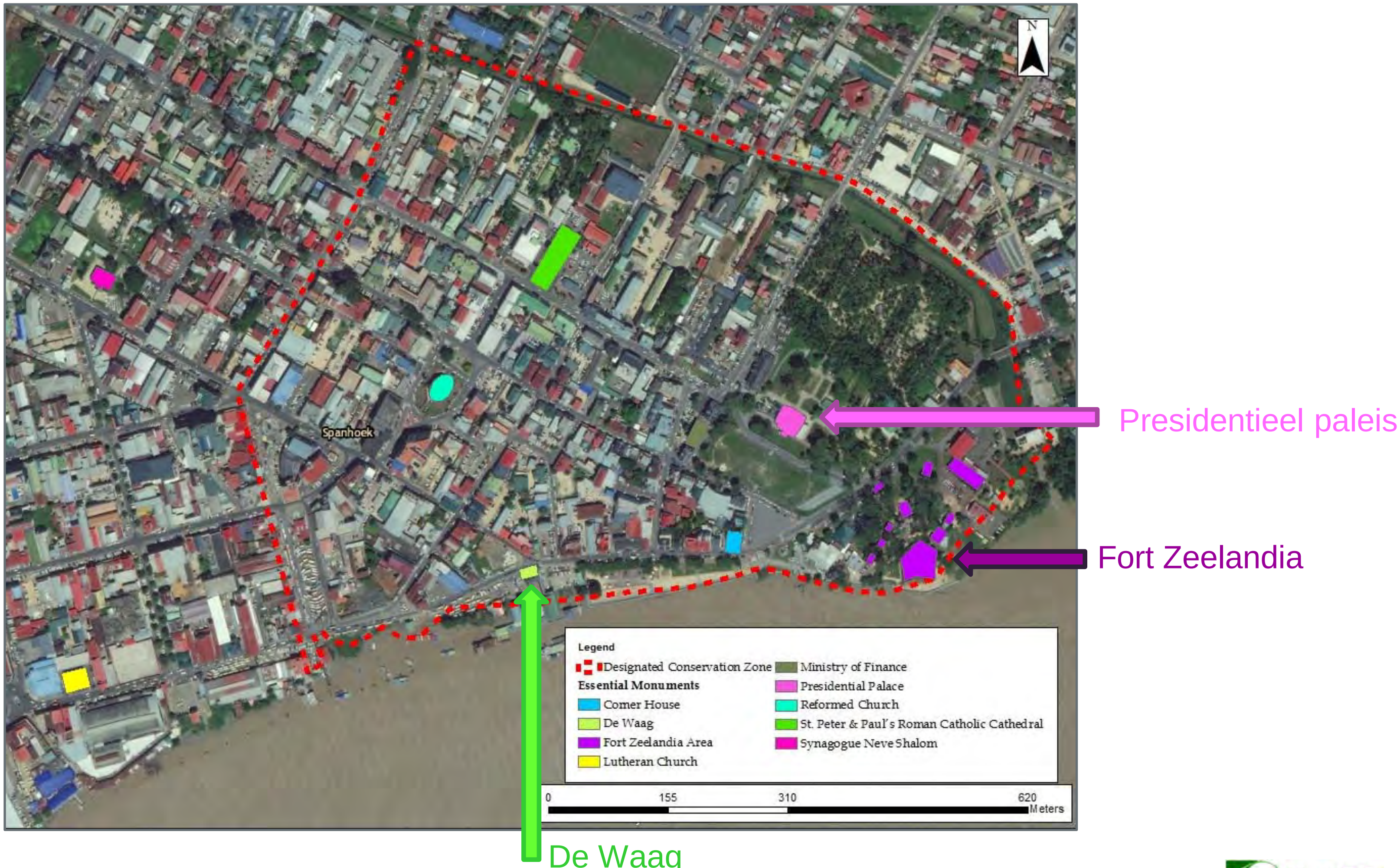
- Hoog Rivier WS
- Regenintensiteit
- Slechte oeverbesch./riolering
- Klimaatvanderingen

Paramaribo Centrum Studie Gebied

ILACO ERM

Paramaribo Centrum Studie Gebied

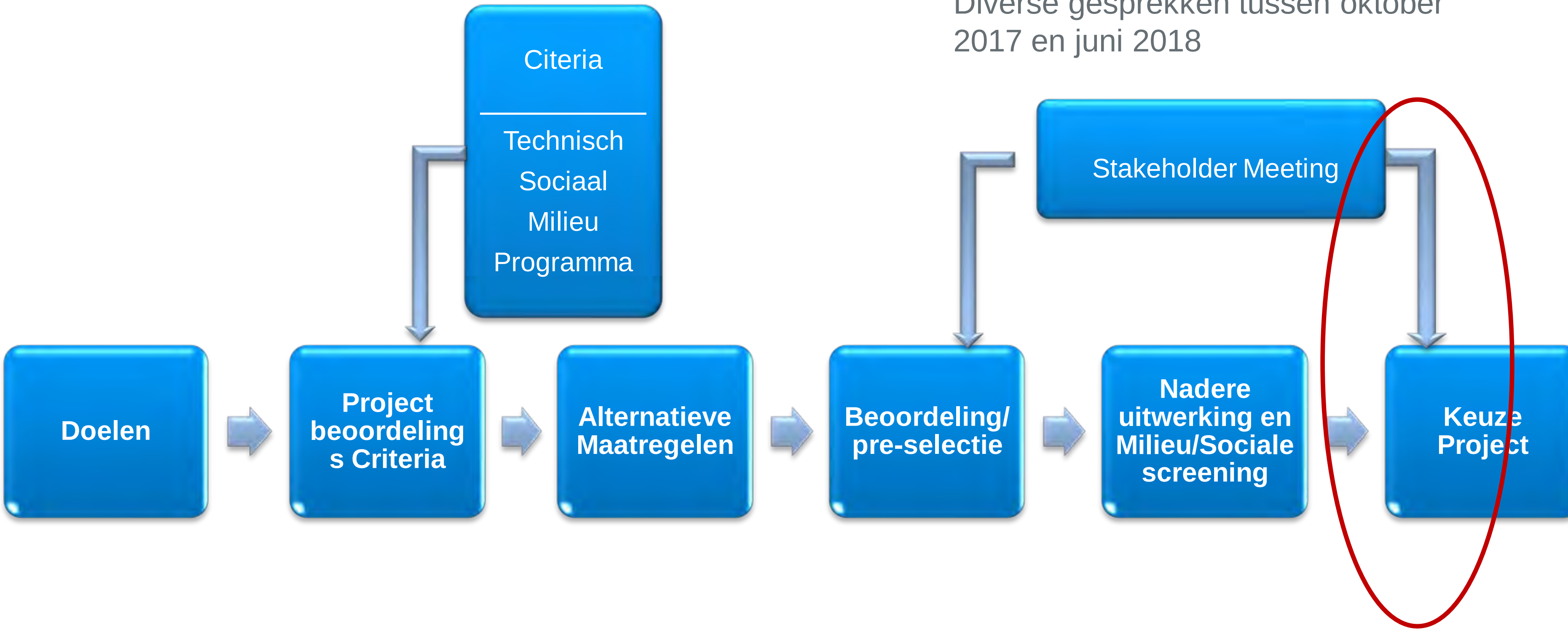
Gebied staat bekend om de historische monumenten UNESCO World Heritage site), toeristische attracties, winkels, en horeca gelegenheden.



Project Proces

Start: augustus 2017

Diverse gesprekken tussen oktober 2017 en juni 2018



Project Proces

Adaptatie Maatregelen Evaluatie Resultaten

- Criteria voor beoordeling (technologie, sociaal, milieu, programma)
- Identificatie van verschillende maatregelen
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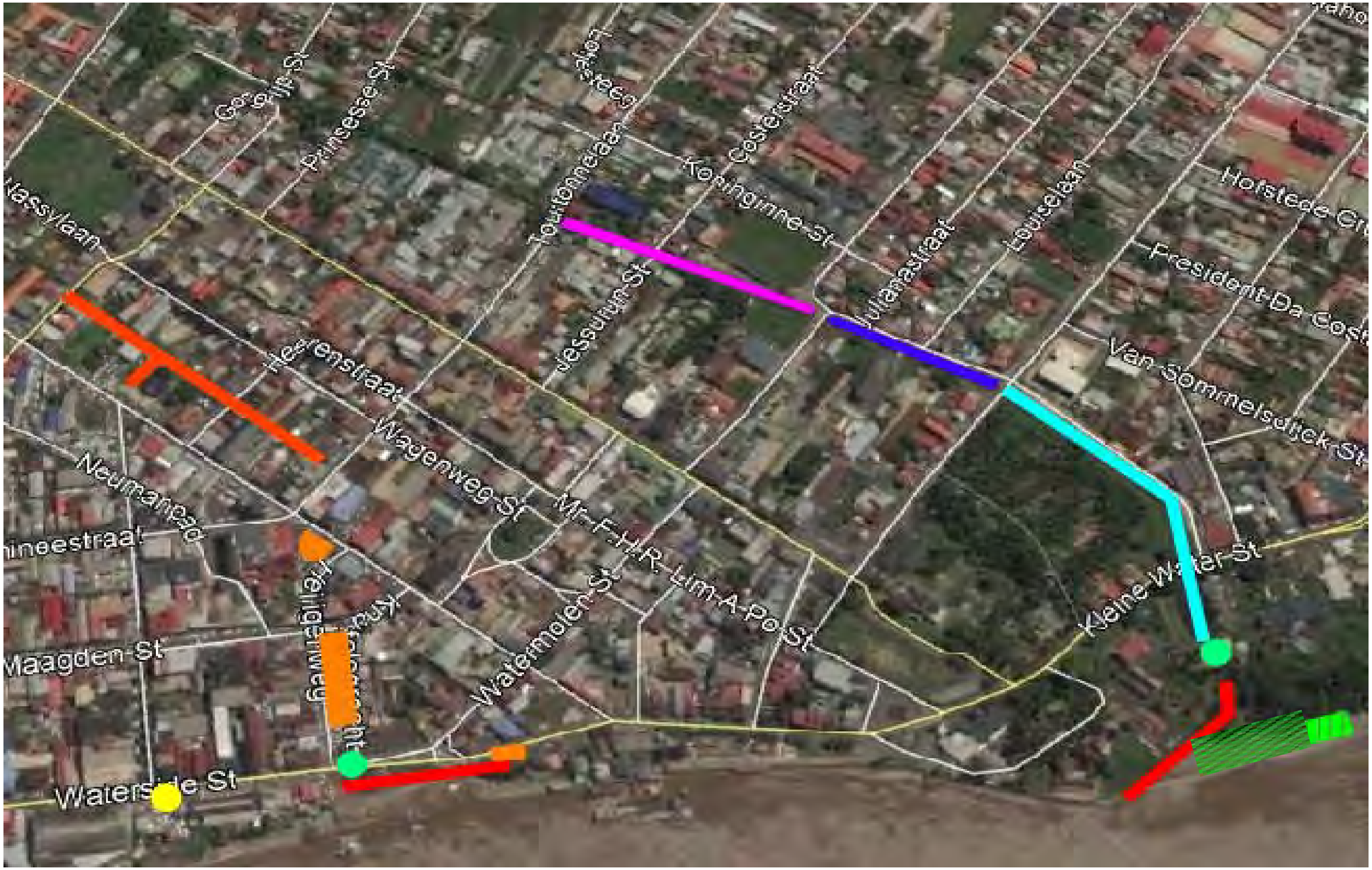
- Selectie van groep aan maatregelen binnen budget

Overzicht voorgestelde maatregelen



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Gekozen Maatregelen- Overzicht

- Gekozen maatregelen:
- 1: Adaptatie Raamwerk/Plan voor Paramaribo
- 2: Hoogwaterbescherming Waterkant (Knuffelsgracht- Riverside)
- 3: Herstel PS Van Sommelsdijckse kreek
- 4: Versterken/verbeteren Mangrove gebied
- 5: Onderhoudsplan riolering Paramaribo en uitvoering WHS
- 6: Overig (capaciteitsversterking OWT&C, e.a.)

Gekozen groep fysieke maatregelen

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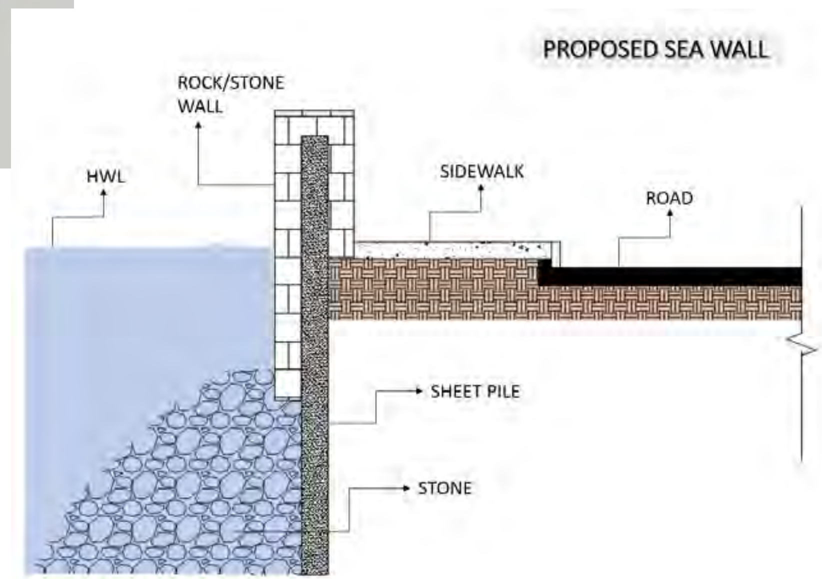
Maatregelen (2)- nw kade Waterkant/ Knuffelsgracht

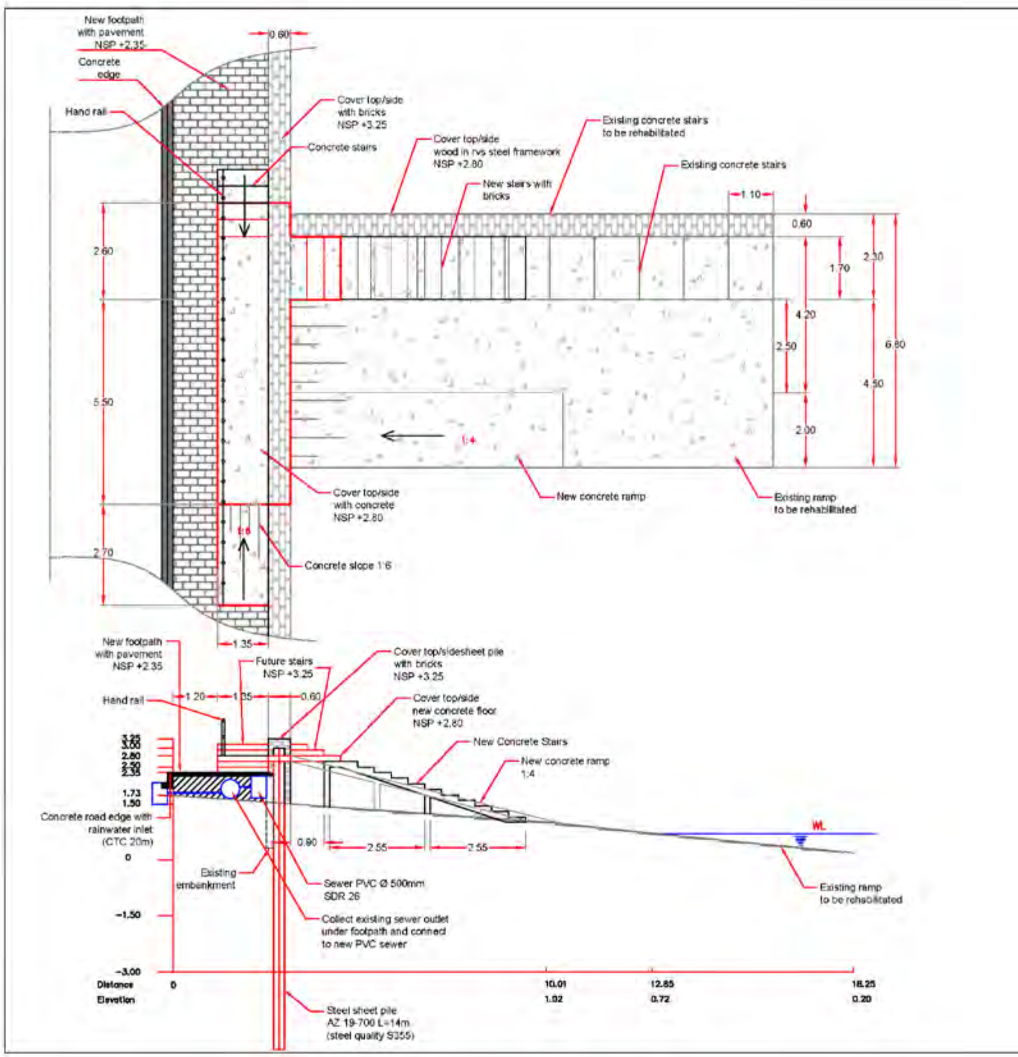
Voorstel: herstel oude veersteiger voor tijdelijke verplaatsing boothouders

Maatregelen (2)- nw kade Waterkant/ Knuffelsgracht

Herstel kade en voetpad Knuffelsgracht-Riverside



Maatregelen (2)- nw kade Waterkant / Knuffelsgracht



- 1) Herstel landing boten/platte brug

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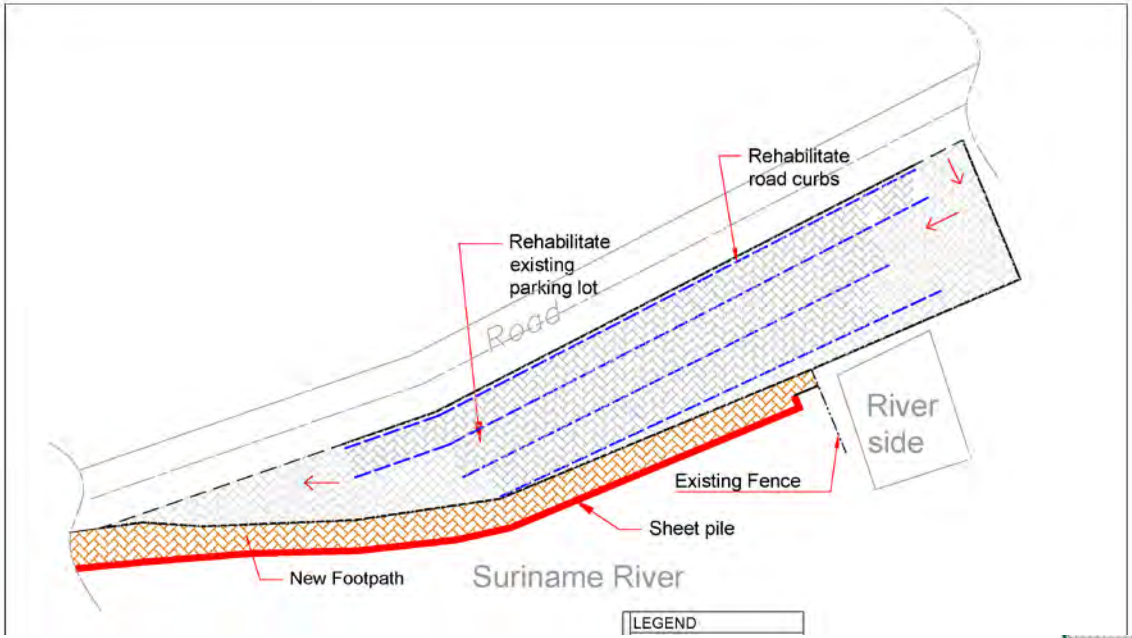
Maatregelen (2)- nw kade Waterkant / Knuffelsgracht

- 1) Herstel parkeerplaats bussen bij Riverside
- 2) Nieuwe riolering onder voetpad nieuwe kade - Knuffelsgracht



Sociale groepen die beïnvloed worden

In het gebied van de Waterkant zullen de volgende groepen mensen tijdelijk last hebben van de constructiewerkzaam-heden:

- 38 veerboten op de route Meerzorg Paramaribo;
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Social Solutions

ERM

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Demografische gegevens (115 mensen)

Gender	Leeftijd	Scholing	Etnische groep
98.3% man 1.7% vrouw	Gem. 45 (22-73)	Geen scholing: 15.7% Lagere school: 39.3% LBO: 19.6% MULO: 18.6% VOS of hoger: 6.9%	Hindustaan: 67% Javaan: 14.8% Creool: 10.4% Anders: 7.8%

Gemiddeld daginkomen, na aftrek benzinekosten

	Bussen (N=67)	Veerboten (N=30)	Inf. taxi's (N=8)
Vergunningshouders/ eigenaren	SRD 170	SRD 80	SRD 79
Alleen chauffeurs	SRD 112	SRD 67	NVT

Mogelijke effecten en mitigerende maatregelen

- Mogelijke effecten tijdens uitvoering en oplossingen:
  - Constructie en extra verkeer geluid – beperk constructie tijden tot overdag, bepaalde materieel niet toestaan, monitoren geluidniveau, etc.,
  - Stof – besproeien met water om stof te verminderen, gebruik plastic sheets, etc.,
  - Tijdelijk verkeershinder – gebruik borden, verkeersomleiding ism Politie, verkeersregelaars, bouwmethode aanpassen
  - Tijdelijk verplaatsen van landingsplaats voor boothouders – rehabilitatie van de oude veersteiger en opruimen/fatsoeneren van het terrein bij de steiger
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  - Zorg voor goede communicatie tijdens uitvoering

Mogelijke effecten en mitigerende maatregelen

Tijdelijke verplaatsing van de bussen

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Mogelijke effecten en mitigerende maatregelen

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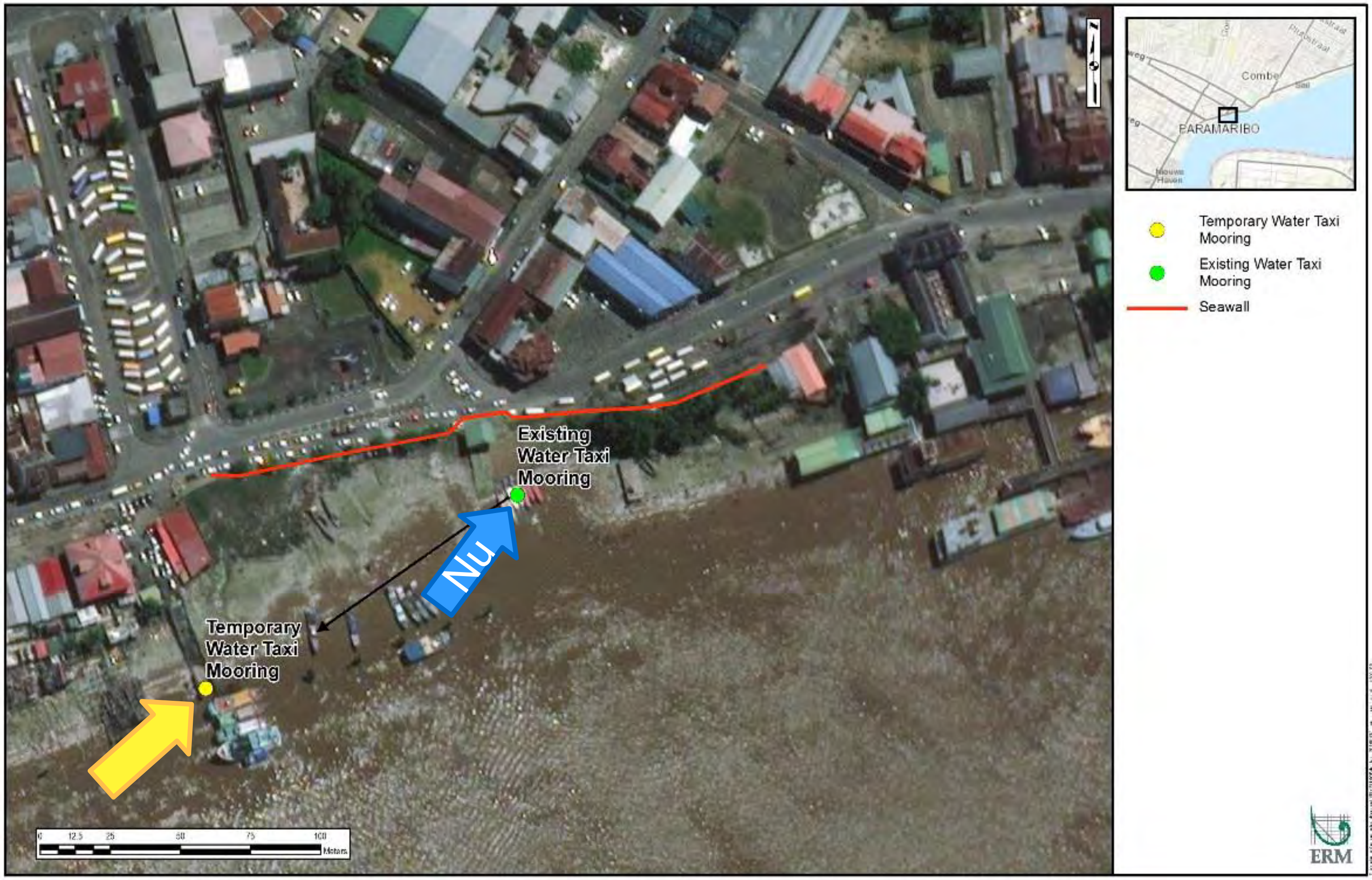

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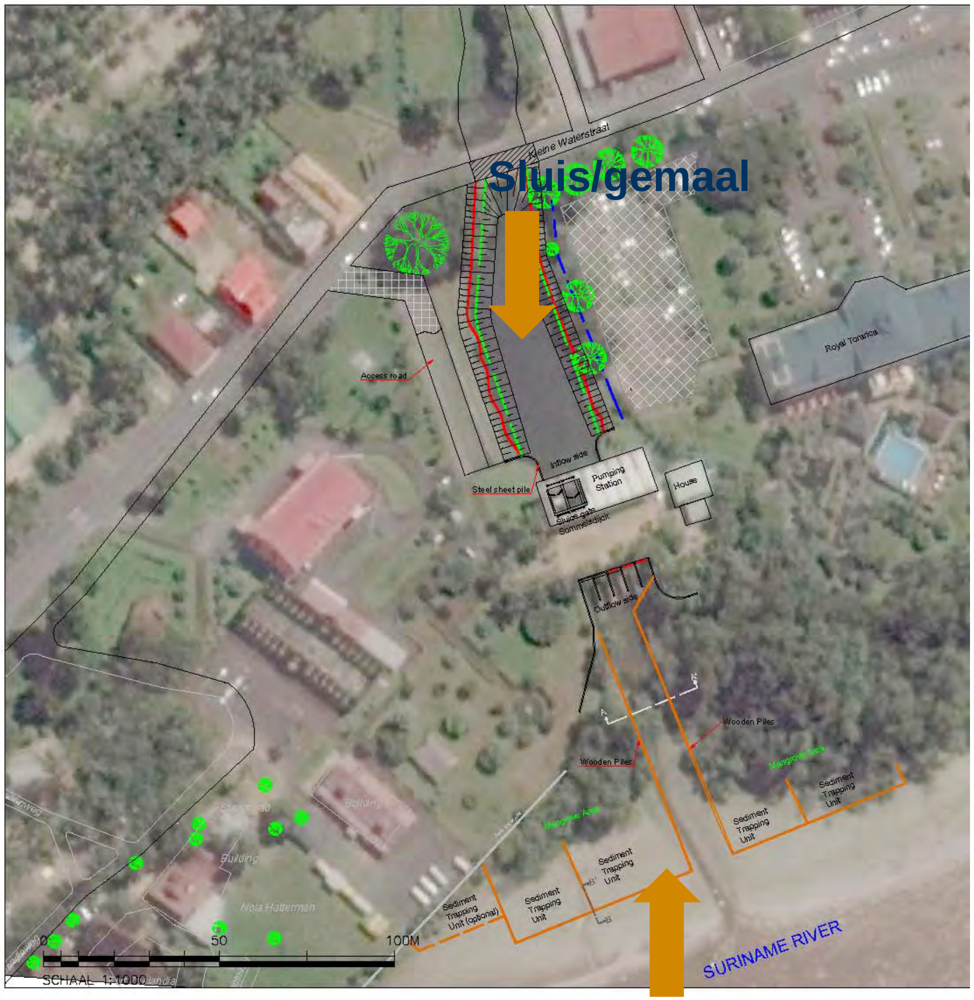
Maatregelen (3)- Herstel Pompstation V Sommelsdijck

- Herstel Pompstation en Sluis Sommelsdijckse kreek
- Uitdiepen basin

Maatregelen (4)- Versterken Mangrove zone



Versterken mangrove zone

Overige Maatregelen (5)- Onderhoud riolering

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Rondvraag

Vragen, opmerkingen?

Vervolgtraject

- 1: Eindrapport: juli 2018
- 2: Aanvraag financiering Adaptation Fonds (indienen, beoordelen, evt aanpassingen en goedkeuring): augustus- december 2018
- 3: Na goedkeuring: opstarten project begin 2019 (duur totaal project ca. 4 a 5 jr)
- 4: Voorbereiding en start uitvoering maatregelen: in 2019/2020

Notes on passengers of ferry boats and buses

1 Ferry Boats

Data were gathered in the morning, rush hour (6-9 am) of 3 July 2018

In the early morning, between 6-7, the ferry boats from Commewijne to Paramaribo fill (23 persons) and leave every 3 minutes. Between 7am and 8am, it takes about 5-7 minutes to fill the boat and leave. Between 8am and 9am, the time between the first passenger entering and the boat leaving becomes 15 to 20 minutes.

The time it takes for the ferry boats to cross the river varies, depending on the tide and power of the motor. With a 40 PK outboard motor, it takes typically about 5 minutes to cross, and with a 15 PK about 8 minutes.

The boat drivers commented that persons taking the ferry boats across are persons working across the river, students, and persons shopping for groceries or consumer items. They are not of one specific socioeconomic status. Judging from their uniforms, passengers included bank workers, policemen, military staff, all kinds of public workers, staff from the national telephone company, and so forth. They can be of lower, middle or higher income level strata; if they want to get across fast they take the boat.

Boat drivers estimated that approx.. 70% of their passengers are work commuters, and 10-20 % may be school children and students attending school[1] (elementary, middle or high school) or University across the river (often because a parent or both parents work in Paramaribo). People who take the ferry are all kinds of persons, not necessarily the poorest people. It is for many person just their regular commute to work; many of them work in (government) offices in Paramaribo.

On the morning of observation, the following numbers of male and female passengers were counted;

- Women: 983 (61.1%)
- Men: 627 (38.9%)

On the morning of the observations, only one person with a disability (walking with crutches) took the ferry boat. The ferry boat drivers commented that persons with disabilities typically take the regular public bus of the National Transportation Company (NVB), which costs only SRD 0.85- and runs from the community of Meerzorg (Commwijne district) to the centre of Paramaribo (Heiligenweg). RThe reason to take this bus is that at the end station (Heiligenweg), there are many other buses to all parts of the city, but when they take the ferry boat they will have to walk some distance to take another bus.

[1] Most school children and students use the special school buses

2 BUSES

Data were gathered in the morning, rush hour (6-9 am) of 4 July 2018

Bus drivers reported that most of their passengers are working people (commuters) and students. No persons with disabilities were observed, and it was reported that these persons seldom take the Waterkant buses. Persons taking the buses are mostly persons of the lower and middle income groups, and students.

2.1 PG BUSES

In the early morning, between 6-7, the PG buses at Waterkant fill and leave within 5 minutes. Between 7am and 9am, it takes about 5-10 minutes to fill the bus and leave. Bus drivers reported that when the middle and high schools function optimally, their turn-over is faster (the PG bus route passes along a couple of elementary, middle and high schools). However, with the school holidays approaching, students make repetition rounds and do not attend school daily.

On the morning of observation, the following numbers of male and female passengers were counted for the PG buses;

- Women: 890 (65.7%)
- Men: 465 (34.3%)

2.2 LIJN 4 BUSES

Data were gathered in the morning, rush hour (6-9 am) of 4 July 2018

In the early morning, between 6-7, the Lijn 4 buses at Waterkant fill and leave within 7 minutes. Between 7am and 8am it takes them about 10 minutes to fill up, and between 8am and 9am, it takes about 15 minutes to fill the boat and leave.

