

TERMS OF REFERENCE

I. General information

Assignment name	Consulting services for the Environmental and Social Impact Assessment (ESIA) of drainage and road infrastructure works in Newport West, Kington (Jamaica)
Beneficiary	SAJ / NWA
Country	Jamaica
Total estimated number of months	Tranche 1 – Preliminary ESIA study (Firm): 12 months Tranche 2 – Final ESIA study (Optional): 4 months

II. Context and justification of the need

1. Expertise France

Expertise France (EF) is a public agency and the inter-ministerial actor in international technical cooperation, subsidiary of the Agence Française de Développement Group (AFD Group). As the second largest agency in Europe, it designs and implements projects that sustainably strengthen public policies in developing and emerging countries. Governance, security, climate, health, education... It operates in key areas of development and contributes alongside its partners to the implementation of the Sustainable Development Goals (SDGs). For a world in common.

For more information: www.expertisefrance.fr

2. The Euroclima programme

Euroclima is the European Union's (EU) flagship cooperation programme on environmental sustainability and climate change in Latin America and the Caribbean (LAC). It aims to contribute to the LAC region's green transition, through efforts to mitigate and adapt to climate change and to protect and conserve biological diversity. Two main outcomes are expected:

- The enabling environment for a green transition (integrated policies, legal frameworks, sector plans and financial instruments) will be strengthened, in line with climate, biodiversity and circular economy objectives.
- Transformative approaches in key areas for the green transition will be developed, demonstrated and scaled up through the mobilization of public and private funding.

Euroclima contributes to the implementation of the Global Gateway Investment Agenda in the region. Global Gateway is the EU's offer to bridge the infrastructure investment gap by using public financing to leverage private capital and investment for projects that contribute to the green and digital twin transition. In the Caribbean region, Euroclima is funded by the European Commission, for a 5-year

period, and is implemented by EU Member States agencies or MSAs (AECID, Expertise France, FIIAPP, GIZ) and the UN (ECLAC, UNDP, UN Environment). The programme forms part of the regional Team Europe Initiatives “Latin America and Caribbean Green Transition” and “A Partnership for a Caribbean Green Deal”.

Through Euroclima, the EU has initiated Country Dialogues to enhance its role in defining cooperation priorities. The Country Dialogue is conducted with the key institutions for climate action in each country, which allows for the alignment of the program’s strategies with nationally established priorities to ensure cohesion and synergies with other activities. In consultation and coordination with the country and under the leadership of the National Focal Point (NFP), the programme supports the design of the Dialogue process on a case-by-case basis.

For more information: <https://www.euroclima.org/>

3. The Euroclima programme in Jamaica

The Global Gateway Investment Agenda (GGIA) is driving transformative action in Jamaica across climate, energy, transport, digital infrastructure, and regional cooperation. Aligned with the EU’s commitment to sustainability and resilience, these initiatives directly support Jamaica’s Vision 2030, fostering economic growth, strengthening climate adaptation, improving disaster risk management, and enhancing citizen security. The Euroclima Country Action Plan (CAP), approved on January 28th of 2025, aims to accelerate a green transition and embed long-term sustainability. Actions are targeting key sectors, focusing on urban green transition, waste management, water security, port sustainability, and renewable energy.

These actions align with the EU Multi-Annual Indicative Programme (2021-2027) and complement broader initiatives like the World Bank’s Kingston Waterfront Improvement Project and regional waste management strategies. Adaptive management strategies are also being implemented to respond effectively to evolving environmental and socio-economic conditions. Through strategic partnerships, innovative financing, and decisive action, Jamaica is making tangible progress toward a climate-resilient economy, modernized infrastructure, and a sustainable future for all its citizens.

4. Background of the action

The Euroclima programme is helping Jamaica advance its goal of transforming Kingston into a leading green logistics hub in the Caribbean. Yet this ambition faces a major challenge: in the Newport West area, recurrent flooding and outdated drainage systems have become serious obstacles, undermining port accessibility, reducing competitiveness, and deterring future investments. While private operators have invested heavily to expand port capacity in recent years, public infrastructure has not kept pace. This gap has led to operational disruptions, with estimated annual losses of USD 17 million.



Photos of localized flooding in the Newport West and MGD area (October 2020, CEAC Drainage Report)

In response, the Shipping Association of Jamaica (SAJ), which brings together the main port operators, has launched an initiative to redevelop the area under a Public-Private Partnership (PPP) framework, working closely with the National Works Agency (NWA), National Water Commission (NWC) and with the backing of the Jamaican government.

The European Union, through the Euroclima programme and its Global Gateway strategy, is supporting this effort by financing the environmental and social impact studies needed to shape this critical investment. It is also facilitating dialogue among key players. This coordinated approach aims to deliver sustainable water management solutions that will protect port operations, strengthen Jamaica's climate resilience, and attract further green investments aligned with Vision 2030 Jamaica.

The project itself is structured into several phases (see **Annex 1**). It starts with the development of a Preliminary Design, guided by a Road Map that sets out the technical and strategic priorities. This is followed by the Detailed Design phase, where engineering specifications and construction plans are finalised, leading ultimately to the Construction phase.

The Environmental and Social Impact Assessment (ESIA) is embedded across these stages. A Preliminary ESIA will first be carried out in parallel with the Preliminary Design to identify key risks, opportunities, and regulatory requirements, and to secure the necessary environmental permit from the NRCA. A Final ESIA (Optional) will then be prepared alongside the Detailed Design to update and refine the assessment, serving as an addendum to the existing environmental authorisation if required, to ensure that all environmental and social aspects remain adequately addressed in line with the final technical design. This integration ensures that sustainability considerations inform every major technical decision, facilitating regulatory approvals and supporting the long-term success and resilience of the investment.

III. Objectives and desired results

1. General objective

The general objective of the assignment is to conduct a comprehensive Environmental and Social Impact Assessment (ESIA) for a road, drainage and utilities (water and sewerage) infrastructure upgrade project designed to improve access to the Port of Kingston. The ESIA will assess the project's potential environmental and social impacts, identify mitigation measures, ensure alignment with national regulatory requirements and international standards, and facilitate the delivery of a resilient, sustainable, and inclusive infrastructure investment.

2. Specific objectives

1. Conduct baseline studies to characterise the environmental, utilities (water and sewerage infrastructure), hydrological, social, and traffic conditions in the project area, including Marcus Garvey Drive, Tinson Pen, and Newport West;
2. Assess the potential environmental and social impacts of the proposed drainage and road infrastructure works, including climate vulnerability (in accordance with the requirements of the Government of Jamaica PIAB Policy) and disaster risk (Jamaica Systemic Risk Assessment Tool);
3. Design and propose appropriate mitigation and enhancement measures, including a costed Environmental and Social Management Plan (ESMP) aligned with national and IFI standards;
4. Carry out a stakeholder engagement process, including consultations with affected populations, institutional stakeholders (such as Ministries, Agencies and Department of the Government of Jamaica), and port users, and document the outcomes;
5. Ensure alignment with International Financial Institution (IFI) environmental and social standards and other applicable safeguards;
6. Support the regulatory approval process by submitting the Preliminary ESIA and all associated documentation to NEPA and the NRCA, and assist in obtaining the environmental permit.
7. Prepare the Final ESIA, incorporating any necessary updates or addenda resulting from the Detailed Design phase, and submit these to NEPA if required to ensure continued compliance with regulatory authorisations (optional).

3. Anticipated results

The ESIA is undertaken in two stages: first a scoping study and a Preliminary ESIA study (Tranche 1 - Firm) and then the Final ESIA study (Tranche 2 - Optional).

The scoping study will define the issues that need to be addressed in the ESIA study, considering the specific context in which the project will be implemented.

The ESIA scoping study will deliver the following results:

- an overview of the project, the applicable legislative and institutional framework;

- an indication of the project alternatives and their variants to be studied;
- a description of the key stakeholders and their concerns, including social and cultural settings such as population and demographics, income and employment, housing and land, community and utilities, gender equality and empowerment, sanitation and public health;
- a stakeholder engagement plan (to be implemented while the Preliminary ESIA study as such is conducted);
- a description of the key environmental aspects and project-environment interactions that should be addressed in the Preliminary ESIA;
- a description of the geographical area to be considered in the environmental baseline and in the identification of impacts;
- recommendations on specific impact identification and evaluation methodologies to be used in the Preliminary ESIA;
- a description of the proposed methodology for identifying and assessing environment and climate change-related risks, constraints and opportunities.

The Preliminary ESIA study will deliver the following:

- an identification and assessment of the potential significant environmental impacts of the project in its different alternatives;
- recommendations, including a Preliminary Environmental & Social Management Plan (ESMP), for the implementation of proposed measures to mitigate negative impacts and optimise positive ones;
- recommendations on how to adapt project design to optimise the exploitation of opportunities, manage risks and operate under the constraints imposed by the natural environment, including climate variability, climate change and the availability or scarcity of natural resources;
- **the preparation and submission of all necessary documentation to obtain the environmental permit from the NRCA, in compliance with applicable regulatory requirements.**

The Final ESIA study (optional) will deliver the following:

- a comprehensive and updated assessment of all significant environmental and social impacts of the definitive project design;
- detailed recommendations along with a fully developed ESMP, setting out mitigation, enhancement, and monitoring measures, with associated responsibilities and indicators;
- final proposals for any necessary design adaptations to maximise opportunities, address risks, and ensure that the project can be implemented sustainably within the environmental and climatic context of the area;
- the preparation of any required updates or addenda to the existing environmental authorisation to secure final regulatory confirmation from the NRCA.

IV. Description of the assignment

1. Background

The National Environment and Planning Agency (NEPA) and EXPERTISE FRANCE require an Environmental and Social Impact Assessment (ESIA) to be carried out for the formulation of the Newport West area Flood Mitigation Project in Kingston, Jamaica.

The ESIA must examine the potential impacts the project may have on the environment and social landscape, as well as options for mitigating and/or optimising these impacts.

Simultaneously, recognising that the implementation of the project and the achievement of its objectives will also depend on environmental and climate-related risks, constraints and opportunities, it has been decided to also add an assessment of these aspects.

The project is described as follows: the project aims to address severe flooding and congestion issues impacting the port and surrounding areas of Newport West, Marcus Garvey Drive, and Tinson Pen in Kingston. The study will also consider the Chesterfield Road area, as the outflow of the main drainage infrastructure is expected to cross land located southwest of Chesterfield Road. It involves major drainage infrastructure upgrades, to include upgrade and or relocation of water and or sewerage infrastructure, and the construction of a new roadway bypass north of the existing Tinson Pen aerodrome (identified as Alternative 2 – Tinson Pen Bypass), complemented by interchange features to enhance traffic flow and connectivity to the Port of Kingston. The most up-to-date layout of this solution, including the interchange, is provided in **Annex 2**. In addition, the assessment shall take into account the railway corridor owned by the Jamaica Railway Corporation, which, although currently unused, will be impacted by the proposed drainage improvement works. The alignment of this railway corridor is also shown in **Annex 2**. This phased investment will be implemented through Preliminary and Detailed Design stages, followed by Construction, to ultimately safeguard port operations and support Kingston's development as a resilient logistics hub.

The following technically feasible alternatives have been identified: the additional alignment and infrastructure options described in the Road Map given in **Annex 1**, including the elevated road corridor, the Spanish Town Road diversion, and the multi-level interchange as stand-alone solutions, will be considered within the ESIA process. These will serve as comparative alternatives to ensure that the selected design represents the best balance between technical feasibility, environmental and social performance, and long-term sustainability.

Existing information on the project and the environment can be found in the Road Map document (see **Annex 1**).

Previous technical studies, such as the CEAC 2020 feasibility study (provided in **Annex 3**), the Stanley Consultants drainage assessments, and the Engineering Assessment Report for Newport West and Kingstown Wharves Ltd., are acknowledged and will need to be reviewed and integrated into the ESIA process when made available. These studies shall serve as important references for analysing project alternatives, design constraints, and potential cumulative impacts.

2. Kick-off meeting

A Kick-Off Meeting (KOM) shall be organised between the Contractor, Expertise France, NWA, SAJ, NEPA, and other relevant stakeholders within two (2) weeks of the issuance of the Notice to Proceed

(NTP). This meeting will serve to formally launch the assignment, clarify any outstanding technical or administrative points, review the overall project schedule and expectations, and establish clear communication and reporting protocols. The Contractor shall prepare a brief presentation outlining their preliminary understanding of the assignment, initial observations, and the proposed approach for the inception phase.

3. Inception Report

The Inception Report will be the Contractor's first key deliverable under this assignment. It will confirm their understanding of the assignment's objectives, provide a detailed plan for executing the ESIA, and establish a common framework for collaboration with NEPA, Expertise France, and other stakeholders. This document will ensure that all parties are aligned on the technical approach, the scope of work, and the coordination arrangements before progressing to subsequent phases.

a) Understanding of the project and its context

The Contractor shall prepare a clear and structured description of their understanding of the project's objectives, rationale, expected outcomes, and strategic context, including the significance of the Newport West area for Jamaica's logistics sector and climate resilience agenda. The report must highlight the Contractor's appreciation of existing issues such as flooding risks, outdated drainage infrastructure, water/sewerage sub-surface works and port accessibility constraints, as well as their implications for the socio-economic fabric of the area.

b) Detailed work plan and methodology

The Contractor shall outline the proposed overall approach and methodology for delivering the ESIA assignment.

This includes a clear sequencing of activities, key analytical tools and methods proposed, linkages between the Preliminary ESIA and Final ESIA phases, and how the process will ensure integration with the ongoing Preliminary and Detailed Design phases of the project.

A detailed Gantt chart or equivalent shall be provided, showing timelines, milestones, and interdependencies.

c) Team composition and responsibilities

A comprehensive presentation of the Contractor's team shall be included, specifying the roles and responsibilities of each expert (e.g. Team Leader, Environmental Specialist, Social Specialist, Climate/Resilience Expert, Stakeholder Engagement Specialist, Water Utility Specialist, GIS and Mapping Expert), Civil Engineer.

The Contractor shall also indicate the estimated input (in person-days) per expert by phase.

d) Initial stakeholder mapping and engagement plan

The Contractor shall present a preliminary mapping of key stakeholders, including government agencies (NEPA, NWA, PAJ, NWC), local authorities, private operators, community representatives, NGOs, and groups potentially affected by the project. This mapping must include an outline of the stakeholder engagement plan to be implemented across the ESIA phases, highlighting how early consultations will be conducted to capture local concerns and priorities. It should also include a proposed strategy for records and documentation of all consultations.

e) Preliminary identification of key environmental and social aspects

Based on the existing Road Map, technical studies and consultations to date, the Contractor shall identify and discuss the main environmental and social aspects likely to require close attention. This includes considerations of physical and biological conditions, vulnerability to climate variability and change, public health and safety, socio-economic dynamics, and port-related operational factors.

f) Data requirements and coordination needs

The Inception Report shall specify the initial data needs and gaps identified for the effective delivery of the ESIA, including baseline data, hydrological and climatic records, socio-economic profiles, and regulatory references. It shall also propose arrangements for coordination with Expertise France, NEPA, SAJ, NWA, NWC and other relevant entities to secure necessary data, logistical support, and regulatory guidance.

g) Quality assurance and risk management strategy

The Contractor shall describe how quality control will be ensured throughout the assignment (including internal reviews and validation steps) and set out an initial risk assessment, detailing anticipated challenges (e.g. access to sites, data gaps, stakeholder sensitivities) and proposed mitigation measures.

h) Condition for approval

The Inception Report will serve as the foundation for executing the assignment. Its formal written approval by Expertise France, in consultation with NEPA and key stakeholders, will be a prerequisite before proceeding to subsequent ESIA activities.

The Inception Report shall be submitted no later than two (2) weeks after the Kick-Off Meeting.

Deliverable: Inception report

4. ESIA scoping study

The ESIA scoping study constitutes a critical step in defining the scope, priorities, and methodological framework for the overall assessment. It will ensure that key environmental and social issues, stakeholder concerns, and regulatory requirements are fully captured and inform the subsequent stages of the ESIA. This phase will establish the thematic and geographical boundaries of the assessment and provide clear guidance for the detailed studies to follow.

a) Overview of the project and its alternatives

The Contractor must describe the project and its main technical alternative, specifying that the currently selected design will be assessed alongside other alignment or infrastructure options identified in the project Road Map. This includes alternatives which are significantly different from an environmental and/or social perspective (e.g. location alternatives affecting different ecosystems or options involving sizable differences in greenhouse gas emissions and/or carbon sequestration potential).

The Contractor will also define the constraints to be considered when proposing mitigation measures and adjustments to the project.

They must assess whether variations to the proposed alternatives warrant further analysis in the ESIA.

b) Legislative, institutional and planning framework

A description must be made of the institutional and legislative framework relevant to the project and its ESIA, including an indication of the key applicable legislation, planning processes (e.g. land use planning, beach control act 1956, harbours act, port authority act, NRCA Act 1991, NRCA Act, Ambient Air quality standards regulations, etc), standards and norms that will have to be addressed in the ESIA study.

This shall include specific reference to the NEPA requirements provided in **Annex 4** of these Terms of Reference, as well as compliance with the Equator Principles, which set international benchmarks for environmental and social risk management in project finance.

Reference should also be made to existing national environmental assessments or profiles (e.g. Jamaica's Country Environmental Profile, JaNEAP, State of the Environment reports, Ja-NAP), the State of the Jamaica Climate reports, which include downscaled climate change projections and any relevant Strategic Environmental Assessment (if applicable).

c) Description of the key stakeholders and their concerns

The engagement of stakeholders in the ESIA process is a key success factor. The Contractor should identify key stakeholders (key groups and institutions, environmental agencies, NGOs, representatives of the public and others, including those groups potentially affected by the likely significant environmental impacts of the project, as well as private sector actors likely to be impacted by or to influence the project, such as shipping operators, port authorities, logistics companies and local businesses).

Particular attention should be paid to typically less represented groups such as women and vulnerable groups.

Stakeholders will be engaged to identify their concerns and values with respect to the project under consideration. This will contribute to the identification of key project–environment interactions that will need to be addressed in the ESIA study.

The stakeholder engagement strategy to be employed will be revised by EXPERTISE FRANCE in consultation with NEPA before being implemented to avoid unnecessary conflicts and raising of expectations.

Records must be kept of all consultations and comments received.

d) Description of the key environmental aspects and project–environment interactions that should be addressed in the ESIA

Particular attention should be paid to the direct and indirect impacts that are likely to be the most significant, considering the sensitivity of the environment, the pressures resulting from the project and the expectations of the stakeholders.

Based on these considerations and on background information on the local environment as well on other environmental assessments (including SEAs), the Contractor should identify environmental issues to be specially considered under the following categories:

- Physical environment, including (micro-) climate, climate variability and climate change, air quality, water resources (surface and groundwater), geology, geomorphology, soil quality and risk of natural disasters, topography drainage;
- Biological conditions: biodiversity (including rare, endangered and endemic biodiversity components), and biological resources of cultural, social, or economic importance;
- Socio-economic conditions: consider the aspects that depend on environmental changes (public health; vulnerability to disasters; vulnerability to increasing climate variability and the expected effects of climate change; access to natural resources and associated conflicts), those that can produce environmental impacts, and, more broadly, the socio-economic conditions that might be affected by the project and are not considered in other studies at the formulation stage.

Note that project-related emissions of greenhouse gases are unlikely to be considered 'significant' at the global scale. Nevertheless, at the project scale a project or some project alternatives may offer significant opportunities to reduce emissions, store carbon or implement the principle of a 'climate-neutral development path'. If this is the case, the assessment of such opportunities should be included in the scope of the ESIA.

e) Description of the scope of the environmental baseline

Based on the information obtained above and on an appreciation of the areas of project influence, the Contractor must provide indications on the scope of the environmental baseline needed for the ESIA.

Distinct geographical units can be proposed according to the type of expected impact (including indirect impacts).

All geographical units identified must be justified.

f) Recommendations on specific impact identification and evaluation methodologies to be used in the ESIA

The Contractor should provide an indication of the most appropriate impact identification and evaluation methodologies to be used in the ESIA. These may include internationally recognised tools such as impact matrices, checklists, GIS spatial analyses, hydrological or traffic models, or other quantitative and qualitative approaches adapted to the nature and scale of the project.

Special attention should be given to those environmental interactions that will merit quantitative analysis and those for which qualitative analyses should be carried out.

g) Proposed methodology for identifying and assessing environmental and climate-related risks, constraints and opportunities

The Contractor should provide an indication of the methodology they plan to use to identify and then assess the risks, constraints and opportunities linked to the biophysical environment in which the project will operate, including the availability or scarcity of natural resources (soils, water, energy, materials etc.), increasing climate variability, and (to the extent they can be predicted) the projected effects of climate change.

The ESIA scoping study shall be completed and submitted no later than two (2) months after the issuance of the Notice to Proceed (NTP).

Deliverable: Scoping report

5. Preliminary ESIA study

The Preliminary ESIA study builds on the findings of the scoping phase to provide an initial assessment of the project's potential environmental and social impacts. It will help identify key risks, opportunities and regulatory requirements, propose preliminary mitigation and enhancement measures, and secure the necessary environmental permit from the NRCA. This process will support informed decision-making as the project advances towards the Detailed Design phase.

a) Environmental and social baseline study

- *Existing environment and socio-economic conditions*

The baseline study shall include a description of the initial state of the environment and the socio-economic conditions within the selected boundaries of the study area, focusing on aspects that can be influenced by the project or that could influence its efficiency or sustainability.

This includes demographic characteristics, livelihoods, land and resource use patterns, community infrastructure, public health indicators, and any factors that could affect community vulnerability to project impacts.

More specifically, the baseline shall cover, but not be limited to: topography, geology, soils, hydrology, climate, air quality, noise and vibration, biodiversity (including sensitive habitats and species), land use patterns, demographics, livelihoods and economic activities, public health and education, cultural heritage, disaster vulnerability, and risks of disease transmission (such as HIV/AIDS).

In addition, the Contractor shall review the NEPA Guidelines provided in **Annex 4**, and incorporate any additional environmental or social variables that may be specifically required under Jamaican regulatory practice.

As far as possible, indicators (e.g. environmental quality indices, socio-economic or health benchmarks) should be identified for all key variables to be studied, establishing a baseline for impact identification and future monitoring.

All indicators must be adequately explained and justified. If location alternatives are considered, the study should focus on the differences in the appropriateness and sensitivity of both the environment and the socio-economic context to the pressures resulting from the project.

- *Expected future situation without the project*

The Contractor should describe the expected trends and situation of environmental and social variables on the short- medium- and long-term, assuming that the project will not be implemented.

This 'no project' scenario will be considered as a benchmark for predicting the project's impacts.

Nevertheless, if the situation without project seems unrealistic, the most probable alternative should be used as a reference.

b) Impact identification and evaluation

The Contractor will identify and describe the potential significant environmental and social impacts of the project alternatives, and evaluate them.

Significant potential impacts (direct, indirect and cumulative) must be identified, using impact identification methodologies proposed by the scoping study.

Impact identification shall take into consideration the sensitivity of the environment and local communities, the legislative framework (including NEPA requirements in **Annex 4**), the pressures resulting from the project, and stakeholder expectations.

Impact identification must address the aspects identified by the scoping study, and should cover — but not necessarily be limited to — the following:

- project activities (under construction, operation and decommissioning/abandonment);
- associated activities and structures (e.g. base camps during construction);
- location;
- general layout, size;
- time span of the project;
- means, materials and resources required (e.g. energy and water consumption, hazardous materials);
- polluting discharges and emissions;
- noise and vibration;
- production of odours, luminous emissions;
- solid and hazardous waste production;
- land-take requirements;
- presence of workers;
- access and transport;
- social effects, including on livelihoods, land access, local economic activities, public health and safety, mobility, and the population's vulnerability to increasing climate variability and climate change.

The state of the environment and communities resulting in the short, medium and long term from project implementation will be described based on the same indicators or criteria as the baseline study.

The impact evaluation must be assessed in comparison with the expected state of the environment under the no-project scenario.

The impacts should be described according to their nature and characteristics (e.g. direct and indirect, temporary or permanent, continuous or intermittent, reversible or irreversible, positive or negative, short- medium- or long-term, their magnitude, their mitigability and compensability, their transboundary nature, accumulation and synergies with other impacts).

Where appropriate, impacts on humans should be disaggregated by sex, age and other relevant social criteria.

The ESIA shall explicitly assess differentiated impacts on women, youth, elderly persons, and other vulnerable or marginalised groups, considering how these groups may experience project impacts differently.

Not all impacts need to be quantified. In some circumstances the attempts at quantification may result in meaningless numbers that are of no value to the decision-making process. It is thus important to recognise when a clear description of the impact characteristics and the reasons behind a certain qualification will be more useful (e.g. to propose mitigation measures and base a decision) than attempts to produce less meaningful quantification.

Impacts should be identified for the construction, operation and decommissioning phases of the project, and all associated developments should be considered (e.g. power lines associated with a hydroelectric dam, management/disposal of ashes generated by an incinerator, extraction of materials for construction activities).

c) Measures and recommendations in relation to impacts

Measures must be proposed to enhance positive effects, to eliminate/mitigate/compensate undesired effects.

These measures (generally referred to as mitigation measures) must be technically feasible, economically sound and socially acceptable (i.e. they must consider the views of the main stakeholders).

The Contractor must seek ways to optimise such measures, such that one mitigation measure does not reduce the effectiveness of another or, worse yet, cause an undesired significant impact itself.

The measures can have several distinct aims:

- reducing the extent, scale or time-scale of activities that produce negative impacts in favour of less damaging activities or activities producing positive effects;
- changes in the effects of an activity, without changing the activity itself (for example, adding anti-pollution filters);
- strengthening the protection of the receiving environment with respect to project impacts or other hazards;
- rehabilitating or restoring damaged resources;
- compensating for damage, e.g. by achieving improvements to resources similar to the ones affected.

The residual impacts (i.e. the final environmental or social impact after the application of the proposed mitigation measures) must be identified and assessed. Based on this assessment the alternatives must be compared and recommendations made on the best alternative. In particular, for the evaluation of the alternatives, the analysis must include an assessment of travel delays experienced by the public — this information will be provided by the entity in charge of the Preliminary Design. A suitable marker or parameter shall then be defined to rate each alternative's net benefit to the travelling public. The comparison of alternatives must be summarised in tabular form.

d) Preliminary Environmental and Social Management Plan

The Preliminary Environmental and Social Management Plan (ESMP) is a document that identifies the actions needed to implement the Preliminary ESIA recommendations, including environmental and social monitoring required during the implementation phase of a project.

The Preliminary ESMP should clearly translate the recommendations from the Preliminary ESIA into an operational plan.

The Preliminary ESMP of the project should include:

- a table (logical framework type) showing the objectives, expected results, objectively verifiable indicators, activities (mitigation/optimisation measures), and responsibilities for the implementation of those activities;
- specific measures and indicators to address impacts on vulnerable groups, including women, youth, and marginalised populations, ensuring their inclusion in mitigation and monitoring plans;
- a set of Environmental Quality Objectives (EQOs) linked to key indicators identified in the baseline, establishing performance targets for the construction and operational phases;
- institutional arrangements for its implementation and for environmental and social monitoring: responsibilities, role of the environmental authorities, role and participation of stakeholders;
- suggestions for contracts (environmental clauses: standards, potential requirement to prepare an Environmental Management Plan of the enterprise) and contracting modalities (such as payments linked to results);
- a monitoring and supervision plan (including appropriate indicators, frequency of monitoring, means to gather and analyse the data, reporting system);
- a response plan in case of accidents or unexpected results from the environmental and social monitoring;
- recommendations on general emergency preparedness relevant to potential project-related risks, to guide the later development of a detailed Emergency Response Plan if required;
- a formal Grievance Redress Mechanism (GRM) to record, process and resolve complaints from affected communities and other stakeholders in a transparent and timely manner;
- integration or reference to specific thematic plans as relevant, such as a Health and Safety Management Plan, a Biodiversity Management Plan, or a Water Management Plan, depending on the risks identified;
- a proposed schedule for activities (monitoring and mitigation/optimisation measures), extending beyond construction into the operational phase as needed to ensure sustained compliance with environmental and social obligations;
- an indication of means (including personnel, vehicles) and costs of implementing the Preliminary ESMP.

The Preliminary ESMP shall include specific provisions for the training and awareness-raising of all project staff and contractors to ensure that they understand and comply with environmental and social obligations, monitoring requirements, emergency procedures, and stakeholder engagement protocols. This shall include orientation sessions prior to the commencement of works and refresher trainings as needed during implementation.

e) Limitations of the Preliminary ESIA

The Contractor should underline all the major limitations, weaknesses and uncertainties of the study. The Contractor is required to state any assumptions made in the prediction and assessment of the potential environmental or social impacts and risks, to highlight areas where information is deficient and to make clear how the assessment of significance has been determined, for example the use of established standards, quality objectives, stakeholder views and professional judgement.

f) Conclusions on environmental and social impacts

This section will summarise the key results of the Preliminary ESIA, the recommendations (referring to the Preliminary ESMP to be attached) and the assessment of the residual impacts.

The Contractor is also required to provide any information relevant for further economic and financial analyses or for the general formulation study.