On the morning of observation, the following numbers of male and female passengers were counted for the Lijn 4 buses;

- Women: 375 (60%)
- Men: 250 (40%)

	ORGANISATION/INDIVIDUALS	REPRESENTATIVE
1	Standhouders Waterkant (Belangen Organisatie Waterkant)	Marjon Emanualson
2	Beheersraad Waterkant	Mw. Kastile Pinas (Coor.)
3	Crafters Waterkant	Noriene Bolman-Baank
4	Surinaamse Scheepsvaart Maatschappij (SMS)	Dhr. Ashok Rambali (Wrnd dir)
	Surinaamse Scheepsvaart Maatschappij (afd. PFC)	Dhr. Main
5	Stichting Waaggebouw	Dhr. Azaad
6	Uitbater Waaggebouw	Dhr. Azaad
7	Broki	Dhr. Doorson
8	River Side Café	Dhr. Omzigten
9	Boothouders Waterkant	Dhr. Michael Nathoe
10	NV Cactus	
11	Representative PLO (PG/LIJN4)	VIA O.W.
12	Pasha Group Casino (Magic Island Casino)	
13	Stichting Gebouwd Erfgoed Suriname (SGES)	Dhr. S. Fokke (Dhr. Patandin)
14	Nederlandse Ambassade Suriname	Dhr. Patandin
15	Sunil Oemrawsingh	
16	Maritieme Autoriteit Suriname (MAS)	Bernice Mahabier
17	Centrale Bank van Suriname (CBvS)	
18	Management Hotel La Petit Maison	
19	SURALCO (HOEKHUIS)	
20	Directie AHKCO	
21	David Findlay (De West)	
22	Management VSH Appastementen	
23	Rudisa Vastgoed	
24	Ministerie van Sociale Zaken	
25	Rekenkamer van Suriname	
26	Jenny Tours	Mona Lisa
7	Bonnie Tours	Silvie
	GOVERNMENT	
21	Kabinet President (afd. Coordinatie Milieu)	Dhr. Patandin
22	Kabinet President (afd. Bestuurs- en Admin. Aangelegenheden)	Eugene van der San (Dir.)
23	Ministerie van Onderwijs, Wetenschap & Cultuur (Directoraat Cultuur)	Mrs. Elvira Sandie
24	Stichting Surinaams Museum	
25	Nola Hatterman Art Academy	
26	Staatsraad	
27	Ministerie van Ruimtelijke Ordening, grond- en bosbeheer	
28	Kabinet vice President	
29	Stichting Planbureau Suriname	
30	Ministerie van Justitie en Politie (afd. Voorlichting)	
30	Ministerie van Justitie en Politie	
31	Stadspoltiecommandant Buro Centrum	Dhr. Jethoe
32	Buurtmanager Paramaribo- Centrum	onderinspecteur Colli
33	Commandent Brandweer Knuffelsgracht	Dhr. Aramake
34	Ministerie Regionale Ontwikkeling	
35	EBS	
36	SWM	
37	TELESUR	mw. Blufpand (secr.dir)
38	Districtsraad Paramaribo	Mw. Dorette Prika
39	District- Commissaris Paramaribo Noord-Oost	
40	Verkeerspolitie	
41	Ministerie Handel, Industrie en Toerisme	
42	Ministerie van Financien	Iris Sandel
42	Ministerie van Financien	Sagita Jaggan
43	Voorzitter Parlement	
44	Nationale UNESCO Commissie Suriname	
45	Stadsherstel N.V.	
	TOURISM SECTOR	
	Stichting Toerisme Suriname	
	SHATA (Suriname Hospitality and Tourism Association)	
	IDB	
	Stephany van Doorn	Dhr. Patandin
	OTHERS	
	Pers	via OW
	Vereniging Surinaams Bedrijfsleven (VSB)	
	NIMOS	
	ADEK	
	IGSR	

Maatregelen Klimaatverandering Adaptatie Studie

Paramaribo, Suriname

ILACO ERM

The world's leading sustainability consultancy

Agenda

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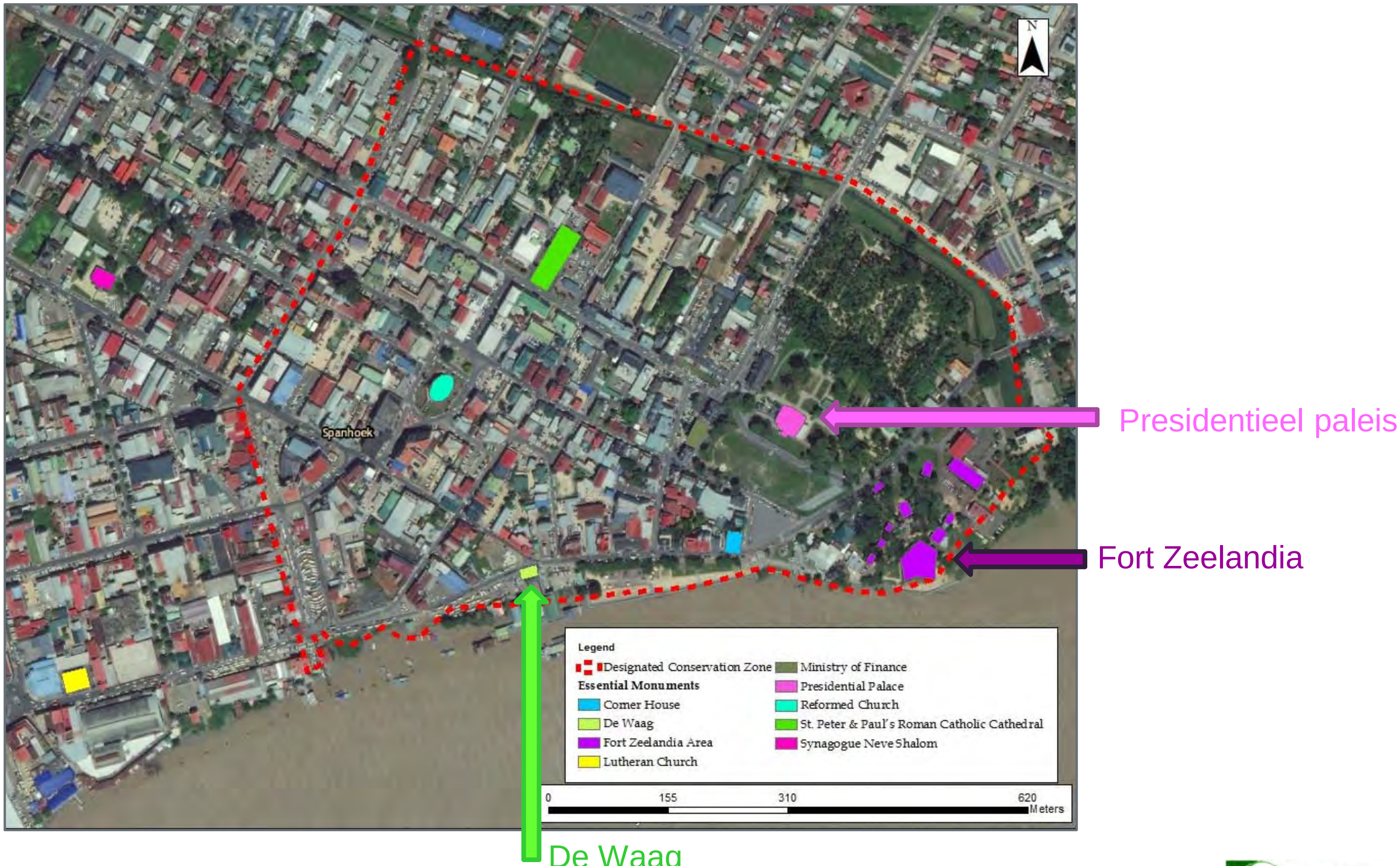

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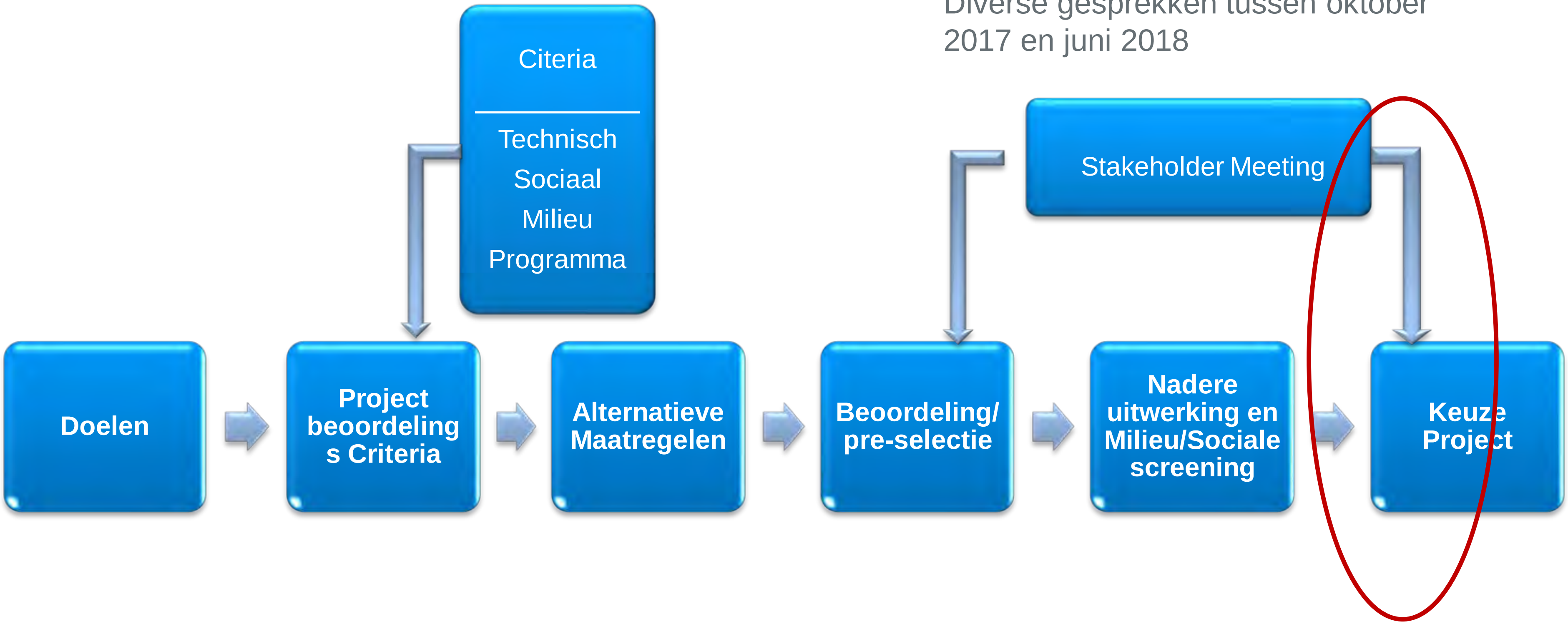

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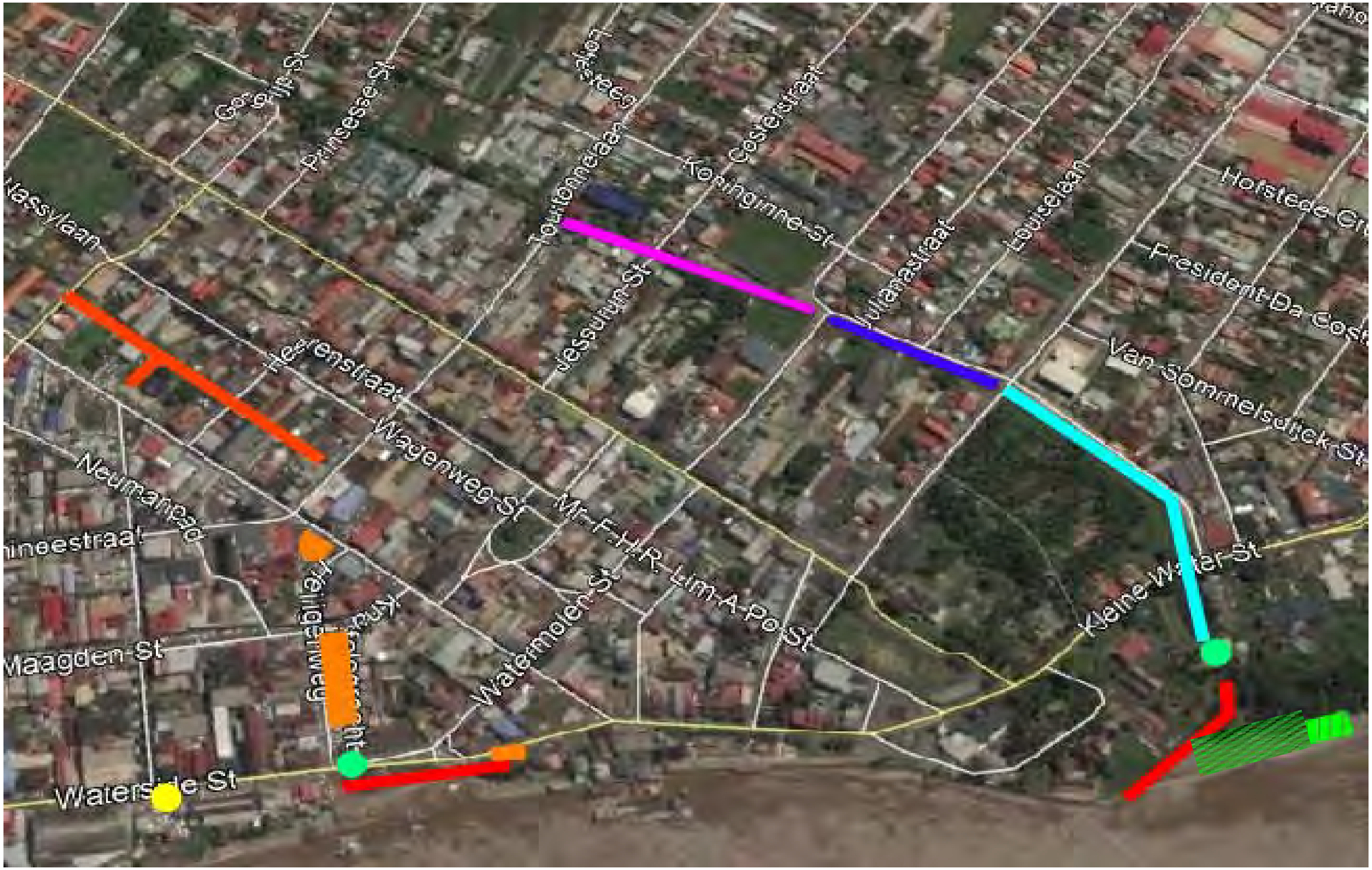

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The world's leading sustainability consultancy

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Maatregelen (2)- nw kade Waterkant/ Knuffelsgracht

Voorstel: herstel oude veersteiger voor tijdelijke verplaatsing boothouders

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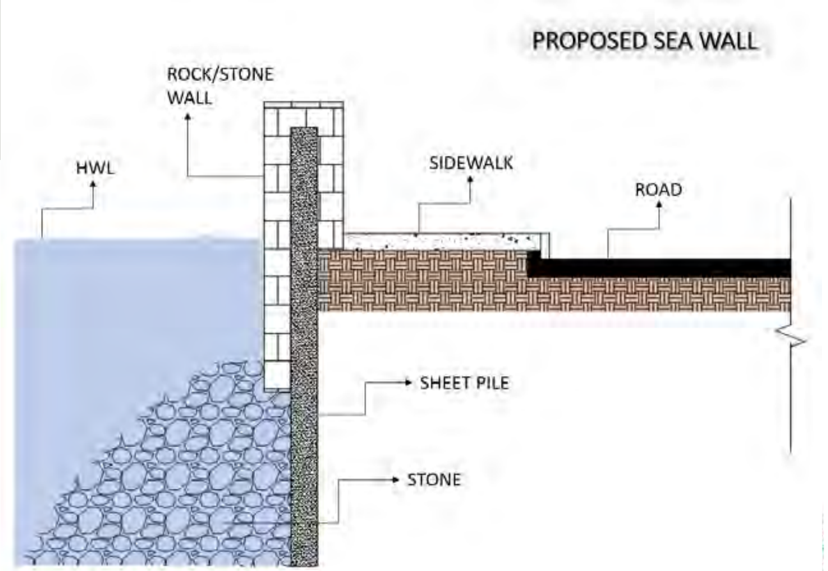
Herstel kade en voetpad Knuffelsgracht-Riverside



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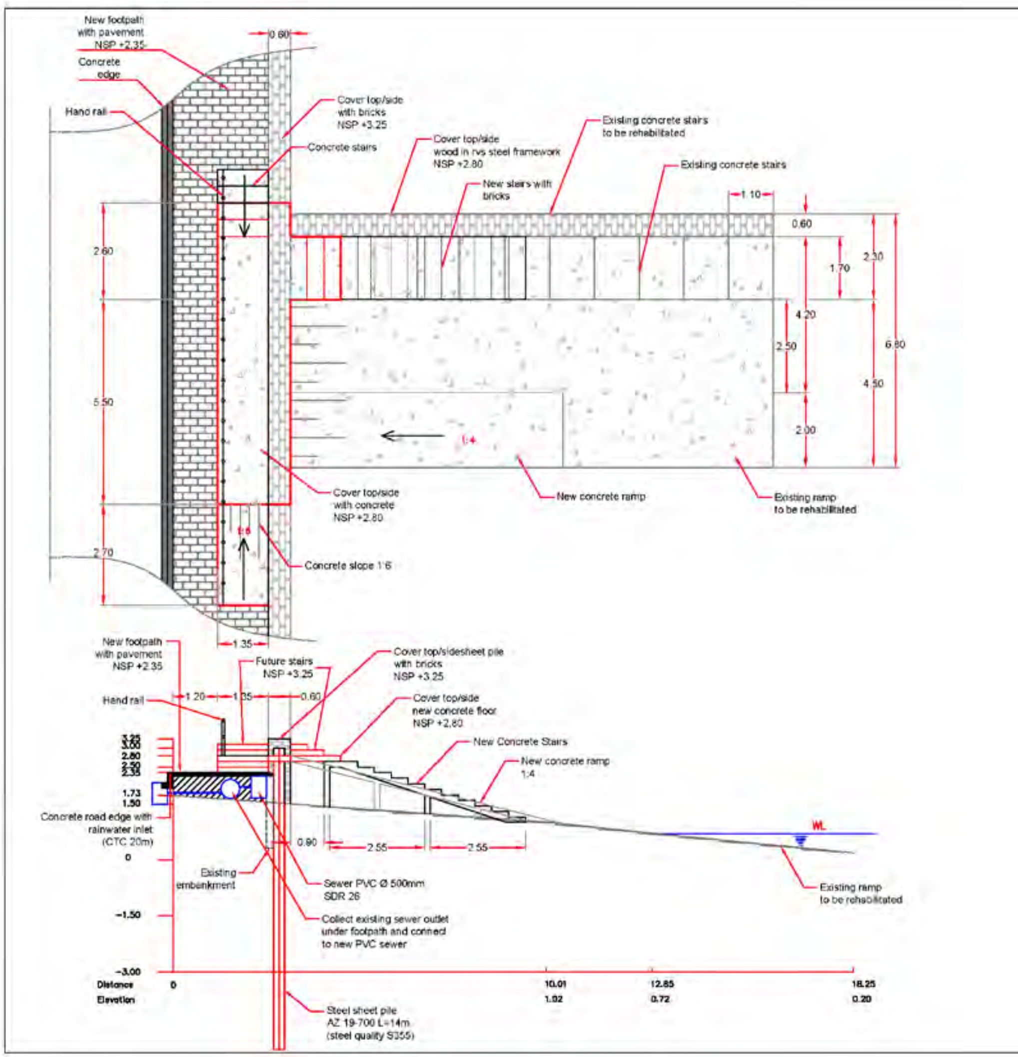

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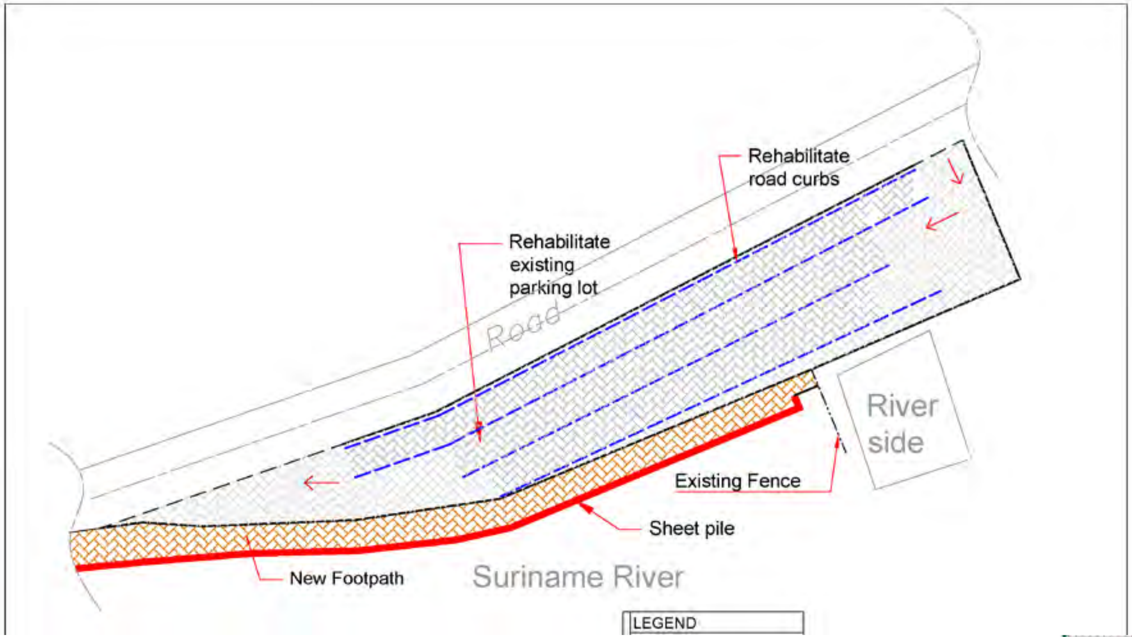

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  - Zorg voor goede communicatie tijdens uitvoering

Mogelijke effecten en mitigerende maatregelen

Tijdelijke verplaatsing van de bussen

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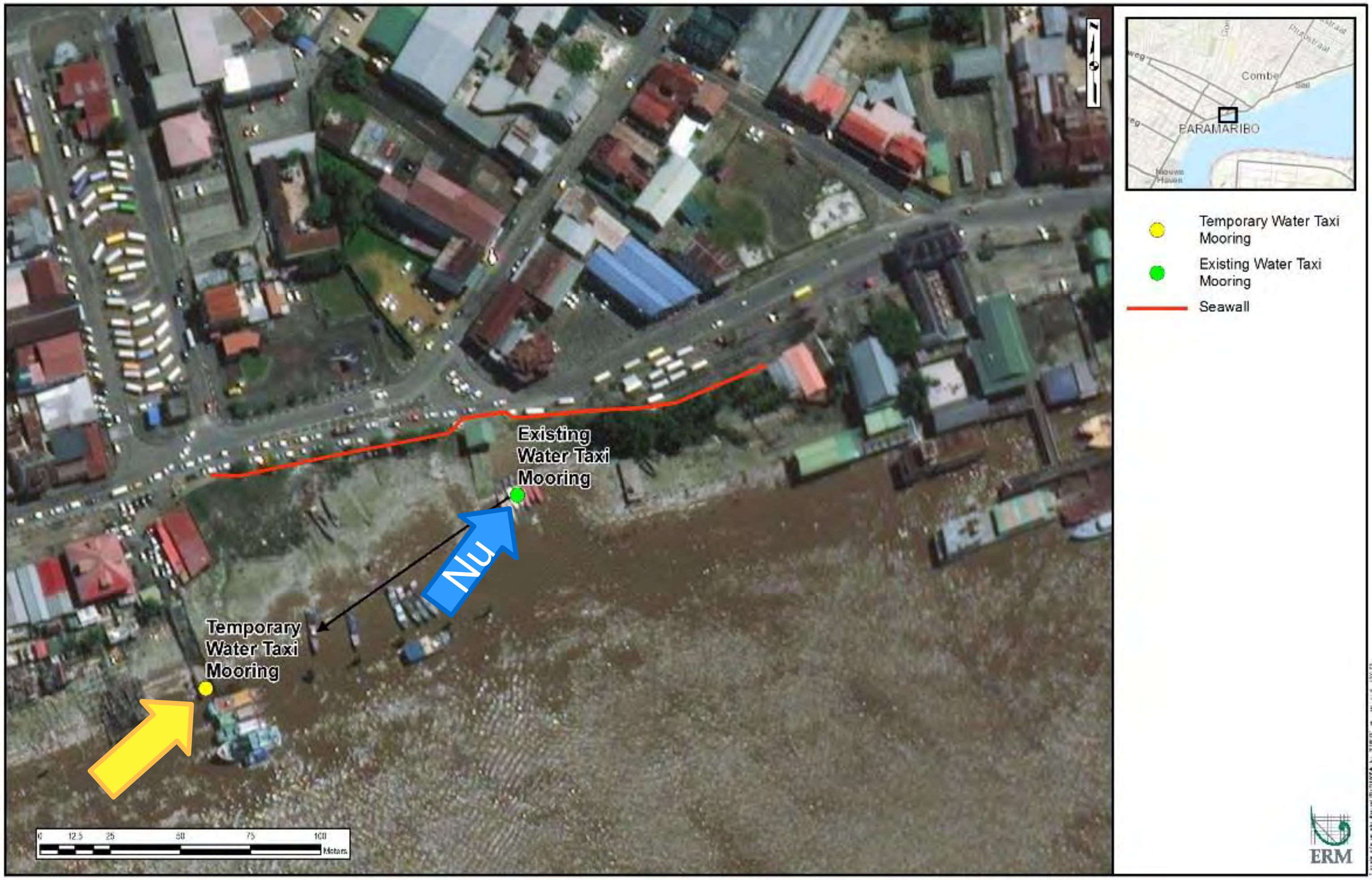
Mogelijke effecten en mitigerende maatregelen

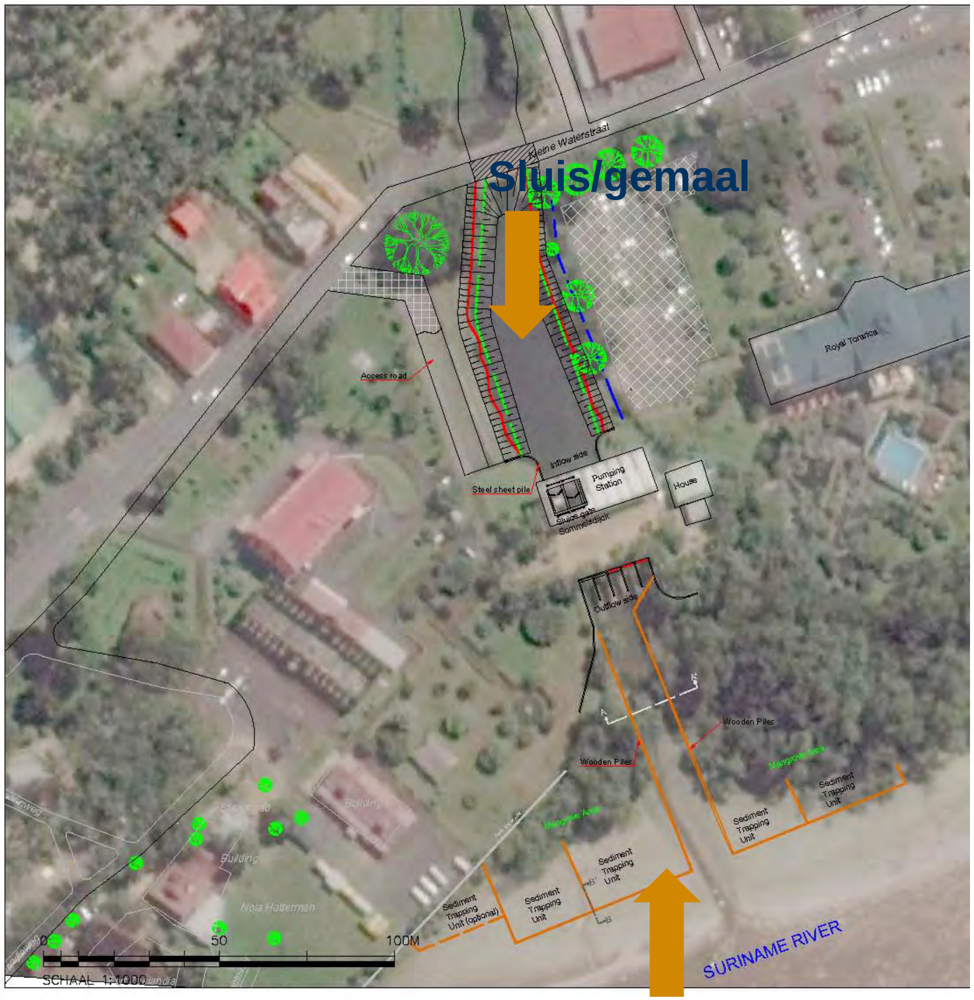
Tijdelijke verplaatsing van de boten



Maatregelen (3)- Herstel Pompstation V Sommelsdijck

- Herstel Pompstation en Sluis Sommelsdijckse kreek
- Uitdiepen basin

Maatregelen (4)- Versterken Mangrove zone



Versterken mangrove zone

ILACO ERM

Overige Maatregelen (5)- Onderhoud riolering

Rondvraag

Vragen, opmerkingen?

Vervolgtraject

- 1: Eindrapport: juli 2018
- 2: Aanvraag financiering Adaptation Fonds (indienen, beoordelen, evt aanpassingen en goedkeuring): augustus- december 2018
- 3: Na goedkeuring: opstarten project begin 2019 (duur totaal project ca. 4 a 5 jr)
- 4: Voorbereiding en start uitvoering maatregelen: in 2019/2020

APPENDIX C:

Construction Environmental Management Plan

This Construction Environmental Management Plan provides a working template that will be used by the selected construction contractor (the Contractor) appointed by the Project Proponent (the Government of Suriname and the IDB). It details the specific mitigation requirements and focus areas idenitified through the Environmental and Social Impact Assessment, but also recognizes that the selected Contractor will have their own policies and procedures that will need to be inputted to this plan. It also recognizes that as the Contractor develops the Project designs, this may influence how construction will be undertaken and progress, and these aspects will need to be integrated into this plan. Text in red are sections of the CEMP which the Contractor needs to complete.

1. Introduction

1.1. Overview

This document is the Construction Environmental Management Plan (CEMP) for the Adaptation Fund for Urban Investments for the Resilience Program (the "Project"), a Category B Project, that focuses on the Paramaribo waterfront area and comprises three components:

- Construction of a new flood protection wall;
- Sommelsdijck Canal pump station and sluice gates rehabilitation; and
- Enhancement of mangroves.

The CEMP sets out the expectations of the Project Proponent (i.e., the Government of Suriname, GoS, and its partner, the Inter-American Development Bank, IDB) and defines how the Contractor will implement and manage environmental matters.

1.2. Objectives

The CEMP will ensure that the Project is delivered in full compliance with legal requirements, and also address the requirements of the IDB policies. Specifically, it will ensure the Project aligns with:

- Emerging environmental legislation (if in place at the time of construction) being developed by the National Institute for Environment and Development in Suriname (NIMOS); and
- Guidance Note NIMOS Environmental Assessment Process (2017), effective January 2018.

The IDB has established its own policies and safeguards to ensure that projects financed by the IDB group are sustainable. These include the following environmental policies:

- OP-703 – Environmental and Safeguards Compliance Policy; and
- OP-704 – Natural and Unexpected Disasters Policy.

2. *Project Description*

This section needs to include specific details on the proposed works, duration relevant plans etc. The following provide guidance on what is needed.

- **Scope of Construction Works:** Description of the full range of construction works / activities proposed (e.g. clearing of land, placement of piles, filter rock, geotextile fabric and armour rock; installation of piles; etc.).
- **Description of the Construction (Disturbance) Footprint:** Full description of the existing land / marine areas that will be disturbed by the construction works and those immediately adjacent;
- **Timing of Works:** Provide a description of both the total duration of the works and the time of year they will occur. The latter would include consideration of expected climate during this time (e.g. anticipated rainfall / cyclone events, wind direction and speeds);
- **Site Plan:** The project site plan would clearly show the full extent of the proposed works area of the construction project. This would typically include a map with the full construction boundary and disturbance footprint marked clearly over a current aerial photograph (i.e. including all construction activities, associated laydown areas etc.). It would also include site specific information, for example the location of any important waterways or adjacent vegetation to be protected, national heritage listed areas, or the location of sediment and erosion traps, electrical services etc.

3. *Project Roles, Responsibilities And Contacts*

All positions across the project have environmental responsibilities to some extent. These vary in relation to duties described in Table 1, but everyone has a base level duty of care to prevent environmental harm.

Table 1: Project Roles, Responsibilities and Contact Details

POSITION	RESPONSIBILITIES	LINE MANAGER	NAME	CONTACT DETAILS*
Project Manager				
Site Supervisor				
Environment Manager				
HSE Representative				

4. *Training, Awareness and Competency*

Outline how environmental training, awareness and competency will be delivered / assessed throughout the project, to ensure the relevant aspects of this CEMP are communicated to the project team and front line staff (including contractors and sub-contractors). Examples may include:

- Site Environment Induction
- Daily Pre-Start Meetings
- Environmental Toolbox Talks
- Incident bulletins
- Sub-contractors kick-off meeting
- Contractor and client site kick-off meeting

5. *Environment Management*

This section presents a summary of the environmental risks and controls that have been identified for the proposed construction project. The Contractor should determine what additional risks and proposed management controls are required based on their final design and work method statements. A project risk assessment or job hazard analysis for specific task(s) should be performed.

The following tables are based on the ESIA that has been performed. Note that this is not an exhaustive list, and it would be expected that Contractor develop risk management strategies, controls etc. that suit the scale/nature of finalized construction project.