The limitations of the Preliminary ESIA and its key assumptions should be articulated.

g) Identification and evaluation of environmental and climate-related risks, constraints and opportunities

The Contractor will identify and describe the potentially significant risks, constraints and opportunities associated with the environment in which the project will operate, including (but not necessarily limited to) the following aspects:

- availability – or scarcity – and quality of the natural resources (e.g. water, land, soils, energy, materials, minerals, plant, animal species, ecosystem services) on which project implementation and the achievement of objectives will depend, considering existing pressures, current trends and the projected effects of climate change;
- exposure to climate-related risks (e.g. resulting from increasing climate variability, expected effects of climate change). This will be done by reviewing relevant national, sub-regional and local reports and studies on the effects of climate variability and climate change, including proposed responses to address those effects by project partners and within the project context as relevant. These responses may include technical, policy and institutional components;
- exposure to other environmental risks or constraints (e.g. biological conditions, pests, invasive species, wildfires, pollution originating from other human activities outside the scope of the project);
- exposure to natural disasters, semi-natural disasters and technological accidents, including those that may become more severe or more frequent as a result of climate change.

Although the analysis is likely to point out primarily to risks and constraints, the existence of opportunities associated with the natural and social environment (e.g. availability of abundant natural resources which - if properly used and managed - can improve the project's effectiveness, efficiency or sustainability; positive trends resulting from the projected effects of climate change) should also be investigated.

The main environmental and climate-related risks, constraints and opportunities associated with the project must be identified making use of the methodology proposed by the scoping study.

In order to determine which of them are 'significant' and may thus require a change in project design or the adoption of specific adaptation measures, it is suggested to characterise and evaluate risks, constraints and opportunities against the following criteria:

- relevance: are the identified risks, constraints and opportunities somehow relevant to the problems the project aims to address and to its objectives?;
- effectiveness: can the identified risks, constraints and opportunities positively influence the achievement of project results and objectives, or on the contrary jeopardise it?;
- efficiency (i.e. 'value for money' or 'value for resources'): can the identified risks, constraints and opportunities contribute to the production of outputs and results at a 'low' or 'reasonable' cost in terms of resource use, or on the contrary lead to a disappointing 'ratio' between outputs/results produced and resources employed?;
- sustainability: can the identified risks, constraints and opportunities promote, or on the contrary prevent, the sustainable production of project benefits over the project's planned lifetime, from a financial, economic, environmental and social point of view?;
- impact: can the identified risks, constraints and opportunities contribute to the generation of positive, or on the contrary negative, overall developmental impacts of the project on the wider society in which it operates?

h) Proposed adaptation and risk management measures

Where significant risks, constraints and/or opportunities have emerged from the above evaluation, the Contractor should propose measures and formulate recommendations to improve (if necessary) the integration of these factors into project design.

Recommendations will take into account any measure already put in place or considered by project partners, as well as their capacity to undertake such measures.

Actions may include:

- measures to strengthen the project's and project partners' adaptive capacity in the face of increasing climate variability and climate change (e.g. building early warning or emergency preparedness and disaster risk reduction mechanisms, diversification of income sources, improved access to financial services including insurance, development of capacities in these areas);
- measures to control or manage some identified risks (e.g. choice of project location to reduce exposure to natural disasters);
- measures to improve the project's ability to operate under identified constraints (e.g. choice of most water-efficient or energy-efficient production options);
- measures to better exploit some opportunities offered by the natural environment (e.g. use of a locally abundant source of renewable energy).

If the proposed adaptation, optimisation or risk management measures involve an additional cost (compared to the options currently considered), the report should include an estimation of these costs. It should also identify who would be in charge of implementing these measures.

i) Limitations of the risk and constraint assessment

The Contractor should underline all the major limitations, weaknesses and uncertainties of this part of the study.

They are required to highlight areas where information is deficient and to make clear how the assessment of significance has been determined, for example the use of quality objectives, stakeholder views and professional judgement.

j) Conclusions on environmental and climate-related risks, constraints and opportunities

This section will summarise the key results of the second part of the study, the recommendations and a brief description of the residual risks (i.e. those that cannot be controlled or satisfactorily managed within the limited scope of the project).

The Contractor is also required to provide any information relevant for further economic and financial analysis or for the general formulation study.

The limitations of the risk, constraint and opportunity assessment and its key assumptions should be summarised.

k) Stakeholder consultations and public meetings

The Contractor shall manage the organisation and facilitation of formal public meetings required under NEPA's EIA process, in close coordination with Expertise France, SAJ and/or NWA. This includes preparing and presenting non-technical summaries, engaging with affected communities and interest groups, addressing their concerns, and producing official records of the sessions (including minutes, lists of participants, and questions raised). The Contractor shall ensure that these consultations are conducted in accordance with NEPA guidelines and consistent with international standards on stakeholder engagement.

All major deliverables shall be made publicly accessible through NEPA's disclosure channels and other appropriate means, to ensure that affected communities and stakeholders can review and provide input as needed.

The Contractor shall deliver the Preliminary ESIA study within six (6) months of the NTP.

Deliverables:

- **Preliminary ESIA report incl. Preliminary ESMP**
- **Management of stakeholder consultations and public meetings.**

6. Management of interactions with NEPA

The Contractor shall be responsible for managing all technical and administrative interactions with the National Environment and Planning Agency (NEPA), in close coordination with Expertise France and SAJ and/or NWA, NWC throughout the Preliminary ESIA phase. This includes clarifying applicable regulatory requirements, coordinating pre-submission exchanges, preparing the complete ESIA application dossier in accordance with NEPA guidelines, responding to technical comments or requests for clarification, and attending any required meetings or site visits convened by NEPA.

The primary objective is to ensure that the Preliminary ESIA process fully aligns with Jamaican regulatory procedures and that all conditions are met to secure the environmental permit (NRCA Certificate) needed to proceed with the next stages of project preparation and design.

Deliverable: Management of interactions with NEPA.

7. Final ESIA study (Tranche 2 - Optional)

The Final ESIA study will build upon the results of the Preliminary ESIA and will be undertaken in parallel with the Detailed Design phase. It will deliver an updated assessment of all significant environmental and social impacts related to the final project design, propose refined mitigation and enhancement measures, and ensure continued compliance with NEPA requirements and international good practice. This study will serve to complement the existing environmental authorisation by providing any additional technical justification or updates required by NEPA to maintain the validity of the NRCA certificate, thereby enabling the project to proceed smoothly to the construction stage.

a) Updated impact assessment

The Contractor shall provide a detailed identification and evaluation of all direct, indirect, cumulative, and residual environmental and social impacts associated with the final project design. This assessment shall integrate updated baseline data where needed and reflect the final technical parameters of the project.

b) Comprehensive Environmental and Social Management Plan (ESMP)

The Contractor shall prepare a fully detailed ESMP, translating the findings of the impact assessment into concrete measures. This plan shall include:

- a matrix (logical framework) detailing objectives, expected results, indicators, activities (mitigation and enhancement measures), responsibilities and timelines;
- institutional arrangements for implementation and monitoring, clarifying the roles of NEPA, local authorities, the Contractor and other stakeholders;
- recommendations for environmental and social clauses to be included in future works contracts and modalities such as payments linked to compliance;
- a monitoring and supervision plan with indicators, methods, frequency and reporting systems;
- a contingency plan for incidents or unexpected results from monitoring;
- an indicative budget and resource plan (personnel, equipment) for ESMP implementation.

c) Stakeholder consultations and public meetings

As part of the Final ESIA, the Contractor shall manage the organisation and facilitation of any additional public meetings or disclosure sessions that may be required to reflect updates from the Detailed Design phase.

This shall be done in close coordination with Expertise France, SAJ and/or NWA, NWC. The Contractor's responsibilities include preparing and presenting updated non-technical summaries, engaging with affected communities and interest groups to discuss any new or revised project aspects, addressing their concerns, and producing official records of these sessions (such as minutes, lists of participants, and documented questions or feedback).

The Contractor shall ensure that all such consultations are conducted in accordance with NEPA guidelines and remain consistent with international standards on stakeholder engagement.

d) Support to the permitting process and maintenance of the NRCA certificate

The Contractor shall prepare any supplementary documentation or addenda required to reflect the outcomes of the Detailed Design, and shall support the Client in ensuring that the existing NRCA certificate remains valid and fully aligned with the final project specifications. This includes responding to any additional comments from NEPA, participating in follow-up technical meetings, and providing clarifications as needed to maintain regulatory approval for the project to advance to construction.

The Contractor shall complete and submit the updated Final ESIA study and final ESMP within two (2) months of the issuance of the Service Order activating this optional tranche, and shall subsequently support the permitting process as needed to ensure that the existing NRCA certificate is confirmed or updated, all within a total period not exceeding four (4) months from the same date.

Deliverables:

- **Final ESIA report incl. ESMP**
- **Management of stakeholder consultations and public meetings.**
- **Management of interactions with NEPA.**

8. Work Plan

The work plan should include but not necessarily be limited to the following activities:

a) **ESIA scoping study**

- Fact-finding and initial data collection;
- Identification and engagement of key stakeholders;
- Preparation of a stakeholder engagement strategy;
- Analysis and preparation of the scoping report, including definition of the ESIA scope, key issues and methodologies.

b) **Preliminary ESIA study**

- Review of available documentation (e.g. Country Environmental Profile, relevant SEAs, previous technical studies, identification and pre-feasibility reports);
- Review of relevant environmental and social literature, policies, legislation, regulations and standards (including NEPA requirements and IFI standards);
- Fieldwork and baseline analyses covering physical, biological and socio-economic aspects;
- Mid-term data quality review to validate the consistency and reliability of data collected;
- Continued stakeholder engagement and consultations;
- Identification and evaluation of potential environmental and social impacts;
- Development of preliminary mitigation, enhancement and monitoring measures;
- Preparation of the Preliminary Environmental and Social Management Plan (ESMP);
- Preparation and submission of the preliminary ESIA report suitable for NEPA's permitting process;

- Support to the Client throughout the review process until the NRCA certificate is obtained.

c) Final ESIA study (optional)

- Integration of the final detailed technical design and any updated data;
- Organisation and facilitation of any additional public meetings or disclosure sessions required by NEPA guidelines;
- Updated impact assessment and refinement of mitigation and monitoring measures;
- Preparation of the detailed ESMP, including any specific plans (Health and Safety, Biodiversity, Water Management) as needed;
- Preparation and submission of the updated Final ESIA report and supporting documentation to reflect the Detailed Design, ensuring consistency with NEPA requirements;
- Support to the Client in maintaining or updating the existing NRCA certificate, including coordination with NEPA until confirmation of continued regulatory approval.

On the basis of the proposed work plan and time schedule outlined, the Contractor must provide a detailed work plan for the ESIA study in their proposal.

9. Anticipated deliverables

Final deliverables – Tranche 1 (Firm)		
Item	Deliverable	Deliverable submission deadline
1.1	Inception Report	NTP date + 4 weeks
1.2	Scoping Report	NTP date + 2 months
1.3	Preliminary ESIA report incl. Preliminary ESMP	NTP date + 6 months
1.4	Management of stakeholder consultations and public meetings	NTP date + 12 months
1.5	Management of interactions with NEPA	NTP date + 12 months
Final deliverables – Tranche 2 (Optional)		
Item	Deliverable	Deliverable submission deadline
2.1	Final ESIA report incl. ESMP	Service Order + 2 months
2.2	Management of stakeholder consultations and public meetings	Service Order + 4 months
2.3	Management of interactions with NEPA	Service Order + 4 months

10. Coordination

The Contractor shall designate a single contact person responsible for the operational implementation of the assignment. This designated person will act as the main counterpart to Expertise France, ensuring internal coordination of activities, communication with stakeholders, and timely delivery of outputs.

A Kick-Off Meeting (KOM) shall be held within two (2) weeks of contract notification, with the participation of the Client, Expertise France, and the relevant Jamaican authorities. Close collaboration must be maintained throughout the assignment with the Shipping Association of Jamaica (SAJ), the National Works Agency (NWA), NEPA, NWC and other institutional stakeholders, from preparation through to completion. Furthermore, regular exchanges shall be organised with Expertise France to provide progress updates, discuss risk mitigation measures, and secure validation of deliverables.

V. Place, duration and terms of performance

1. Implementation period

- Tranche 1 – Preliminary ESIA (Firm): up to twelve (12) months from the Notice to Proceed (NTP), covering all activities required to complete and submit the Preliminary ESIA, secure the NRCA environmental permit, and deliver all related documentation.
- Tranche 2 – Final ESIA (Optional): up to four (4) additional months from the issuance of the Service Order activating this tranche, covering the preparation of the updated Final ESIA, any necessary public consultations or disclosure activities, and support to ensure that the existing NRCA certificate remains valid or is amended as required.

The activation of the optional tranche shall occur no later than six (6) months following the completion of the firm tranche.

2. Start date

The assignment shall commence on the date specified in the Notice to Proceed (NTP) issued by Expertise France following contract signature, which shall mark the official start of the firm tranche.

3. End date

The assignment shall end upon completion of all deliverables under the firm tranche and, if activated, the optional tranche, including all related administrative closure and final validations.

4. Interim data quality reviews

An interim data quality review meeting shall be organised approximately halfway through the data collection and analysis process, to allow the Client and relevant stakeholders to assess the consistency, completeness and reliability of the data before proceeding to subsequent assessment and reporting stages.

VI. Required expertise and profile

The proposed mission shall be conducted by a team of six (6) experts, who should have the following profiles:

- one (1) expert level I or II with at least ten (10) years of experience in conducting environmental and social impact assessments (ESIAs), who will serve as the Team Leader, responsible for overall coordination, technical quality assurance, and acting as the main counterpart to Expertise France and the Jamaican authorities;

- one (1) Hydrology and Climate Specialist, with at least seven (7) years of relevant experience in drainage infrastructure, flood risk analysis, and climate change adaptation measures in urban or coastal contexts;
- one (1) Social and Stakeholder Engagement Specialist, with at least seven (7) years of experience in socio-economic assessments, analysis of community vulnerabilities, public consultations, and grievance redress mechanisms;
- one (1) Biodiversity / Ecology Specialist, with at least five (5) years of experience in assessing coastal and urban ecosystems, biodiversity components, and developing management measures;
- one (1) GIS and Mapping Expert, with at least five (5) years of experience in spatial analysis, mapping areas of influence and impacts, and supporting cumulative impact assessments;
- one (1) Health and Safety / Public Health Specialist, with at least five (5) years of experience evaluating public health impacts, occupational health and safety risks, and preparing emergency response and accident management frameworks.

The team shall collectively demonstrate solid local or regional knowledge of the Caribbean context, particularly Jamaican regulatory frameworks and NEPA requirements. Experience in applying International Financial Institution (IFI) standards, such as the Equator Principles or the environmental and social standards of IFC or World Bank, is required.

The composition and exact distribution of expertise within the team are not rigidly fixed; an overall analysis will be performed to verify that the proposed team provides an equivalent level of skills and experience across the required technical areas. All experts must demonstrate excellent analytical, communication and stakeholder facilitation skills. English will be the working language for the assignment, and all final reports must be submitted in English.

For each specialist proposed, a curriculum vitae of no more than four (4) pages shall be provided, clearly detailing their relevant qualifications and experience.

VII. Assignment reports

1. Monthly progress report

The Contractor shall submit concise monthly progress reports summarising activities carried out, encountered difficulties, mitigation measures, and updated schedules. These reports shall also highlight any key findings or early observations relevant to the ESIA. Reports shall be submitted electronically (PDF format) to Expertise France.

2. Inception report

The Inception Report shall be submitted within two (2) weeks following the Kick-Off Meeting. It shall detail the Contractor's understanding of the assignment, methodology, work plan (including Gantt chart), stakeholder mapping, data needs, coordination mechanisms, and initial identification of key issues. The report shall be delivered electronically (PDF) to Expertise France for review and approval.

3. ESIA Scoping study

The scoping study must be prepared in the format specified in **Annex 5**.

The draft scoping report shall be submitted electronically by NTP + 2 months, with Expertise France providing consolidated comments within three (3) weeks.

The Contractor shall incorporate these comments and submit the final scoping report electronically (PDF) within two (2) weeks.

4. Preliminary ESIA study

Feedback on the scoping study shall be provided no later than three (3) weeks after its submission, formally setting the scope of the ESIA.

The draft Preliminary ESIA report shall be submitted electronically by NTP + 6 months, following the format in **Annex 6**, together with all supporting analyses.

Expertise France shall provide comments within four (4) weeks.

The Contractor shall incorporate these comments and manage any subsequent revisions, resubmissions and regulatory interactions within a maximum period of six (6) additional months, to secure the issuance of the NRCA environmental permit no later than twelve (12) months from the NTP.

5. Final ESIA study (optional)

If the optional tranche is activated, the Contractor shall prepare the Final ESIA study building on the approved Preliminary ESIA, integrating the final technical design, updated baseline data, and any additional statutory public meetings or disclosure sessions required under NEPA guidelines.

The draft Final ESIA report, including the detailed ESMP, shall be submitted electronically within two (2) months of the issuance of the Service Order, with Expertise France providing comments within two (2) weeks.

The Contractor shall incorporate these comments and support any necessary regulatory follow-up, ensuring that the updated documentation required to maintain or amend the NRCA certificate is completed and processed within an additional two (2) months, for a total period not exceeding four (4) months from the Service Order.

6. Data deliverables

Alongside each main report, the Contractor shall provide all underlying datasets, including raw survey data and spreadsheets (Excel or CSV formats), as well as geospatial files (KMZ, Shapefile, QGIS or AutoCAD formats) used to produce maps and spatial analyses.

These data files shall be accompanied by metadata describing data sources, collection methods and quality assurance procedures.

VIII. Practical information

- Language of assignment: English
- All travels shall be borne by the service provider and be included as part of the financial proposal. Expert(s) remain solely responsible for organizing their own travel, accommodation, transport, insurance, communication and internet costs.
- SAJ / NWA will arrange the following during field missions: meeting room and internet.
- SAJ / NWA shall facilitate meetings with the stakeholders when deemed appropriate.

- The Government of Jamaica shall assist with necessary documentation for entry and work in Jamaica, if needed.
- During the implementation of the assignment, the visibility of the European Union as donor of the Euroclima Programme must be ensured, in accordance with the Euroclima Programme's rules on communication and visibility, which take into account the European Union's requirements for communication and visibility: https://international-partnerships.ec.europa.eu/knowledge-hub/communicating-and-raising-eu-visibility-guidance-external-actions_en. All reports and deliverables must include the emblem of the European Union (with the words "Financed by the European Union"), the logos of the Euroclima Programme and Expertise France, as well as the following "standard" disclaimer: "This publication has been produced with the financial support of the European Union. The contents are the sole responsibility of <name of author/partner> and do not necessarily reflect the views of the European Union or Expertise France". Euroclima Programme Templates will be shared accordingly.

IX. Annexes

- **Annex 1 – Road Map**
- **Annex 2 – Selected Layout to be considered & Railway Corridor layout**
- **Annex 3 – CEAC Feasibility study**
- **Annex 4 – NEPA Guidelines for conducting EIA**
- **Annex 5 – Standard format for the ESIA scoping report**
- **Annex 6 – Standard format for the Preliminary & Final ESIA report**

ANNEX 1 – ROAD MAP



This project is funded by the European Commission



Framework Contract SEA 2023 – INTPA/2022/EA-OP/0102
Lot 4 : Sustainable transport, infrastructures, green cities, connectivity
and sustainable mobility

Specific contract No 300104202
SEA-2023-27004

Road map

Final Version

26/05/2025

This project is implemented by the SUEZ Consulting (SAFEGE) consortium



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		QA by	Virginia Serbali – CSI	

This report has been prepared by CSI Ingenieros under the SUEZ Consulting (SAFEGE) Consortium and does not necessarily reflect the views and opinions of the European Commission.

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1. Introduction

1.1 Background

Marcus Garvey Drive is a critical arterial road in Kingston, Jamaica serving as a major transportation link for commuters, businesses, and industries. However, the area has faced recurring challenges related to flooding, particularly in low-lying zones such as Tinson Pen Gully and the aerodrome, which disrupt traffic flow, hinder economic activities, and pose safety risks to the community.

The existing drainage and road infrastructure have proven inadequate to manage heavy rainfall and mitigate flood risks effectively. A preliminary review of previous reports and assessments, including data from 2021, highlights deficiencies in drainage systems, urban planning, and environmental safeguards. Recent climatic shifts and increased urbanization in the surrounding areas further exacerbate the issue. As the port seeks to expand the logistic area into the Tinson Pen aerodrome it is now critical to solve the flooding issues in the area while having minimal effects on the existing traffic flow in the area.

To address these challenges, a comprehensive evaluation is needed to identify and implement effective Road realignment and flood mitigation measures. This includes updating the master plan, assessing existing infrastructure, and quantifying the socioeconomic impact of flooding. The project will also involve collaboration with stakeholders, regulatory compliance, and a phased approach to design and implementation.



Figure 1: Location map of the project area.

1.2 Purpose and Scope of the Report

The purpose of this report is to provide a detailed scoping framework for the consultancy services and subsequent construction works aimed at mitigating flood risks and upgrading road and drainage infrastructure along Marcus Garvey Drive. This report seeks to identify the

current deficiencies in the drainage and road systems, assess the socioeconomic impact of recurring flooding, and outline the necessary steps for developing sustainable solutions.

The scope of this report includes:

A. Needs Identification:

- ▶ Evaluate the conditions and deficiencies in the existing drainage and road systems, particularly those leading to frequent flooding along Marcus Garvey Drive.
- ▶ Determine needs in the critical area, including Newport West, Tinson Pen and Marcus Garvey drive, through a rapid visual inspection and analysis of past studies and reports.
- ▶ Identify technical and social requirements for flood mitigation, incorporating updates to the master plan and integrating new data on drainage conditions.

B. Stakeholder Mapping and Engagement:

- ▶ Identify key stakeholders, including but limited to shipping agents, local government officials, transportation operators, and commercial entities.
- ▶ Outline regulatory requirements and approvals necessary for the project.

C. Project Planning and Design:

- ▶ Develop a phased approach to project implementation, including feasibility studies, preliminary and detailed design, environmental impact assessments (EIAs), and tender documentation.
- ▶ Create an estimated timeline and budget for construction activities, assuming key project elements such as proposed road alignments and flood control structures.

D. Risk Assessment and Mitigation:

- ▶ Identify and analyse potential risks affecting project implementation, including regulatory delays, adverse weather conditions, traffic disruptions, and social impacts.
- ▶ Propose strategies to mitigate identified risks, addressing concerns from various stakeholder groups and ensuring minimal disruption to the community.

2. Review of Existing Studies

2.1 Port Logistics and land use

The Jamaica Logistics Hub Initiative: Market Analysis and Master Plan (2017) highlights significant needs and potential developments to enhance logistics capacity and support the growing demands of the Port of Kingston. As cargo volumes increase, the port faces pressing constraints in logistics and storage space. The report estimates that approximately 400,000 to 500,000 square meters of new warehousing and logistics facilities are required across 75 hectares, particularly near the Tinson Pen area and the Kingston Container Terminal (KCT) West Terminal. Projections further indicate a need for expanded industrial land, with an estimated 162 to 169 hectares required by 2030–2035 to support the Caymanas Economic Zone (CSEZ) and other logistics initiatives.

The Tinson Pen Aerodrome has emerged as a key site for redevelopment, with plans to repurpose the space into a logistics and warehousing hub. Currently housing the Jamaica Defence Force Air Wing, its relocation to Vernamfield is under discussion, which would clear the way for integrating Tinson Pen into the port's logistics infrastructure. The report underscores the strategic value of this transformation but acknowledges uncertainties about the timeline and regulatory approvals required for the aerodrome's redevelopment.¹

To facilitate the port's growth and support logistics activities, improvements to road infrastructure and connectivity are critical. The report proposes the realignment of major access roads and the creation of dedicated freight corridors to minimize congestion and expedite cargo movement. These upgrades aim to enhance links between the port, the CSEZ, and other logistics facilities, while accommodating the projected increase in traffic volumes. Specific suggestions include modifying the South Coast Highway and arterial routes around Marcus Garvey Drive, ensuring seamless integration of transport and logistics operations.

These developments are integral to realizing Jamaica's vision as a global logistics hub, addressing current constraints while aligning with projected growth in cargo flows and industrial activity.

2.2 Traffic demand on The Marcus Garvey Drive (MGD)

The Marcus Garvey Drive carriageway is a six-lane roadway spanning 2.44km from East Avenue and Harbour Street. The roadway was built in 2017 by China Harbour Engineering Limited for approximately US\$20 million to reduce transit time and improve the safety of the corridor² for the 40,000 (2016) vehicles using the roadway daily. This roadway acts as a major arterial road connecting Kingston to Portmore via the Portmore toll road with a throughput of 13.6 million vehicles per year for 2022 and 2023 with an upward 5-year trend. The Marcus Garvey Drive (MGD) thoroughfare has experienced frequent flooding in the vicinity of the Tinson Pen Aerodrome, which significantly impacts the traffic flow along this corridor, becoming impassable during rainfall events with a return period as low as 1 RP.

¹ Jamaica Logistics Hub Initiative: Market Analysis and Master Plan 2017

² <https://www.nwa.gov.jm/news/first-legacy-project-delivered-improved-six-lane-marcus-garvey-drive-completed-under-midp>

2.3 Drainage in flood control within the Project area

Flood control and drainage assessments for Marcus Garvey Drive, Tinson Pen, Shoemaker Gully, and Newport West reveal significant risks and deficiencies in the current infrastructure. The project area forms part of a larger urban catchment stretching from Half-Way Tree and Trafalgar Road in the north to Marcus Garvey Drive in the south. Financial impacts include losses of USD 5 million per flood event and an Average Annualized Loss (AAL) of USD 17.5 million for direct damages and indirect disruptions to traffic on Marcus Garvey Drive under a “do nothing” scenario.

Surveys of existing drains and hydrological analyses show that 26 km of drainage channels in the project area are undersized, with capacities below the 5-year Return Period (RP) rainfall event. Flooding begins even in 1-year RP rainfall events, far below the desirable 100-year RP standard outlined by ODPEM and NWA guidelines. Climate projections indicate that extreme rainfall could increase by 30–35% by 2050–2060, with peak flows expected to significantly exceed the current channel capacities. Marcus Garvey Drive and critical drainage channels, including the Tinson Pen Drain and Jew and Shoemaker Gullies, suffer from inadequate dimensions and flat slopes, leading to insufficient hydraulic performance. The four catchments in Newport West also exhibit limited drainage capacity, with poor street-level drainage exacerbating flood risks.

Proposed improvements target 8,730 meters of flood control works. Key upgrades include expanding the Tinson Pen Drain from Chesterfield Road to Hunts Bay to reduce water levels along Marcus Garvey Drive. Widening and deepening of Marcus Garvey, Tinson Pen, Jew, Oakland, Clifton, and Shoemaker Gullies are recommended. Improvements in Newport West involve upgrading underground concrete box drains, while 24 existing crossings must be replaced to meet 100-year RP standards. Flood plain analyses confirm that these measures would substantially mitigate flooding risks.

Additionally, minor drainage works are proposed, involving the installation of 189 inlets and over 5,578 meters of new drainpipes. The total cost for achieving the 100-year RP design condition is estimated at USD 131.4 million. Phased implementation prioritizes the detention basin and canal (USD 17.8 million), followed by improvements to Marcus Garvey Drive and the Tinson Pen and Jew Gullies (USD 65.4 million). Finally, works on Newport West, Shoemaker Gully, and additional Jew Gully improvements are scheduled. These upgrades are essential to addressing current vulnerabilities and adapting to future climate impacts.

3. Needs Identification

3.1 Flood Control and Drainage

3.1.1. Evaluation of Existing Drainage and Flood Control Infrastructure

The project area is generally flood-prone and severe flood-related losses have been documented. Upgrading the Marcus Garvey Drive Road works has brought more visibility to the project, with expectations that the associated flood control works will be improved. The reality is that the existing and aged flood control works are undersized, over half a century old, and require major improvements. For example:

1. The Jew, Tinson Pen, and Marcus Garvey gullies and crossings are exceeded in 2-year RP rainfall events and ill-configured, resulting in 0.3 to 1.2 m of flooding in some areas that severely hampers one of the main arterial roads in the KMA.
2. Newport West 600mm drainpipes are severely undersized for the catchments and flood depths of 0.3 to 0.9 meters are common in frequent events (Figure 2 and Figure). This brings disruption to the major shipping hub of Jamaica.
3. Shoemaker serves a considerable urban catchment that has been built out over the years and has crossings and drains that are also over ½ century old and crosses Marcus Garvey in the vicinity of PetroJam.

The area is generally flooded prone, thus it was expected that records of historic flooding events would be present. The main discharge points within the project area, namely Jew Gully and the Tinson Pen drain, are known to flood when rainfall events with a return period exceeding 2-Yrs occur. It is evident that the national disaster database has room for improvement in updating and capturing more flood-prone areas. The most notable flooding is located at the Tinson Pen Aerodrome and MGD causing severe interruption to traffic flow. Additional flooding was observed along MGD and New Port West during a 1 RP event shown in Figure 3.



Figure 2: Existing Drainage Layout in Newport west (Sourced from the Nowal Whyte and associates limited Proposed drainage plans).



Figure 3: Photos of localized flooding in the Newport West and MGD area (October 2020, CEAC Drainage Report).