Air Quality and Dust Management

AIR QUALITY AND DUST MANAGEMENT			
Objective(s)	1. To ensure the impacts of air quality and dust on adjacent areas and the community are minimised.		
Management Strategy	Air quality and dust issues managed principally by emission controls at source, and administrative controls during works.		
		Responsibility	**Timing**
Control(s)	The air quality impacts could be minimized using the following measures: • Maintain all construction equipment in accordance with manufacturer's specifications. • Avoid burning non-vegetative wastes (refuse, etc.) at construction sites. • Avoid unnecessary idling of construction equipment or delivery trucks when not in use. Dust impacts could be minimized using the following measures: • Area to be disturbed minimised. Clearance lots to be approved by Project Manager. • Where dust is identified as an issue, dust control measures will be implemented. These will primarily be the use of water carts, but may include surface treatments. • Vehicle movements controlled (Traffic Management Plan) and kept to established tracks and haul roads. • Dust awareness issues in environmental induction process		
Performance Indicator(s)	No complaints from adjacent commercial premises and/or community.		
Monitoring	Daily inspection of works sites to occur, including: • visual check for dust crossing the site boundaries • visual check of high potential dust areas, such as haul roads, stockpiles and operational areas.		
Reporting	Any complaints or incidents to be reported to PPA project manager.		
Corrective Action(s)	Investigate cause of excessive dust Implement controls immediately (e.g. water carts) Implement corrective measures prior to the recommencement of site works Implement administrative controls if required, such as rescheduling of dust generating activities to more favourable weather conditions.		

Noise Management

NOISE MANAGEMENT			
Objective(s)	1. To minimise the impacts of noise on the amenity of the surrounding areas. 2. Construction activities undertaken in accordance with best practice controls.		
Management Strategy	Noise to be managed primarily through administrative and equipment controls during the construction phase.		
		Responsibility	**Timing**
Control(s)	The noise impacts associated with the Project components could be minimized using the following measures: • Maintain all construction equipment in accordance with manufacturer's specifications. • Schedule construction and rehabilitation work during daylight hours when increased noise levels are more tolerable. • Schedule construction and rehabilitation work to minimize activity during peak periods of tourism and recreation (weekends, holidays, etc.). • Develop and implement a Construction Communications Plan to inform adjacent receptors (e.g., commercial businesses, churches, and tourists) of construction activities. • Use vibratory piling instead of impact piling during shore-based construction activities to avoid generating impulsive noise. • Pre-start checks and maintenance schedules to ensure equipment performance is as required. • Noise-dampening equipment to be used on equipment with excessive noise generating characteristics.		
Performance Indicator(s)	No complaints from adjacent commercial premises and/or community.		
Monitoring	Daily inspection of works sites to occur Service logs for equipment/machinery used on site		
Reporting	Any complaints or incidents to be reported to PPA project manager.		
Corrective Action(s)	Investigate cause of excessive noise Implement corrective measures prior to the recommencement of site works Reschedule of noise-generating activities to reduce noise annoyance		

Sediment and Erosion Control

SEDIMENT AND EROSION CONTROL			
Objective(s)	1. To ensure that the effects of erosion and sedimentation on the environment are minimised. 2. Minimise soil disturbance, degradation and erosion.		
Management Strategy	Ensure that direct impacts (land disturbance) are limited to the works area, and that secondary impacts do not impact adjacent areas.		
		Responsibility (Role)	**Timing**
Control(s)	Measures to be applied include: • Disturbance area will be minimised and clearly demarcated. • Works will only be conducted within the works zone. • Vehicle movements will be restricted to the defined roads/tracks. • Where possible, works area will be designed to ensure stormwater runoff drains into the site. • Where runoff from the site is required, it will be via the longest flow path possible to ensure maximise sediment retention. Flows to undisturbed areas will be prioritised. • Where required, sediment controls will be put in place. These will include, but not be limited to, rock check dams, sediment basins, sediment fences and silt socks. • Sediment controls will be reviewed during site inspections and/or after significant rainfall (more than 10mm in 24hrs resulting in site runoff).		
Performance Indicator(s)	No evidence of significant sediment deposition outside the works area. No evidence of significant rilling, gullies or other instances of run-off erosion.		
Monitoring	Daily inspection of work site to occur. Sediment controls will be reviewed during site inspections and/or after significant rainfall (more than 10mm in 24hrs resulting in site runoff). Review will include removal of accumulated sediments as required.		
Reporting	Incident report for non-conformance of sediment control Logging of sediment control structures - location and condition during weekly site inspection		
Corrective Action(s)	Investigate cause of sediment control failure Review flow path and determine most appropriate controls are in place, additional controls which can be place in-stream and/or changes that can be made to flow path Review similar controls on-site (even though these may not have failed) for similarities		

Turbidity

TURBIDITY			
Objective(s)	1. To minimise the volume of fine sediments / silts introduced into the Suriname River through various construction activities. 2. To minimise / manage the spread of sediments generated by construction activities		
Management Strategy	Undertake monitoring of turbidity through observations and in-situ measurements to proactively manage turbid plumes / sediment input.		
		Responsibility	**Timing**
Control(s)	Mitigation measures to minimize the potential impacts of the Project include: • Monitoring for turbid plumes generated by piling, drilling and material placement activities will be undertaken. Observations will be recorded daily during those activities and will be from an elevated location ensuring line of sight is maximised. These observations will include (but are not limited to) recorded information (*pro forma*) and site photographs demonstrating: o Plume extent (e.g. estimated distance in metres from the drill rig or construction work face), o Plume direction o Prevailing metocean conditions (e.g. wind, tide, swell) o Start-up and shut down times for drilling / piling operations o Any other notable visual characteristics of the plume or piling / drilling activity. • All material from drilling / mucking out operations will be recovered on land and not discharged directly into the marine environment.		
Performance Indicator(s)	No plumes of sediment released, or complaints from community.		
Monitoring	Daily (documented) observations and panoramic photographs of turbid plumes generated by work activities Daily inspections of worksite		
Reporting	Incidents (including breaches of this management plan) to be reported immediately to the Project Manager and Environment Manager.		
Corrective Action(s)	Should turbidity be identified, response will be to cease the work creating the plume until monitoring levels fall within compliance. Should the monitoring levels exceed the requirements on a continual basis, Contractor shall investigate additional measures to control turbidity		

Biodiversity

BIODIVERSITY			
Objective(s)	1. To minimise the impact to biodiversity		
Management Strategy	Ensure impacts to biodiversity are minimised, and impacts outside the disturbance zone are avoided.		
		Responsibility (Role)	**Timing**
Control(s)	Mitigation measures to minimize the potential impacts of the Project on biodiversity include: • When designing and planning work elements, minimize temporary and permanent construction footprints. • Demarcate work area with fencing to minimize disturbance or removal of natural vegetation. • Proper disposal of dredged material to avoid wildlife exposure. • Conducting canal- and mangrove-related works outside the waterbird breeding season (April – September). • Minimize lighting in and around construction sites. • Implement noise and air emission abatement measures. • Implement sediment control procedures during in-water works to minimize the release of fine sediments to downstream waterways, particularly the Suriname River. • Provide site specific information on biodiversity within the Environmental Induction. • Domestic animals prohibited on-site. • Ensure appropriate waste management (lidded bins), including food scraps, to reduce potential for feral species to become established on-site.		
Performance Indicator(s)	No disturbance outside the disturbance zone No injury or death of any fauna caused by vehicles or excavations No injury or death of protected fauna. No domestic animals on-site		
Monitoring	Daily inspection of work site to occur.		
Reporting	Sightings and incidents reported in weekly contractor.		
Corrective Action(s)	Investigate cause of incident Review opportunities/constraints for further minimisation of potential incidents parameters Implement corrective measures prior to the recommencement of site works		

Oil and Other Noxious Substances

OIL AND OTHER NOXIOUS SUBSTANCES			
Objective(s)	1. To minimise the potential for spills of oils and other noxious substances to as low as reasonably practicable.		
Management Strategy	Reduce quantity of hydrocarbons stored to that required, implement appropriate controls and provide appropriate training and resources for a spill response.		
		Responsibility (Role)	**Timing**
Control(s)	• All hydrocarbons to be stored in an appropriate bund that is capable of holding 110% of a spill from the largest container, or 10% of total volume of stored liquids, whichever is greater. • Refuelling of vehicles/equipment will be undertaken on land (not over water), unless the task is not possible. • To reduce the impact of a spill, the lowest volume of hydrocarbons required will be stored in proximity to the Suriname River and in the onshore lay down areas. • A copy of the current hydrocarbon MSDS will be kept at an appropriate location on site. • Drip trays shall be placed under mechanical stationary equipment such as gensets if such equipment is not internally bunded. • Onsite spill response training will be carried out on a periodic basis. All deficiencies • identified through training and testing of the procedures will be documented and rectified immediately. • All equipment will be regularly serviced to reduce emissions and reduce the chance of oil leaks on site and in marine environments. Appropriate controls in place to contain hydrocarbon leaks should they occur whilst servicing. Controls may include use of drip trays when changing oil and transporting waste oils in bunded containers. • Only qualified personnel are to carry out services on plant, equipment and vessels. • Training / awareness to be included in site induction (including all staff, contractors, subbies etc.). • Appropriate volume and type of spill response materials will be available at each work site • Spill will be contained and cleaned-up immediately. Resultant wastes (soils, rags and absorbent material) appropriately stored and disposed of by an appropriately licenced waste contractor as controlled waste. • All spills reported and investigated as required.		

OIL AND OTHER NOXIOUS SUBSTANCES			
Performance Indicator(s)	Minor spills (<10L) to land contained, controlled and all contamination removed / cleaned-up within 24 hours. No spills to marine waters. No contamination of soil or surface / ground waters. No spills that require an emergency response		
Monitoring	Incident report outlining corrective actions taken and preventative measures to be implemented Statistics reported in weekly meetings and monthly reports.		
Reporting	All marine spills (regardless of volume) to be reported to the Ministry of Works and NIMOS.		
Corrective Action(s)	Stop work immediately, contain spill (if safe). Investigate cause of spill and assess. Implement improvements as required. Investigate and assess adequacy of response – implement improvements as required. Implement corrective measures prior to the recommencement of site works.		

Housekeeping and Wastes

HOUSEKEEPING AND WASTES			
Objective(s)	Reduce waste volume, maximise recycling, reuse and recovery, prevent any construction waste/litter entering the environment.		
Management Strategy	Minimise environmental impacts through appropriate controls and site inductions of employees and sub-contractors.		
		Responsibility (Role)	**Timing**
Control(s)	• Provide appropriate waste bins, type, volume and service frequency to accommodate anticipated waste streams. • All loads arriving or leaving the site will be appropriately secured. • Provide information regarding waste management in site specific inductions, including waste separation and importance of securing vehicle loads. • Ensure licensed contractors are used to collect controlled wastes		
Performance Indicator(s)	Hazardous materials all appropriately disposed. Recycling of all recyclable construction metal waste Records kept of waste leaving site.		
Monitoring	Daily inspection of work site to occur. Review of waste bins (% full, time to next service). Waste volumes leaving site from waste contractors		
Reporting	Environmental incident reports.	Project Manager	Throughout project
Corrective Action(s)	Investigate cause of inappropriate waste disposal Review cause of issue and develop response, such as variation to bin size, service schedule or waste separation awareness. Implement controls	Project Manager	Throughout project

APPENDIX D:

Livelihood Restoration Plan

1. *Introduction*

This Livelihood Restoration Plan (LRP), prepared for the Government of Suriname (GoS) and Inter-American Development Bank (IDB) as part of their application to the Adaptation Fund for Urban Investments for the Resilience of Paramaribo (the Project), details the measures put in place to compensate and support the livelihoods of the persons economically displaced by the Project. The Project is committed to meeting international best practice—specifically the Inter-American Development Bank's Operational Policy-703 (OP-703) Environment and Safeguards Compliance and OP-710 Operational Policy on Involuntary Resettlement.

For the purposes of this plan, the following definitions[12] are used:

- **Affected population:** People who are directly affected by project related activities through the loss of employment, housing, land or other assets.
- **Compensation:** Money or payment in kind to which the affected people are entitled, as decreed by government regulations or laws.
- **Project Affected Persons (PAP):** Persons affected by the Project.
- **Project impacts:** The direct and indirect physical and socioeconomic impacts caused by the project within the project area.
- **Rehabilitation:** Reestablishment of livelihoods, living conditions and social systems.
- **Relocation:** Moving of people, assets, and public infrastructure.
- **Resettlement:** The entire process of relocation and rehabilitation caused by project related activities.
- **Resettlement impacts:** The direct physical and socioeconomic impacts of resettlement activities in the project and host areas.
- **Vulnerable groups:** Distinct groups of people that may suffer disproportionately from project-related activities.

It is believed that the Project has developed and will implement appropriate mitigations such that economic displacement will not occur. This plan has been drafted pre-emptively.

1.1. Project Background

The IDB launched the Emerging and Sustainable Cities (ESC) Program (SU-T1081) and the Paramaribo Urban Rehabilitation Program (SU-L1046) in Paramaribo, Suriname in

[12] Inter-American Development Bank, "Involuntary Resettlement in IDB Projects: Principles and Guidelines," http://services.iadb.org/wmsfiles/products/Publications/362003.pdf

2016. Both programs identify key issues to sustainability and implement tangible solutions—although the first is focused on the entire city of Paramaribo, while the second is focused exclusively on the historic center.

These programs identified that climate change is a critical risk to Paramaribo and, in particular, the urban area is highly vulnerable to floods due to rising sea levels, increasing intensity of precipitation, and eroding coastal and riverbanks.

In this context, the Housing and Urban Development (HUD) team at IDB prepared and submitted a concept note proposal to the Adaptation Fund to:

- Implement a group of strategic and cost-effective adaptation hard measures in the historic downtown area of Paramaribo that illustrate the benefits of building climate resilience as part of a long-term planning strategy for the city and its metropolitan area;
- Establish a framework for managing knowledge and disseminating lessons learned that could be used in future resilience programs for the city of Paramaribo and that could be part of a city-level Adaptation Plan;
- Build capacity across local communities and GoS stakeholders responsible for decision making in Paramaribo to ensure strong implementation and enforcement of the Adaptation Plan; and
- Ensure there is a robust plan and implementation structure to allow the Proposed Project to be implemented, monitored, evaluated and lessons learned disseminated.

In March 2017 the Adaptation Fund agreed to endorse the project concept and enclosed a list of required feasibility and related studies to be included in the full application. The IDB has contracted Environmental Resources Management, Inc. (ERM) to prepare the full application.

1.2. *Project Proponent*

The Project, if approved by the Adaptation Fund Board, will be led by the GoS, specifically the OWTC. The IDB, as part of the ESC and Paramaribo Urban Rehabilitation Programs, will continue providing advisory support to the GoS.

The LRP herein will be implemented by the Social/Community Coordinator and his/her team at the OWTC.

1.3. Project Alternatives Analysis

The Project components described in Section 1.4 were selected based on a systematic evaluation of several plausible alternatives. The process involved identifying, evaluating, and selectively reducing the number of alternatives that could potentially meet the overall objective of addressing flooding in the Paramaribo waterfront area while also meeting IDB's environmental and social safeguard policies.

The process of selecting Project components involved a screening exercise of a broad universe of potential adaptation measures or alternatives, resulting in the identification of 14 targeted site-specific alternatives.

The estimated order-of-magnitude costs and the relative merits (based on established evaluation criteria) of each potential component were used as a means of reducing the alternatives to those that could be implemented within the budgetary limitations and required standards for the Project. Ultimately, three groups of alternatives were assembled for further analysis, out of which one group emerged as the most favorable for its 99% potential of offering net positive benefits.

At this stage, it was recognized that the set of alternatives selected would not implicate any physical resettlement, which was highly valued and met a key objective of OP-710 to avoid or minimize the need for resettlement.

To supplement the technical analysis, a stakeholder meeting was held in November 2017 with key identified stakeholders to present the set of potential adaptation measures, to inquire about additional stakeholders that could potentially be affected, and to receive suggestions and concerns with regards to the ESIA and the adaptation measure options being evaluated. Supplemental information was also gathered through in-person interviews and phone consultations with individual stakeholders and stakeholder groups throughout November 2017 to May 2018. Finally, after the Draft ESIA was made publicly available, a final round of meaningful stakeholder engagement was conducted in July 2018 to engage in a two-way exchange on specific Project information and the planned mitigation measures.

Through the stakeholder engagement activities, the selected alternatives continued to appear fully feasible through the lens of OP-710, given that no additional impacts in terms of physical resettlement were discovered. Chief among stakeholder's concerns relevant to this LRP, are the following:

- Generally, all stakeholders stressed the need for timely and transparent communication about Project activities and sharing of Project updates and reports.
- Restaurants, bar, and small business owners emphasized the importance to conduct construction works from the river side, rather than the street side, to minimize nuisance and loss of local business.
- Owners and/or drivers of the commuter boats reported that they are not opposed to temporary relocation to the old ferry landing; however, they emphasized that safe and proper facilities must be created at the temporary location, in line with the needs of the boat passengers. It was emphasized that the relocation must be temporary. These stakeholders expressed desire to have information about when, how, and how long construction will take place, well ahead of time. Boat owners and drivers expect a loss of revenue as a result of the construction, as some clients may opt to take the bus, which is cheaper (SRD 0.85) than the boat commute.

- Owners and drivers of bus transport PG and LIJN 4 manifested concerns that they will not be able to return to their present location and they would lose income if they have to park at another location. They suggested that moving the busses slightly towards the street could alleviate this concern, depending on the exact location of construction activities.

In finally reviewing the selected Project components, which are described in the next section, it was considered that these fully align with OP-710 as there is no need for physical resettlement and that with the implementation of certain mitigation measures, including this LRP and those described in Section 5.0 ahead, Stakeholder's concerns could be fully addressed such that no economic displacement is expected for this Project.

1.4. Project Description

The GoS is proposing three discrete components (adaptation measures) to address the flood risks of Paramaribo as part of its application to the Adaptation Fund, as described in detail below. Together, these project components are a strong measure for coastal flood protection and address coastal and inland critical flood areas, and are adaptive based on future needs.

As illustrated in Figure 1, these components are concentrated primarily along the waterfront (on Waterkant Street) in the historic district and at the mouth of the Van Sommelsdijck Canal.

Figure 1: Aerial of Project Components

1.4.1. Construction of a New Flood Protection Wall

If the full application is accepted, a new flood protection wall, approximately 250 meters (m) long, would be constructed along the shoreline from Knuffelsgracht Street to the SMS Pier along the south side of the waterfront area (on Waterkant Street, see Figure 2). This new floodwall would consist of metal sheets that would be driven several feet into the ground, which would be reinforced along the embankment with riprap/stone. The new flood protection wall would be capped with 2 to 4 m wide walkways; and the existing landing for water taxis and steel jetty would be rehabilitated or replaced during wall construction.

Figure 2: Aerial View of Waterfront Area (Along Waterkant Street)

1.4.2. Rehabilitation of Pumping Station and Sluice Gates at Sommelsdijck Canal

The existing pump stations and sluice gates at Sommelsdijck Canal would be rehabilitated, as shown in Figure 3.

To facilitate the proper water flow and functioning of the sluice gate and pump station at Sommelsdijck Canal, the portion of the canal that is immediately behind (upstream of the pump) would need to be dredged/excavated. It is estimated that up to 1,000 cubic meters of sediment would need to be removed from the canal. Because this material could be contaminated with organic and inorganic pollutants, it would be disposed of in a designated dredge spoil disposition area located within 15 km of the canal. The transport of the spoil would be conducted by trucks (with sealed / liner inside) or by pontoons (using suction pumps), depending on the location of the disposition area as approved by prior consultation with NIMOS.

Figure 3: Rehabilitation Components of Sluice/Pumping Station at Sommelsdijck Canal

1.4.3. *Enhancement of Mangroves*

An existing mangrove forest is immediately downstream of Sommelsdijck Canal pump station at the confluence of the canal and the Suriname River as shown in Figure 4. This area would be slightly expanded and enhanced by planting additional mangroves and constructing other natural features (trapping units/wooden quays) to facilitate growth, sediment entrapment, and protection against erosion.

Figure 4: Mangroves North and South of the Canal Confluence

1.5. *Objectives of the Livelihood Restoration Plan*

In accordance with the IDB's policy OP-710, the objective of the LRP is to minimize Project-related disruptions to the affected population—in this case temporary economic displacement lasting for the duration of construction, which is anticipated to be 4 to 8 months. The Project will not result in any physical displacement and no residences are affected. Lastly, and as stated above, it is believed that the Project has developed and will implement appropriate mitigations such that economic displacement will not occur. This plan has been drafted pre-emptively.

According to OP-710 when temporary relocation is necessary, special consideration will be given to avoiding irreversible negative impacts (such as permanent loss of employment), providing satisfactory temporary services, and, where appropriate, compensating for transitional hardships. This LRP has been prepared in order to meet this objective and ensure that any hardships encountered due to temporary relocation of productive activities in the waterkant area will be mitigated or compensated. With these measures, affected persons can be assured that their productive capacity and income levels are maintained at an equivalent or better level as compared to before the Project.

1.6. *Scope and Organization of the Livelihoods Restoration Plan*

The LRP describes the policies, procedures, proposed compensation rates, mitigation measures, and schedule to guide the compensation of affected people who will be economically displaced by the Project.

This LRP is organized as follows:

- Chapter 1 presents an overall introduction, Project description and context for the LRP.
- Chapter 2 presents the administrative and legal framework that has guided LRP preparation.
- Chapter 3 presents stakeholder participation and the consultation activities conducted to inform LRP planning.
- Chapter 4 presents the socio-economic conditions of the Project affected persons (PAPs).
- Chapter 5 presents the impacts on PAPs.
- Chapter 6 presents the policies guiding compensation and outlines the Project`s strategy for compensation.
- Chapter 7 presents the mechanisms available to PAPs for the processing and resolution of grievances or claims related to the Project.
- Chapter 8 presents the roles and responsibilities of the different parties involved in the implementation of the LRP.
- Chapter 9 presents the monitoring measures in place to determine whether LRP objectives are met.
- Chapter 10 presents the anticipated implementation schedule.

2. *Administrative and Legal Framework*

2.1. Administrative Framework

The GoS will be responsible for resettlement and compensation associated with the Project. In particular, the OWTC —which is responsible for planning, building, and constructing road and walkway infrastructure, parking, drainage, sewage, waste management, green zones, park development, bridges, sea walls, and dikes in the Paramaribo—will serve as the Project lead and manage the LRP. Where necessary, the OWTC will engage with:

- **The Cabinet of the Presidency:** The Cabinet of the Presidency is responsible for representing the interest of the President and Suriname writ-large with relations to the development of this Project.
- **National Institute for Environment and Development:** The National Institute for Environment and Development (NIMOS) is responsible to achieve national environmental legislation in the broadest sense of the word, prepare and enforce the regulations regarding the protection of the environment, and coordinate and monitor compliance.
- **Ministry of Education, Science and Culture:** The Ministry of Education, Science, and Culture (MINOWC) is responsible for the development and enforcement of policies to enhance the protection of the Historic Site and its monuments in Project area.
- **Ministry of Regional Development – District Commissioner:** The District Commissioner is responsible for issuing licenses to all resort users including, but not limited to, shops, parking, businesses, cultural activities, and advertisements on public spaces.
- **Ministry of Transport, Communication and Tourism:** The Ministry of Transport, Communication, and Tourism is responsible for public transportation, including the placement of bus stops, as well as the development of tourism.

2.2. Legal Framework

2.2.1. Constitution of the Republic of Suriname

Suriname does not have an exhaustive legal framework related to physical and economic resettlement. The concept is rooted solely in Article 34 of the Constitution of the Republic of Suriname states the following[13]:

> ***1. Property, both of the community and of private persons, shall fulfil a social function. Everyone has the right to the undisturbed enjoyment of his property, subject to the limitations which originate in the law. 2. Expropriation shall take place only in the general interest, pursuant to rules to be laid down by law and against compensation guaranteed in advance. 3. Compensation need not be previously assured if, in case of an emergency, immediate expropriation is required. 4. In cases determined by or pursuant to the law, the right to compensation shall exist if, in the public interest, the competent authority destroys or renders property unusable or restricts the exercise of property rights.***

With that being said, the GoS recognizes the persons' right of property ownership and, in the cases of expropriation, their right to compensation—if the property is not seized due to an emergency. In practice, there is no history of government expropriation, however.[14]

Given that the Project will not physically displace stakeholders or make use of any expropriation, no regulatory concepts are triggered.

1.1.1. IDB Environmental and Social Safeguards

The GoS has committed the Project to align with the IDB's environmental and social safeguards, specifically the OP-703 Environment and Safeguards Compliance and OP-710 Operational Policy on Involuntary Resettlement, the latter of which is most relevant to this LRP. These safeguards are guided by international best practices and are relatively consistent with widely used International Finance Corporation (IFC) guidelines regarding environmental, health, and social management.

OP-710 describes principles for operations that may require resettlement, including:

- Every effort will be made to avoid or minimize the need for displacement
- When displacement is unavoidable, a plan must be prepared to ensure that the affected people receive fair and adequate compensation and rehabilitation

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[13] United Nations Educational, Scientific, and Cultural Organisation, "Constitution of Suriname, 1987," http://www.unesco.org/education/edurights/media/docs/dfcff4209dad7879549a7d46dc0bcbf82919c591.pdf

[14] United Stated Department of State, "2015 Investment Climate Statement – Suriname," https://www.state.gov/e/eb/rls/othr/ics/2015/241752.htm

According to OP-710, a plan that is developed to ensure affected people receive fair and adequate compensation and rehabilitation, in this case the LRP, must take into account the following criteria:

- **Baseline information.** Accurate baseline information must be compiled as early as possible. It will include information on the number of people to be resettled and their socioeconomic characteristics.
- **Community Participation.** The plan will include the results of consultations carried out in a timely and socio-culturally appropriate manner with a representative cross-section of the displaced and host communities. Consultations will take place during the design phase and will continue throughout the execution and monitoring of the plan, directly or through representative institutions and community organizations. Care will be taken to identify the most vulnerable subgroups and to ensure that their interests are adequately represented in this process.
- **Compensation and Rehabilitation Package.** Compensation and rehabilitation options must provide a fair replacement value for assets lost, and the necessary means to restore subsistence and income, to reconstruct the social networks that support production, services and mutual assistance, and to compensate for transitional hardships. These measures must be taken in a timely manner to ensure that transitional hardships are not unnecessarily prolonged and do not result in irreparable harm. The options that are offered should be appropriate for the people affected, and should reflect their capabilities and realistic aspirations. The design of compensation packages, as well as the community consultation and decision making mechanisms included in the resettlement program, will take into account the characteristics of the resettled population as identified in the disaggregated baseline data with respect to gender, ethnicity, age, and any other factors pointing to special needs and/or vulnerability.
- **Legal and Institutional Framework.** The resettlement plan must identify the legal and institutional context within which the compensation and rehabilitation measures have to be implemented. This then allows an assessment of whether any additional measures are needed to restore the livelihoods of the affected population to the pre-displacement standard, and to design mechanisms capable of delivering the goods or services that are needed, including effective and expeditious procedures for the resolution of disputes.
- **Environment.** Resettlement plans must take environmental considerations into account in order to prevent or mitigate any impacts that result from the development of infrastructure, densification of the host area, or pressure on natural resources and ecologically sensitive areas.
- **Timeliness.** A preliminary plan must be prepared as part of the Environmental and Social Impact Assessment (ESIA). It must undergo a process of meaningful

consultation with the affected population, and must be available as part of the ESIA, prior to the IDB's analysis mission. It must include sufficient information to be evaluated along with other project components.

- **Monitoring and Evaluation.** Any displacement due to an operation must be fully and specifically covered in the reports on the progress of the overall project. The monitoring activities will focus on compliance with the plan in terms of maintaining economic and social conditions for affected people and include specific monitoring evaluation requirements.

2.3. The Suriname Context Versus IDB Environmental and Social Safeguards

Although the GoS recognizes persons' right of property and, in cases of expropriation, their right to compensation, the associated institutional and legal framework is undefined. The IDB's Environmental and Social Safeguards, on the other hand, are prescriptive, outlining the process for developing a LRP and those components necessary to be included as described in the previous section.

Where the GoS is concerned exclusively with compensation for lost property (i.e., physical displacement), the IDB is concerned with compensation for both lost property and livelihoods (i.e., physical and economic displacement). Given that no physical displacement will occur in this Project, the IDB's Environmental and Social Safeguards provide a relevant framework for the possible economic displacement. The GoS is committed to aligning with the IDB's Environmental and Social Safeguards for the Project.

3. Stakeholder Engagement, Consultation and Participation

This Chapter should be seen as complimentary to the Project's stand-alone Stakeholder Engagement Plan and Communications Plan and it sets out to identify Project stakeholders, and describe the Project's stakeholder engagement activities that have been undertaken to date and outlines future activities. It is written with relation to resettlement and livelihood restoration.

A stakeholder is defined by the IDB as:

> ***"…Individuals, groups, or institutions that have a stake, or an interest, in the project: They may be affected by it (either positively or negatively), or they may have an interest in it and be in a position to influence its outcomes."***

3.1. Stakeholder Engagement Approach

Meaningful and transparent stakeholder engagement is essential to the development of a LRP and it was extensive as part of this Project. It served to:

- Inform stakeholders about the LRP planning process and solicit their feedback and participation;
- Identify PAPs and carry out a census and social survey to obtain socio-economic data on those economically displaced;
- Discuss livelihood restoration options with PAPs;
- Manage expectations related to the LRP; and
- Provide stakeholders with a socially acceptable and culturally appropriate grievance redress procedure.

3.2. Identification of Stakeholder

Identification of stakeholders is necessary as part of determining PAPs, managing stakeholder expectations and providing meaningful, transparent and timely communication. An initial identification was conducted as part of SU-T1081 in 2016 when the Project and potential components were still being conceptual designed in the larger Paramaribo area. This identification was conducted in consultation with the District Commissioner and the Ministry of Transport, Communication and Tourism, and, at a high-level, included:

- Government entities;
- Academic institutions;
- Consortiums (e.g., Caribbean Local Economic Development Project);

- Local businesses (i.e., businesses in the study area);
- Area residents and land owners;
- Recreational visitors and tourists; and
- Religious institutions.

In May 2018, as the Project was refined and components were selected, a census and socio-economic survey were completed in the immediate Area of Influence whereby PAPs were identified and baseline conditions were determined. PAPs included:

- 38 water taxis that operate from the Project Area;
- 103 bus owners and operators of PG and LIJN 4, two Paramaribo service providers; and
- 8 taxicab drivers.

The survey also elicited feedback on livelihood restoration options.

3.3. Stakeholder Consultation

The Ministry of Public Works (OWTC) and the Cabinet of the President were then engaged in April 2018 regarding relations to the LRP process and were invited to share any comments or questions on issues relating to their perceptions or areas of expertise. They agreed with the process as described in Section 6.0.

PAPs were engaged as part of an initial public consultation in November 2018 and again in May 2018 as part of the census and socio-economic survey. After the Draft ESIA was made publicly available, another round of consultations were carried out in early July 2018. In these consultations specific information was shared about the Project and its components and stakeholders were engaged in a two-way exchange to understand their views on the Project and the proposed mitigation measures, especially those aspects that are likely to most directly affect them, including specific engagements with bus and water taxi transportation providers. PAPs will continue to be engaged as part of the ESIA and stakeholder engagement process.

During these consultations, PAPs did not express any objections to the Project because they are aware of increasing climate change risks and the need to reduce downtown flooding and improve infrastructure. They value the historic city and the importance of preservation and conservation and are concerned about its neglect and lack of maintenance. They expressed proactive attitudes towards the Project plans that would likely affect them (construction and temporary relocations) and made suggestions as to how mitigation measures could be tailored to best fit their needs, which the Project will take into account.

3.4. Managing Stakeholder Expectations

Stakeholder engagement has revealed that the Project will need to closely manage stakeholders' expectations. Many stakeholders have little confidence that the Project will be implemented because of the frequent consultations in the immediate Project Area—none of which have yet materialized.

3.5. Future Engagements

Future stakeholder engagement activities planned will include those related to LRP disclosure, implementation, and monitoring and evaluation. Other Project related engagement and consultation is also planned related to the ESIA process.

4. *Socio-Economic Baseline Survey*

4.1. Methodology

PAPs were identified in the following ways:

- Physical observations of their location and proximity to the Project during weekdays and weekends, day and night;
- Engagement with the GoS and appropriate ministries (e.g., OWTC, Transport and Communication) in order to get a list of registered businesses and associated agents; and
- Engagement with local associations and business in order to get a list of employees.

Specifically, in terms of approach, the survey team sought official information and registries of the buses and water taxis from the GoS ministries to generate an initial list of potential PAPs in the waterfront area. The survey teams then engaged in two full days of field observations, selecting a weekend day and a weekday to diversify results, from which they produced a field-generated list, which could be cross-referenced with the official information previously obtained. During these field observations, the team was able to engage with initial interviewees to ensure they were covering relevant areas. Finally, with an established idea of the survey population, the survey interviews were then carried out on May 14 and May 25, 2018.

The OWTC established an official cut-off date of May 14, 2018 and the field team shared an official letter showing this date with survey participants (for further detail, please see Section 6 below). To ensure a broad representation of transportation providers, the interviewers approached every person from the target groups who was present in the waterfront area. After explaining the Project and the reason for the interview, if the person agreed to participate, the survey was carried out. Questions covered demography, livelihood activities, income and expenditure, and the extent of Project impacts.

The primary data presented in the following sub-section was generated directly from surveys, key informant interviews, and direct observation.

4.2. Population and Demographic

Of the 151 stakeholders included in the census, demographical and socio-economic data was collected for 115 of them. Some stakeholders were unwilling to participate in the socio-economic survey or the interviewers were unable to make contact with them for the duration of the census.

An overview of demographical information is provided in Table 1 below.