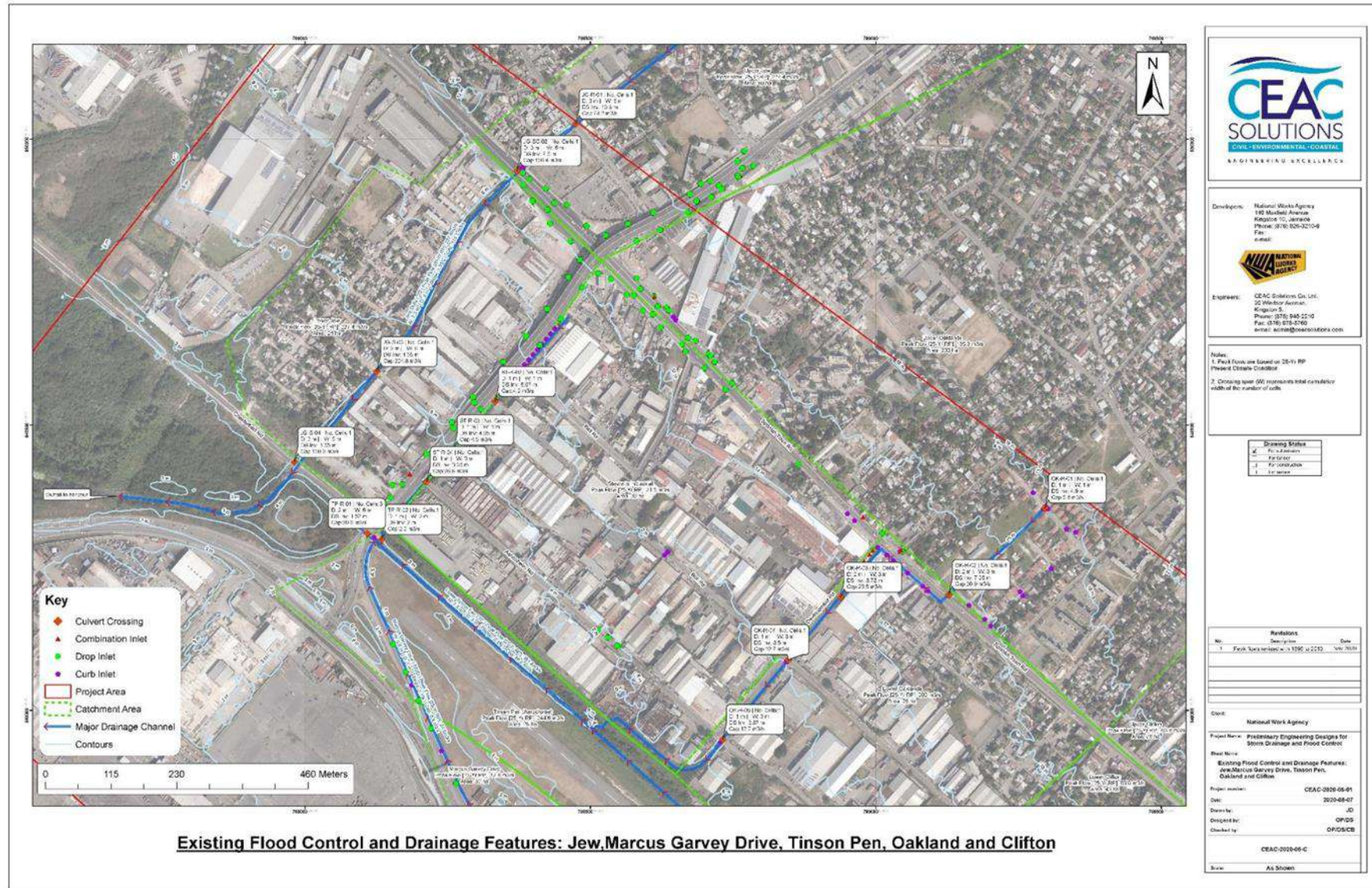


Figure 4: Existing Flood Control and Drainage Plan for the MGD, Tinson Pen and Clifton areas



Existing Flood Control and Drainage Features: Tinson Pen, Oakland, Clifton & Marcus Garvey Drive

Figure 5: Existing Flood Control and Drainage Plan for Tinson pen, Oakland, Clifton and MGD.

Figure

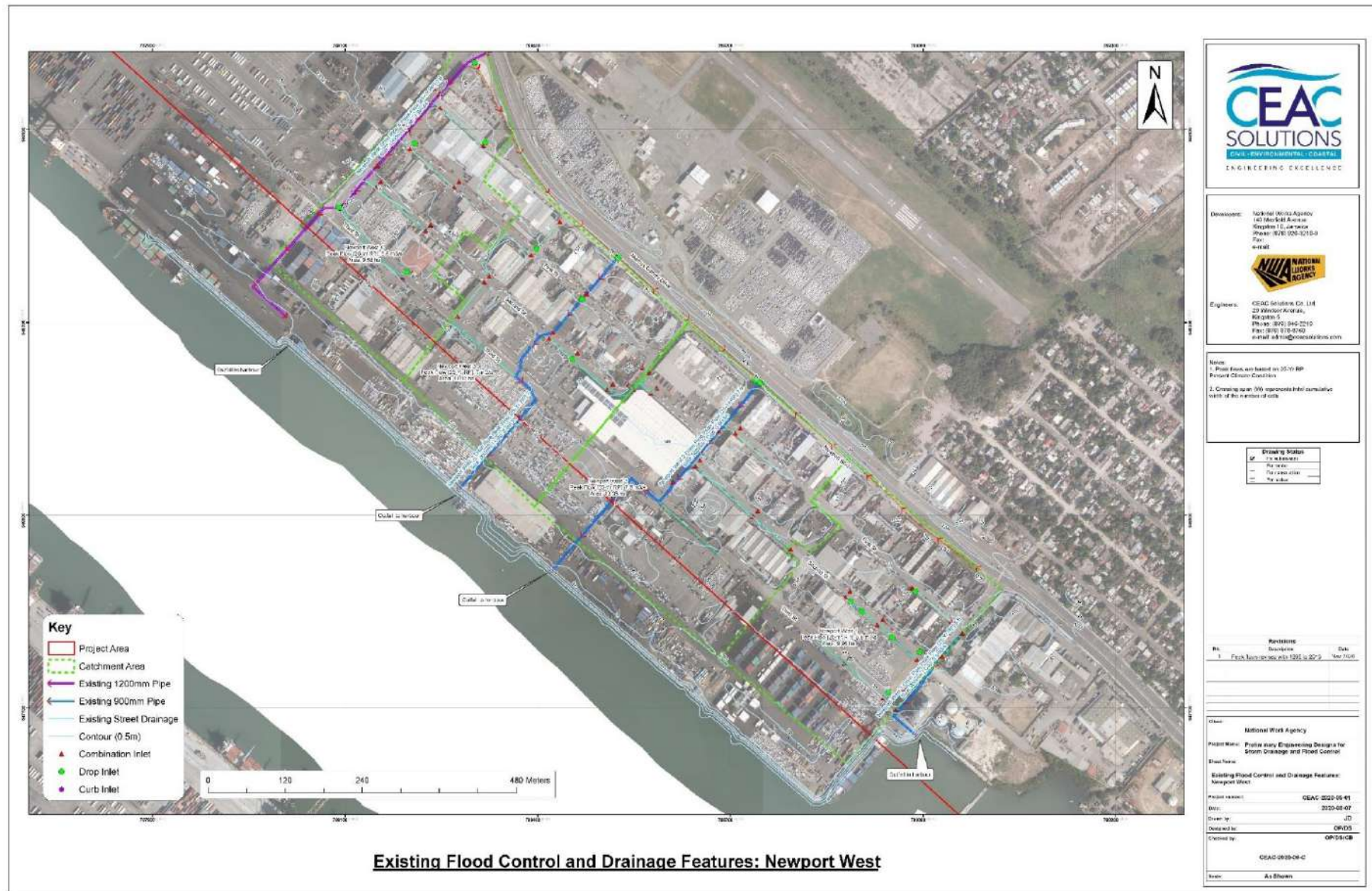


Figure 6: Existing Flood Control and Drainage Plan for Newport west.

3.1.1.1. Description of Floodplain and Flood Control

Three catchments affect the project area: i) Marcus Garvey, Tinson Pen and Jew Gully (~9.4 km²), ii) Shoemaker (6.8 km²) and Newport West (0.5 km²). The major catchments were further broken down to sub-catchments which correspond to the streams identified.

The Marcus Garvey Drive, Tinson Pen, Jew catchment is a 940ha large area located to the North of the designated project area. The north-most sub-catchments comprise of areas which carry runoff from northern Kingston to Jew Gully, which terminates to the Kingston Harbor. These consists of several major and minor drainage systems which leads to the Tinson Pen Drain. The Tinson Pen drain intersects the Jew Gully before discharging to the Kingston Harbor. The south-most catchments comprise of the drainage system which services the Marcus Garvey Drive roadway and also lead to the Tinson Pen drain. Considerable extreme rainfalls over a steep catchment consisting of relatively impervious soils in a highly developed urban catchment that leads to high peak runoffs.

The Shoemaker catchment is 675 hectares comprised of areas to the east of the project area, including New Kingston, Cross Roads, and Trench Town, which carry runoff to the Shoemaker Gully, and Trench Town Drain which intersects the shoemaker gully before discharging to the ocean. This has a minor impact on MGD and Tinson Pen as most of the water within this area is diverted to the Shoemaker Gully except for the MGD road surface which has a relatively small impact on the flooding observed in site.

Newport West catchment is approximately 47ha large runoff within these catchments flow to several strategically placed inlets, which then lead to the ocean via underground drainage pipes.



Figure 7: Major Catchments affecting the project area (excerpt for the area (October 2020, CEAC Drainage Report).

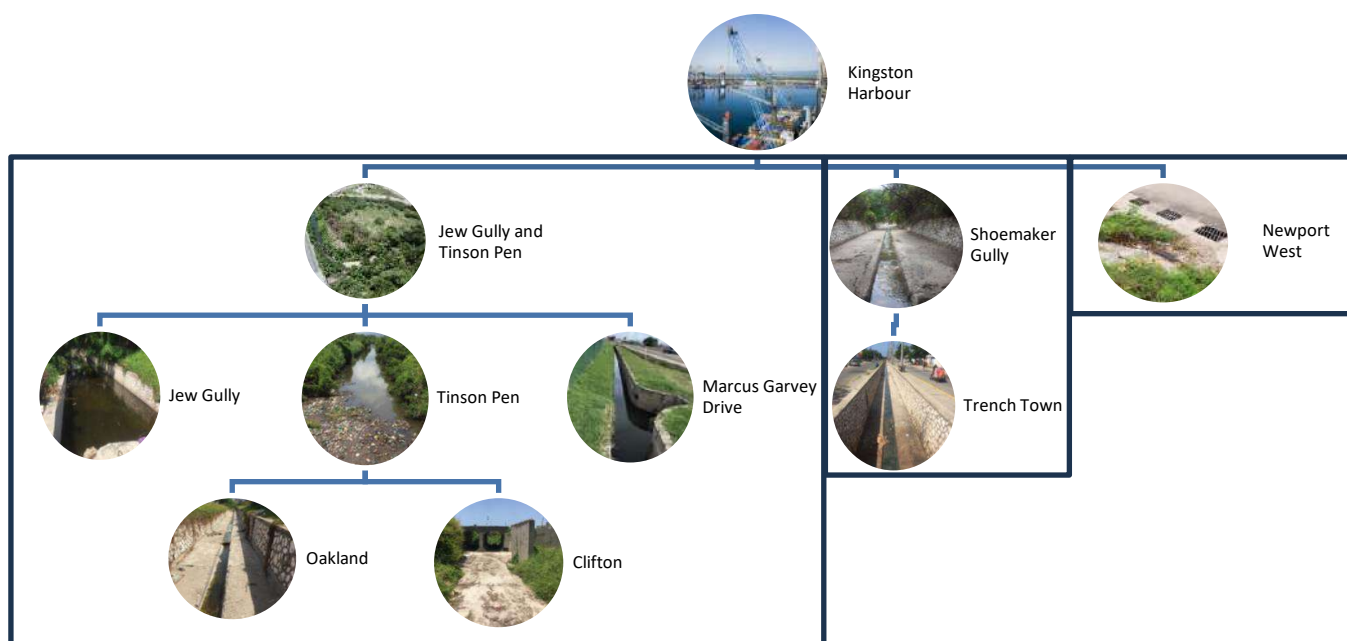


Figure 8: Drainage schematic of flood control in the area.

3.1.1.2. Hydrology

The hydrological regime of the main catchments and the project area were investigated to determine the runoff flow rate and velocities to aid in determining the adequacy of the existing drainage system and to assist in developing solutions at the identified areas within the project area.

Rainfall for various return periods was provided by the National Meteorological Service of Jamaica for the two closest gauges (Halfway Tree and Cavaliers), in addition to the rainfall data spanned over 71 years of historical data from National Oceanographic and Atmospheric Administration (NOAA). The project area can be typified as being in an area of moderate extreme rainfall, based on the spatial data for the island³. 24-hours 100-year RP depths of 492 mm (that are commonly used to mitigate flooding of floor levels) are comparable to the rest of the KSA that have a depth of 200 to 300 mm.

Future climate extreme rainfall was estimated based on the findings and recommendations of IPCC (2018). This estimation is based on the probability ratio of heavy precipitation as a function of global warming and event probably. Climate change factors for the 2 to 100-yr were determined to 1.2 to 1.45 for the 2°C above pre-industrial levels conditions. We believe these conditions to be robust to 2050 to 2060 period in the RCP8.5 scenario when Sea Level Rise is estimated to be about 0.4 meters above present levels. Change factors (CCF) were applied to the present climate 24-hour rainfall depth extremes to determine the estimated future climate rainfall extremes.

Table 1: Present climate HWT and Cavalier rainfall (mm) for 2 to 100-year RP from reanalyzed data (1895 to 2013).

RP	Rainfall (mm) HWT Station	Rainfall (mm) Cavalier Station	Rainfall (mm) Average	Increase due to Future Climate Extreme Rainfall (mm) at 2C
2	88.3	108	98	108
5	147.4	179	163	182
10	192.8	233	213	238

³ NWA Guidelines for preparing hydrologic and hydraulic design reports for drainage systems of proposed developments (2015)

25	256.6	309	283	312
50	308.6	371	340	368
100	364.4	437	401	424

To determine the distribution of rainfall over the 24-hour period a Synthetic mass-curves (SCS type 3) to determine the relative peak flows for the respective drainage infrastructure. The Type III rainfall distribution curve most accurately reflects the 24-hour rainfall distribution experienced by the island. The SCS distribution curves can be seen in Figure 9 Rainfall Hyetographs were generated using the present and future climate condition extreme rainfall.

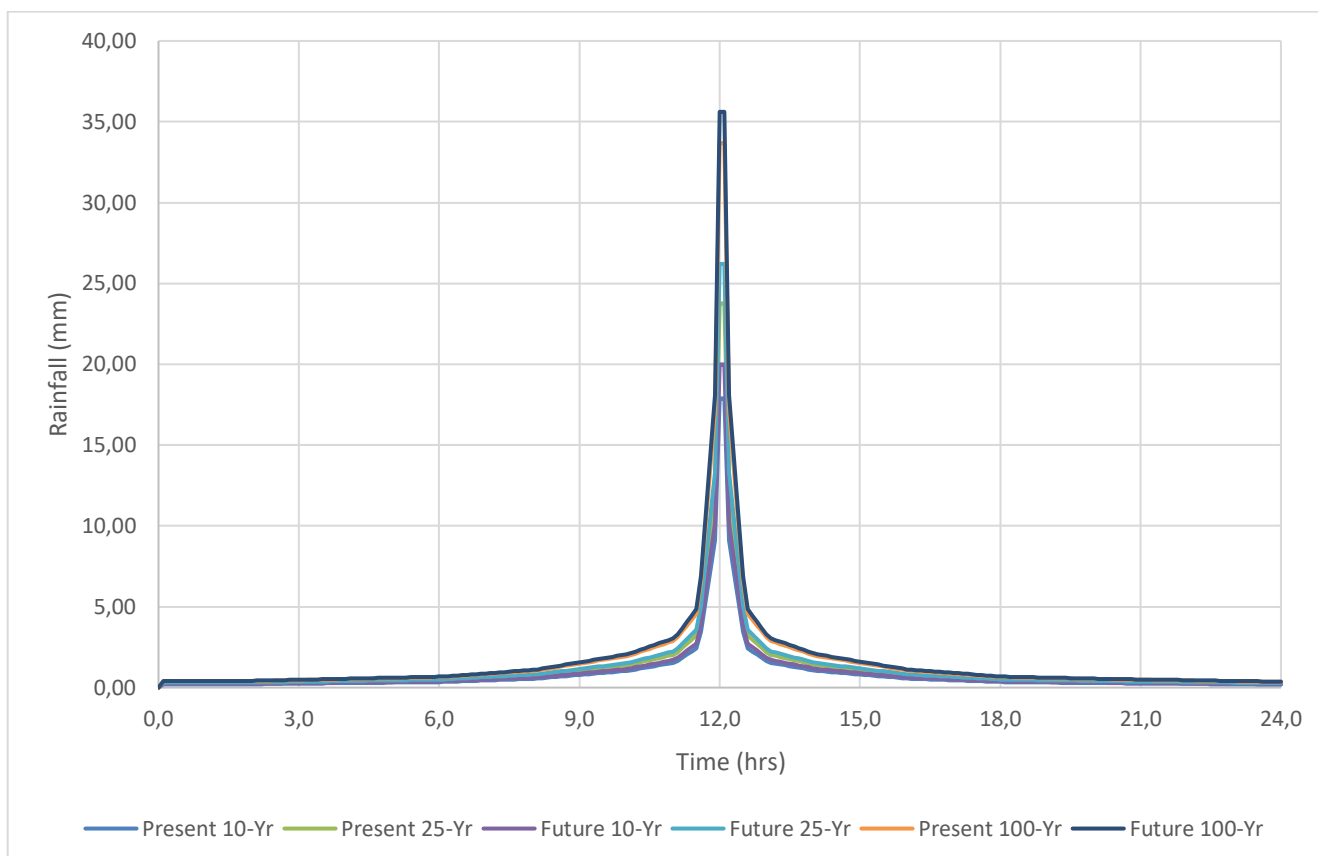


Figure 9: Iso-Hyetograph of average Sept. 2019 Event, 10-Yr, 25-Yr, and 100-Yr RP Rainfall Intensities - Present Climate and Future Climate.

3.1.1.3 Description of Local Drainage Features

The project area is located at the lowest points of the three main catchments in focus, where the flow within the catchments concentrates in the Jew and Tinson Pen Gullies, Shoemaker Gully and Newport West Drains, where they run to the ocean. The catchment area contains mostly developed land with a homogeneous mixture of commercial, industrial and residential spaces, though dominated by residential. Two rainfall stations were used to conduct the analysis as their proximity to the assessment area gave a good representation of the rainfall in the project area, and the catchments leading to it.

The Newport West area is predominantly flat terrain serviced by a drainage system that consists of a network of strategically placed gutters, inlets, and culverts, which discharge to the neighbouring harbour. Analysis of the topographic data revealed that the roads within the area have slopes ranging from 0.16% to 0.6%, and a general slope of 0.15% towards the harbour. After field reconnaissance a total of 96 inlets consisting of curb inlets, drop inlets, and combination inlets.

The Tinson Pen/Marcus Garvey Drive area is generally very mildly sloped, with an array of inlets, gutters, and culverts that serve to drain the area. However, this does not prevent flooding in the area as any rainfall event exceeding 1 – 2 years results in significant localized flooding. Analysis of the topographic data revealed that the road within the area have slopes generally ranging from 0.07% to 0.6%, and a general area slope of 0.15% towards the north.



Figure 10: Photos of localized flooding in the Newport West and MGD area (October 2020, CEAC Drainage Report)

3.1.2. Proposed Improvement to Drainage Infrastructure

Flooding is initiated in the 1-year RP rainfall event across the project area. This is in comparison to the desirable limit of frequency of flooding to the 25-year RP or greater, in keeping with the NWA Guidelines. Preliminary capacity assessment of Marcus Garvey Drive, Tinson Pen Drain and Jew Gully confirm the inadequacy of the existing channel sizes due to both the flat slopes of channel and the small dimensions. Newport West three major catchments are also served by pipes that have limited carrying capacity when compared to the peak runoff within the catchment area. Additionally, localized flooding in Newport West is also due to inadequate street level drainage. Much of the infrastructure is over 50 years old and not designed to handle urban growth and increased impervious surfaces that now exacerbate runoff volumes.

Marcus Garvey Drive, Tinson Pen, and Jew Gully upgrades include considerable channel widening and deepening to carry the 100-year RP. Tinson Pen Drain improvements include widening the channel to 63m and deepening to 3.4m and upgrading the crossing at the Marcus Garvey Drive from a 3-cell to 5-cell culvert. Jew Gully improvements include widening to 14m and deepened to 5.5m. It is noted that the extent of this improvement is limited by the presence of the residents along the banks

of the gully. A detention pond is also required where the Tinson Pen drain and Jew Gully intersect that will allow for the lowering of the outfall level to mean sea level. This basin will have an invert of - 3.0 m and serves as a debris collection and cleaning point before runoff gets to the harbor. 50 meters upstream of MGD, the outfall channel should be dredged and widened to 20 meters in width and 4.5 meters in depth. Newport West improvements include upgrading underground concrete box drains to 5.5m x 1.2m, 3.4m x 1.2m and 1.3m x 1.2. Consultations will be required with Port Authority of Jamaica to fine tune the approach to construction of the drains through Newport West.

Flood plain mapping of the project area indicates that there is major flooding within the area of interest most notable along the Tinson Pen gully, along Marcus Garvey drive and within Newport West (particularly along Eight street, Third Street and Fourth Street). These areas flood in as low as the 1 RP event and flooding increases significantly in the higher return period events. With the implementation of the proposed improved flood control measures the flooded areas are reduced with the 25 RP improvement and completely eliminated with the 100 RP improvements. The flood plain mapping highlights the Tinson Pen aerodrome is vulnerable to flooding and as such will hamper any major redevelopment without the implementation of comprehensive drainage works.

Proposed minor drainage works required within the catchments include the installation of 189 inlets in the project area, along with 4079m of 900mm, and 1,499m of 1200mm culverts that conform to the presented NWA Guidelines for inlet sizing, spacing and distance from high point requirements.

The importance of maintenance was underlined in the assessment of siltation rates from the catchments. Annual desilting of the proposed detention basin, canal to Hunts Bay and flood control channels should be anticipated. The potential for blockage can result in increased flood levels. A routine maintenance program should be implemented and was accounted for the economic analysis.

Table 2: Proposed dimensions of the drainage channels for 10 to 100-year return period.

Catchment	Improvement Length (m)	25 Year RP		100 Year RP	
		Width (m)	Depth (m)	Width (m)	Depth (m)
Oaklands	1058	6	4	10	4
Clifton	845	6	3	10	3
Marcus Garvey Drive	1562	4	1.5	6	1.5
Tinson Pen	1462	20	3	26	3
Jew Gully	790	10	5.5	14	5.5
Lower Jews gully (outlet)	To be determined after survey	75	5	75	5
Newport West 1	200	3.4	1.2	3.4	1.2
Newport West 2	460	5.5	1.2	5.5	1.2
Newport West 3	300	3.4	1.2	3.4	1.2
Newport West 4	160	1.3	1.2	2.3	1.2

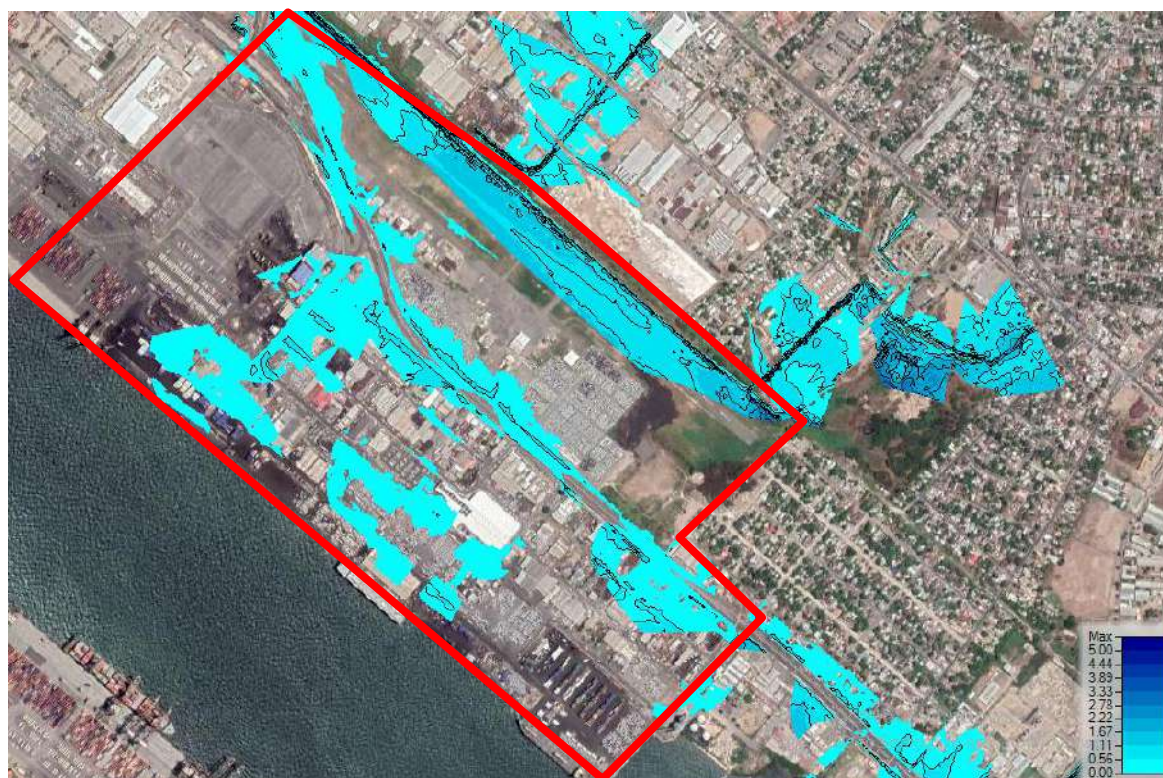


Figure 11: Flood map of the Newport west Marcus Garvey Drains with existing drainage infrastructure with the 25RP future flood plain (Red Box highlighting the project area).



Figure 12: Flood map of the Newport west Marcus Garvey Drains with drainage infrastructure built to 25 RP (Red Box highlight project area).

3.1.3 Quantification of Losses from Flood Events

Both direct and indirect losses (vehicles delay and diversions) are comparable from the 2 to 50-year RP. This suggests that property damages are comparable to vehicle-related losses. Catastrophic events however result in a considerable increase in direct losses and suggest that more severe events (100-year RP) could cost more than USD \$35 Million.

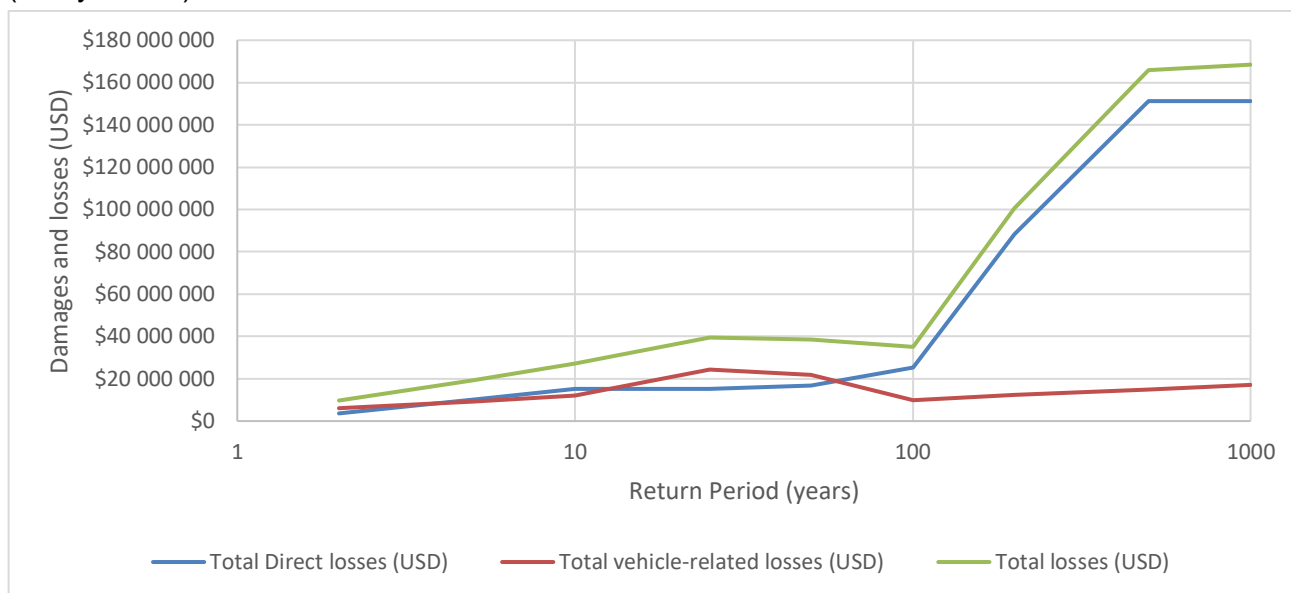


Figure 13: Direct and indirect losses flood losses.

An average annualized loss (AAL) of USD 17,494,576 considers the direct losses to commercial assets and indirect cost of delays and added fuel cost of detours/diversions when the project area is impassable for over several hours. Both direct damage to the roadway (Marcus Garvey Drive) and residual losses from prolonged business closures were not considered. The estimate is therefore believed to be conservative. Additional estimates for AAL for the project scenario were estimated in the feasibility analysis. The AAL was used to inform the feasibility analysis.