The majority of these PAPs are male (98.3 percent), while only two of them are female (1.7 percent)—with the average age of 44.7 years old, and outliers aged 22 and 73.

Educational attainment is low for all PAPs. More than half of them had no more than primary education. One of every five PAP had completed lower vocational education after primary school (19.6 percent), and a similar share had completed middle school (18.6 percent). Approximately 7 percent of PAPs attained an education beyond middle school, and none had been to college or university.

Despite the relatively low levels of formal education, the majority of PAPs are fluent in the Dutch language (92.1 percent)—and those who are not fluent could understand it. All PAPs are fluent in the Suriname creole language, Sranantongo.

Two-thirds of PAPs are of Hindustani, persons of East Indian migrant descent. The next largest ethnic groups are Javanese (14.8 percent), persons of Indonesian migrants from the island of Java descent, and Creoles (10.4 percent), persons of mixed-African heritage. Fewer individuals are Maroons (2.6 percent), descendants of run-away African slaves, or Indigenous (0.9 percent). Approximately 4.3 percent of PAPs self-identified as mixed ethnic heritage.

Those individuals who self-identified as Maroons and Indigenous in the Project Area were interviewed. They speak Dutch fluently, had a similar educational attainment as other identified stakeholders. They are in the immediate Project Area solely because of employment opportunities occupied indiscriminately by Indigenous and non-Indigenous People alike. The Project does not impact the physical and food security, lands, territories, resources, society, rights, traditional economy, way-of life and identity or cultural integrity of Indigenous Peoples in the immediate Project Area or in Paramaribo/Suriname at large.

Table 1: Demographics

Stakeholder Group	Gender	Mean Age (Range)	Educational Attainment	Ethnicity
All (N=115)	98.3% Male 1.7% Female	44.7 (22-73)	No formal education, 15.7% Primary school, 39.2% Lower vocational ed., 19.6% Middle school, 18.6% High school, 5.9% Higher vocational, 1% (Valid N=102)	Hindustani, 67% Javanese, 14.8% Creole, 10.4% Mix, 4.3% Maroon, 2.6% Indigenous, 0.9%

4.3. Employment and Income

PAPs are primarily associated with the transport industry (i.e., water taxis, buses, and taxicabs). The daily income of the persons in the transport industry vary considerably (Table 2), which is further exacerbated considering that some individual are license owners (i.e., owner of a bus), license owners and drivers, and drivers. The incomes listed in Table 2 were self-reported as part of the census/socio-economic survey.

Table 2: Estimated Average Daily Income By Stakeholder Group

		Buses (N=67) **	**Ferry boats (N=30)**	**Taxicabs (N=8)**
License owners / owners	SRD	170	80	79
	USD	23	11	11
Only drivers	SRD	112	67	N/A
	USD	15	9	

For the purposes of this baseline, annual incomes for the transport industry were calculated by deducting annual estimated costs from annualized daily incomes. Costs vary by transport group and are captured in Table 3 below.

Table 3: Annual Average Estimated Costs (Usd)

Item	**Buses (N=40) ****	**Ferry boats (N=26)**	**Taxicabs (N=8)**
Gasoline	3,930	5,785	2,306
Maintenance	1,179	893	228
Labor expenses	1,566	10	N/A
Insurance	141	N/A	79
Taxes	119	48	17
Other expenses, (e.g., payment to government, inspection fee)	291	40	17

Item	Buses (N=40) **	Ferry boats (N=26)	Taxicabs (N=8)
Total annual costs	9,211	6,577	2,622

Estimated annual incomes for the different PAPs in the transport industry, distinguishing between license owners (including persons who both have a license and drive the vehicle) and persons who are only drivers, are presented in Table 4. On average, these persons earn between USD 2,000 and USD 3,500 annually. Some of the estimated annual incomes are equal to or less than Suriname's hourly minimum wage (SRD 6.14/USD 0.82; USD 1,705.60 per year).

Table 4: Estimated Average Annual Income by Stakeholder Group (USD)

	Buses	Ferry boats	Taxicabs (N=8)
License owners / owners	1,962 (N=24)	2,241 (N=22)	2,670
Only drivers	3,388 (N=30)	2,704 (N=5)	N/A

5. *Project Impacts*

5.1. Overall

The urban area of Paramaribo is highly vulnerable to floods and the Project, being designed to alleviate some of this, has an overall net benefit. Although the Environmental and Social Impact Assessment (ESIA) determined that the Project would likely result in some environmental and social impacts, these impacts could be readily mitigated and managed with an Environmental and Social Management Plan (ESMP) inclusive of this LRP. This, in addition to other mitigations described in the ESIA, minimizes to the greatest extent possible, and likely eliminates completely, the scope of economic displacement associated with the construction of the Project.

5.2. Loss of Income

The construction of a new flood protection wall, which is expected to last between 4 to 8 months, could directly impact businesses in the Project Area. Although Waterkant Street will remain opened, land-based transportation businesses will be limited to the two bus lines—PG and LIJN—while taxicabs would not be able to continue loading/unloading/parking immediately in front of the existing flood protection wall due to safety concerns during construction. Similarly, water-based transportation businesses (i.e., water taxis) would not be able to continue loading/unloading/docking at their current dock due to the same safety concerns. Given the concentration of and the short duration of the potential impact, the magnitude has been determined to be small to medium. A small portion of PAPs have low annual income levels an attribute associated with medium to high vulnerability.

This impact's significance is determined to be moderate to major and wholly dependent on the vulnerability of the PAP. In order to minimize the impacts to minor to moderate, the mitigations that follow below were recommended in the ESIA. It is important to note that these mitigations measures were developed taking into account the results of the stakeholder engagement activities carried out from November 2017 to May 2018 (See section 1.3.). In these engagements, certain stakeholders expressed a desire for works to take place on the river side as opposed to street side, while transportation operations were amenable to moving temporarily to agreeable locations; the Project will largely be able to accommodate these positions as described below.

- The majority of construction activities are executed from the waterside (please note this mitigation measure would reduce impacts on land-based transportation businesses only).
- Buses that park along Waterkant Street remain in the larger Project Area and are temporarily relocated to the Bus Terminal, which is expected to remain open, 200 meters west of their existing location and 100 to 200 meters east and west along Knuffelsgracht Street (Figure 5).

- Water taxis remain in the larger Project Area and are temporarily relocated to the "old steel jetty" 100 meters east of their existing location, and the old pier's current condition is improved in order to be of equal or better quality than their existing location (Figure 6).
- A Traffic Management Plan is developed and implemented to help facilitate busing routes and alternative stops in the immediate study area as appropriate.
- A Livelihood Restoration Plan (LRP) is developed and implemented for any stakeholder that is potentially impacted during construction in order to make them whole, although this is not expected after implementing the other mitigation measures.

Figure 5: Temporary Relocation of Buses

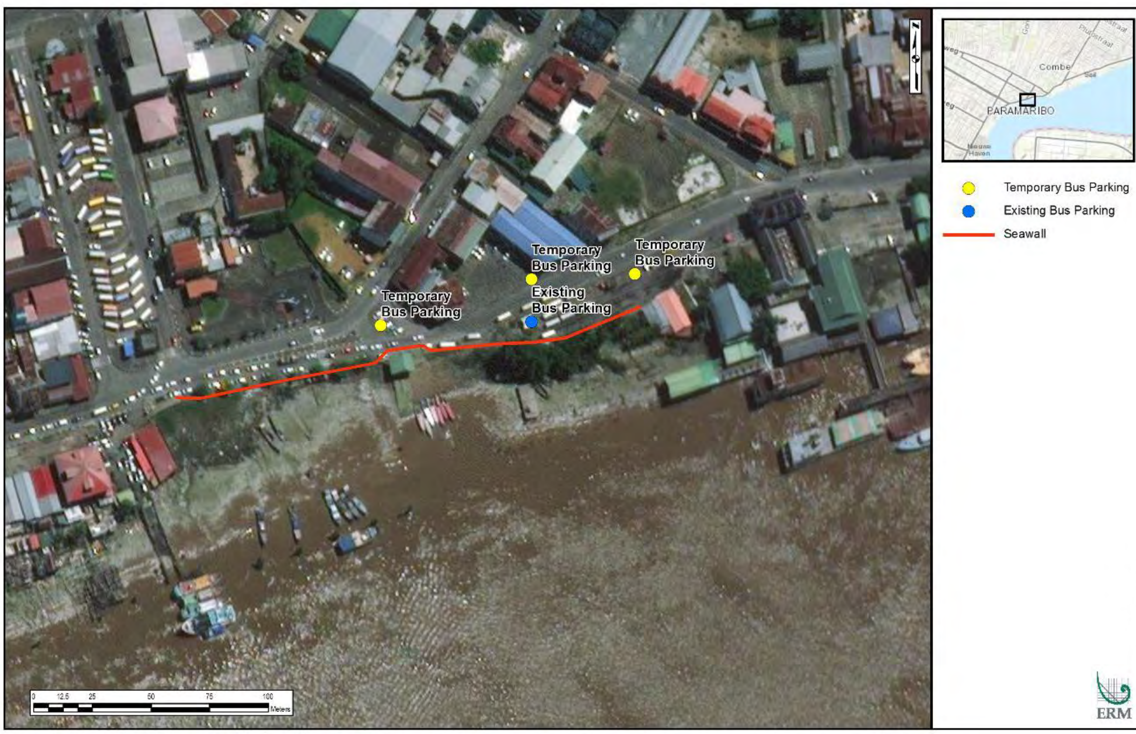
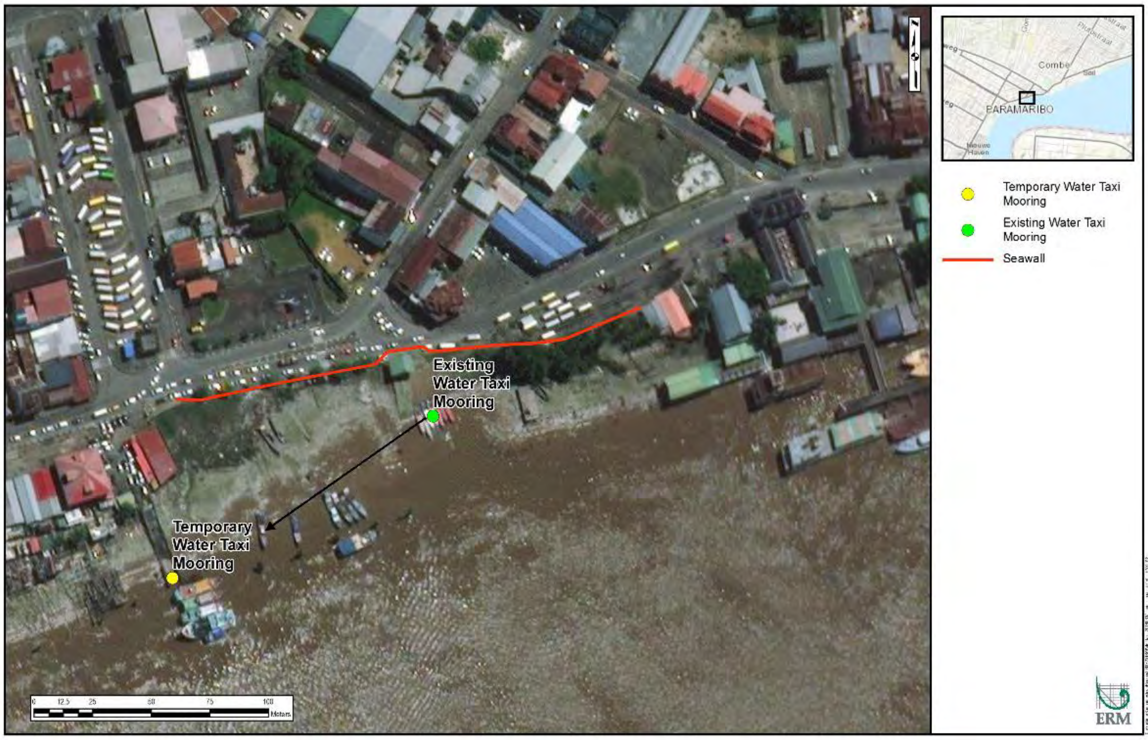


Figure 6: Temporary Relocation of Water Taxis



An additional round of meaningful stakeholder engagements were carried out in July 2018 after the Draft ESIA became publically available. Two meetings were held with specific stakeholder groups likely to be most directly affected by the Project – bus and water taxi transportation providers – in which specific Project information was shared and participants were engaged in a two-way exchange to obtain their views and feedback on the Project and the planned mitigation measures most relevant to them. Stakeholder engagement reports are available in Appendix B. Finally, a Stakeholder Engagement Plan and Communications Plan has been developed and will continue to be implemented, in addition to a Grievance Mechanism. This mechanism is designed to receive, facilitate investigation, and respond to grievances from Project stakeholders and Affected Persons; and it will be managed by a designated personnel (e.g., Community/Social Coordinator for the OWTC).

After construction, both land- and water-based businesses in the transport industry are expected to return to their preconstruction locations as proposed by each respective stakeholder group, at such point their conditions will have no further potential impacts, being then equal or better to the pre-Project scenario.

5.3. Impacts on Vulnerable Groups

As part of the census, a total of four individuals self-identified as Maroon or Indigenous, both of which can be labeled as Indigenous People in accordance with OP-765. These Indigenous People are fully integrated into urban life in Paramaribo, have similar educational attainment as other PAPs, and hold the same types of jobs, as identified in the baseline. They are in the immediate Project Area solely because of employment opportunities occupied indiscriminately by Indigenous and non-Indigenous People alike. The Project does not in any way impact the physical and food security, lands, territories, resources, society, rights, traditional economy, way-of life and identity or cultural integrity of Indigenous Peoples in the immediate Project Area or in Paramaribo/Suriname at large.[15]

Similarly, only two women were identified in the census and occupy roles in the transport industry similar to men. The Project does not call for a large transient workforce during construction; therefore, there no subsequent gender-based violence is expected. The Project does not disproportionately impact women in any way.

No additional mitigations are necessary with relations to livelihood restoration.

[15] An additional consultation was carried out on 16 July 2018 with the person who self-identified as Indigenous during the census. The purpose of the consultation was to ensure that this person had the opportunity to voice any particular concerns that he may have had as a result of his Indigenous identity vis-à-vis the Project. The person did not feel that the Project would generate any particular negative impacts due to his identity, as he was born in Paramaribo and does not live in community with his indigenous community or speak the language. He further affirmed to understand the Project, its nature, duration and mitigations, and stated to have no comments or concerns and did not believe the Project would affect his livelihood in anyway.

6. *Compensation Framework*

This chapter lays out the framework for compensation to be allocated to the PAPs in the event economic displacement. As stated above, it is believed that the Project has developed and will implement appropriate mitigations such that economic displacement will not occur. This plan has been drafted pre-emptively.

6.1. Goals and Objectives

The goals and objectives of the compensation framework include the following:

- Provide transparent, fair and timely compensation for any material losses to all PAPs in accordance with the IDB's Involuntary Resettlement Policy (OP-710).
- Restore the livelihoods and welfare of PAPs such that any material losses they suffer due to the Project are compensated at full value, and their well-being is at least equal to their pre-Project conditions, or better.

6.2. Eligibility

This section summarizes the eligibility criteria and provides an overview of activities undertaken to implement these.

6.2.1. Eligibility Policy

PAPs are eligible for compensation if the incur an economic loss due to the Project if they are:

- First, directly affiliated with the transport industry in the waterfront area, that is:
    - Owners, license owners, and/or drivers of buses (routes PG and LIJN 4).
    - Owners, license owners and/or drivers of water taxis (Route Meerzorg-Paramaribo).
    - Owners and drivers of informal taxicabs that use the waterfront area to seek customers (mostly persons coming from the water taxis).
- Second, were included in the Census conducted in May 2018 or their status as a waterfront transportation provider can be otherwise proven by the Ministry of Transport, Communication and Tourism. PAPs must be able to demonstrate that they have incurred an economic loss (e.g., receipts, pay stubs or the like).

6.2.2. Establishment of Entitlement Cut-off Date

Prior to the commencement of the baseline survey activities, engagement was conducted to explain the Project and get an initial idea of the population in the waterfront area. OWTC established an official cut-off date of May 14, 2018 and gave its permission for the survey to proceed. This date was advertised in the local newspapers and, during the field surveys, the field team shared an official letter showing this date with survey participant and explained the cut-off date and Project details.

6.3. Entitlements

Given that the potential impacts are likely to be mitigated through the mitigation measures described in Section 5, the only other impacts might be losses in income should commuters chose alternative means of transportation during the Project's construction period. Thus, the entitlements envisioned in this LRP consist of cash compensation for lost wages.

The Program will use the mean calculated average daily earnings for each category of transportation provider, as described in Table 5, as the maximum amount that could be claimed as a loss on a daily basis.

Table 5: Average Daily Earnings

	Buses	Ferry boats	Taxicabs
License owners / owners	SRD 170	SRD 80	SRD 79
Drivers	SRD 112	SRD 67	N/A

The maximums for compensations will assume that transportation providers work up to six days per week, with the exception of PG providers, which will only be compensated for any losses for up to three days of work per week per their A/B bus structure. In terms of total potential eligible people, the census recognized a total of 151 people on the days of the field visits. As such, it is assumed that the maximum number of eligible people should be similar, but could reasonably surpass 151 by some degree to account for people not working or otherwise not physically present those days.

Compensation will only be provided during the construction period, which will be defined by the OWTC and communicated to the transportation providers through the activities contemplated in the Project Stakeholder Engagement Plan and Communications Plan. At present, the Project anticipates that the construction is likely to be completed in 4 to 8 months, with the period for relocation of the transportation providers to be less.

6.4. Budget

Based on the adequacy of the mitigation measures, it is highly likely that no losses in income will be experienced and the LRP will not have to pay any compensation. Nonetheless, this plan has been drafted preemptively and will make appropriate budgetary provisions within the overall Project should claims be filed.

If the application to the Adaptation Fund is successful, and the Project proceeds, a maximum possible budget for compensations could be calculated. This budget would be based on the number of PAPs in each category of transportation provider, their respective average daily income and a maximum temporary displacement of 8 months with 6 working days per week for most, except for the PG providers where only three days of work per week is presumed for drivers. Further stakeholder engagement activities and specifically engagement with the transportation providers will give the Project further indications as to the adequacy of the mitigation measures such that the budget can be calculated with more precision at a later date.

6.5. Calendar

The Project is committed to carrying out the construction activities, and in particular the new flood protection wall, in as timely a manner as possible with the least possible effect to transportation providers. At present construction is expected to last 4 to 8 months and will require temporary relocation of transportation services for less than that total time. **Prior to any relocations**, the Project is committed to the following, which will ensure that adequate mitigation measures are in place prior to the possibility of any impacts taking place:

- Rehabilitation of the "old steel jetty" so that it is in equal or better conditions than the current water taxi unloading and loading location;
- Agreements reached with the Bus Terminal so that buses have permission to use it for the duration of the temporary relocation;
- Completion of the Traffic Management Plan to facilitate busing routes and alternative stops as appropriate; and
- Installation of appropriate signage in areas where patrons congregate to inform them of relocations in advance.

The Grievance Mechanism, described in the next section, will also be fully operational prior to any construction activity, so that any grievance or concern from a PAP may be appropriately addressed.

7. Grievance Mechanism

The Project has developed a grievance mechanism to document, track, manage and resolve all grievances and complaints raised by internal and external stakeholders in an accessible, timely and transparent fashion. The procedure is detailed in the Stakeholder Engagement and Communications Plan, and it will be utilized to handle any grievance with regard to economic displacement and this LRP.

When a PAP incurs economic displacement, they are to access the Project's grievance mechanism in person, or by letter, phone, fax, or email. Then the following process will be initiated:

1. The grievance will be recorded and logged within 3 working days of receipt of the grievance.
2. The PAP will receive Project acknowledgement of the grievance within 3 working days of the grievance being recording (i.e., 6 working days from the date the grievance was filed).
3. Within 15 days of acknowledging the grievance, the grievance will be assigned to the Community and Social Coordinator to investigate. The Community and Social Coordinator, with support from other functions across the Project Proponent's organization, will make a determination of eligibility for reimbursement of lost income based on the above Compensation Framework.
4. Within 3 working days of making this determination, the PAP will be contacted with the decision.
5. In the instance that the PAP disagrees with the Community and Social Coordinator's decision, the PAP can appeal and the decision will be raised to Project Proponent's upper management. This decision will be final.

8. Organizational Framework

This Chapter presents a summary of the personnel and organizational framework for the planning and implementation of the LRP.

In order to implement the LRP, the OWTC and the selected construction firm will need to allocate sufficient resources devoted to managing and implementing the LRP. As such, this chapter suggests some possible structures to implement the plan. As the Project progresses, the Proponent should refine these approaches to fit the personnel arrangements and implementation decided upon with the construction firm.

It is assumed that the OWTC will appoint a:

- **Community and Social Coordinator** – full time resource (40 hours a week) to manage the implementation Livelihood Restoration Plan, in addition to the Stakeholder Engagement and Communications Plan. Requirements for this role will be a degree in social sciences (or equivalent) and at least 10 years' experience of stakeholder engagement and livelihood restoration, including managing such to meet international standards.

9. *Monitoring*

Monitoring is the systematic collection of information about a Project's progress. It is done to determine whether resources are being used for their intended purpose and are effective, and to promote transparency. According to best practice, Projects that induce economic displacement should monitor and report on the effectiveness of LRP implementation, including the disbursement of compensation, the effectiveness of consultation, and the restoration of livelihoods. More specifically, the monitoring objectives of M&E for this LRP are to evaluate whether:

- Actions and commitments described in the LRP are implemented in a responsive and timely manner.
- PAPs understand their rights.
- Compensation measures are effective in enabling PAPs to maintain their livelihoods.
- Grievances submitted by stakeholders are addressed and that the majority are resolved.

9.1. Methodology and Process

A monitoring plan should be created and consulted with stakeholders in advance of any construction activities. Roles and responsibilities for monitoring should be clearly defined. The monitoring plan should utilize baseline data, establish milestones for monitoring according to the Project's construction schedule, and set a final milestone by which to ensure that restoration is achieved in a post-construction phase when waterfront transportation providers are allowed to return to their original work locations. The plan should specifically assess whether transportation providers are suffering losses in their incomes and whether they are successfully utilizing the compensations provided for in this plan. Some indicators which could be used to monitor include but are not limited to:

- Pre-Project income levels
- Current income levels
- Use of compensation
- Satisfaction with level of compensation
- Ease of access to compensation
- Grievances filed with regard to the LRP
- Resolutions achieved to any grievances filed with regard to the LRP

Monitoring should be carried out periodically, and the Project Proponent should use adaptive management to incorporate any relevant feedback into the LRP processes should any issues arise. Such adaptive measures can be established in the monitoring plan in consultation with stakeholders.

10. Schedule

With this document the initial LRP planning has been completed. Activities undertaken during this phase included:

- Engagement with government and local people
- Socio-economic Baseline Survey
- Drafting of the LRP according to IDB standards and international best practice
- Inclusion of the LRP in the draft ESIA for public disclosure and consultation

After the development of the ESIA, the next steps will be to take into account the public feedback regarding the LRP and refine the plan as necessary, especially regarding any feedback received from waterfront transportation providers. Once the ESIA is approved and the Project Proponent moves forward with selection of a construction firm, the LRP will be further developed in consultation with PAP and implemented accordingly, along with the other management plans included in this Project.

Letter from OWTC Explaining the Proposed Waterfront Rehabilitation Project

MINISTERIE VAN OPENBARE WERKEN, TRANSPORT EN COMMUNICATIE

DIRECTORAAT CIVIELTECHNISCHE WERKEN

Mr. Jagernath Lachmonstraat no. 167

Paramaribo-Suriname Tel: 464088

Paramaribo, 04 mei 2018

Ons Ref: SS/ODN/SM /Ag. No. 1925
Bijlagen: (-)
Betreft: Consultaties met belanghebbenden

Project: Renovatie van de Waterkant tussen Knuffelsgracht en Waaggebouw i.h.k.v. het Adaptation Fund project.

Geachte Heer, Mevrouw,

Met dit schrijven informeer ik u dat het Ministerie van Openbare Werken, Transport en Communicatie, met ondersteuning van de Inter-American Development Bank (IDB), bezig is met de voorbereiding van een projectvoorstel voor renovatie van de waterkant tussen Knuffelsgracht en Waaggebouw.

Als onderdeel van dit projectvoorstel worden er interviews afgenomen met alle belanghebbenden die mogelijk tijdelijke hinder zullen ondervinden van de voorgestelde projectwerkzaamheden. Het gaat hierbij voornamelijk om winkeliers, eigenaars van horeca gelegenheden, bushouders, en boothouders bij Plattebrug.

De interviews zullen afgenomen worden gedurende de maand mei 2018, door medewerkers van het ingenieursbureau ILACO en het onderzoeksbureau Social Solutions.

Het Ministerie van Openbare Werken, Transport en Communicatie verzoekt u, als belanghebbende, om uw medewerking aan dit onderzoek.

Bij voorbaat dank voor uw tijd en inzet.

De Directeur van het
Directoraat Civieltechnische Werken,

Dhr. S. Soman BSc.

Letter from OWTC Indicating the Cut-off Date

MINISTRY OF PUBLIC WORKS, TRANSPORT & COMMUNICATION

DIRECTORATE OF CIVIL TECHNICAL WORKS

Mr. Jagernath Lachmonstraat no. 167

Paramaribo-Suriname Tel: 464088

To : Mr. Cesar A. Falconi
Country Representative of the
Inter American Development Bank
Peter Bruneslaan 2 - 4
Paramaribo

Paramaribo, May-7-2018

Ref.no. : SS/ODN/SM /Ag. No.1929
Enclosures : (-)
Subject: Adaptation Fund Programme
Stakeholder Survey approval

Dear Sir,

To continue the preparatory works for the project application to the Adaptation Fund, for the rehabilitation of the Waterfront in Paramaribo, we have no objections on the format to be used for the stakeholder survey for Waterkant regarding the Livelihood Restoration Plan (LRP).

The consultants ERM\ Ilaco can continue with the scheduled survey starting from the 14th of May 2018.

With regards,

Mr. S. Soman
Permanent Secretary of the
Directorate of Civil Technical Works

c.c.: PS CTW\ Mr. W. Lackin\ Ilaco Suriname

ILACO SURINAME N.V.				
Datum 8-5-18				
AAN	GEZ	DAT	KOPIE	VERZ
RP	R	8/5		
VOLG NR 114				
DOSSIER [illegible]				

Survey Form

REPUBLIC OF SURINAME

STAKEHOLDER SURVEY VOOR WATERKANT LRP

FORM NUMBER:

0. ALGEMEEN

A. SOORT ONDERNEMING		
PG Bus = 1	Bar / Restaurant = 4	
Lijn 4 Bus = 2	Winkel = 5	
Boot taxi = 3	Taxi (auto) =6	
	Anders (specify) = 77	

B. GENERAL INFORMATION INTERVIEW					
B.1	Naam Respondent		B.4	Interviewer	
B.2	Telefoon nummer		B.5	Supervisor	
B.3	Plaats van interview				

C. CONTROL DATA							
INTERVIEW POGINGEN							RESULTAAT CODES
VISIT		DAG	MAAND	JAAR	RESULT	COMMENTAAR (INDIEN WEIGERING OF GEDEELTELIJK, GEEF REDEN)	COMPLEET 1
C.1	1						GEDEELTELIJK COMPLEET 2
							WEIGERING 3
C.2	2						NIET GEVONDEN 4

1.A. GEGEVENS VAN ALLE PERSONEN DIE EEN INKOMEN VERDIENEN IN DEZE ONDERNEMING/BUSINESS

LEG UIT: Ik zou u informatie willen vragen over alle arbeidskrachten binnen uw onderneming; dwz iedereen die een inkomen verdient door het bezit van kapitaalgoederen en/of het uitvoeren van werkzaamheden.

INTERVIEWER: Begin met het invullen van vraag 1.01 en 1.02 voor alle arbeidskrachten. Vul daarna de rest van de vragen in per arbeidskracht, waarbij je rij voor rij de vragen stelt.

PERS. CODE	1.01 VOOR EN ACHTERNAAM	1.02 GESLACHT	1.03 LEEFTIJD	1.04 ETHNISHE GROEP		1.05 PRAAT NEDERLANDS?	1.07 HOOGSTE **AFGERONDE** OPLEIDING	
	ENUMERATOR: Registreer ALLE mensen die een inkomen verdienen aan deze onderneming. De eerste persoon (PC=1) is de eigenaar.	Vrouw = 0 Man = 1	Onb. leeftijd<18 =999 Onb. leeftijd volw. = 888	Hindustaan = 1 Creool = 2 Inheems = 3	Marron = 5 Javaan = 6 Anders (spec.) = 77	Helemaal niet = 0 Beetje, niet vloeiend = 1 (Bijna) vloeiend = 2	Niets = 0 Lagere school = 1 LBO / LTS etc= 3	MULO = 4 WN=99 VOS (Havo/VWO) = 5 Anders (specify) = 77
1								spec:
2								spec:
3								spec:
4								spec:
5								spec:
6								spec:

FORM NUMBER:

1.B. WERKZAAMHEDEN VAN ALLE PERSONEN DIE EEN INKOMEN VERDIENEN IN DEZE ONDERNEMING/BUSINESS

LEG UIT: Zou u me informatie kunnen geven over de specifieke taken van de verschillende personen die u zojuist genoemd heeft?

INTERVIEWER: Gebruik de persoonscodes van 1A om de rest van de vragen voor elke werker in te vullen, rij voor rij.

PERS. CODE	1.08	1.09	1.10		1.11		1.12	1.13
	FUNCTIE/ WERK (Meerdere mogelijk)	BESCHRIJVING JOB	LID VAKBOND/BEROEPSGROEP		ANDER WERK DAT [PC] DOET [PC]		[PC] VERDIENT BELANGRIJKSTE INKOMEN IN HH	AANTAL PERS. DAT AFHANKE- LIJK IS VAN [PC]
	1 Vergunninghouder 2 Chauffeur 3 Assistant/hulp 4 Eigenaar van vermogen/middelen 66 Anders SPECIFY	Beschrijf in het kort de taken die [PC] vervult	0 Geen lid van vakbond/groep 1 PLO 2 OBS	66 = Anders SPECIFICEER	0 1 2	Geen ander werk Werk in informele sector (SPECIFY) Formeel werk (SPECIFY)	0 Nee 99 WN 1 Ja	AANTAL
1				Spec:		Spec:		
2				Spec:		Spec:		
3				Spec:		Spec:		
4				Spec:		Spec:		
5				Spec:		Spec:		
6				Spec:		Spec:		
7				Spec:		Spec:		

1.C INKOMSTEN VAN ALLE PERSONEN DIE IN DEZE ONDERNEMING/BUSINESS WERKEN

LEG UIT: Zou u me informatie kunnen geven over de inkomsten van de verschillende personen die u zojuist genoemd heeft?

INTERVIEWER: Gebruik dezelfde persoonscodes als in 1A, om de rest van de vragen voor elke werker in te vullen, rij voor rij. **De vragen gaan over het jaar 2018: de maanden januari-april.**

PERSON CODE	1.14			1.15	1.16	1.17	1.18	1.19
	Tijdens het werk als een [JOB] in dit jaar (2018), wat verdiende [PC] per periode? Periode is bv dag, week of maand.		Voor (Bruto) of Na (Netto) aftrek van kosten?	Tijdens het werk als [JOB], in een normale week, hoeveel dagen per week werkte [PC]??	In het werk als [JOB], hoeveel weken per maand werkte [PC]??	In het werk als [JOB]. Hoeveel maanden heeft [PC] gewerkt in 2018?	ALLEEN MENSEN DIE NIET DE VERGUNNINGHOUDER/EIGENAAR ZIJN: Wat waren in 2018 de gemiddelde weekelijkse uitgaven van [PC] om zijn/haar werk als [JOB] te kunnen doen?	Heeft [PC] deze week gewerkt? 0 = Nee, REDEN: 1 = Ja
	SRD	dag/week/maand	Bruto / Netto	AANTAL DAGEN	AANTAL WEKEN	AANTAL MAANDEN	SRD	
1								
2								
3								
4								
5								
6								

2. VRAGEN OVER DE ONDERNEMING

ALLEEN VOOR VERGUNNINGSHOUDERS VAN BUSSEN EN BOTEN

2.01 **Is/zijn uw bus(sen) of boten geregistreerd bij OWTC? Zo ja, kunt u me dan het registratienummer geven?**

0 Geen geregistereerde bus / bussen /boot /boten **PG of Lijn 4 of boot**

Reg nr: ______________________ PG / Lijn 4 / Boot

Reg nr: ______________________ PG / Lijn 4 / Boot

Reg nr: ______________________ PG / Lijn 4 / Boot

Reg nr: ______________________ PG / Lijn 4 / Boot

Reg nr: ______________________ PG / Lijn 4 / Boot

INTERVIEWER: ONDERSTAANDE VRAGEN ZIJN VOOR DE VERGUNNINGHOUDER EN/OF EIGENAAR VAN DE ONDERNEMING

2.02 **Wat voor eigendoms- of gebruikstitel heeft u op de belangrijkste kapitaalgoederen die deel uitmaken van deze onderneming (bus, boot of bedrijfspand)?**

1 Goederen alleen eigendom van de respondent ; GA NAAR 2.10

2 Eigendom gehuurd van .... (SPECIFY IN Q2.09)

3 Gedeeld eigendom, met 1 persoon, namelijk: ...... (SPECIFY IN Q2.09)

4 Gedeeld eigendom met meer dan 1 persoon, namelijk __________ persons (naar Q2.09)

5 Eigendom is bezit van de familie / een familielid (SPECIFY IN Q2.09)

6 Andere eigendomstitel / recht, namelijk: ____________________

2.03 Naam van de belangrijkste eigenaar of gedeelde eigenaar (NVT als er geen andere eigenaar is)

2.04 Wat is de waarde van de kapitaalgoederen die u bezit en gebruikt voor dit werk? (b.v "Indien u nu uw bus(sen) / boot / bedrijfspand zou verkopen, wat zou u hiervoor ontvangen?) WAARDE IN USD. GEBRUIK 1 USD = 7.5 SRD

2.10 In welk jaar bent u begonnen met uw onderneming/business?	Jaar:
2.11. Is uw bedrijf geregistreerd bij KKF?	0. Nee 1. Ja

RUIMTE VOOR AANTEKENINGEN

APPENDIX E:

Construction Health & Safety Plan

This Construction Health and Safety Plan (CHSP) provides a working template that will be used by the selected construction contractor (the Contractor) appointed by the Project Proponent (the Government of Suriname and the IDB). It details the typical requirements and focus areas for health and safety, however it is recognized that the selected Contractor will have their own policies and procedures that will need to be inputted to this plan. It also recognizes that as the Contractor develops the Project designs, this will influence how construction will be undertaken, and these aspects will need to be integrated into this plan. Text in red are sections of the CHSP which the Contractor needs to complete.

1. *Introduction*

1.1. Overview

This document is the Construction Health and Safety Plan (CHSP) for the Adaptation Fund for Urban Investments for the Resilience Program (the "Project"), a Category B Project, that focuses on the Paramaribo waterfront area and comprises three components:

- Construction of a new flood protection wall;
- Sommelsdijck Canal pump station and sluice gates rehabilitation; and
- Enhancement of mangroves.

The CHSP sets out the expectations of the Project Proponent (i.e., the Government of Suriname, GoS, and its partner, the Inter-American Development Bank, IDB) and defines how the Contractor will implement and manage environmental matters.

1.2. Objectives

The CHSP will ensure that the Project is delivered in full compliance with legal requirements, and ensures:

- All workers (including subcontractors are fully trained and experienced to do the tasks requested of them;
- Implements measures to eliminate hazards, and where elimination is not possible, puts in place controls to ensure that hazards and risks are mininmized to acceptable levels; and
- Ensures protection and well-being of the surround communities and visitors.

It is intended that through the implementation of this plan:

- Identified Hazards that may be encountered during the project;
- Assessments made to quantify the risk; and
- Control measures that require being introduced to minimize the risks.

The CSHP is a dynamic document that will change and develop throughout the project. The Plan will be reviewed monthly to ensure that the content reflects the needs of the project. Additionally, the Plan will be reviewed in the light of any unforeseen occurrence.

2. *Project Description*

This section needs to include specific details on the proposed works, duration relevant plans etc. The following provide guidance on what is needed.

- **Scope of Construction Works:** Description of the full range of construction works / activities proposed (e.g. clearing of land, placement of piles, filter rock, geotextile fabric and armour rock; installation of piles; etc.).
- **Description of the Construction (Disturbance) Footprint:** Full description of the existing land / marine areas that will be disturbed by the construction works and those immediately adjacent;
- **Timing of Works:** Provide a description of both the total duration of the works and the time of year they will occur. The latter would include consideration of expected climate during this time (e.g. anticipated rainfall / cyclone events, wind direction and speeds);
- **Site Plan:** The project site plan would clearly show the full extent of the proposed works area of the construction project. This would typically include a map with the full construction boundary and disturbance footprint marked clearly over a current aerial photograph (i.e. including all construction activities, associated laydown areas etc.). It would also include site specific information, for example the location of any important waterways or adjacent vegetation to be protected, national heritage listed areas, or the location of sediment and erosion traps, electrical services etc.

3. *Site Conditions and Requirements*

Details must be presented clearly in this plan related to existing site conditions, security and restrictions. This should cover items such as:

- Personal Protective Equipment Requirements - Safety footwear, dust masks, safety goggles, hi-vis vests appropriate gloves and hard hats will be provided and worn as set out by the specific work activities by all site operatives and visitors.
- Existing Services – The Contractor will take all reasonable precautions including carrying out cable detection to avoid contact with live services. This will only be undertaken by competent persons.
- Tree Protection - Temporary protective fencing will be installed if trees and/or vegetation is to be protected.

- Ground Conditions - A Site investigation has not been completed, but will be prior to works commencing and the results will be fed into this plan.
- Potential Risks to Construction Workers – to consider items such as:
- The concentrations of contaminants at the site are understood to be low and are unlikely to require measures beyond that required for health and safety purposes on a construction site. But suitable precautions should be in place.
- Health and safety measures for work in excavations and confined spaces below ground put in place.
- Management of water ingress into excavations, and suitable fencing and protection where excavations are open.
- Cross reference the requirements of the Construction Environmental Management Plan.
- Site security will be maintained during the construction phase. Fencing will be erected to form a secure construction site to prevent entry by children, members of the public, trespassers and vandals. Warning signage to be placed at strategic points on the perimeter fencing. Information signage to be placed at the site entrance.
- The Contractor will liaise with the local residents and businesses prior to any works being undertaken to make them aware of works taking place and address any concerns by these affected parties. Access to the work sites will have secure gates will prevent entry to unauthorised persons.
- Working hours will be generally 0800-1700 on weekdays, 0900-1400 on Saturdays. No works will be permitted on Sunday's or Bank Holidays.
- Priority will be given to maintaining continuous safe access.

4. *Policy and Systems*

Outline the Contractors policy and management systems for the Project.

5. *Project Roles, Responsibilities And Contacts*

All positions across the project have health and safety responsibilities. These vary in relation to duties described in Table 1, but everyone has a base level duty of care to manage health and safety and avoid accidents and incidents.

Table 1: Project Roles, Responsibilities and Contact Details

POSITION	RESPONSIBILITIES	LINE MANAGER	NAME	CONTACT DETAILS*
Project Manager				
Site Supervisor				
Health & Safety Manager				
HSE Representative				

6. Training, Awareness and Competency

Outline how health and safety training, awareness and competency will be delivered / assessed throughout the project, to ensure the relevant aspects of this CHSP are communicated to the project team and front line staff (including contractors and sub-contractors). Examples may include:

- Site Health & Safety Induction
- Daily Pre-Start Meetings
- Health & Safety Toolbox Talks
- Incident bulletins
- Sub-contractors kick-off meeting
- Contractor and client site kick-off meeting

The Contractor must also detail its organization and arrangements for the promotion of safety, health, and welfare. Overall responsibility for the site and its management will be the Contractor. On the first arrival at site, allowance must be made for:

- Site induction for individuals, which will include ''Site Safety Rules''.
- Mandatory Booking in and out of site (includes lunch and breaks).
- Registering workers with appropriate training and competency certificates where necessary.
- Providing inspection and other certificates for equipment and machinery to be used safely.
- Daily / weekly site briefing.
- Demonstrating how contractors will monitor safety and its duration and issuing copies of these reports to the Site Project Manager.
- Pre-existing health issues.

7. *Complaints*

A complaints procedure shall be outlined within the Contractor's safety management system and shall be available and used whenever a member of the public wishes to raise a complaint.

8. *General Monitoring Arrangements*

Safety standards will be monitored by the Contractor through:

- A continuous inspection process by the Site Project Manager is in force. A checklist for these inspections is included with the site safety records. These inspections will include all contractors working on the site and a report of all actions required will be given to the contractor's foremen with instructions to rectify non-conformance in a timely manner.
- Once per week the Site Project Manager or appointed representative will inspect fire equipment, first aid equipment (and replenish if necessary), registers and site documentation.
- Monthly by the Contract Manager or appointed representative, who will carry out an inspection of the site and produce a written safety inspection report for distribution.
- The scheduled progress meeting chaired by the senior Contractor representative will as part of agenda discuss health and safety reports, and relevant discussions between the Client, the Contractor and other relevant stakeholders.

9. *Emergency Procedures*

The Contractor shall document emergency procedures covering the following:

- On-site facilities and responsibilities e.g. First Aid kits and designated First Aiders.
- Escalation procedures for incidents and accidents.
- Numbers for local emergency services and details of nearby hospitals and other emergency needs.
- Site evacuation procedures and an Emergency Plan for different types of emergencies e.g. fire, flooding etc.
- Incident reporting requirements and accident investigation procedures.

10. Health and Safety Risk Management

This section will be completed by the Contractor to presents a summary of the key health and safety risks and controls that have been identified for the proposed construction project. The Contractor should determine what additional risks and proposed management controls are required based on their final design and work method statements. A project risk assessment or job hazard analysis for specific task(s) should be performed.

The following table template should be used for each of the following health and safety risks:

- Excavations
- Working over and on water
- Use of heavy plant and equipment
- Use of and Contact with Power Tools
- Working at Height
- Manual Handling
- Live Services
- Tag out procedures
- Noise, Vibration, and Dust
- Hot Works
- Confined Spaces
- Spills
- Traffic management and protection of neighboring communities/busineses.
- Storage of Waste Materials
- Temporary Works

Note that this is not an exhaustive list, and it would be expected that Contractor develop risk management strategies, controls etc. that suit the scale/nature of finalized construction project.

Contractor to develop risk management strategies, controls etc. that suit the scale/nature of finalized construction project.

Template

H&S RISK			
H&S Risk Identified			
Method statements and Risk assessment	Either detail here or refer to separate document		
Management Strategy			
		Responsibility	**Timing**
Control(s)			
PPE Requirements			
Performance Indicator(s)			
Monitoring			
Reporting			
Corrective Action(s)			

APPENDIX F:

Cultural Heritage Management Plan

This Cultural Heritage Management Plan (CHMP) provides a working template that will be used by the selected construction contractor (the Contractor) appointed by the Project Proponent (the Government of Suriname and the IDB). It details the specific mitigation requirements and focus areas identified through the Environmental and Social Impact Assessment, but also recognizes that the selected Contractor will have their own policies and procedures that will need to be inputted to this plan. It also recognizes that as the Contractor develops the Project designs, this may influence how construction will be undertaken and progress and these aspects will need to be integrated into this plan. Text in red are sections of the CHMP which the Contractor needs to complete.

1.0 Introduction

This CHMP has been prepared for the Project recognizing the rich heritage context of the Historic Inner City of Paramaribo, which was inscribed as a UNESCO WHS on 29 June 2002.

2.0 Baseline Conditions

The Project will include a series of adaptation components within the Historic Inner City of Paramaribo. At the time of nomination, the WHS consisted of 244 formally protected monuments (Figure 4 13). Approximately 50 percent of these monuments are located within the Designated Conservation Zone, and approximately 15 percent are located in two adjacent buffer zones. The Designated Conservation Zone and buffer zones comprise an area of approximately 90 hectares. In addition to monuments inscribed in the UNESCO WHS, the Conservation Zone includes monuments included on Suriname's national list of protected monuments.

The Project components are located within 150 m of nine listed monuments, including three monuments listed in the UNESCO WHS as shown in Figure 1:

- New Flood Protection Wall: The new flood protection wall would be within 150 m of seven listed monuments including the Monument of the Revolution listed monument and the UNESCO WHS-listed De Waag Building. The floodwall would be visible from all seven structures.
- Rehabilitation of the Sommelsdijck Canal Pump Station and Sluice Gates and enhancement of mangroves: The pump station is adjacent to two listed monuments: the UNESCO WHS-listed Fort Zeelandia complex and the Garden of Palms listed monument.

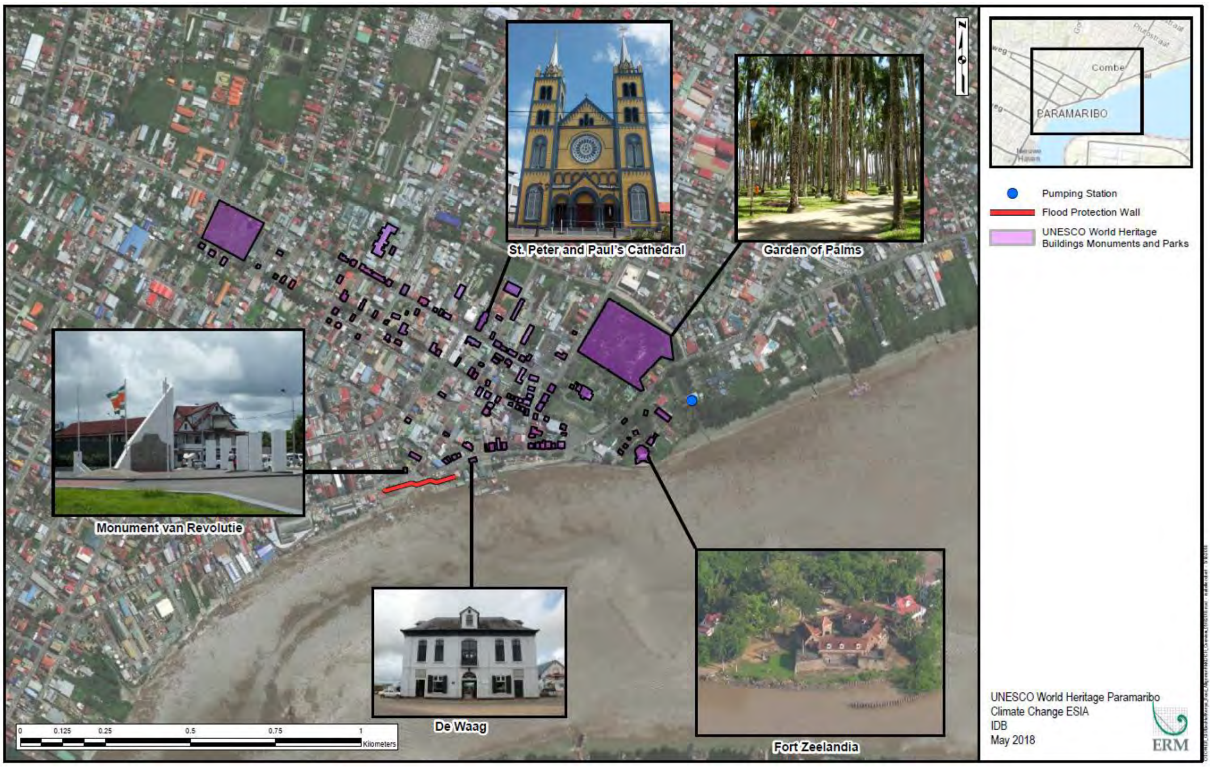


Figure 1: Listed Monuments and Proposed Project Components

According to the PWHSMP, approximately 400 known pre-Columbian archaeological sites are in Suriname. Of these, only a few are located in and around Paramaribo. Within the Paramaribo WHS, the only known pre-Columbian archaeological resources are at the waterfront. Additional resources are located at Kwatta, Charlesburg, and Blauwgrond, approximately 5 to 10 kilometers (km) from the inner city.

Urban archaeological resources can be found at construction sites within the historic inner city, and consists mostly of clay pipes, bottles, coins, brick foundations, and brick water cellars. Archeological resources preserved within standing historic structures include the remains of a fountain or pond under the floor of the St. Peter and Paul Cathedral (which dates back to the Jewish Theater building "The Resurrected Phoenix,") brick foundations of an earlier building constructed at Great Combe Road (Grote Combéweg) #2, and brick foundations of houses destroyed during the city fires of 1821 and 1832 (e.g., Waterfront 12). Several historic brick wells, cellars, and ovens have also been documented by the SBHF in Paramaribo.

As noted in the PWHSMP, there is the potential to find additional archaeological remains in the Paramaribo WHS associated with the first European inhabitants of Paramaribo, as well as the Indigenous settlement near the Garden of Palms. Due to the presence of Pre-Columbian and historic European archaeological resources within Paramaribo, any Project ground disturbing activities have the potential for uncovering previously undiscovered archaeological resources.

3.0 *Regulatory Background And Authority*

3.1 *Laws and Regulations*

Suriname has had legislation on the historic environment since the 1950s. This section provides a summary of relevant regulations, including those specifically addressing the WHS:

- The Monuments Act (1963, revised 2002): This was the first legislation that focused on the protection of built heritage that includes unique monuments and archaeological assets. This Act was revised in 2002. In the revision, the Act established the Monuments Committee. It also provides general guidance to maintain both designated historic monuments as well as city and town views. The International Council on Monuments and Sites (ICOMOS), Suriname Built Heritage Foundation (SBHF), and the Monuments Committee are collaborating on providing proposed revisions to the Act to accommodate the Paramaribo WHS.
- The Building Act (1958): This act oversees licenses for new construction and residential areas in Suriname.
- The Town Planning Act (1972): The Act established that the OWTC that is responsible for the execution of spatial planning and development of urban areas.
- The Planning Act (1973): The Act established that the Ministry of Planning and Development Cooperation is responsible for a comprehensive and sustainable policy for spatial, ecological, and socioeconomic issues.
- The Monuments List of Paramaribo: This list includes monuments that the Ministerial Resolution of Paramaribo has designated as protected.
- The State Resolution for Monuments Registration (2000): This Resolution registered all designated monuments as officially protected. The Monuments Committee maintains the register.
- The State Resolution for establishing an Aesthetic Building Committee (2001): This Resolution formally designated the Historic Inner City of Paramaribo as a conservation zone with two buffer zones. It also created the Building Committee, which supervises building plans. The Committee has the authority to evaluate building plans according to a special set of building criteria (building codes), which were published in 2003 to control new construction within the WHS and buffer areas.
- State Resolution on the implementation of Article 4, Section 2 of the Building Code of 1956: This Resolution was approved by the President of the Republic of Suriname in 2011 (S.B. 31 October 2011 No. 74). The resolution established an Expert Building Committee (Special Advisory Committee) to review new building plans within the site according to aesthetic criteria for modern architecture, which were published in the Gazette.

3.2 International Standards

Inter-American Development Bank

The IDB's Implementation Guidelines for the Environment and Safeguards Policy defines cultural sites as:

> *"Any natural or manmade areas, structures, natural features and/or objects valued by a people or associated people to be of spiritual, historical, and/or archaeological significance."*

This definition along with the definition provided in IDB Directive B.9 refers to ally physical or tangible cultural resources, whether found on land or in underwater settings.

The IDB's Technical Note *Managing the Impacts of IB Projects on Cultural Heritage* (N^0 IDB-TN-896) states that measures to avoid, minimize, or mitigate impacts to cultural heritage should be described in a Cultural Heritage Management Plan (CHMP). The CHMP should be integrated into the larger Project ESMP, but have its own separate timetable and budget. The CHMP should include the following elements:

- An overview of the cultural heritage baseline and impact assessment;
- The measures to be implemented to protect cultural property;
- Monitoring arrangements, including indicators to assess results and performance benchmarks; and
- Reporting requirements and any external audits that may be required.

In addition, the Implementation Guidelines for the Environment and Safeguards Compliance Policy, referring to Policy Directive B.9 states that, "Projects likely to encounter chance finds should develop and implement specific procedures to handle chance finds occurrences integrated into the Project's ESMP. The IDB Technical Note *Managing the Impacts of IB Projects on Cultural Heritage* includes the following requirements for an IDB Project Chance Finds Procedure:

- A formal protocol for the temporary cessation of construction work if a chance find should be encountered. The authority to halt construction should be incorporated into the construction and supervision contracts and subcontracts, and should clearly identify the persons or authorities that should be notified immediately upon the discovery of any possible archaeological or paleontological finds; and
- A protocol document, register, and protect to secure the site and the archaeological finds, including their proper storage and transportation. This should clarify the procedures to establish the ownership of finds. The protocol should also reference any

procedures that may be required when human remains are uncovered;
- Guidance and training for all workers and other employees engaged at the site; and
- Institutional coordination and communication mechanisms among the local and national authorities responsible for the protection of cultural heritage.

In areas with a high potential for chance finds, the IDB Technical Note *Managing the Impacts of IB Projects on Cultural Heritage* (N0 IDB-TN-896) recommends Project implement a project-specific, construction monitoring program staffed by a qualified, professional archaeologist(s).

International Finance Corporation Performance Standard 8

The principal international standard for the protection of cultural heritage is the IFC Performance Standard (PS) 8 (Cultural Heritage). The objective of PS 8 is to "protect cultural heritage from the adverse impacts of project activities and support its preservation…[and] promote the equitable sharing of benefits from the use of cultural heritage." PS 8 defines cultural heritage as:

i. tangible forms of cultural heritage, such as tangible moveable or immovable objects, property, sites, structures, or groups of structures, having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values;
ii. unique natural features or tangible objects that embody cultural values, such as sacred groves, rocks, lakes, and waterfalls; and
iii. certain instances of intangible forms of culture that are proposed to be used for commercial purposes, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles.

PS 8 differentiates between replicable, non-replicable, and critical cultural heritage, which are defined as follows:

- <u>Replicable Cultural Heritage</u>: Defined as "tangible forms of cultural heritage that can themselves be moved to another location or that can be replaced by a similar structure or natural features to which the cultural values can be transferred by appropriate measures. Archaeological or historical sites may be considered replicable where the particular eras and cultural values they represent are well represented by other sites and/or structures."
- <u>Non-replicable Cultural Heritage</u>: Includes "(i) cultural heritage [that] is unique or relatively unique for the period it represents;

or (ii) cultural heritage [that] is unique or relatively unique in linking several periods in the same site."

- Critical Cultural Heritage: Includes "(i) the internationally recognized heritage of communities who use, or have used within living memory the cultural heritage for long-standing cultural purposes; or (ii) legally protected cultural heritage areas, including those proposed by host governments for such designation."

The preferred mitigation measure for all cultural heritage impacts is avoidance. When this is not possible, PS 8 provides the following mitigation hierarchy (from preferred to least preferred) for replicable cultural heritage:

- Minimize adverse effects and implement *in situ* restoration measures;
- Restore the functionality of the cultural heritage in a different location;
- Permanent removal of historical and archaeological artifacts following national laws and internationally recognized practices by competent professionals; and
- Compensation for the loss of cultural heritage.

The removal of non-replicable cultural heritage should only take place if there is no technically or financially feasible alternative and the benefits of the project outweigh any heritage losses. The removal of critical cultural heritage should only take place in "exceptional circumstances" and after extensive consultation with affected communities and other stakeholders.

PS 8 also requires the development and implementation of chance find procedures. Chance finds are defined as "tangible cultural heritage encountered unexpectedly during project construction or operation," and a Chance Find Procedure is defined as "a project-specific procedure that outlines the actions to be taken if previously unknown cultural heritage is encountered." The requirement is a recognition of the fact that no survey, regardless of methodology, is sufficient to ensure that all archaeological resources are identified in a project area, and that there is therefore always the potential for the inadvertent discovery of cultural heritage during ground-disturbing construction or operational activities.

According to the IFC Guidance Note 8, the Chance Find Procedure should "include record keeping and expert verification procedures, chain of custody instructions for movable finds, and clear criteria for potential temporary work stoppages that could be required for rapid disposition of issues related to the finds. It is important that this procedure outlines the roles and responsibilities and the response times required from both project staff, and any relevant heritage authority, as well as any agreed consultation procedures. The procedure should be incorporated into the Management Program and implemented through the client's Environmental and Social Management System."

4.0 Mitigation/Enhancement Measures And Residual Impacts

As described in the Project's ESIA, construction of Project components would have negligible impacts to the UNESCO WHS. However, as a precautionary and proactive step, the Project proponent will consult with the following cultural heritage stakeholders:

- UNESCO WHC
- ICOMOS
- Expert Building Committee or Special Advisory Committee
- Suriname Department of Culture
- The SBHF formed to implement the PWHSMP

These consultations should focus on developing management plans and measures to avoid or minimize short-term Project impacts to the Paramaribo WHS. Implementation of approved plans would result in residual impacts of negligible significance. They should be undertaken in conjunction with the Ministry of Education, Science, and Culture (MINOWC).

Given the sensitive nature of the area and its rich heritage and archaeological sensitivity, the Project will also implement a Chance Finds Procedure, which will be adopted by the Contractor who undertakes the work. Section 5.0 describes this procedure.

5.0 Chance Finds Procedures

5.1 Construction Monitoring

The Contractor will implement a cultural heritage construction monitoring program for all ground disturbing activities in consultation with national level authorities and other key stakeholders. The purpose of this monitoring is to:

- Identify, record, and protect cultural heritage that was not identified during baseline studies and other pre-construction phase cultural heritage investigations (i.e., chance finds); and
- Protect cultural heritage identified during baseline studies and other pre-construction phase cultural heritage investigations (i.e., known resources).

The program will utilize "active" and "passive" forms of cultural heritage construction monitoring. Active construction monitoring will be conducted in areas of known cultural heritage resources (e.g., the archaeological “lots” described above) and in areas that have not been previously surveyed for cultural heritage. Active construction monitoring will be conducted by a cultural heritage specialist or specialists (CHS) that meet the professional qualification standards of the Suriname government and international cultural heritage organizations. The CHS will actively monitor construction activities and inspect construction sites in specified areas with the sole purpose of identifying previously undiscovered cultural heritage resources.

Passive cultural heritage construction monitoring will be conducted in areas that have been previously surveyed for cultural heritage and where no cultural heritage resources have been found. Passive cultural heritage monitoring will be conducted by all the Project proponent, contractor, and subcontractor staff during their daily activities. All Project staff will receive training in the identification of potential chance finds and the chance find procedures and will be responsible for reporting any potential chance finds.

5.2 Identification, Assessment, and Treatment of Potential Chance Finds

Chance finds may be made by anyone on the Project, including archaeologists, architectural historians, non-cultural heritage site workers, and visitors or guests.

The Chance Finds Procedure will use a multi-tiered approach for identifying, assessing, and resolving potential chance finds. The purpose of this approach is to empower cultural heritage monitors in the field to resolve minor chance finds without necessitating consultations with national level authorities and minimize construction delays by allowing for the quick resolution of non-significant finds by a CHS in the field. The defining characteristics of each chance find tier and the processes for assessing them and determining if consultation is required will be developed in consultation with the Government and other cultural heritage stakeholders, as appropriate. A preliminary three-tiered chance finds hierarchy is presented in Table 1. All potential chance finds identified by Project personnel will be reported to a CHS who will determine if the potential find is a chance find and assign it to a chance finds tier. Figure 1 provides a detailed description of the Chance Find Procedure.

Table 1: Three-tiered Chance Find Hierarchy.

Chance Find Type	Characteristics	Evaluation Process
Minor Chance Finds	Modern features or objects. Isolated historic or prehistoric artifacts that are out of context or lack research potential or value.	Construction work will stop in the area of the find. If a CHS is not present, the potential find will be reported to a CHS. The CHS will determine if a site visit is necessary. If a CHS is present or determines a site visit is necessary, the find will be documented and collected/resolved in the field by the CHS without MINOWC consultation. Construction activities will then resume in the area.
Potentially Significant Chance Finds	Potentially significant historic or prehistoric features or artifacts.	Construction work will stop in the area of the find. If a CHS is not present, the potential find will be reported to The Project proponent (if found by a contractor) and a CHS within 24 hours. The CHS will then conduct a site visit. If the find is determined to represent a potentially significant chance find, the CHS will develop a treatment plan. The find will be reported to the MINOWC within 15 days and the CHS will consult with the MINOWC regarding the treatment plan.
Human Remains	Modern, historic, or prehistoric burials, isolated human remains, and/or associated features and/or artifacts (i.e., grave goods).	Construction work will stop in the area of the find. If a CHS is not present, the potential find will be reported to a CHS. The CHS will report the find to stakeholders, including local, regional, or national law enforcement agencies. The CHS will initiate consultation with the MINOWC and other stakeholders (e.g., potential descendent communities), as appropriate, to develop a treatment plan. Construction works will resume in the area upon completion of the treatment plan.

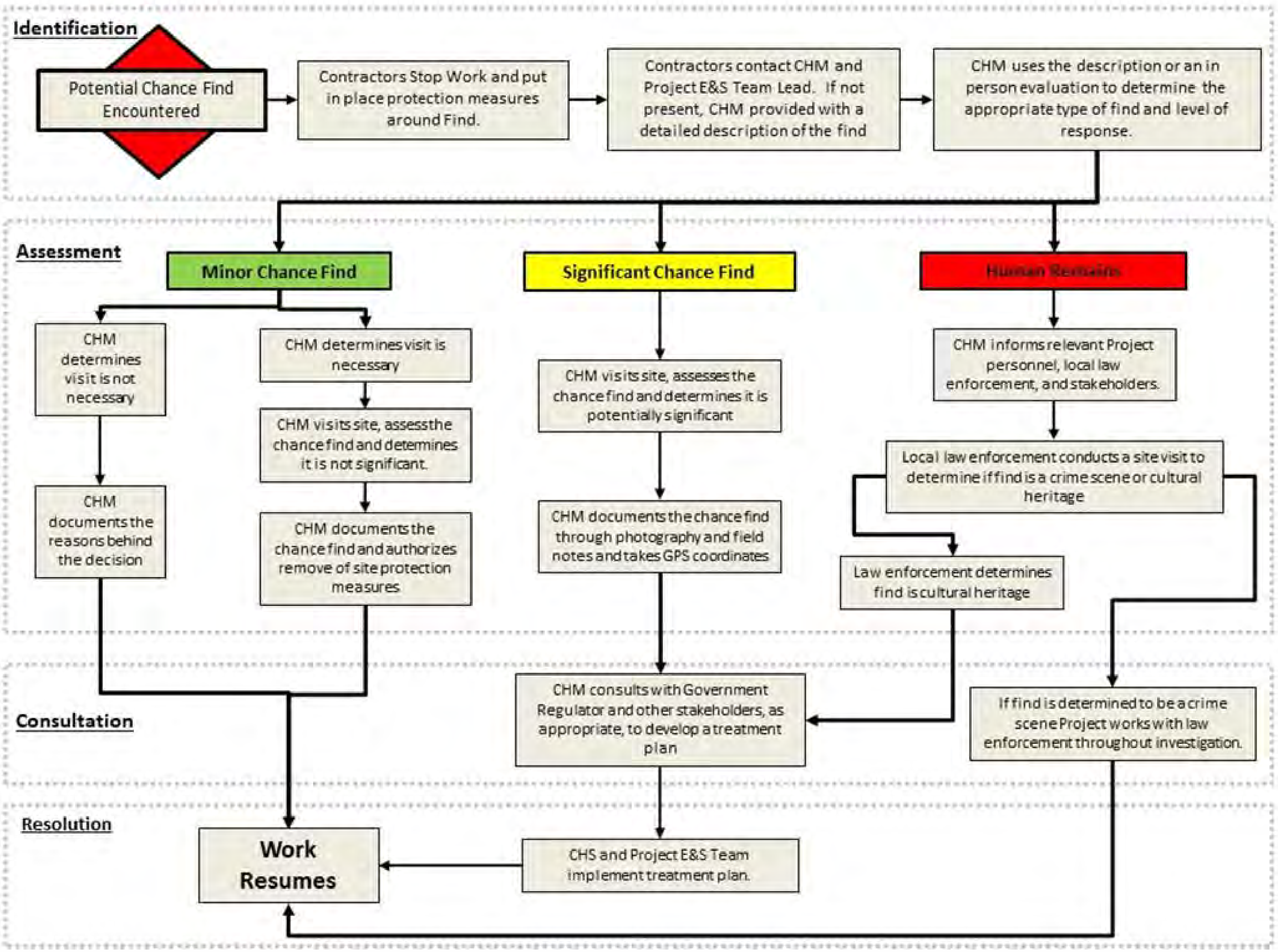


Figure 1: Chance Finds Procedure

Artifacts collected in connection with chance finds should be minimized. Terrestrial chance finds retained because they are accidentally unearthed or broken free of their soil matrix should be retained. If the CHS is not present, terrestrial chance finds that have broken free of their soil matrix should be retained by the contractor or The Project proponent project personel who uncovered the chance finds. Precise notation of the original location of the finds, with photographs taken of their original context, should be taken by the contractor or The Project proponent project personel who uncovered the find. Artifact photos and site photos may be useful for consultation regarding chance finds and should be taken as soon as possible. Details of how the artifacts should be collected and stored, notes and photographs taken at the time of discovery will be provided in the CFP training.

Artifacts and associated notes and photographs taken by any Project personnel should be given to a CHS as part of the CHS evaluation of the find. The artifacts belong to the Government of Suriname, and the CHS will be responsible for giving them to the MINOWC. Treatment plans to be considered for terrestrial chance finds include preservation in place through avoidance or specialized construction techniques, collection after recordation, and rescue excavations in advance of additional construction work if avoidance is not possible. Only after all treatment work is agreed and any required excavations are carried out is project activity allowed to resume in the area.

Underwater chance finds retained because they are accidentally brought to the surface should be immediately placed in a container filled with sea water from the area of the chance find and maintained there indefinitely, as exposure to the air can cause artifacts that have been underwater to decompose or oxidize very rapidly. In the absence of the CHS, placing artifacts in a container filled with sea water from the area of the chance find will be the responsibility of the contractor or The Project proponent project personnel. Artifact photos should be taken as soon as possible. Artifacts and associated notes and photographs taken by any Project personnel should be given to the CHS. Details of how the artifacts should be collected and stored, notes and photographs taken at the time of discovery will be provided in the CFP training.