Anecdotal information suggests frequent flood events in the project area. Losses to single entities per event have been documented as high as USD8 million. Hydraulic analysis suggests that the existing drainage networks (Shoemaker, Tinson Pen, Marcus Garvey and Jew Gullies) capacities are less than the 5-year RP and in some instance less than the 2-year RP. It was observed that for the 5-year return period inundation levels varied from 0.1-0.4 m, while for the 100-year return period the inundation depth varied from 0.8-1.8m. The AAL is estimated to be USD 17,494,576 based on the estimated direct and indirect losses. This represents the societal cost of flooding in the project area.

3.1.4. Review of Major Changes in Drainage and Flood Control Since 2021

Since the October 2020, CEAC Drainage Report there has been no major modification to the drainage and flood control along the MGD, Tinson pen, and New Port West areas. There have been two major impacts on the drainage in the area; 1) Street-level drainage has degraded due to lack of maintenance and debris 2) The Earth drain north of Tinson Pen Aerodrome has been cleared of debris and silt in hurricane preparation, however the works done are short-lived as the upstream debris and silt quickly return to the reduced capacity. The street-level drainage consisting of mostly grated inlets are almost all partially covered by debris and open channel drains are silted with vegetation growing in the drains.



Figure 14: Condition of the existing drainage in the Newport West and Marcus Garvey drive area.

3.1.5 Technical Requirements for Flood Mitigation

The following are the recommendations to alleviate flooding in the project area:

Tinson Pen, Jew Gully, Marcus Garvey Drive

1. For the Tinson Pen Drain, it is proposed that the drainage system be upgraded by:
 - a. Widening 1462 meters of the channel to 18m, and deepening to 3m to carry the flow, which results in the drain having a capacity of 459m³/s, which exceeds the future 100-Yr RP event of 367m³/s.

- b. The crossing at Marcus Garvey Drive is to be upgraded from a 3-cell to a 5-cell culvert, matching the width of the drainage channel.
 - c. The crossing coming from the Stewarts industrial area to the Tinson Pen Drain to be upgraded to a 2-Cell concrete box culvert, measuring 2m deep x 6m wide.
2. For the Jew Gully Drainage channel, it is recommended that:
 - a. The 790 meters of the channel be widened to 14m and deepened to 5.5m to carry the flow for the 100-Yr RP event. The result is a drain with a capacity of 430 m³/s, which exceeds the 100-Yr RP peak flow of 367 m³/s.
3. For the Marcus Garvey Drive drain, it is recommended that 1661 meters of the drainage channel be upgraded by widening to a width of 6m, and a depth of 1.5m to assist in easing the current flooding situation in the area. The resulting drain will have a capacity of 24m³/s, which exceeds the peak flow of the future 100-Yr RP event of 19m³/s. The modelling conducted indicates that the improvement of the Tinson Pen and Jew Gully Drains will significantly reduce the instances of flooding along the Marcus Garvey Drive area.
4. The construction of a detention basin and canal to Hunts Bay, where the Tinson Pen drain and Jew Gully intersect. This basin has a proposed functional capacity of approximately 40,000m³ and an invert of -3.0 m, and serves as a debris collection and cleaning point before runoff gets to the harbour.

Newport West

To reduce the instances of flooding in the Newport West area, it is recommended that a large section of the 1120 meters of drainage system, including inlets and the underground pipe network be upgraded to meet the needs of the catchment area. The improvement includes the strategic upgrade of key inlets and upgrading the underground piping to underground concrete box drains. The Newport West 1 drainage area does not require any improvement. These works will be very intrusive to the port's activities given the drainage infrastructure in this area is underground running from MGD to the sea, especially along drain 3 that conflicts with buildings on First and Second Street.

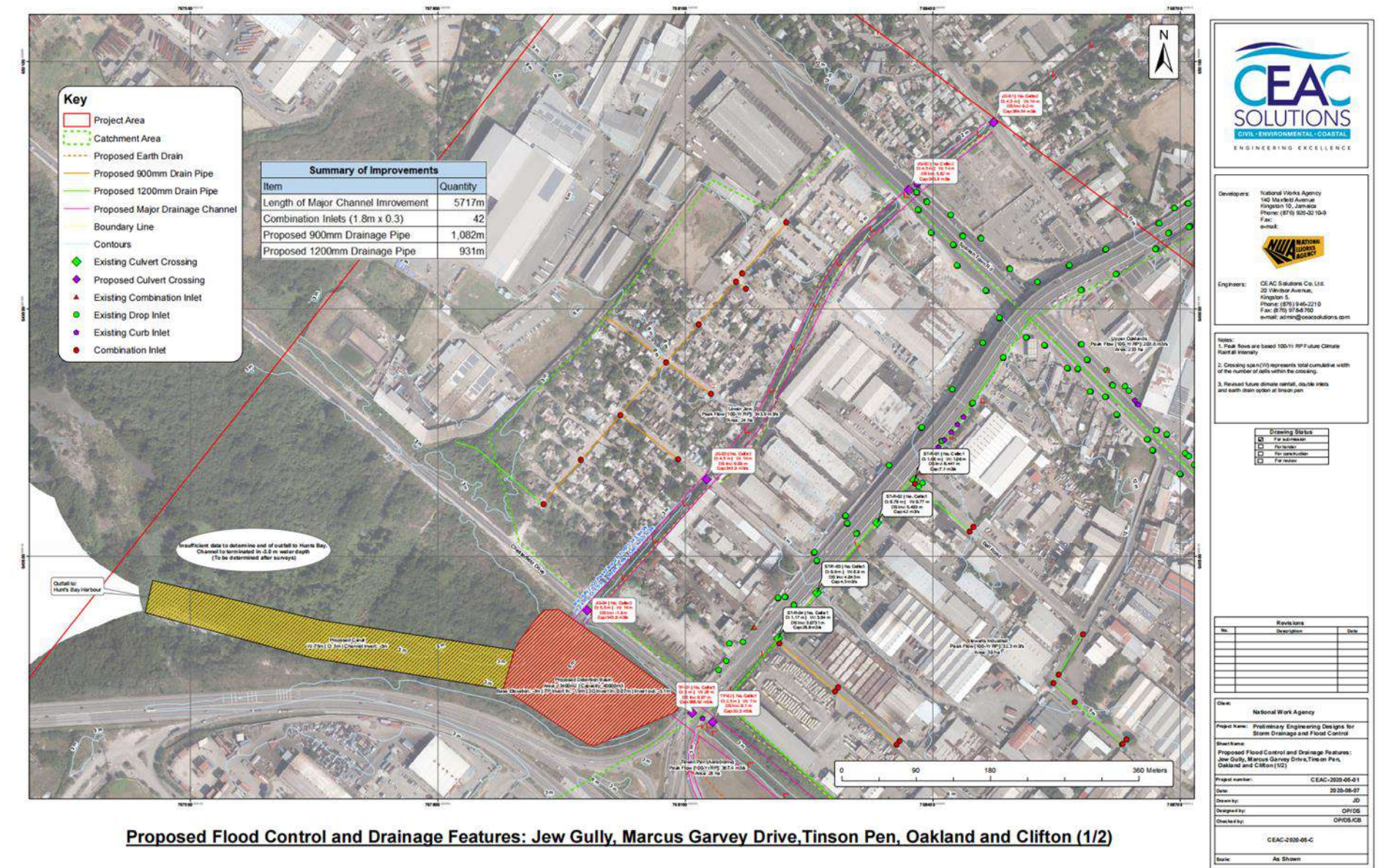
1. Newport West 1 area upgrades existing 900mm culvert to 3.4m *1.2m box culvert
2. Newport West 2 area upgrades existing 900mm culvert to 5.5m *1.2m box culvert
3. Newport West 3 area upgrades existing 900mm culvert to 3.4m *1.2m box culvert
4. Newport West 4 area upgrades existing 900mm culvert to 2.3m *1.2m box culvert

Culvert Crossings and Street Drainage

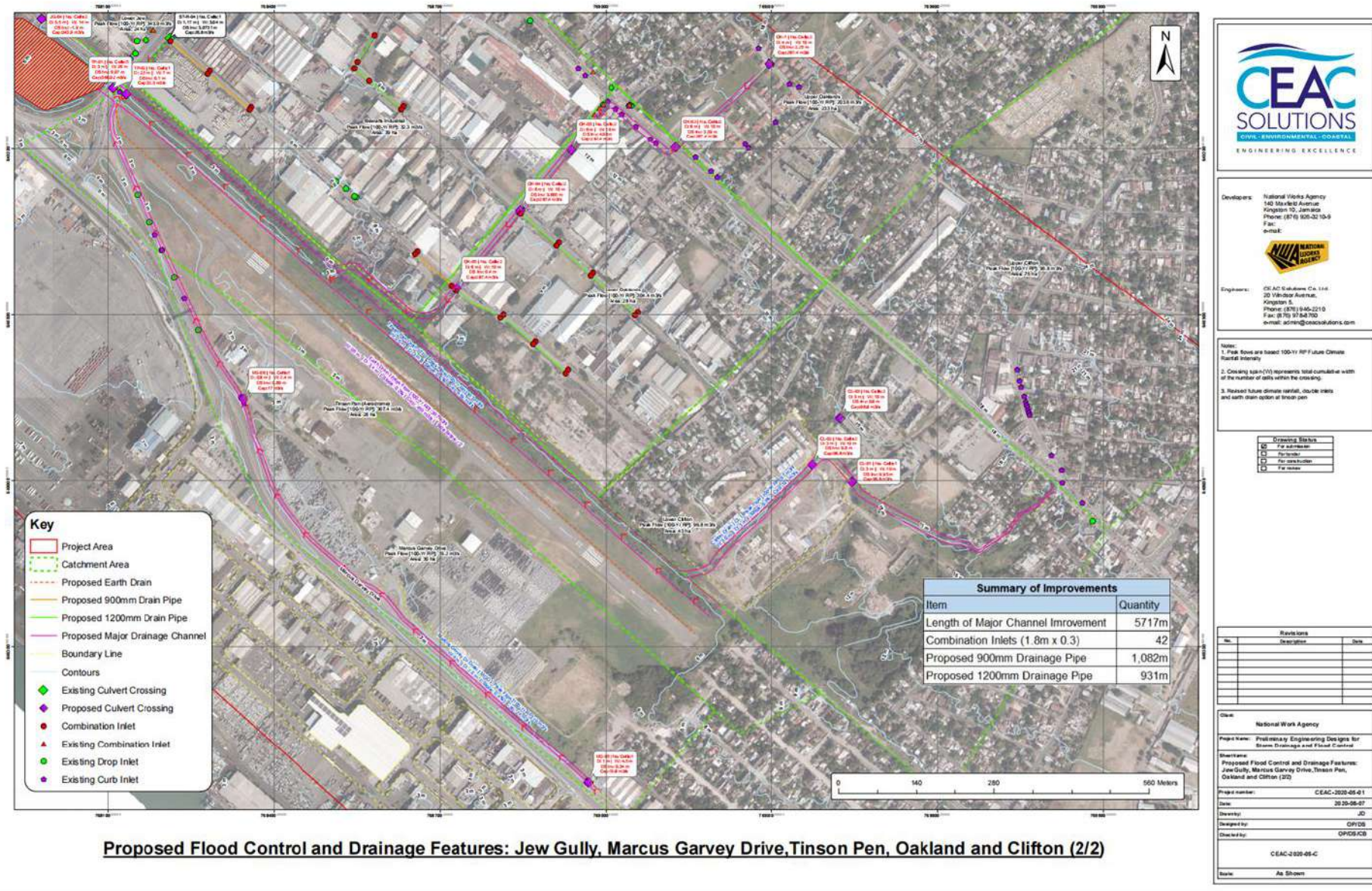
In addition to the upgrading of the drainage channels, it is also recommended that some of the existing culvert crossings be upgraded, as in several instances they significantly reduce the capacity of the channel. As such, 14 culvert crossings have been identified for upgrade. Street drainage in several identified areas was found to be lacking, as such it is recommended that upgrades be implemented to assist with carrying runoff from identified areas to their associated drains efficiently. A total of 189 combination inlets, along with approximately 4km of 900mm culverts, and 1.5km 1200mm culverts were recommended to assist with drainage of the study area.

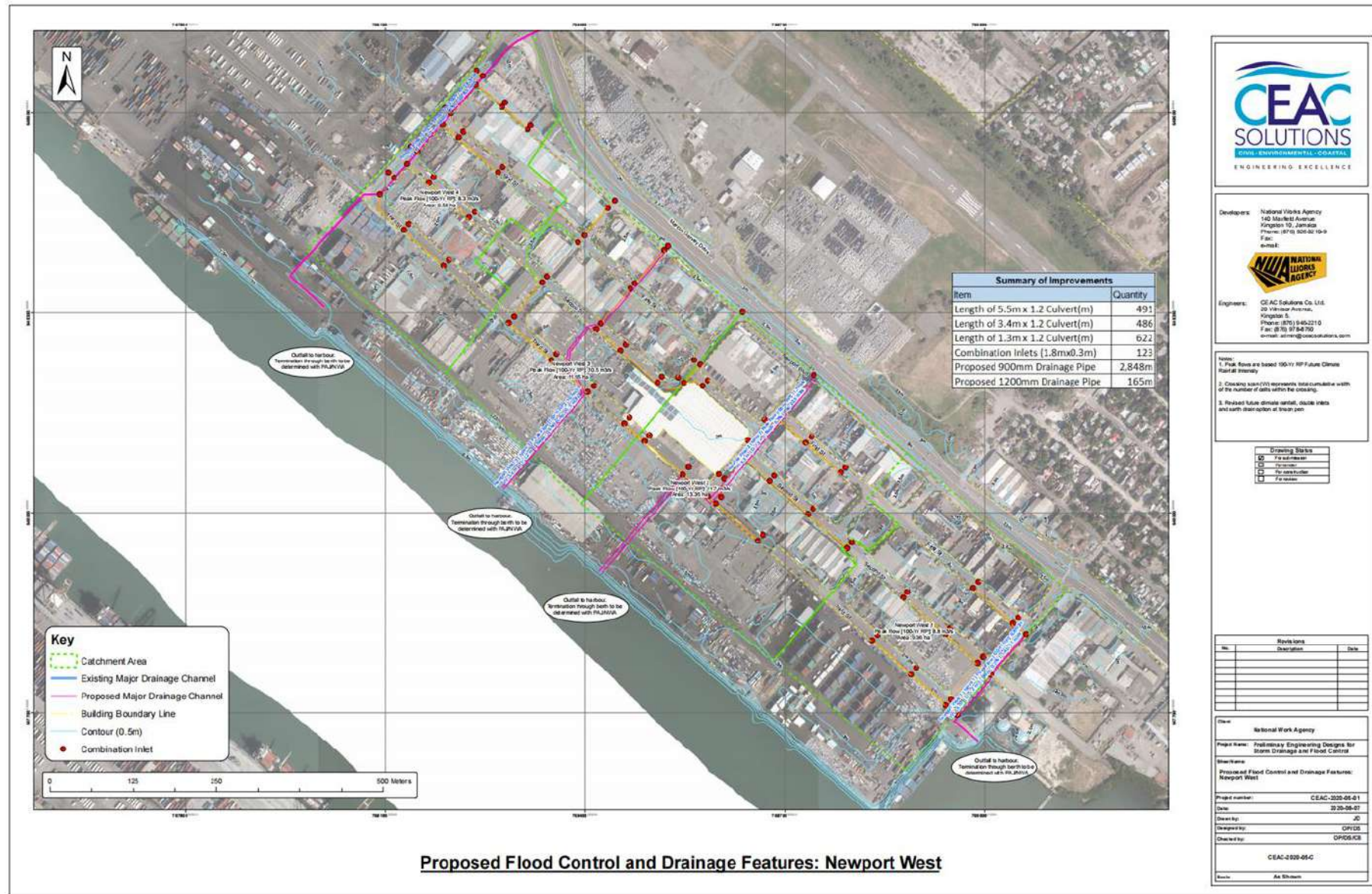
Alternately to reduce the scope of works, a flood control scenario using 25 RP flood control solutions can be explored given the risks are thoroughly explored in a feasibility study.