5.3 Record Keeping

In order to align the CFP with IFC PS 8 guidance regarding CFP record keeping, the CHS and The Project proponent non-cultural heritage staff, contractors, and subcontractors will be required to maintain records on monitoring, chance finds, and the implementation of treatment plans. These will include:

- Daily monitoring records indicating areas and activities monitored, chance finds identified, the results of any chance find assessments, and communications and instructions (such as stop work and resume work);
- Monthly reports summarizing reporting period activities, including chance finds identified, the results of any chance find assessments, internal and external communications and instructions, and supporting photographic documentation (or other reference materials as appropriate); and
- Any additional reports prepared to fulfill specific requirements of the MINOWC.

5.4 Cultural Heritage Training Program

All Project personnel are required to receive training and demonstrate competency in the identification of chance finds and chance find procedures (i.e., actions that are required in the case of a potential chance find). This training will be incorporated into the overall induction process for The Project proponent, contractor, and subcontractor personnel, and will include a quick reference handout. The Project will maintain records of all cultural heritage trainings provided to Project personnel.

All employees must be aware that it is illegal and forbidden to disturb or remove cultural heritage objects offsite for personal gain. Disciplinary action will be taken against any personnel who violate this requirement. To support the training process, the Project proponent will develop training materials for use in the overall induction process.

5.5 Site Protection

Known cultural heritage sites will be protected from Project-related damage. This includes sites identified in advance of construction activities and those found during construction (i.e., chance finds). Sites may be located in Project areas or adjacent to them. Site protection measures may include warning signs, physical barricades, or other visual indicators of areas of high cultural heritage sensitivity. In some cases, it may be necessary to modify construction techniques to protect sites in work areas. Site information will be provided to Project personnel in written and verbal form in official transmittals, meetings, and tool box talks as appropriate to ensure that known cultural heritage sites are protected.

6.0 Contacts

Contractor to insert relevant details

APPENDIX G:

Hazard and Risk Management Summary

1. *Introduction*

The IDB, in conjunction with the Government of Suriname, prepared and submitted a concept note proposal to the Adaptation Fund to finance the development of a series of projects that would contribute towards increasing the adaptive capacity of communities living in Paramaribo city and the adjacent urban areas to cope with observed and anticipated impacts of climate change on floods and sea level rise. The main objectives of this study were to implement a group of strategic and cost-effective hard adaptation measures in the historic downtown area of Paramaribo that illustrate the benefits of building climate resilience as part of a long-term planning strategy for the city and its metropolitan area. It will also establish a framework for managing knowledge and disseminating lessons learned that could be used in future resilience programs for the city of Paramaribo and that could be part of a city-level Adaptation Plan.

As part of this overall strategy, an extensive site-specific risk analysis related to flooding in the historic center of Paramaribo (Study Area) was conducted (see Figure 1 below). Physical hazards due to flooding from extreme climate events were calculated which were then used to estimate vulnerability based on asset, population density, and land use information. Maximum water levels and precipitation for 10-, 25-, 50-, and 100-year return periods were used to inform this analysis as well as future climate change projections. The physical hazards from flooding were evaluated using high resolution numerical modelling of the Study Area and estimating risk using analytical approaches developed by ERM along with a geospatial data analysis (GIS) system. In addition to the baseline flood assessment of the Study Area, a flood modelling study was conducted by applying infrastructure improvement alternatives to evaluate the effectiveness of these alternatives as well as assess the need for additional flood management measures.

Figure 7: Study Area

Figure 8: Study Area Showing Monumental Assets and Social Receptors

2. *Methodology*

The analysis was performed using HEC-RAS and FLO-2D models, which are approved by the U.S. Federal Emergency Management Agency for delineating flood hazards, regulating floodplain zoning and designing flood mitigation in riverine as well as urban systems. These models were used to estimate the likely occurrence of flooding hazards within the Study Area for 10-, 25-, 50-, and 100- year return periods using site-specific data collected from various Surinamese institutions, published reports and site visits. A probabilistic inland flood hazard analysis was performed using historic precipitation data to obtain Intensity Duration Frequency (IDF) distribution during wet season using a nearest neighbor weather generator tool. Similarly, probabilistic coastal flood hazard analysis was performed using Highest Water Levels (HWLs) obtained for various return periods in the Suriname River near the Study Area. Similar inland and coastal flooding analysis was also conducted for future years (2020, 2050 and 2080) using climate change projections for precipitation (derived new IDFs for climate change years) and sea level rise obtained from Regional Climate Models driven by HadAM3 and ECHAM4. A series of both inland and coastal flooding hazard maps of the Study Area and the Canal were created for the subsequent socio-economic risk analyses that resulted in the development of economic and population risk maps that quantified damages in terms of financial loss and population affected in the Study Area.

3. *Results*

Analysis of flood modelling results show that in the Study Area, most of the flooding occurs due to HWLs in the Suriname River caused by storm surges occurring at spring high tide conditions. The baseline simulations clearly show that flooding in the Study Area begins at the low ground elevation level of the Waterkant Street and Paramaribo Central Market, spreads inland and then expands east and west of the Water Taxi area towards the existing flood wall (see Figures 3-6 below). The ground elevation near the Fort Zeelandia and the Van Sommeldijckse Canal area well above the 100-yr baseline HWL resulting in no flooding. Inland flooding in the Study Area is caused by precipitation and water logging shows up in various regions, spread out sporadically with more inundation occurring along the Van Sommeldijckse Canal (see Figures 7-9 below). The inland flooding happens due to overflow from the drainage system at the Canal and various manholes in the street and non-operating condition of sluice gates and pumps at Knuffelsgracht Steet and near Central Market.

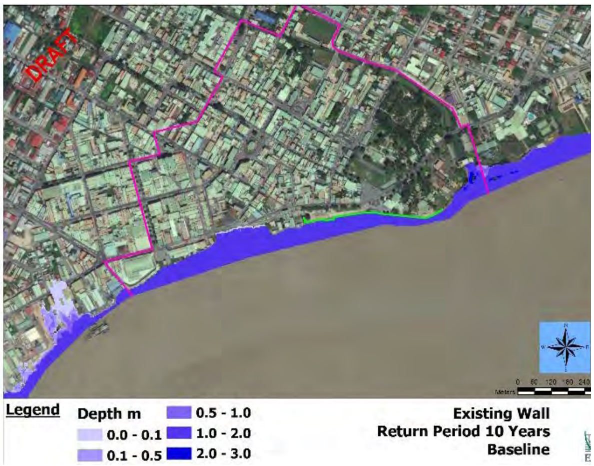


Figure 3: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 10 year return period

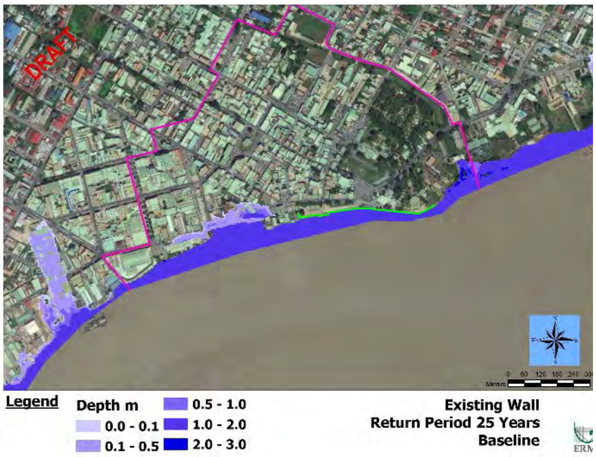


Figure 4: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 25 year return period

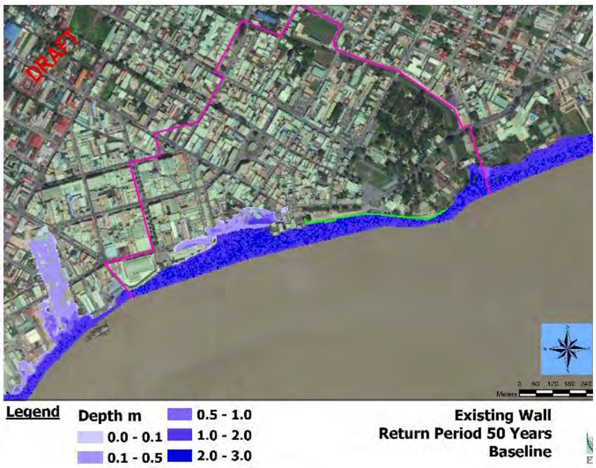


Figure 5: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 50 year return period

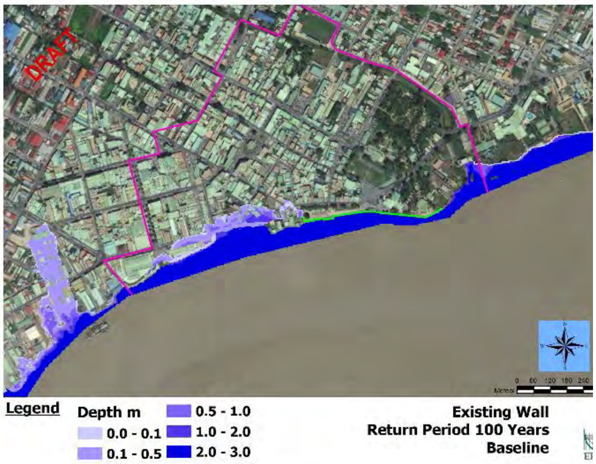


Figure 6: Coastal flooding inundation map of the Study Area with the existing flood wall for the baseline scenario at 100 year return period

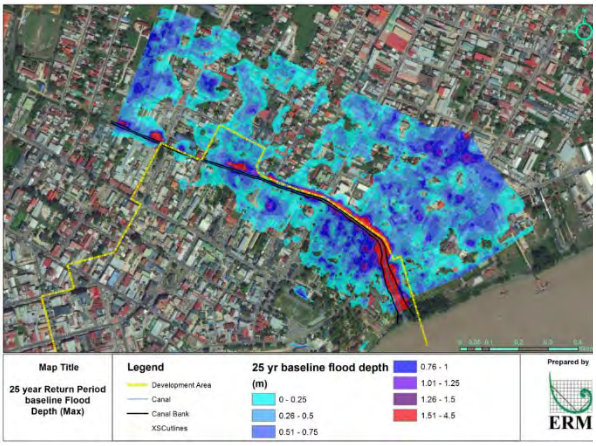


Figure 7: Inland flooding map, including canal water overflow for the baseline scenario at 25-year return period

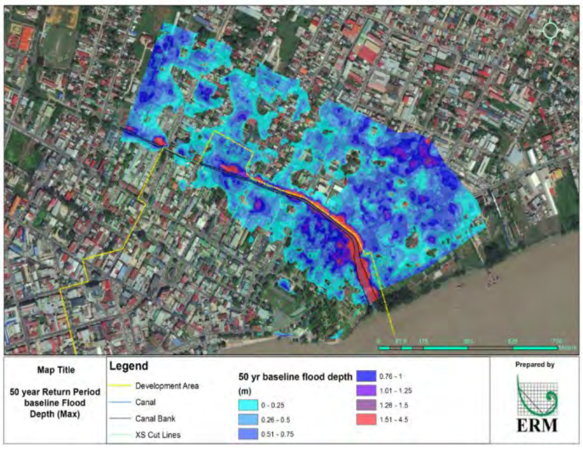


Figure 8: Inland flooding map, including canal water overflow for the baseline scenario at 50-year return period

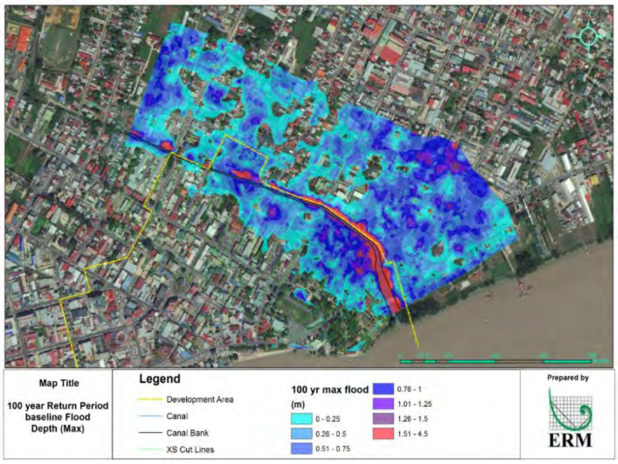


Figure 9: Inland flooding map, including canal water overflow for the baseline scenario at 100-year return period

With climate change, coastal flooding occurs more frequently causing more damage and disruption due to sea level rise. As sea level rises, coastal flooding events shift from being minor to more extensive, resulting in more damages. Sea level rise occurrence is a slow, multi-decadal process that alone results in gradual coastal erosion, subsidence and saline intrusion. However, when we use extreme value theory to combine sea-level projections with wave, tide and storm surge, the intensity and frequency of coastal flooding increases to a catastrophic level (due to gradual destabilization of the coastal region by sea level rise being impacted by extreme flood waves). Even regions with limited water-level variability will be subjected to unusual flood events. This can be clearly seen in the hazard maps of the Study Area developed for climate change scenarios at various return periods (Figures 10-16 below). Areas inundated with 0.0 m to 0.5 m of water correspond to low hazard; areas inundated with 0.5 m to 1.0 m of water correspond to medium hazard and areas inundated with greater than 1.0 m of water tend to correspond to high hazard levels. The general coastal flooding pattern remains the same near the

Water Taxi area for future years due to climate change. However, the flooding spreads to a larger region on the east and west of the Water Taxi area resulting in more inundation along the rear of the existing flood wall. In addition, more flooding happens in the Fort Zealandia area and on either side of the Van Sommeldijckse Canal for future years due to climate change. This happens because of the limited storage and drainage capacity of the Canal, and small-sloped flood plain regions on either side of it. There is not much change in the inland flooding for future years because of small percent increase in precipitation due to climate change.

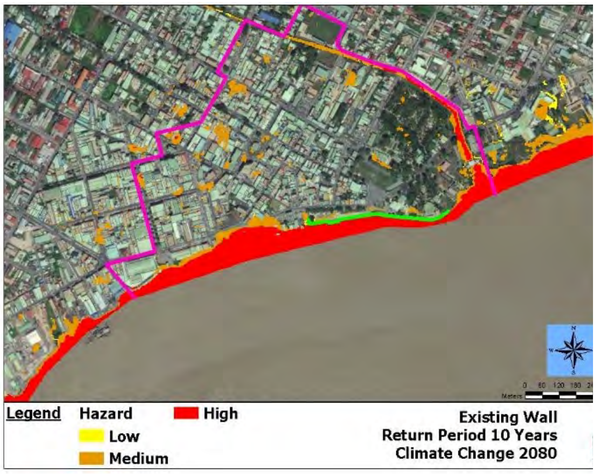


Figure 10: Coastal and inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 10-year return period

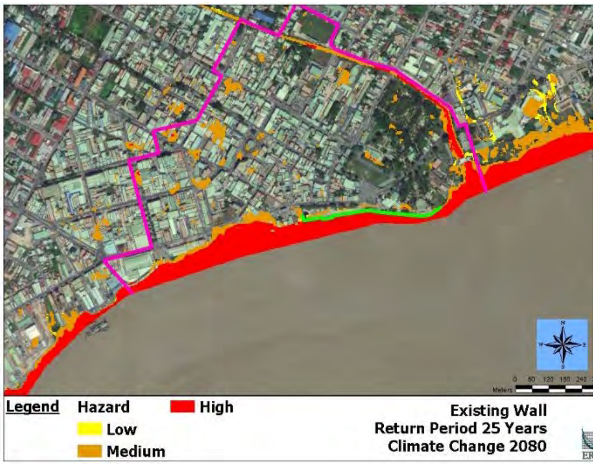


Figure 11: Coastal and inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 25-year return period

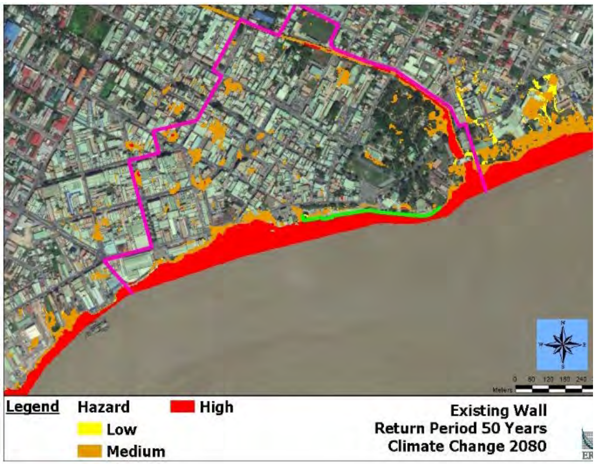


Figure 12: Coastal and inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 50-year return period

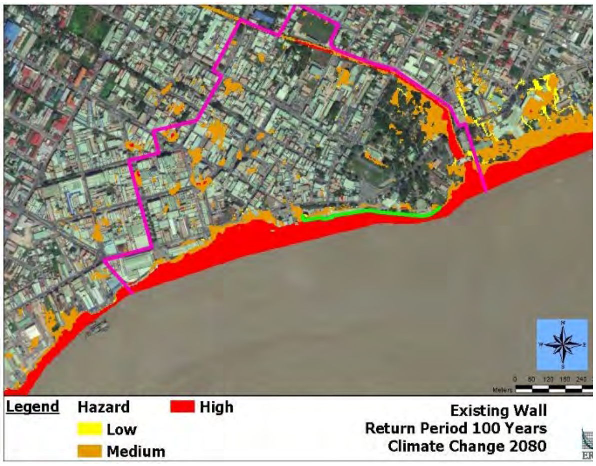


Figure 13: Coastal and inland flooding hazard map of the Study Area with the existing flood wall for the climate change 2080 scenario at 100-year return period

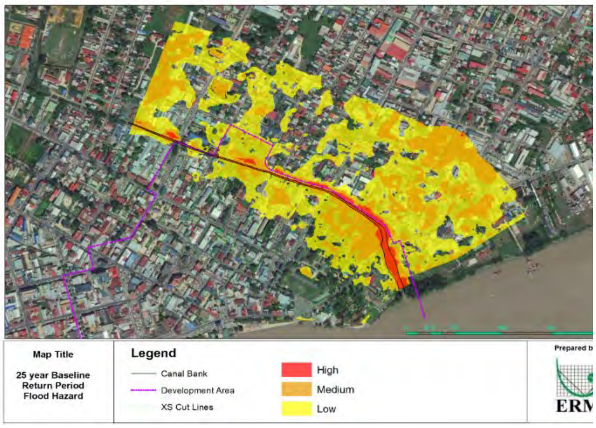


Figure 14: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 25-year return period

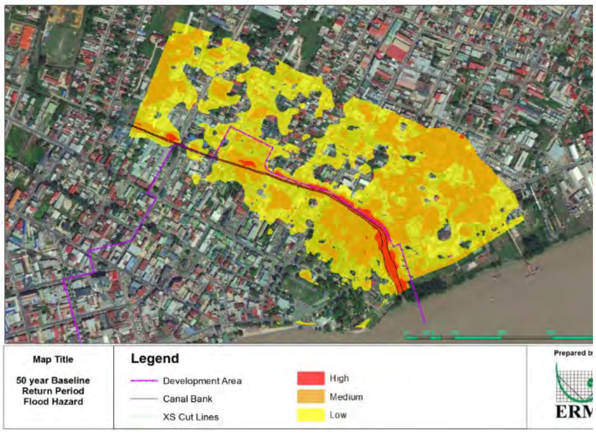


Figure 15: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 50-year return period

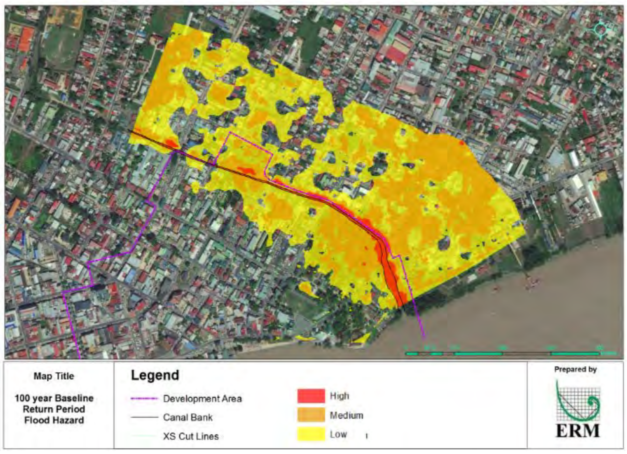


Figure 16: Flooding hazard map of the Canal and its surroundings for the climate change 2080 scenario at 100-year return period

Based on the current study, we can conclude that two important topographical features of the riverbank controls the coastal flooding dynamics in the Study Area: 1) the inland elevation and 2) the inland slope. The first one restricts the onset of flooding and the second one restricts the spread of flooding. For inland flood dynamics, slope initiates the flooding (run off) and low infiltration and inefficient natural and constructed storm water drainage system spreads the flooding resulting in human and property risks. The current study results clearly show that the most of the flooding in the Study Area is caused by the combined influence of storm surge, tides and sea level rise, using extreme value theory. In addition, the impact from an increase in sea level rise, overlaid even on a typical storm surge is much larger than the corresponding increase in extreme precipitation resulting in less inland flooding as compared to coastal flooding.

A literature review of various studies conducted elsewhere on coastal adaptation measures shows that there is no single solution is possible to address various flooding events analyzed in this study. Because of this, a range of various adaptation solutions were selected to address the different mechanisms of flooding which occurs at various locations in the Study Area. These adaption measures were selected to address the two key critical areas (one near the Water Taxi area and the other near the Fort Zeelandia and the Van Sommeldijckse Canal area) that are identified to be prone to flooding. A set of 14 site-specific alternatives were identified and were evaluated in detail using a scoring method based on criteria that were classified into four main categories: 1) Technological achievement, 2) Socio-political achievement, 3) Environmental achievement and 4) Programmatic achievement (see Table 1 below).

Table 1: Site-Specific Alternatives

Technology/Alternatives	Site-Specific Alternative
Regulations and Policies	Alternative 1: Government policy, zoning, and land use options
New Flood Protection Wall	Alternative 2: New flood protection wall from Knuffelsgracht Street to SMS Pier
Rehabilitate Existing Old Retaining Wall	Alternative 3: Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal
Rehabilitation –Existing Flood Control Mechanicals	Alternative 4: Rehabilitate Van Sommelsdijck pumping station and sluice gates
	Alternative 5: Rehabilitate sluice gate and pumping station at Knuffelsgracht Street
	Alternative 6: Rehabilitate Jodenbree Street sluice gate near Central Market
Rehabilitate Drainage System	Alternative 7: Rehabilitate Van Sommelsdijck Canal
	Alternative 8: Rehabilitate drainage system along Waterfront between Knuffelsgracht and SMS Pier
	Alternative 9: Improve Viotte Kreek drainage system
Shoreline Erosion Protection/ Stabilization	Alternative 10: Riprap/gabions/ articulated concrete blocks along shoreline
	Alternative 11: Create buffer with enhanced mangrove plantings
Stormwater Retention and Release	Alternative 12: Install underground stormwater retention system
	Alternative 13: Construct aboveground stormwater retention and release system
	Alternative 14: Construct permeable pavements or similar alternatives to impervious surfaces

Based on the scoring analysis, the following set of preferred adaptation measures were considered for the development of alternative groups (see Figure 17 below for a depiction of alternatives 2 and 3).

1) Alternative 2 - New flood wall immediately east of Knuffelsgracht Street and Waterkant Street intersection along the bank of Suriname River to address both the baseline and future flooding in these areas

2) Alternative 3 - Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommeldijckse Canal to address both the baseline and future flooding in these areas.
3) Alternative 4 - Rehabilitate Van Sommeldijckse pumping station and sluice gates to increase discharge to the Suriname River
4) Alternative 5 - Rehabilitate sluice gate and pumping station at Knuffelsgracht Street
5) Alternative 7 - Rehabilitate Van Sommeldijckse Canal to increase water storage capacity
6) Alternative 8 - Rehabilitate drainage system along the waterfront between Knuffelsgracht and SMS Pier
7) Alternative 11 - Create buffer with enhanced mangrove plantings to reduce the flood velocity and erosion

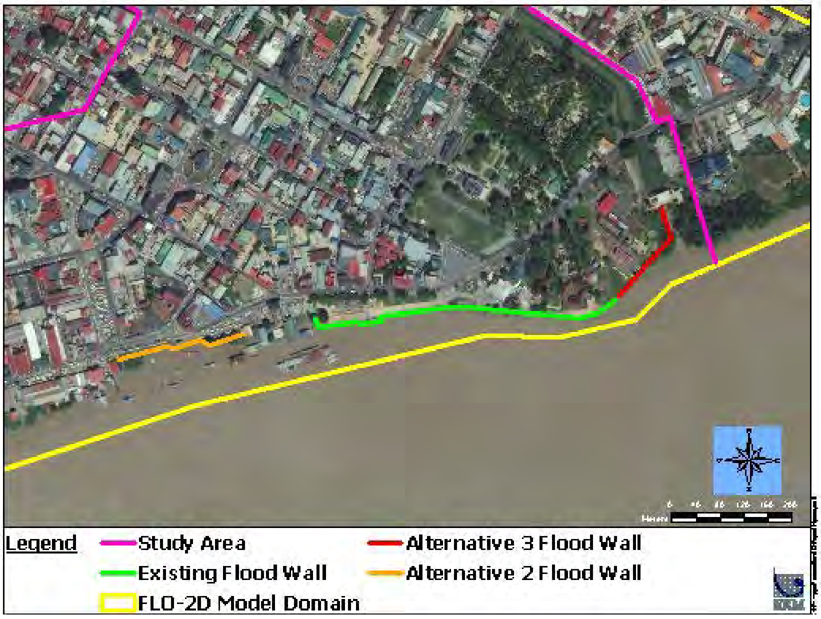


Figure 17: Alternative 2 and 3 Conceptual Design Layouts Around the Existing Flood Wall

Formulation of the proposed adaptation measures consists of assembling these seven highest-ranked alternatives (Alternatives 2, 3, 4 5, 7, 8, and 11) listed above into three groups as A, B and C that represent options that best address the critical components of the project, i.e., address the current and future expected flooding in the Study Area (Table 2 below). Flood walls are vulnerable to erosion on a longer time horizon due to increase in hydraulic head and water velocities from HWLs due to sea level rise in a tidal system. The drainage canal system fails over the years due to sedimentation resulting in an increased flooding in the nearby floodplain regions. In addition, the flood modelling results were used to identify the operational and failure conditions (HWLs, return periods and future climate change years) for the various adaptation alternatives identified for this study.

Table 2: Alternative Groups

Group	Alternative	Alternative Description	Benefits	Drawbacks
Group A	Alt 2	New flood protection wall from Knuffelsgracht Street to SMS Pier	• Strong measure for coastal flood protection • Adaptive to future by increasing wall height • Addresses critical flood area • Address both coastal and inland flooding	• May temporarily obstruct view • Inland flood control requires operation of pump and gates • Flood wall overlaps with existing water taxi business and may have impacts on livelihoods • Management of potentially impacted sediment • Resolution of historic land concession required
	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates		
	Alt 11	Create buffer with enhanced mangrove plantings		
Group B	Alt 3	Rehabilitate existing old retaining wall between Fort Zeelandia and sluice gate in Van Sommelsdijck Canal	• Minimal construction disturbance to rehabilitate existing wall • Added functionality along canal for walkways • Address both costal flood and limited (reduced segment of canal improvement)	• Critical flood area not addressed • Only portion of canal is rehabilitated • Inland flood control requires pump and gates operation • Management of potentially impacted sediment
	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates		
	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)		
	Alt 11	Create buffer with enhanced mangrove plantings		
Group C	Alt 4	Rehabilitate Van Sommelsdijck pumping station and sluice gates	• No view obstruction • Added functionality along canal for walkways • Address both coastal flood and limited (reduced segment of canal improvement)	• Critical flood area partially addressed by new pump station (PS) – Alt 5 • Construction disturbance at new PS – Alt 5 • Inland flood control requires pump and gates operation
	Alt 5	Rehabilitate sluice gate and pumping station at Knuffelsgracht Street		
	Alt 7 (*reduced)	Rehabilitate Van Sommelsdijck Canal (250 m)		
	Alt 11	Create buffer with enhanced mangrove		

The effectiveness of various alternatives were evaluated by modeling them using the baseline flood model setup. For example, the flood modelling study results for Alternatives 2 and 3 and Alternative 4 show that there is significant improvement in the reduction of flood hazard along the river waterfront (using alternative 2 and 3, see Figure 18) and in the vicinity of the Van Sommeldijckse Canal for small return periods (alternative 4, see Figure 19). For future years of 2050 and 2080 with large return periods, effectiveness of flood control decreases due to the routing of flood water from neighboring regions of the riverfront. A similar analysis holds good for other alternatives (adaption measures) identified in the conceptual design and impact scoping report related to green infrastructure (absorption of flood wave energy) and drainage system (storm water removal rate larger than rainfall intensity).

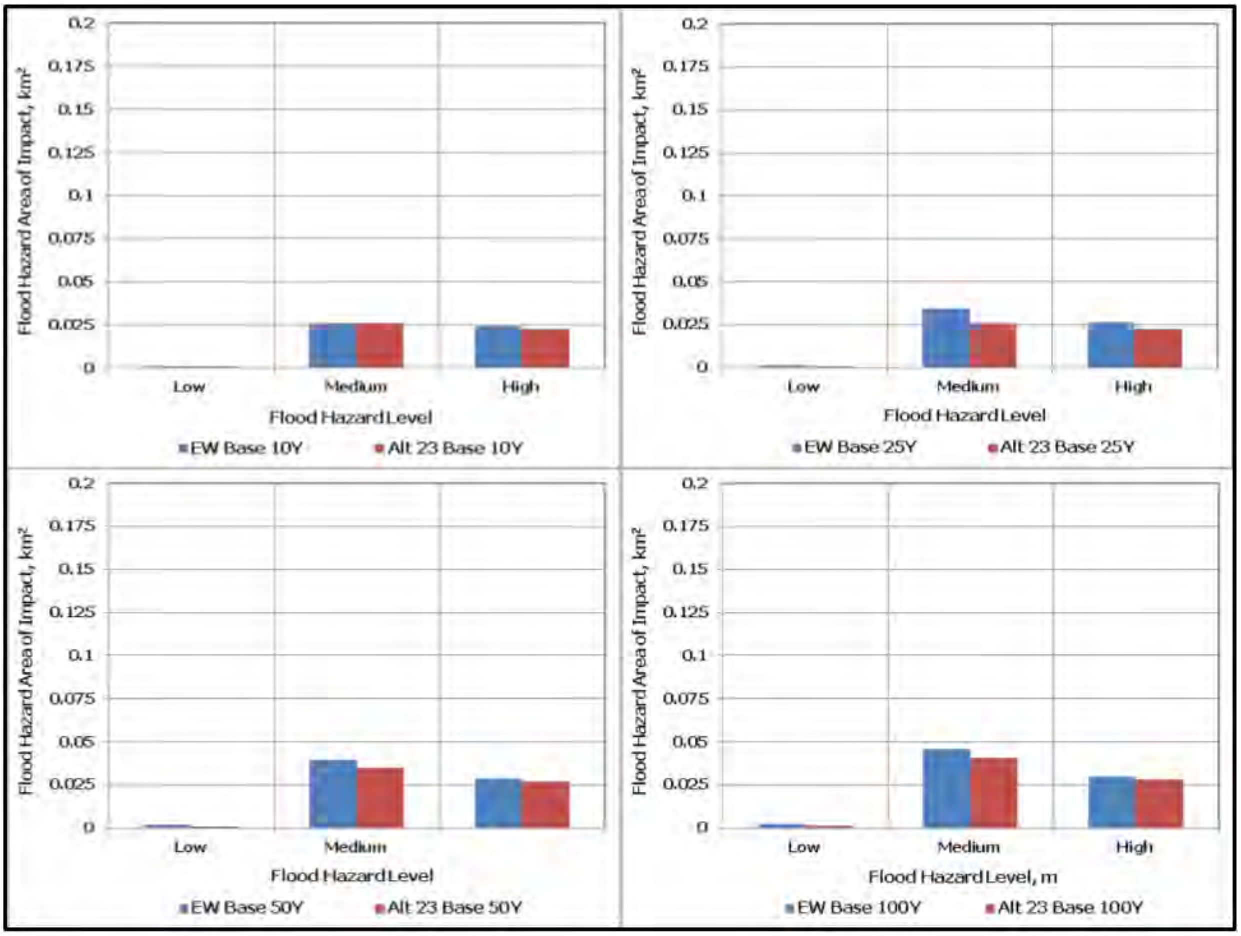


Figure 18: Comparison of coastal flooding hazard areas of impact within the Study Area between the existing floodwall (EW) and with the addition of the Alternative 2 and 3 conceptual design floodwalls for the baseline scenario at 10-, 25-, 50-, and 100- year return periods

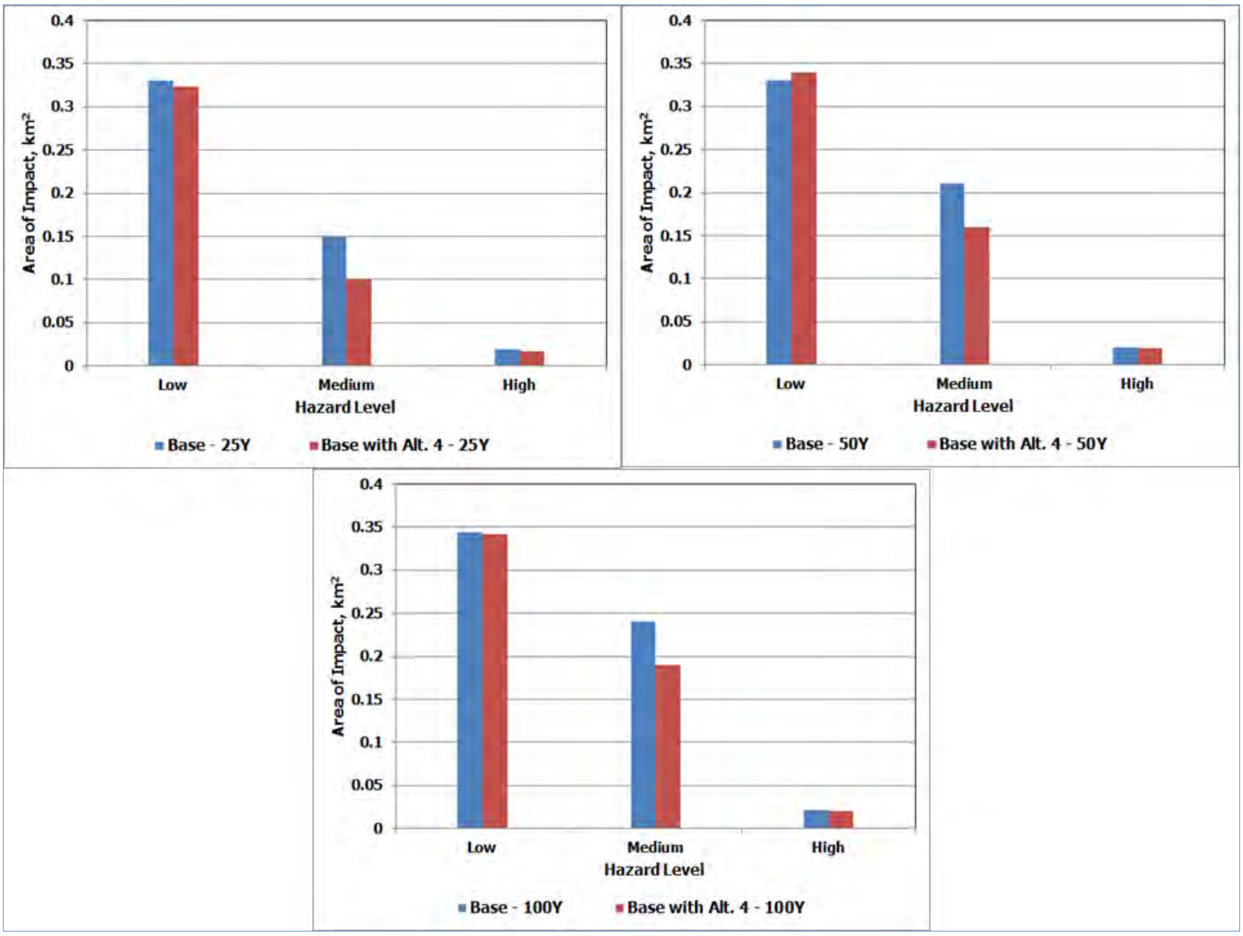


Figure 19: Graphical comparison of flood hazard areas of impact of the Canal and its surroundings between the existing configuration and with the addition of the Alternative 4 option at 25-, 50- and 100-year return periods

Potential Hazard and Risk Management Conclusion

Recent flooding in Houston, Texas caused by Hurricane Harvey (2017) showed that adding more flood walls, though they minimized flooding in specific regions, increased flooding in other regions due to flood wave deflection. Further review of similar flood adaption measures used in other regions of the world shows that no single solutions can provide 100% flood control resulting from climate change. Multiple solutions along the river front will be needed to develop a sustainable solution for longer time horizons with climate change. The initial adaptation proposals that have been made are a starting point to build an adaptation and resilience strategy, but cannot succeed in isolation. Future investment will be needed on current nearby projects as this combination of solutions progresses; this is where the Paramaribo can build its sustainable adaptive ability. A multiphase approach to developing alternatives is essential so that investment on initial phases provides a solid foundation for additional phases of improvement using future monitoring of sensitive assets and climate change.

The flood hazard analysis performed for various alternatives were then used to determine functionality threshold and related vulnerability scoring for seven alternatives that were grouped into A, B and C.

The three groups, along with projected cost, benefits, and drawbacks of each group were analyzed and based on the review of these benefits and drawbacks, including a comparative analysis, alternatives within Group A were identified as the preferred adaptation measures. Therefore, ERM proposes the Group A alternatives as the preferred alternatives for the first phase of the adaptation program for the downtown area of Paramaribo.

APPENDIX H:

Traffic And Pedestrian Management Plan

This Traffic and Pedestrian Management Plan (TPMP) provides a working template that will be used by the selected construction contractor (the Contractor) appointed by the Project Proponent (the Government of Suriname and the IDB). It details the specific mitigation requirements and focus areas identified through the Environmental and Social Impact Assessment, but also recognizes that the selected Contractor will have their own policies and procedures that will need to be inputted to this plan. It also recognizes that as the Contractor develops the Project designs, this may influence how construction will be undertaken and progress, and these aspects will need to be integrated into this plan. Text in red are sections of the TPMP which the Contractor needs to complete.

1.0 Introduction

1.1 Overview

This document is the Traffic and Pedestrian Management Plan (TPMP) for the Adaptation Fund for Urban Investments for the Resilience Program (the "Project"), a Category B Project, which focuses on the Paramaribo waterfront area and comprises three components:

- Construction of a new flood protection wall;
- Sommelsdijck Canal pump station and sluice gates rehabilitation; and
- Enhancement of mangroves.

The TPMP sets out the expectations of the Project Proponent (i.e., the Government of Suriname, GoS, and its partner, the Inter-American Development Bank, IDB) and defines how the Contractor will implement and manage environmental matters.

1.2 Objectives

The purpose of the TPMP is to minimize the interface wherever possible between the public (pedestrians, visitors, tourists, residents etc.) and site and project-related traffic. This document provides practical guidance on the planning and control measures that will be implemented.

The objectives of this plan are:

- Minimize the impact on the public road network approaching and adjacent to the project by road based construction traffic. This will be achieved by identifying clear controls on routes, vehicle types, vehicle frequency, vehicle quality and hours of site operation.
- To establish main principles for vehicle and pedestrian movement within the site boundary maintaining positive segregation between personnel and plant and vehicles.

The main construction contractor is responsible for the execution of the plan, and the plan as a document is 'dynamic', and will be revised and added to as the project evolves.

2.0 Project Description

This section needs to include specific details on the proposed works, duration relevant plans etc. The following provide guidance on what is needed.

- **Scope of Construction Works:** Description of the full range of construction works / activities proposed (e.g. clearing of land, placement of piles, filter rock, geotextile fabric and armour rock; installation of piles; etc.).
- **Description of the Construction (Disturbance) Footprint:** Full description of the existing land / marine areas that will be disturbed by the construction works and those immediately adjacent;
- **Timing of Works:** Provide a description of both the total duration of the works and the time of year they will occur. The latter would include consideration of expected climate during this time (e.g. anticipated rainfall / cyclone events, wind direction and speeds);
- **Site Plan:** The project site plan would clearly show the full extent of the proposed works area of the construction project. This would typically include a map with the full construction boundary and disturbance footprint marked clearly over a current aerial photograph (i.e. including all construction activities, associated laydown areas etc.). It would also include site specific information, for example the location of any important waterways or adjacent vegetation to be protected, national heritage listed areas, or the location of sediment and erosion traps, electrical services etc.

3.0 Project Roles, Responsibilities And Contacts

All positions across the project have traffic and pedestrian responsibilities to some extent. These vary in relation to duties described in Table 1, but everyone has a base level duty of care to prevent environmental harm.

Table 1: Project Roles, Responsibilities and Contact Details

POSITION	RESPONSIBILITIES	LINE MANAGER	NAME	CONTACT DETAILS*
Project Manager				

Site Supervisor				
Environment Manager				
HSE Representative				

4.0 *Training, Awareness and Competency*

Outline how traffic training, awareness and competency will be delivered / assessed throughout the project, to ensure the relevant aspects of this TPMP are communicated to the project team and front line staff (including contractors and sub-contractors). Examples may include:

- Site Induction
- Daily Pre-Start Meetings
- Toolbox Talks
- Incident bulletins
- Sub-contractors kick-off meeting
- Contractor and client site kick-off meeting

This awareness and training must also be extended to delivery drivers and trade contractors.

5.0 *Traffic and Pedestrian Management*

Work Area Considerations

This section presents a summary of the risks and controls that have been identified per work areas for the proposed construction project when considering traffic management and interface with pedestrians. The Contractor should determine what additional risks and proposed management controls are required based on their final design and work method statements. A project risk assessment or job hazard analysis for specific task(s) should be performed.

The following tables are based on the ESIA that has been performed. Note that these do not contain an exhaustive list of potential issues, and it would be expected that Contractor develop risk management strategies, controls etc. that suit the scale/nature of finalized construction project.

Flood Wall Work Area

<table>
<tr><th colspan="3">FLOOD WALL WORK AREA</th></tr>
<tr><td>Work Area and Route Maps</td><td>Route Maps: Maps will need to be shown that identify the main roads and pedestrian footpaths, construction site access points and delivery locations that will be affected by construction activities and which will be used for deliveries.

The following aspects need to be carefully considered (as shown in the figure below):
Roads: Waterkant Street and Knuffelsgracht Street
Parking: Public transport parking area
Pedestrians: Pavements for the above roads and the general waterfront area.</td><td>
</td></tr>
<tr><td>Specific Considerations</td><td colspan="2">The contractor should identify and prepare specific actions – including the following aspects:
During construction of the floodwall, the south lane of Waterkant Street may need to close temporarily. It will need to be undertaken in consultation with the OWTC and Traffic Police.
Part of the existing bus parking near the SMS Pier will be used during construction of the floodwall. This may take few months. The parking area will be rehabilitated afterwards, including improvement of the drainage. During construction a re-arrangement of the parking of busses will be required. The parking of the buses could be done in the general area along river side and along the main road in close cooperation with the Traffic Police.
Delivery of materials such as steel, for the construction of flood wall will need oversize vehicle and equipment. Safe passage of these large vehicles and equipment though common road should be considered.</td></tr>
</table>

Sommelsdijck Canal Pump Station

SOMMELSDIJCK CANAL PUMP STATION		
Work Area and Route Maps	**Route Maps**: Maps will need to be shown that identify the main roads and pedestrian footpaths, construction site access points and delivery locations that will be affected by construction activities and which will be used for deliveries. The following aspects need to be carefully considered (as shown in the figure below): • **Roads**: Kleine Waterstraat and the service road to the pump station • **Parking**: Parking along the access road • **Pedestrians**: Minimal impact expected given it is not in a location of much pedestrian traffic.	
Specific Considerations	The contractor should identify and prepare specific actions – including the following aspects: • For the rehabilitation of the pump station, excavation/dredging of water basin is planned by utilizing excavator and/or hydraulic crane. The excavated materials will be loaded in sealed dump trucks for transportation to an approved sludge drying bed/area identified/approved by the City. Traffic may be briefly impacted during mobilization/demobilization of the heavy construction equipment such as excavator/crane. Similarly, hauling of materials off site via dump trucks needs proper traffic management for sharing road with normal traffic and also to ensure debris and soil are not tracked onto the main road. • Delivery of the pump, including unloading would need oversize vehicle and heavy equipment. Safe passage of these large vehicles and equipment should be consider in the traffic management plan.	

Specific Work Practices

This section presents a summary of the risks and controls that have been identified for specific work practices when considering traffic management and interface with pedestrians. The Contractor should determine what additional risks and proposed management controls are required based on their final design and work method statements. A project risk assessment or job hazard analysis for specific task(s) should be performed.

The following tables are based on the ESIA that has been performed. Note that these do not contain an exhaustive list of potential issues, and it would be expected that Contractor develop risk management strategies, controls etc. that suit the scale/nature of finalized construction project.

Pedestrian Safety

PEDESTRIAN SAFETY			
Objective(s)	3. To ensure and protect pedestrians both inside and outside the construction work sites. 4. Ensure clear separation of pedestrians from work activities and traffic.		
Management Strategy	Controls, signage and physical separation.		
		Responsibility (Role)	**Timing**
Control(s)	Measures to be applied include: • Ensure pedestrian routes are clearly separated from vehicle routes by fencing and/or a kerb, or other suitable means. • Ensure pedestrian routes are wide enough to safely accommodate the number of people likely to use them at peak times. • Ensure pedestrian routes allow easy access to relevant local work, tourist and residential areas. • Ensure pedestrian routes are kept free of obstructions. • Ensure pedestrian routes are clearly and suitably signed. • Ensure pedestrians can safely cross the main vehicle routes. • Ensure pedestrians have a clear view of traffic movements at crossings and at gates which lead onto traffic routes. • Ensure pedestrians have clearly marked, separate access for use at loading bays and site gates. • Ensure pedestrian routes provide safe access to welfare facilities.		
Performance Indicator(s)	No accidents or incidents.		
Monitoring	Daily inspection of work areas, route signage and protection.		
Reporting	Incident report for non-conformance of pedestrian issues.		
Corrective Action(s)	• Investigate cause of any accident/incident/near miss. • Review controls and requirements		

Vehicle Routes

VEHICLE ROUTES			
Objective(s)	1. To ensure clear and well-signed vehicle routes into and out of the construction site. 2. Ensure non-construction traffic impacts are minimized.		
Management Strategy	Controls, signage and physical separation.		
		Responsibility (Role)	**Timing**
Control(s)	Measures to be applied include: • Ensure routes suitably consider pedestrian issues (as above). • Ensure routes are wide enough to safely accommodate the number of vehicles likely to use them at peak times. • Ensure routes allow easy access to delivery areas. • Ensure routes free of obstructions, and are clearly and suitably signed. • Ensure routes eliminate or reduce the need for reversing. • Ensure that at the final point of exit can the driver see pedestrians on the pavement. • Ensure temporary structures are protected from vehicle impact. • Ensure provision of suitable parking areas. • Ensure routes are planned to reduce the need for excessive vehicle movement. • Ensure measures to prevent vehicles depositing mud on the roadways.		
Performance Indicator(s)	No accidents or incidents.		
Monitoring	Daily inspection of work areas, route signage and protection.		
Reporting	Incident report for non-conformance of traffic movements.		
Corrective Action(s)	• Investigate cause of any accident/incident/near miss. • Review controls and requirements		

Vehicle Reversing

VEHICLE REVERSING			
Objective(s)	To minimize vehicle reversing by following the reversing hierarchy.		
Management Strategy	Management controls.		
		Responsibility (Role)	**Timing**
Control(s)	Implementation of the reversing hierarchy: 1. ***Eliminate need to reverse*** — Implement one-way systems around the site and in loading and unloading areas Provide designated turning areas. 2. ***Reduce reversing operations*** — Reduce the number of vehicle movements as far as possible. Instruct drivers not to reverse, unless absolutely necessary. 3. ***Ensure adequate visibly for drivers*** — If possible, consider use of CCTV, convex mirrors, Fresnel lens, etc. to overcome restrictions to visibility from the driver's seat, particularly at the sides and rear of vehicle. Design vehicle reversing areas which: • Allow adequate space for vehicles to manoeuvre safely • Exclude pedestrians; and • Are clearly signed and have physical stops or buffers to warn drivers that they have reached the limit of safe reversing areas. 4. ***Ensure safe systems of work are followed*** — Ensure everyone on site understands site rules on vehicle safety. Drivers and signallers need to be in constant communication during reversing operations. Signallers should not be put at risk from vehicle movement, e.g.by standing directly behind reversing vehicles. Ensure all vehicles on site are fitted with appropriate warning devices. 5. ***Provide warnings when vehicles are reversing*** — Ensure reversing warning lights and alarms are in good working order and instruct workers to keep clear of moving vehicles.		
Performance Indicator(s)	No accidents or incidents.		
Monitoring	Daily briefings of drivers and contractors. Inspection of driving practices.		
Reporting	Incident report for non-conformance of traffic movements.		
Corrective Action(s)	• Investigate cause of any accident/incident/near miss. • Review controls and requirements		

Drivers Safe Work Practices

DRIVERS SAFE WORK PRACTICES			
Objective(s)	To minimize vehicle incidents through good driver behaviors and practices.		
Management Strategy	Management controls.		
		Responsibility (Role)	**Timing**
Control(s)	Implementation of the following safe work practices for drivers: • Only operate vehicles if you are competent and authorized to drive them • Do not drive when your abilities are impaired by ill health, poor vision, prescribed/illegal drugs or alcohol • Make sure you fully understand the operating procedures of the vehicles you control • Know the site routes and follow them. Take care at pedestrian crossovers. • Understand the system of signals used on site • Visiting drivers: seek appropriate authority to enter the site and operate vehicles • Know the safe operating limitations of your vehicles ,particularly relating to safe maximum loads and gradients • Carry out daily checks on your vehicles and report all defects immediately to supervisors • Follow site procedures and comply with all Site rules • Do not drive at excessive speeds • Wear appropriate PPE when out of the cab • Ensure that windows and mirrors are kept dean and dear • Keep the vehicle tidy and free from items which may hinder the operation of vehicle controls • Do not allow passengers to ride on vehicles unless safe seating is provided • Park vehicles on flat ground wherever possible, with the engine switched off, the handbrake and trailer brake applied and where necessary use wheel chocks • Do not reverse without reversing aid or banksman assistance • Where visibility from the driving position is restricted, use visibility aids or a signaller. Stop if you lose site of the signaller or the visibility aids become defective. • Do not remain on vehicles during loading operations, unless the drivers position is adequately protected • Ensure loads are safe to transport • Do not attempts to get off moving vehicles • Do not make adjustments with the engine running and guards removed • Do not smoke during refuelling operations • Do not use a mobile phone whilst driving on site		
Performance Indicator(s)	No accidents or incidents.		

DRIVERS SAFE WORK PRACTICES			
Monitoring	Daily briefings of drivers and contractors. Inspection of driving practices.		
Reporting	Incident report for non-conformance of traffic movements.		
Corrective Action(s)	• Investigate cause of any accident/incident/near miss. • Review controls and requirements		

Signalers/Banksman Practices

SIGNALERS/BANKSMAN PRACTICES			
Objective(s)	To minimize vehicle incidents through good driver behaviors and practices.		
Management Strategy	Management controls.		
		Responsibility (Role)	**Timing**
Control(s)	Implementation of the following practices: • Use relevant safety procedures and correct signalling systems • Ensure drivers understand the correct signalling systems • Signal instructions clearly • Ensure you are visible to the driver and the driver is visible to you; if not, stop the vehicle moving • Stand in a safe location at all times • Warn pedestrians and make sure they are kept away from vehicle operations • Wear appropriate protective clothing, including high-visibility clothing • Report work hazards to supervisors • Make sure you can get to and from your work location safely • Do not ride on the vehicle you are directly unless you are in a designated safe position • Do not direct vehicles if your ability is affected by alcohol or drugs • Do not use a mobile phone whilst directing vehicles		
Performance Indicator(s)	No accidents or incidents.		
Monitoring	Daily briefings of drivers and contractors. Inspection of driving practices.		
Reporting	Incident report for non-conformance of traffic movements.		
Corrective Action(s)	• Investigate cause of any accident/incident/near miss. • Review controls and requirements		

Other Plant and Equipment

OTHER PLANT AND EQUIPMENT			
Objective(s)	To minimize plant and equipment incidents through good operator behaviors and practices.		
Management Strategy	Management controls.		
		Responsibility (Role)	**Timing**
Control(s)	Implementation of the following practices: • Allow only competent people to drive site plant/equipment • Provide stop blocks at the edges of excavations, pits, spoil heaps, etc. to prevent plant/equipment falling. The blocks need to be positioned a sufficient distance away from any unsupported edges and slopes to prevent the weight of the vehicle causing collapse • Do not operate the site plant/equipment controls unless seated on the driving seat • Do not carry passengers unless purpose built seats are provided • Do not drive on gradients in excess of those safe for the plant/equipment (see manufactures instructions) • Avoid manoeuvring on sloping ground • Drive at appropriate speeds for site conditions • Load on a flat ground with brakes applied • Get off plant/equipment when it's being loaded • Ensure loads are distributed evenly and do not let them obscure your vision • Securely fix loads which may cause danger if they move • Stop the vehicle, take out of gear and apply parking brake, before tipping loads • Do not drive around with the skip in the vertical discharge position • Use the appropriate towing pins (not bent pieces of reinforcement bars) • Do not leave the engine running when you leave the vehicle • Be aware of the difference in performance of the site plant/equipment when loaded and unloaded, particularly speed, braking and stability on slopes • Be aware of the different handling and braking characteristics of the vehicle in the wet or icy conditions • Do not alter tyre pressures outside the manufacturers specifications • Do not use a mobile phone whilst operating plant/equipment		
Performance Indicator(s)	No accidents or incidents.		
Monitoring	Daily briefings of drivers and contractors. Inspection of driving/operating practices.		
Reporting	Incident report for non-conformance of plant and equipment movements.		

OTHER PLANT AND EQUIPMENT			
Corrective Action(s)	• Investigate cause of any accident/incident/near miss. • Review controls and requirements		

APPENDIX I:

Legislative Review & Gaps Analysis

Legislative Review & Gaps Analysis

For Proposed Climate Change Adaptation Measures in the Historical Inner City of Paramaribo

12 June 2018

Content

1 Introduction

ERM with support of ILACO is preparing a set of adaptation measures for the Historical Inner City of Paramaribo to cope with negative impacts of Climate Change. These measure concentrate around flood control, drainage and water management.

This project is focused on the protection of the Historical Inner City of Paramaribo, which is listed as a World Heritage Site and is considered to be of great value for future generations.

Three measures have been identified during the course of this study. These measures are:

1. Rehabilitate existing embankment retaining wall by constructing new sheet pile wall at the Waterfront between Knuffelsgracht and bar/restaurant Riverside;
2. Rehabilitate the drainage Pumping station and Sluice Gates of the Van Sommelsdijckse Creek and also excavate the water retention basin located in front of the Pumping station to increase its water storage capacity in times of heavy rainfall; and
3. Protect an existing embankment structure between the Sommelsdijckse Creek and Fort Zeelandia by enhancing the buffer of Mangroves growing in front of the dam structure.

1.1 Objective

The objective of this legislative assessment study is:

- to perform a gap analysis of national technical standards such as environmental impact assessment legislation, coastal management regulations, building codes, and
- provide recommendations to close existing gaps.

1.2 Method

This review was mostly a desktop study, where earlier reports on similar issues and other literature were used to provide a list of relevant legislation. In some cases there were personal communications with personnel within relevant institutions to provide a more up-to-date overview in certain areas.

2 Legislative Review

2.1 Introduction

This chapter presents an overview of the legislation that is relevant for the three identified measures. The legislation is reviewed taking note of applicability and is also accompanied by some short remarks on its working in practice. Even though this is mostly a legislative review, this review also provides administrative procedures, such as (department) guidelines and other policies that may be applicable and are issued by government institutions.

The Historical Inner City of Paramaribo has been named a World Heritage Site since 2002 and as such falls under the World Heritage Convention that is regulated by the United Nations Educational, Scientific and Cultural Organisation. The Monument Act of 2002 of Suriname established rules for activities within this area.

2.2 Sheet pile flood wall at the Paramaribo Waterfront

The sheet pile wall at the Paramaribo Waterfront stretches from the old jetty where there used to be an ferry service going to and from Meerzorg, Commewijne, to a bar/restaurant named Riverside which is the first upcoming building on that stretch of waterfront after the old jetty. In between these two points lies an old water taxi landing for small passenger boats also to and from Meerzorg and an existing deteriorated floodwall structure. Also, there is a busy street running along the full stretch of the waterfront and a bus station. Along some parts of the bank there are some bushes and few palm and mangrove trees growing.

The main issues that need to be addressed have to do with the construction of the sheet pile wall, the water taxis, the mangroves, the adjacent road and rehabilitation of the parking area at the bus station. In the table below an overview is given.

Name	Publication Reference	Remarks	Applicable for project
Ministerial Decree Guidelines for land issuance in the estuarine management areas	S.B. 2005 no. 16	– Mangrove forest protects the coast, specifically guidelines on use of mangroves in estuarine areas. – This Ministerial Decree is mainly focused on the mangrove bushes in river estuaries.	Not applicable for project. However, recommended to preserve mangrove where possible.
Building Code	G.B. 1956 no.30 amended by S.B. 2002 no. 72	Rules for construction Constructions should be in accordance with land use plans.	-
State Order on Building Construction	G.B. 1956 no. 108 amended by S.B. 2010 no. 27	Further rules for construction of buildings. Construction permits will be issued based on an approved construction plan.Since 2010 this act is applicable for the whole of Suriname.	Applicable if buildings are to be rehabilitated.
Roads Authority Act	S.B. 1995 no.	– Rules on the management of	Applicable

Name	Publication Reference	Remarks	Applicable for project
	68	roads and bridges. The Roads Authority is established with the main responsibility of management of primary roads, which entails the establishment of rules for construction, rehabilitation and maintenance of primary roads and bridges. – The Roads Authority is in responsible for the management of all primary roads in Suriname. The primary roads are legally determined in a State Order. – The Roads Authority will give guidance on the specific actions that need to be taken when rehabilitating the part of the road and the bus depot.	
State Order on Primary Roads	S.B. 2001 no. 61	– Legal determination of roads that are of national value on both social and economic areas. – The Waterkant was named a primary road and thus falls under the responsibility of the Roads Authority.	Applicable for project. However, it is common practice that the Ministry of Public Works carry out major rehabilitation of roads in the city center. They use the same guidelines as the Road Authority.
Act Establishing the Maritime Authority Suriname (MAS)	S.B. 1998 no. 37	– The roles and responsibility of the Maritime Authority Suriname is to ensure safe and efficient passage of seagoing vessels to and from Suriname on the basis of internationally accepted standards and rules and in accordance with the also ratified by Suriname and the supervision of compliance with legal requirements for shipping and shipping traffic. – Under its general tasks the MAS has specified specific procedures related to the dredging of rivers. These procedures include the submission of a dredging plan and dredging method – For the dumping of the sludge	Applicable. If Contractors will use floating equipment. Applicable if river shore is to be excavated for rip rap protection.

Name	Publication Reference	Remarks	Applicable for project
		the MAS awaits approval by NIMOS.	
Hindrance act	G.B. 1930, no. 64 amended by S.B. 2001, no. 63	Issuance of a hindrance permit. Permits for enterprises which can cause danger, damage or hindrance like spreading waste and noxious fumes	Applicable. Contractors must abide by the relevant clauses.
Harbours Act	S.B. 1981, no. 86	– Rules for the harbour. Prohibiting of discharge of waste, oil, oil-contaminated water and unauthorized goods into public waters. – According to art. 11 a permit is needed from the Harbour Master to install any kind of jetty or mooring structure.	Applicable. If Contractor will use floating equipment. No special permit is needed for the rehabilitation of the existing retaining wall. However, it is customary to inform MAS about these works.
Bill on Coastal Protection (*Wet BeschermdKustgebied*)	--	– Bill proposing general rules for the protection of the coast of Suriname. This Bill is accompanied by a map delineating the area that will fall under the operations of this Act. In this map certain areas are marked but the coastal area adjacent to the capital district of Paramaribo. – This bill gives rules and regulations on the issuance of permits and rights in this area and the construction of dams, dykes, channels, buildings or any other type of construction. – This Act has been submitted to Parliament as an Initiative law (Initiatiefwet) under the Rules of Procedure of the National Assemble of Suriname, by five members including the Speaker of the House. – The act is currently on the agenda but there are no insights as to when it will be discussed and approved.	Not applicable. Law is not yet approved.
Draft Environment Act	--	– Act specifying rules on environmental management,	Act is not yet approved.

Name	Publication Reference	Remarks	Applicable for project
		such as the mandatory Environmental Impact Assessment. – This Draft also holds rules on the establishment of an Environmental Authority that will be responsible for the enforcement of the Environment Act. – It is the intention that NIMOS (Government Foundation established in 1998) will become the Environment Authority. – This Act has been drafted since 2002. The government is currently reviewing it and it is the intention to submit this Bill to Parliament in 2018. – As a Government Foundation NIMOS has been preparing the Environment Act and also acting as the Environmental Institution until the Environment Authority is formally established by law. As such, NIMOS has issued different environmental guidelines.	However, it is general practice to consult NIMOS in new investment projects for review and assessment of relevant ESIA procedures.

2.3 Rehabilitation van Sommelsdijcks Creek Pumping station

This adaptation measure is to ensure a better drainage of the Hisotrical Inner City of Paramaribo and water storage. The activities here will consist of the repair of the pumps in the pumping station at the van Sommelsdijcks Creek and also rehabilitation of the sluice gates and other structures. In front of the floodgate lies a basin that functions as a short term water storage for excess water that cannot be pumped into the Suriname River at that moment. This basin will be deepened through excavation/dredging.

The main issues that need to be addressed here have to do with the excavation of the water basin, dumping of the excavated sludge. It is noted that in general the Ministry of Public Works discharges the excavated sludge for drains and canals to contained open field areas, where the sludge is spread out and dried.

In the table below an overview is given.

Name	Publication Reference	Remarks	Applicable for project
Monuments Act	S.B. 2002 no.	– Rules for the protection of	Not applicable. Not

Name	Publication Reference	Remarks	Applicable for project
	72	historical or cultural objects. A license is required to export goods and wares used before 1900 in Suriname; also for minerals, flora and fauna. – The Van Sommelsdijckse Creek is one of the oldest creeks in Paramaribo, and many historical artefacts could have found their way into this creek over the centuries; – Currently the Division of Culture of the Ministry of Education, Science and Culture is in the process of formulating Guidelines for Archaeological Management. These guidelines will be used when activities take place in areas that are of great archaeological value; – The current status of these guidelines is unknown.	reconstruction or change of the Van Sommelsdijckse Creek is envisaged in this project. It is recommended to inform the relevant authorities of the works.
Building Code	G.B. 1956, no.30 amended by S.B. 2010. no. 27	Rules for construction of buildings. Constructions should be in accordance with land use plans	-
State Order on Building Construction	G.B. 1956 no. 108 amended by S.B. 2010 no. 27	Further rules for construction of buildings. Construction permits will be issued based on an approved construction plan. Since 2010 this act is applicable for the whole of Suriname.	Not applicable as no construction of buildings is envisaged.
Act Establishing the Maritime Authority Suriname (MAS)	S.B. 1998 no. 37	The roles and responsibility of the Maritime Authority Suriname is to ensure safe and efficient passage of seagoing vessels to and from Suriname on the basis of internationally accepted standards and rules and in accordance with the also ratified by Suriname and the supervision of compliance with legal requirements for shipping and shipping traffic.	Applicable if floating equipment will be used by Contractors.
Hindrance act	G.B. 1930, no. 64 amended by S.B. 2001, no. 63	Issuance of a hindrance permit. Permits for enterprises which can cause danger, damage or hindrance like spreading waste and noxious fumes	Applicable. Contractors must abide by the relevant clauses.
Bill on Coastal	--	– Bill proposing general rules for	Not applicable.

Name	Publication Reference	Remarks	Applicable for project
Protection (*Wet Beschermd Kustgebied*)		the protection of the coast of Suriname. – The act is currently on the agenda but there are no insights as to when it will be discussed and approved.	Law is not yet approved.
Draft Environment Act	--	– This Act has been drafted since 2002. The government is currently reviewing it and it is the intention to submit this Bill to Parliament in 2018. – Specifically for dredging NIMOS has issued guidelines on the dumping of the dredged sludge from rivers. These guidelines are on a case-by-case basis. In the near future general guidelines on dredged sludge will be prepared. – Even though currently there is a case-by-case evaluation of the dumping of dredged sludge, some general points can be discerned: o First permissions must be obtained from the MAS on the dredging activities in the rivers; o Samples must be taken of the dredged material and the location where the materials will be dumped; o These samples should be tested for heavy metals and total petroleum hydrocarbon; o Based on the test results NIMOS will give an advise to the MAS specifying if the sludge can be dumped at the intended location and under what circumstances.	Law is not yet approved. However, it is recommended to consult NIMOS for procedures with excavation and discharge of canal and drain sediments.

2.4 Enhancing Mangroves Buffer

The third adaptation measure concerns the protection of an existing dam structure by enhancing a buffer of mangroves. Additional mangroves will be planted which will facilitate sediment entrapment that will in turn protect the existing dam against water waves and surges. Trapping units of wooden quays will be installed in the water in from to the dam where there currently already do exist mangrove bushes.

The main issues that need to be addressed here have to do with the installation of sediment trapping units in the water and the mangroves. In the table below an overview is given.

	Publication Reference	**Remarks**	**Applicable for Project**
Ministerial Decree Guidelines for land lease/issuance in the estuarine management areas	S.B. 2005 no. 16	– Mangrove forest protects the coast, specifically guidelines on use of mangroves in estuarine areas. – This Ministerial Decree is mainly focused on the mangrove bushes in coastal estuaries.	Not applicable as no land issuance is involved. Also, act is for the coastal management areas.
Act Establishing the Maritime Authority Suriname (MAS)	S.B. 1998 no. 37	– The roles and responsibility of the Maritime Authority Suriname is to ensure safe and efficient passage of seagoing vessels to and from Suriname on the basis of internationally accepted standards and rules and in accordance with the also ratified by Suriname and the supervision of compliance with legal requirements for shipping and shipping traffic. – Under its general tasks the MAS has specified specific procedures related to the dredging of rivers. These procedures include the submission of a dredging plan and dredging method – For the dumping of the sludge the MAS awaits approval by NIMOS.	Applicable if Contractors will use floating equipment. Not applicable for sludge disposal as no dredging at the river bank is foreseen. It is recommended to inform MAS about the works, prior to start.
Harbours Act	S.B. 1981, no. 86	– Rules for the harbour. Prohibiting of discharge of waste, oil, oil-contaminated water and unauthorized goods into public waters	Applicable if Contractors will use floating equipment.
Bill on Coastal Protection (*Wet*	--	– Bill proposing general rules for the protection of the coast of	Not applicable.

	Publication Reference	Remarks	Applicable for Project
BeschermdKustgebied)		Suriname. This Bill is accompanied by a map delineating the area that will fall under the operations of this Act. In this map certain areas are marked but the coastal area adjacent to the capital district of Paramaribo is not included. – The act is currently on the agenda but there are no insights as to when it will be discussed.	Act is not yet approved.

2.5 International Technical Standards and Norms

In the case of absence of national technical standards or guidelines in most cases standards of institutes from other countries, such as the US Environmental Protection Agency or the NEN norms of the Netherlands Norm Institute, or from international organizations such as the WHO, IFC, IADB or World Bank are used.

3 Gaps Analysis

This Chapter presents an analysis of the earlier mentioned rules and regulations. Some of these gaps have been put forward as separate gaps, but can be seen as a whole of issues that are of importance to these adaptation measures.

Based on the overview of legislation and other technical guidelines the following gaps can be identified:

1. When considering the legislation on coastal protection it is evident that there is legislation on the protection of the natural environment of the coastal area. But, when spreading out the exact areas on the map we see that one specific area is not covered by any of the laws and that is the coastal area at Paramaribo (see picture of map blow). The MUMA's for example go from the Bigi Pan area in the West to the North Commewijne/Marowijne area in the East, but there is no MUMA established in the coastal area of Paramaribo. Also, when considering the areas of protection by a nature reserve, there are reserves located in the coastal area, but not directly adjacent to Paramaribo. So, from a climate change point of view we see that the most vulnerable part of the coast of Suriname has no form of coastal protection under the current legislation (up to June 2018).

Picture 1 Map of coast of Suriname with layers of nature reserves and MUMA's. The small column (marked with a red circle) which is not shadedis the coast of Paramaribo. (Source: Gonini Geoportal,www.gonini.org. Accessed 30 April 2018)

2. The second group of legislation that then needs to be considered is the group on the land use/management/ infrastructure. Based on the observation above it is imaginable that because of expansion purposes it was not the intention of governments to hamper the growth of Paramaribo as the capital city. But in light of all the knowledge and data that is constantly being gathered, both nationally and internationally, on climate change and its impact on low lying coastal areas, the need for and the absence of rules and regulations on construction for both buildings and other infrastructural works such as roads, etc. becomes even more evident.

3. Furthermore, when considering the whole body of legislation that exists and that can have any implications on the adaptation measures that are considered in this proposal there are many "grey" areas that are not regulated in any way. For example, even though the issue of climate change has been on the national agenda for nearly 20 years, the legislation on infrastructure and urban planning have not

been updated to reflect the challenges that the build environment is facing and will be facing in the future when it comes to the impacts of climate change.

4. Mangrove protection is not well regulated by law, only in river/ coastal estuaries. There is a bill but not yet adopted. This may have adverse consequences for the coastal area of Paramaribo in the context of a changing climate. Especially now with the effects of climate change the protection of the low-lying coast of Paramaribo is of great importance.
5. Dredging is currently mainly regulated through institutional guidelines. Separate legislation on this is missing. Although institutes such as the MAS do have the authority to make certain guidelines, comprehensive rules and regulations on this subject are absent and creating confusion and legal uncertainty within the community on the authorized actions.
6. There is no integrated set of rules that considers and treats the coast of Paramaribo and all economic activities there as a whole. This creates fragmentation in the execution of activities in the coastal area of Paramaribo and each activity is considered separately and not in the context of a dynamic coastal area.

4 Conclusions and recommendations

Few existing legislation is applicable for this Project. These are mostly related to the construction and general rules when using the river.

There are no specific laws for the Environmental and Social protection in this project. However, it is general practice to consult NIMOS for new investments and projects. NIMOS has issued a set of guidelines for ESIA's. It is recommended to consult NIMOS prior to implementation of the measures.

It is evident that the coastal (northern) area of Paramaribo is poorly regulated and protected by law. This has consequences for the further protection of the coast and the implementation of adaptation measures.

It is recommended that for the further planning and implementation of these adaptation measures all relevant stakeholders (government, academic and civil) are consulted and included in this process, to ensure success.

5 References

Integrated Coastal Zone Management Plan - Component II Legal and Institutional Reforms (Intermediate Progress Report), Christine Toppin-Allahar, Humphrey Schurman, 5 May 2009

Integrated Coastal Zone Management Plan - Component II Legal and Institutional Reforms (Final Report), Christine Toppin-Allahar, Humphrey Schurman, 25 August 2009

Milieugerelateerde Wetgeving in Suriname, NIMOS, 2004.

Annex F – Project Execution Plan

MULTIYEAR EXECUTION PLAN (PEP)
SU-G1003 - Urban Investments for the Resilience of Paramaribo

COMPONENTS AND SUBCOMPONENTS	MACRO ACTIVITIES	BUDGET
1. CITY-LEVEL ADAPTATION FRAMEWORK AND PLAN		$ 550,000
1.1 DEVELOPMENT OF CITY-BROAD ADAPTATION PLAN TO BUILD CLIMATE RESILIENCE	Develop bidding documents for Plar Bidding process (publicize, receive, review, analyze and select proposal(s)) - 5 months Sign contract(s) with firm(s) Develop Plan	$ 275,000
1.2. DESIGN OF DISSEMINATION STRATEGY (and implementation)	Develop bidding documents for Dissemination Pla Bidding process (publicize, receive, review, analyze and select proposal(s)) - 5 months Sign contract(s) with firm(s Submit, review, analyze and present comments on the Dissemination Plan and implementation	$ 275,000
2. DOWNTOWN ADAPTATION MEASURES		$ 7,572,000
2.1 ESIA FOR ADAPTATION MEASURES	Develop bidding documents for the Social & Environmental Impact Analysis Bidding process (publicize, receive, review, analyze and select proposal(s)) - 5 months Sign contract(s) with firm(s) Submit, review, analyze and present comments on the ESIA	$ 40,000
2.2 FLOOD WALL WATERKANT CONSTRUCTION (2.75M works + 275k design + 495k contingencies)	Project approval by the Monuments comissior Project approval by Building Committee of Public Works Develop bidding documents for **design and construction works** Bidding process (publicize, receive, review, analyze and select proposal(s)) - 8 months Sign contract(s) with firm(s) Design and Construction works Final recption	$ 3,520,000
2.3 REHABILITATION PUMPING STATION VAN SOMMELSDIJCK (1.55M goods and installation + 245k design + 346k contingencies)	Develop bidding documents for **goods and installation** Bidding process (publicize, receive, review, analyze and select proposal(s)) - 6 months Sign contract(s) with firm(s) Installation of goods - final receptior	$ 2,141,000
2.4 ENHANCEMENT OF BASIN AT VAN SOMMELSDIJCK PUMPING STATION (250k works + 25k design + 44k contingencies)	Project approval by the Monuments comissior Project approval by Building Committee of Public Works Develop bidding documents for **design and construction works** Bidding process (publicize, receive, review, analyze and select proposal(s)) - 8 months Sign contract(s) with firm(s) Construction works Final recption	$ 319,000
2.5 ENHANCEMENT OF MANGROVE AREA (200k works + 30k design + 31k contingencies)	Project approval by the Monuments comissior Project approval by Building Committee of Public Works Develop bidding documents for **design and construction works** Bidding process (publicize, receive, review, analyze and select proposal(s)) - 8 months Sign contract(s) with firm(s) - by group of buildings? capacity of the contractors? Construction works Final recption	$ 261,000
2.6 DESIGN (75k) AND IMPLEMENTATION OF DRAINAGE MAINTENANCE PLAN (400k goods and training + 56k contingencies)	Prepare terms of reference for the Drainage Maintenance Plar Procurement (publicize, receive, review, analyze and select proposal(s)) - 4 months Sign contract with firm Submit, review, analyze and present comments on the Drainage Maintenance Plar Prepare terms of reference for the implementation of the Drainage Maintenance Plan in historic city cente Procurement (publicize, receive, review, analyze and select proposal(s)) - 6 months Sign contract(s) with firm(s Implement Drainage Management Plan in historic center (20km sewers) (50k), supply vacuum/high pressure trucks incl maintenance and training (350k Maintenance of drainage in historic center - final reception	$ 531,000
2.7 CONSTRUCTION SUPERVISION OF ALL WORKS (404k flood wall + 245k pumping station + 36.5k basin pumping station + 29.5k mangrove area + 45k implementation drainage management)	Develop EIO, TORs, RFF Bidding process (publicize, receive, review, analyze and select proposal(s)) - 6 months Sign contract(s) with firm(s Works supervision and final receptior	$ 760,000
3. CAPACITY BUILDING		$ 380,000
3.1 DEVELOPMENT KNOWLEDGE MANAGEMENT PLAN	Prepare terms of reference for Knowledge Management Plan Procurement (publicize, receive, review, analyze and select proposal(s)) - 5 months Sign contract(s) with firm(s) Submit, review, analyze and present comments on the Knowledge Management Plar	$ 150,000
3.2 DEVELOPMENT AND IMPLEMENTATION OF A CAPACITY BUILDING PLAN	Prepare terms of reference for Capacity Building Plan Procurement (publicize, receive, review, analyze and select proposal(s)) Sign contract(s) with firm(s) Submit, review, analyze and present comments on the Capacity Building Plar Capacity training - preparation and delivery of workshops	$ 230,000
4.PROJECT ADMINISTRATION		$ 580,000.00
4.1 Personnel and other recurrent costs	Program Coordinator	$ 100,800.00
	Financial Specialist	$ 57,600.00
	Procurement Specialist	$ 57,600.00
	Community Relations Officer/Consultant	$ 57,600.00
	Environment, Health and Safety Officer/Consultant	$ 57,600.00
	petty cash (600 monthly	$ 28,800.00
4.2 Utilities and office supplies		$ 40,000.00
4.3 Auditing costs		$ 100,000.00
4.4 Monitoring and evaluation activitie		$80,000
Project Cycle Management Fee		$768,000
TOTAL BUDGET		$ 9,850,000

[YEAR 1]

Activity	1	2	3	4	5	6	7	8	9	10	11	12
1.1 Develop Plan							25000			75000		
2.1 Submit, review... the ESIA						10000			30000			
2.2 Design and Construction works											27500	
2.3 Installation of goods - final receptior								24500			98000	
2.4 Construction works											2500	
2.5 Construction works											3000	
2.6 Submit, review... the Drainage Maintenance Plar						7500			22500			30000
3.1 Submit, review... the Knowledge Management Plar						30000			75000		45000	
Program Coordinator	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
Financial Specialist	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Procurement Specialist	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Community Relations Officer/Consultant	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Environment, Health and Safety Officer/Consultant	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
petty cash	600	600	600	600	600	600	600	600	600	600	600	600
4.2 Utilities and office supplies			20000					20000				
4.3 Auditing costs											25000	
MONTHLY EXPENSES ('000s)	7500	7500	27500	7500	7500	55000	32500	52000	135000	82500	208500	37500

[YEAR 2]

Activity	1	2	3	4	5	6	7	8	9	10	11	12
1.1 Develop Plan		125000				$ 50,000.00						
2.2 Design and Construction works		110000			137500		973500			811250		
2.3 Installation of goods - final receptior	122500		568800			474000			474000			
2.4 Construction works		10000			12500		88200			73500		
2.5 Construction works		12000			15000		69300			57750		
2.6 Submit, review... the Drainage Maintenance Plar			15000									
2.6 Implement Drainage Management Plan...										45600		
2.7 Works supervision and final receptior						76000			190000			190000
3.2 Submit, review... the Capacity Building Plar					23000				57000			
3.2 Capacity training											30000	
Program Coordinator	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
Financial Specialist	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Procurement Specialist	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Community Relations Officer/Consultant	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Environment, Health and Safety Officer/Consultant	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
petty cash	600	600	600	600	600	600	600	600	600	600	600	600
4.3 Auditing costs											25000	
4.4 Monitoring and evaluation activitie										10000		
MONTHLY EXPENSES ('000s)	130000	264500	591300	7500	195500	607500	1138500	7500	728500	1005600	62500	197500

[YEAR 3]

Activity	1	2	3	4	5	6	7	8	9	10	11	12
1.2 Submit, review... Dissemination Plan and implementation					$ 27,500.00			$ 68,750.00			$ 68,750.00	
2.2 Design and Construction works	811250			486750		162250						
2.3 Installation of goods - final receptior	284400		94800									
2.4 Construction works	73500			44100		14700						
2.5 Construction works	57750			34650		11550						
2.6 Implement Drainage Management Plan...	182400			136800					45600		45600	
2.7 Works supervision and final receptior			190000		76000		38000					
3.2 Capacity training				30000						30000		
Program Coordinator	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
Financial Specialist	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Procurement Specialist	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Community Relations Officer/Consultant	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Environment, Health and Safety Officer/Consultant	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
petty cash	600	600	600	600	600	600	600	600	600	600	600	600
4.3 Auditing costs											25000	
4.4 Monitoring and evaluation activitie		10000										
MONTHLY EXPENSES ('000s)	1416800	17500	292300	739800	111000	196000	45500	76250	53100	37500	146850	7500

[YEAR 4]

Activity	1	2	3	4	5	6	7	8	9	10	11	12
1.2 Submit, review... Dissemination Plan and implementation				$ 55,000.00						55000		
3.2 Capacity training			30000						30000			
Program Coordinator	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100	2100
Financial Specialist	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Procurement Specialist	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Community Relations Officer/Consultant	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
Environment, Health and Safety Officer/Consultant	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
petty cash	600	600	600	600	600	600	600	600	600	600	600	600
4.3 Auditing costs											25000	
4.4 Monitoring and evaluation activitie							30000				30000	
MONTHLY EXPENSES ('000s)	7500	7500	37500	62500	7500	7500	37500	7500	37500	62500	62500	7500

COMPONENTS		COST	PER CENT OF TOTAL
1. CITY-LEVEL ADAPTATION FRAMEWORK AND PLAN	$	550,000	5.6%
2. DOWNTOWN ADAPTATION MEASURES	$	7,572,000	76.9%
3. CAPACITY BUILDING	$	380,000	3.9%
4.PROJECT ADMINISTRATION	$	580,000	5.9%
Project Cycle Management Fee		$768,000	7.8%
Project Costs without Project Cycle Management Fee	**$**	**9,082,000**	

TOTAL PER YEAR				
YEAR 1	**$**	**660,500.00**		
disbursement 1			*$*	*112,500.00*
disbursement 2			*$*	*548,000.00*
YEAR 2	**$**	**4,936,400.00**		
disbursement 3			*$*	*1,796,300.00*
disbursement 4			*$*	*3,140,100.00*
YEAR 3	**$**	**3,140,100.00**		
disbursement 5			*$*	*2,773,400.00*
disbursement 6			*$*	*366,700.00*
YEAR 4	**$**	**345,000.00**		
disbursement 7			*$*	*130,000*
disbursement 8			*$*	*215,000*
Total	**$**	**9,082,000.00**		

TPC (COMP 1 - 2 -3) + Monitoring and Evaluation $ 8,582,000			
TPM (ADMIN + AUDIT) $ 500,000.00	(max 9.5% of TPC) 5.8%		
PTC+TPM $ 9,082,000.00			
Project Cycle Management Fee $768,000	(max 8.5% of PTC+TPM) 8.5%	$	(50,000)
Total project costs $ 9,850,000.00			

Annual Operations Plan (AOP)
List of Expected Outputs and Outcomes for the Year 1

	Sub Component	Expected result at end of the Year	Verification Means
Component 1. City-level Adaptation Framework and Plan	**1.1 DEVELOPMENT OF CITY-BROAD ADAPTATION PLAN TO BUILD CLIMATE RESILIENCE**	contract signed with consulting firm	signed contract
Component 2. Downtown Adaptation Measures	**2.1 ESIA FOR ADAPTATION MEASURES**	ESIA developed	report accepted by PEU
	2.2 FLOOD WALL WATERKANT CONSTRUCTION (2.75M + 275k design + 495k contingencies) **2.4 ENHANCEMENT OF BASIN AT VAN SOMMELSDIJCK PUMPING STATION (250k + 25k design + 44k contingencies)** **2.5 ENHANCEMENT OF MANGROVE AREA (200k + 30k design + 31k contingencies)**	contract signed with firm for design and works for: construction flood wall Waterkant; enhancement basin at Sommelsdijck pumping station; and enhancement of mangrove area.	signed contract
	2.3 REHABILITATION PUMPING STATION VAN SOMMELSDIJCK (1.55M + 245k design + 346k contingencies)	contract signed with firm for goods and services	signed contract
	2.6 DESIGN (75k) AND IMPLEMENTATION OF DRAINAGE MAINTENANCE PLAN (400k + 56k contingencies)	contract signed with consulting firm	signed contract
	2.7 CONSTRUCTION SUPERVISION OF ALL WORKS (760k)	procurement documents developed (EOI, TOR, RFP)	procurement documents
Component 3. Capacity Building	**3.1 DEVELOPMENT KNOWLEDGE MANAGEMENT PLAN**	plan developed	report accepted by PEU
	3.2 DEVELOPMENT AND IMPLEMENTATION OF A CAPACITY BUILDING PLAN	procurement documents under development (EOI, TOR, RFP)	draft procurement documents

List of Activities and Schedule of Implementation for the Year 2019

	Sub Component	Duration in 2019	Start Date	End Date	Cost 2019	Quarters I	II	III	IV
Component 1. City-level Adaptation Framework and Plan	1.1 DEVELOPMENT OF CITY-BROAD ADAPTATION PLAN TO BUILD CLIMATE RESILIENCE	whole 2019			$100,000.00	x	x	x	x
Component 2.	2.1 ESIA FOR ADAPTATION MEASURES	9 months	jan	sept	$40,000.00	x	x	x	
	2.2 FLOOD WALL WATERKANT CONSTRUCTION (2.75M + 275k design + 495k contingencies) **2.4 ENHANCEMENT OF BASIN AT VAN SOMMELSDIJCK PUMPING STATION (250k + 25k design + 44k contingencies)** **2.5 ENHANCEMENT OF MANGROVE AREA (200k + 30k design + 31k contingencies)**	whole 2019	jan	dec	$33,000.00	x	x	x	x
	2.3 REHABILITATION PUMPING STATION VAN SOMMELSDIJCK (1.55M + 245k design + 346k contingencies)	whole 2019	jan	dec	$122,500.00	x	x	x	x
	2.6 DESIGN (75k) AND IMPLEMENTATION OF DRAINAGE MAINTENANCE PLAN (400k + 56k contingencies)	whole 2019	jan	dec	$60,000.00	x	x	x	x
	2.7 CONSTRUCTION SUPERVISION OF ALL WORKS (760k)	3 months	oct	dec	-				x
Component 3.	3.1 DEVELOPMENT KNOWLEDGE MANAGEMENT PLAN	11 months	jan	nov	$150,000.00	x	x	x	x
	3.2 DEVELOPMENT AND IMPLEMENTATION OF A CAPACITY BUILDING PLAN	1 month	dec	dec	-				x
Project Administration									
Personnel and other recurrent costs		whole 2019	jan	dec	$ 90,000.00	x	x	x	x
Utilities and Office supplies			sept	nov	$ 40,000.00			x	x
Auditing costs			sept	nov	$ 25,000.00			x	x
Monitoring and Evaluation activities			sept	nov	$ 10,000.00			x	x

Proyected Disbursements - time line (US$)

Source	Year 1	Year 2	Year 3	Year 4	Total
IDB	$ 660,500	$ 4,936,400	$ 3,140,100	$ 345,000	**$ 9,082,000**
Local	0	0	0	0	**$ -**
Total	$ 660,500	$ 4,936,400	$ 3,140,100	$ 345,000	**$ 9,082,000**

INFORMATION FOR PROCUREMENT PLAN INITIAL UPLOAD
ONGOING AND/OR LAST PRESENTED

1. Procurement Plan Coverage		
Data	**From**	**Until**
Procurement Plan Coverage:	2019	2022

2. Procurement Plan Details	
Version (1-2018) :	v1. 2019 - 2022

3. Amounts by Investment Category		
Investment Category	**Amount Financed by the Bank**	**Total Amount (Including counterpart)**
Works	USD 4,100,000.00	USD 0.00
Goods	USD 2,672,000.00	USD 0.00
Non Consulting Services		USD 0.00
Training	USD 230,000.00	USD 0.00
Operative Costs	USD 1,348,000.00	USD 0.00
Consulting Services (Firms + Individuals)	USD 1,500,000.00	USD 0.00
Transfers		USD 0.00
Community Participation		USD 0.00
Unassigned		USD 0.00
Total	**USD 9,850,000.00**	**USD 0.00**

4. Components		
Project Components	**Amount Financed by the Bank**	**Total Amount (Including counterpart)**
1	USD 550,000.00	USD 0.00
2	USD 7,572,000.00	USD 0.00
3	USD 380,000.00	USD 0.00
PROJECT ADMINISTRATION	USD 580,000.00	USD 0.00
PROJECT CYCLE MANAGEMENT FEE	USD 768,000.00	USD 0.00
Total	**USD 9,850,000.00**	**USD 0.00**

PROCUREMENT PLAN INITIAL LOAD INFORMATION (ONGOING AND/OR LAST PRESENTED)

WORKS

Executing Agency:	Activity:	Additional Information:	Procurement Method (Select one of the options):	Lots Quantity:	Process Number:	Estimated Amount			Associated Component:	Review Method (Select one of the options):	Dates		Comments - for UCS include selection method
						Estimated Amount, in US$:	Estimated Amount IDB %:	Estimated Amount Counterpart %:			Specific Procurement notice	Contract Signature	
	Design and Construction of Flood Wall Waterfront, Basin Pumping Station Van Sommelsdijck, Enhancement Mangrove Area		International Competitive Bidding	3		$ 4,100,000	100%		2. Downtown Adaptation Measures	Ex-Ante			

GOODS

Executing Agency:	Activity:	Additional Information:	Procurement Method (Select one of the options):	Lots Quantity:	Process Number:	Estimated Amount			Associated Component:	Review Method (Select one of the options):	Dates		Comments - for UCS include selection method
						Estimated Amount, in US$:	Estimated Amount IDB %:	Estimated Amount Counterpart %:			Specific Procurement notice	Contract Signature	
	Rehabilitation Pumping Station Van Sommelsdijck	replacement and rehabilitation pumps and replace sluice gates	International Competitive Bidding			$ 2,141,000.00	100%		2. Downtown Adaptation Measures	Ex-Ante			
	Implementation Maintenance Drainage Plan in city center	maintenance of 20km sewers (50k), supply vacuum/high pressure trucks incl maintenance and training (350k)	International Competitive Bidding			$ 456,000.00	100%		2. Downtown Adaptation Measures	Ex-Ante			

NON CONSULTING SERVICES

Executing Agency:	Activity:	Additional Information:	Procurement Method (Select one of the options):	Lots Quantity:	Process Number:	Estimated Amount			Associated Component:	Review Method (Select one of the options):	Dates		Comments - for UCS include selection method
						Estimated Amount, in US$:	Estimated Amount IDB %:	Estimated Amount Counterpart %:			Bidding Documents	Contract Signature	

CONSULTING FIRMS

Executing Agency:	Activity:	Additional Information:	Procurement Method (Select one of the options):	Process Number:	Estimated Amount			Associated Component:	Review Method (Select one of the options):	Dates		Comments - for UCS include selection method
					Estimated Amount, in US$:	Estimated Amount IDB %:	Estimated Amount Counterpart %:			Specific Procurement notice	Contract Signature	
	Development of City-borad Plan to Build Climate Resilience		Quality and Cost Based Selection		$ 275,000.00	100%		1. City-level Adaptation Framework and Plan	Ex-Ante			
	Design of Dissemination Strategy		Quality and Cost Based Selection		$ 275,000.00	100%		1. City-level Adaptation Framework and Plan	Ex-Ante			
	ESIA downtown Adaptation Measures		Quality and Cost Based Selection		$ 40,000.00	100%		2. Downtown Adaptation Measures	Ex-Ante			
	Design Drainage Maintenance Plan		Quality and Cost Based Selection		$ 75,000.00	100%		2. Downtown Adaptation Measures	Ex-Ante			
	Supervision of all works		Quality and Cost Based Selection		$ 760,000.00	100%		2. Downtown Adaptation Measures	Ex-Ante			
	Development of Knowledge Management Plan and Development & Implementation of Capacity Building Plan		Quality and Cost Based Selection		$ 150,000.00	100%		3. Capacity Building	Ex-Ante			
	Development and implementation of a Capacity building plan		Quality and Cost Based Selection		$ 230,000.00	100%		3. Capacity Building	Ex-Ante			

INDIVIDUAL CONSULTANTS

Executing Agency:	Activity:	Additional Information:	Procurement Method (Select one of the options):	Process Number:	Estimated Amount			Estimated Number of Consultants:	Associated Component:	Review Method (Select one of the options):	Dates		Comments - for UCS include selection method
					Estimated Amount, in US$:	Estimated Amount IDB %:	Estimated Amount Counterpart %:				No Objection to TOR's	Contract Signature	

TRAINING

Executing Agency:	Activity:	Additional Information:	Procurement Method (Select one of the options):	Process Number:	Estimated Amount			Associated Component:	Review Method (Select one of the options):	Dates		Comments - for UCS include selection method
					Estimated Amount, in US$:	Estimated Amount IDB %:	Estimated Amount Counterpart %:			Annual Training Plan (ATP)	End of Activity	

TRANSFERS

Executing Agency:	Transfer Purpose:	Additional Information:	Process Number:	Estimated Amount			Associated Component:	Estimated Number of Transfers:	Dates		Comments - for UCS include selection method
				Estimated Amount, in US$:	Estimated Amount IDB %:	Estimated Amount Counterpart %:			Contract Signature	Transfer Date	

MULTIYEAR EXECUTION PLAN (PEP)
SU-L1046 - PARAMARIBO URBAN REHABILITATION PROGRAM

COMPONENTS AND SUBCOMPONENTS	MACRO ACTIVITIES	BUDGET
1. CITY-LEVEL ADAPTATION FRAMEWORK AND PLAN		
1.1 DEVELOPMENT OF CITY-BROAD ADAPTATION PLAN TO BUILD CLIMATE RESILIENCE	Develop bidding documents for Plan Bidding process (publicize, receive, review, analyze and select proposal(s)) - 5 months Sign contract(s) with firm(s) Develop Plan	$ 275,000
1.2. DESIGN AND IMPLEMENTATION OF DISSEMINATION PLAN	Develop bidding documents for Dissemination Plan Bidding process (publicize, receive, review, analyze and select proposal(s)) - 5 months Sign contract(s) with firm(s) Submit, review, analyze and present comments on the Dissemination Plan and implementation	$ 275,000
2. DOWNTOWN ADAPTATION MEASURES		
2.1 ESIA FOR ADAPTATION MEASURES	Develop bidding documents for the Social & Environmental Impact Analysis Bidding process (publicize, receive, review, analyze and select proposal(s)) - 5 months Sign contract(s) with firm(s) Submit, review, analyze and present comments on the ESIA	$ 40,000
2.2 FLOOD WALL WATERKANT CONSTRUCTION (2.75M + 275k design + 495k contingencies)	Project approval by the Monuments comission Project approval by Building Committee of Public Works Develop bidding documents for **design and construction works** Bidding process (publicize, receive, review, analyze and select proposal(s)) - 8 months Sign contract(s) with firm(s) Design and Construction works Final recption	$ 3,520,000
2.3 REHABILITATION PUMPING STATION VAN SOMMELSDIJCK (1.55M + 245k design + 346k contingencies)	Develop bidding documents for **goods and installation** Bidding process (publicize, receive, review, analyze and select proposal(s)) - 6 months Sign contract(s) with firm(s) Installation of goods - final reception	$ 2,141,000
2.4 ENHANCEMENT OF BASIN AT VAN SOMMELSDIJCK PUMPING STATION (250k + 25k design + 44k contingencies)	Project approval by the Monuments comission Project approval by Building Committee of Public Works Develop bidding documents for **design and construction works** Bidding process (publicize, receive, review, analyze and select proposal(s)) - 8 months Sign contract(s) with firm(s) Construction works Final recption	$ 319,000
2.5 ENHANCEMENT OF MANGROVE AREA (200k + 30k design + 31k contingencies)	Project approval by the Monuments comission Project approval by Building Committee of Public Works Develop bidding documents for **design and construction works** Bidding process (publicize, receive, review, analyze and select proposal(s)) - 8 months Sign contract(s) with firm(s) - by group of buildings? capacity of the contractors? Construction works Final recption	$ 261,000
2.6 DESIGN (75k) AND IMPLEMENTATION OF DRAINAGE MAINTENANCE PLAN (400k + 56k contingencies)	Prepare terms of reference for the Drainage Maintenance Plan Procurement (publicize, receive, review, analyze and select proposal(s)) - 4 months Sign contract with firm Submit, review, analyze and present comments on the Drainage Maintenance Plan	$ 75,000
	Prepare terms of reference for the implementation of the Drainage Maintenance Plan in historic city center Procurement (publicize, receive, review, analyze and select proposal(s)) - 6 months Sign contract(s) with firm(s) Implement Drainage Management Plan in historic center (20km sewers) (50k), supply vacuum/high pressure trucks incl maintenance and training (350k) Maintenance of drainage in historic center - final reception	$ 456,000
2.7 CONSTRUCTION SUPERVISION OF ALL WORKS (760k)	Develop EIO, TORs, RFP Bidding process (publicize, receive, review, analyze and select proposal(s)) - 6 months Sign contract(s) with firm(s) Works supervision and final reception	$ 760,000
3. CAPACITY BUILDING		
3.1 DEVELOPMENT KNOWLEDGE MANAGEMENT PLAN	Procurement (publicize, receive, review, analyze and select proposal(s)) - 5 months Sign contract(s) with firm(s) Submit, review, analyze and present comments on the Knowledge Management Plan	$ 150,000
3.2 DEVELOPMENT AND IMPLEMENTATION OF A CAPACITY BUILDING PLAN	Prepare terms of reference for Capacity Building Plan Procurement (publicize, receive, review, analyze and select proposal(s)) Sign contract(s) with firm(s) Submit, review, analyze and present comments on the Capacity Building Plan Capacity training - preparation and delivery of workshops	$ 230,000
4.PROJECT ADMINISTRATION		
Project Administration	4.1 Personnel and other recurrent costs	$ 360,000
	4.2 Utilities and office supplies	$ 40,000
	4.3 Auditing costs	$ 100,000
	4.4 Monitoring and evaluation activities	$ 80,000
	Project Cycle Management Fee	$ 768,000
TOTAL BUDGET		**$ 9,850,000**

CABINET OF THE PRESIDENT OF THE REPUBLIC OF SURINAME
COORDINATION ENVIRONMENT
Tel. No.: +597-472917/471216 @; co.environment@president.gov.sr
Dr. S. Redmondstraat 116-118, Paramaribo, Suriname, South America

To:
The Secretariat of the Adaptation Fund Board
Email: Secretariat@Adaptation-Fund.org

Our ref.: 233/CM/2018

Paramaribo, July 23, 2018

Subject:
Endorsement for Urban Investmensts for the Resilience of Paramaribo:
"Building adaptive capacity of Paramaribo communities to climate change related floods and sea level rise through strategic urban planning and sustainable infrastructure investments

Esteemed Secretariat,

In my capacity as Designated Authority for the Adaptation Fund in Suriname, I confirm that the above mentioned national project/programme proposal is in accordance with the Government's national and regional priorities in implementing adaptation activities to reduce impacts of- and risk, posed by climate change in the Republic of Suriname.

Accordingly, I am please to endorse the above mentioned project/programme proposal with support from the Adaptation Fund. If approved, the project/programme will be implemented by the Inter American Development bank and executed by the Ministry of Public Works.

Yours sincerely,

Winston G. Lackin,
Ambassador in charge of the Environment/
Presidential Advisor

MINISTRY OF PUBLIC WORKS, TRANSPORT & COMMUNICATION

DIRECTORATE OF CIVIL TECHNICAL WORKS

Mr. Jagernath Lachmonstraat no. 167

Paramaribo-Suriname Tel: 464088

To : Leslie-Ann G. Edwards
Chief of Operations
Inter American Development Bank
Peter Bruneslaan 2 - 4
Paramaribo

Paramaribo, July 27 2018

Ref.no. : SS/ODN/SM /Ag. No. 2947
Enclosures : (-)
Subject: Approval final Proposal SU-G1003 Urban Investments for Resilience of Paramaribo

Dear Mrs. Edwards,

The Ministry hereby approves the final proposal for the Urban Investments for Resilience of Paramaribo as submitted July 25th, 2018 and request you to submit the proposal to the Adaptation Fund.

We would further like to thank the team who have worked on the proposal and look forward to startup the projects as soon as possible.

With regards,

Mr. S. Soman
Permanent Secretary of the
Directorate of Civil Technical Works