Breakdown	25-year RP	100-year RP
Preliminaries	\$10,672,879	\$11,463,231
Marcus Garvey, Tinson Pen and Jew Gullies	\$77,890,928	\$84,036,825
Newport West	\$10,133,419	\$11,938,469
Contingencies	\$16,009,318	\$17,194,847
GRAND TOTAL (USD)	\$114,706,544	\$124,633,372



Proposed Flood Control and Drainage Features: Jew Gully, Marcus Garvey Drive, Tinson Pen, Oakland and Clifton (1/2)





Proposed Flood Control and Drainage Features: Newport West

3.2 Roadway Improvement Requirement

3.2.1 Review of Traffic and Highway Usage Patterns along MGD

Marcus Garvey Drive (MGD) is a vital arterial roadway in Kingston, facilitating connectivity between the city center, key industrial zones, and the Port of Kingston. It supports a diverse mix of traffic, including heavy goods vehicles (HGVs) transporting cargo to and from the port, public transport such as JUTC buses and route taxis, and local commuter traffic. The road is also utilized for access to recreational areas along the waterfront, contributing to mixed traffic patterns. HGVs dominate traffic during peak logistics hours, while public and private commuter traffic peaks during the morning and evening rush hours, creating congestion challenges. The roadway has a throughput greater than 40,000 vehicles per day with a major connection to the Portmore Toll and Hagley Park Road.

The overlapping use of Marcus Garvey Drive for freight, commuter, and recreational purposes creates significant traffic flow issues. Regular congestion occurs at key intersections, especially at access points to Newport West and Tinson Pen. This is further exacerbated by recurring flooding, which frequently renders portions of the roadway impassable, forcing vehicles to divert to alternative routes and causing widespread delays. Traffic analysis shows a predominance of westbound traffic in the mornings, heading toward the port, and eastbound traffic in the evenings, as vehicles return to urban and residential areas.



Figure 15: Traffic situation along the MGD.

Given its critical role in logistics, Marcus Garvey Drive serves as a key freight corridor connecting the Port of Kingston to inland logistics hubs like the Caymanas Economic Zone, as well as the broader South Coast Highway network. However, its dual role as a commuter and freight route creates frequent bottlenecks and conflict points, reducing efficiency and increasing delays. To address these challenges, several targeted improvements are proposed. Upgrades to intersections and access points, particularly those leading to Newport West and Tinson Pen, would improve traffic flow.

In addition to these traffic-specific solutions, addressing the persistent issue of flooding is crucial to maintaining the road's functionality. Upgrades to the drainage infrastructure would prevent road closures and mitigate disruptions during heavy rainfall. Finally, the development of bypass routes for local traffic could reduce conflict points and provide alternatives during peak periods.

3.2.2 Technical Requirements for Traffic Mitigation

After consulting with various stakeholders, four (4) proposed road realignment schemes were conceptualized. The aim of these realignments is to maintain a functional roadway across this major

thoroughfare while accommodating the anticipated increase in traffic flow due to future developments in the area. The three options considered are:

- 1) Modification of the existing roadway to an elevated road corridor (blue)
- 2) Realignment of the roadway northward of the existing Tinson Pen aerodrome (green)
- 3) Realignment of the MGD roadway to an upgraded Spanish Town road (yellow)
- 4) Construction of a multi-level interchange that preserves ground-level connectivity for the port (red)



Figure 16: Layout of the conceptual road realignment options.

3.2.2.1 Elevated Road Corridor

The modification of the existing roadway into an elevated road corridor involves elevating the roadway at the intersection of Fifth Avenue and Marcus Garvey Drive (MGD) and gradually returning it to ground level at the beginning of the Portmore Causeway. The proposed elevated roadway is designed to accommodate port traffic and eliminate flooding delays along MGD. Under this plan, the existing roadway would be repurposed as an internal road within the port, facilitating operations without disrupting external traffic. This option would also allow the port to utilize the Tinson Pen Aerodrome for logistics without obstructions, while minimally disrupting the natural flow of the existing roadway. The elevated six-lane roadway is estimated to span approximately 1.7 km in a road area of approximately 40,200 m², with ramps connecting it to the existing road network. The estimated cost of Bridge works on average is 4500 USD per m², which was derived from comparing several bridge projects on island with prices ranging from 2,600 USD to 10,000 USD per m². This type of work has a high level of variability based on the complexity and of the project, further compounded by the lack comparable projects in Jamaica. Adding a 10% of miscellaneous costs, this solution is projected to require a total investment of around \$183 million USD.



Figure 17: Proposed alignment of the elevated roadway option and cross section of the proposed roadway.

3.2.2.2 Realignment along Tinson Pen

The second option involves the realignment of the roadway to the north of the existing Tinson Pen Aerodrome runway. This would require the construction of 2.7 km of six-lane roadway at grade, with elevated sections to connect seamlessly with the existing roadway at the Portmore Causeway segment of the alignment. This option relies heavily on the implementation of comprehensive flood control measures, as the road passes directly through an existing floodplain. While this alternative integrates the Tinson Pen area into the port's logistics plans, the usable area gained is smaller compared to the elevated roadway option due to the relatively complex transition zones. The estimated cost for this roadway is approximately 24 million USD, however if a complex overpass is needed it may reach up to 80 million USD, assuming no land acquisition costs are incurred.

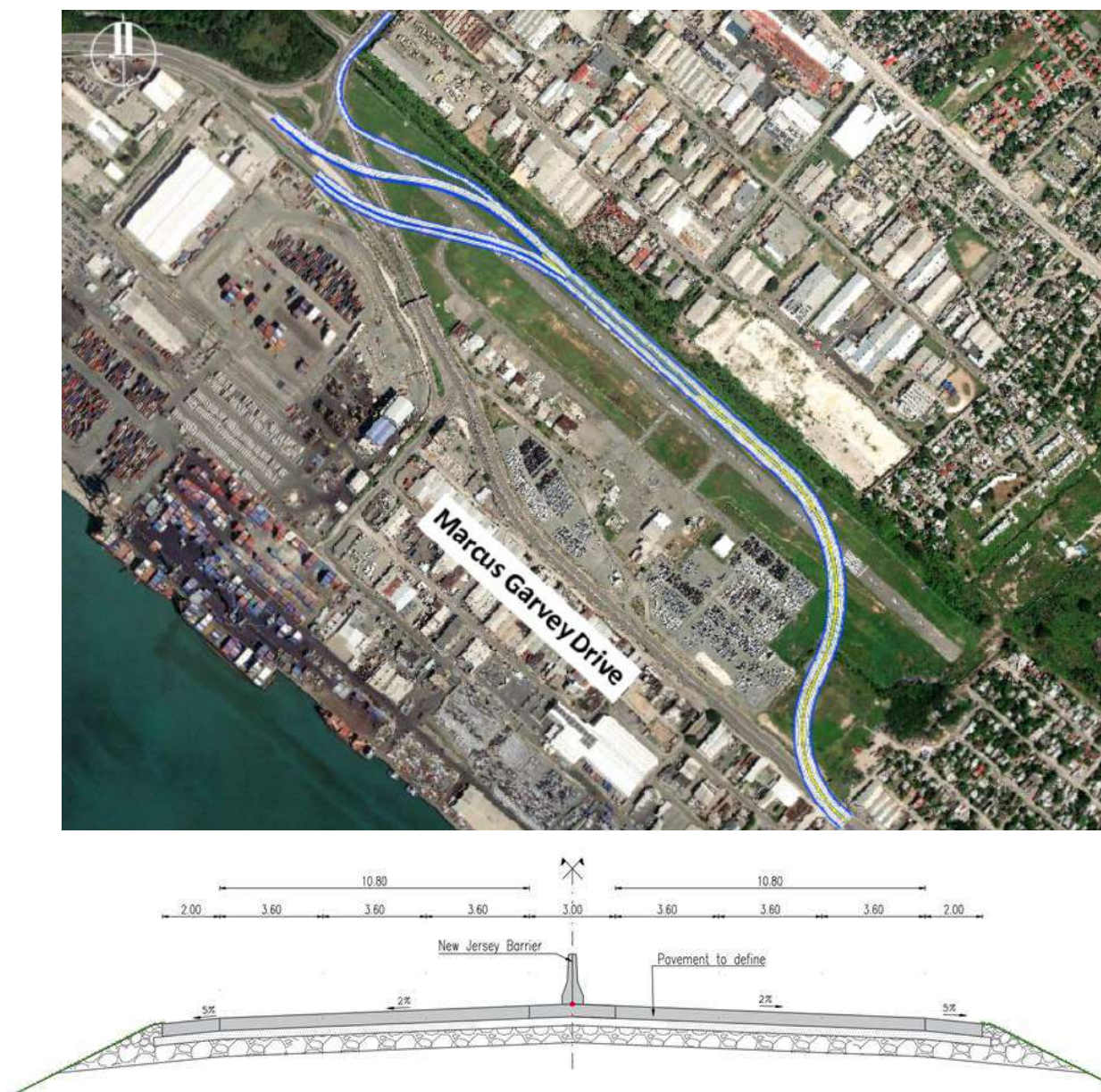


Figure 18: Proposed alignment of the elevated roadway option and cross section of the proposed roadway.

3.2.2.3 Realignment to Spanish Town Road

The realignment of the Marcus Garvey Drive (MGD) roadway to Spanish Town Road is another option under consideration. This involves rerouting traffic to Spanish Town Road, running from the Portmore Causeway to East Avenue. The proposed works include adding two additional lanes along the 3 km stretch of roadway. However, a significant challenge with this option lies in the associated land acquisition and relocation costs, given the extensive development along Spanish Town Road and East Avenue. This realignment would however enable optimal use of the Tinson Pen Aerodrome lands, provided the necessary flood and drainage controls are implemented. The total estimated cost for this roadway, including land acquisition, is approximately \$61 million USD.



Figure 19: Proposed alignment of the elevated roadway option.

3.2.2.4 Multi-level Interchange

This alternative developed by the NWA proposes a multi-level interchange that redirects through traffic via elevated lanes, preserving ground level exclusively for port operations. It enables direct connectivity between the port and the current Tinson Pen Aerodrome lands, improving internal logistics while maintaining traffic flow along MGD.

Although it reduces congestion and reserves ground access for the port, MGD would still act as a physical divider between the port and the aerodrome. The design requires further analysis of grades, acceleration/deceleration lanes, and spatial constraints.

The estimated cost by the NWA is 26 million USD, excluding potential design complexities or land acquisition. Further geometric evaluation is needed to confirm feasibility.



Figure 20: Proposed alignment of the multi-level interchange.

3.2.2.5 Comparison of Roadway Realignment Options

The various roadway improvements can be summarized in the following table:

Table 3: Comparison of the various traffic solutions.

Option	Description	Advantages	Disadvantages	Estimated Cost
1) Elevated Road Corridor	Modification of the existing roadway with an elevated 6-lane road (1.7 km). Ramps connect it to the current roadways.	<ul style="list-style-type: none"> • Eliminates flooding delays even without drainage program • Minimal disruption to natural traffic flow and no need to change the street layout • Port traffic unobstructed • Allows for complete use of Tinson Pen aerodrome for logistics 	<ul style="list-style-type: none"> • High construction cost • Security concern by the Port • Elevated sections have to be constructed to allow for straddle carrier ~ 10 high to transit to the new logistic area • Extreme difficulties for expansion/ addition of new lanes once built • The Tinson Pen aerodrome must necessarily be relocated • Soil may be unfavourable for piled structures 	~\$183 million USD
2) Realignment North of Tinson Pen	Constructs a 6-lane road (2.7 km) on grade north of Tinson Pen aerodrome with elevated sections at Portmore Causeway	<ul style="list-style-type: none"> • Integrates Tinson Pen into port logistics • Lowest construction cost and easier to intervene • The design layout can be adapted to different possibilities • Low land acquisition cost 	<ul style="list-style-type: none"> • Dependent on comprehensive flood control • Located in an active floodplain • Less optimal use of Tinson Pen lands due to transition complexities • The Tinson Pen aerodrome must necessarily be relocated • It limits the possible port expansion to the north 	~\$24 million USD

3) Realignment to Spanish Town Road	Diverts traffic through port property to Spanish Town Road, adding two lanes along a 3 km stretch	<ul style="list-style-type: none"> • Most favorable use of Tinson Pen aerodrome • Accommodates future traffic growth and takes the bulk of the traffic off the port 	<ul style="list-style-type: none"> • High cost due to land acquisition and relocation • Extensive development in Spanish Town Road and East Avenue areas • Requires significant flood and drainage control measures 	~\$61 million USD
4) Construction of Multi-level Interchange	Multi-level interchange that elevates and reorganizes traffic while reserving ground level for exclusive port operations	<ul style="list-style-type: none"> • Separates port logistics from general traffic and reduces congestion on MGD • Maintains connectivity between port and Tinson Pen lands at ground level • Improves internal port circulation through functional reorganization 	<ul style="list-style-type: none"> • MGD remains a physical divider between port and existing aerodrome area • Conceptual stage: feasibility depends on grades and acceleration/deceleration lane geometry • May face spatial and structural constraints 	~\$26 million USD

4. Stakeholder Mapping and Analysis

4.1 Identification of Key Stakeholders

The following are key stakeholders to be consulted regarding the implementation of this project:

Table 4: List of key Stakeholders impacted by the project.

Category	Business Name	Importance
Government Agencies	NEPA (National Environment & Planning Agency)	NEPA ensures compliance with environmental regulations, critical for the planning, design, and implementation of flood control and drainage works.
	NWA (National Works Agency)	NWA is responsible for the design, maintenance, and improvement of road infrastructure, including flood mitigation measures along Marcus Garvey Drive.
	PAJ (Port Authority of Jamaica)	PAJ oversees the Port of Kingston and surrounding logistics areas, playing a key role in coordinating flood control measures that impact port operations and access routes. Guide the logistics master plans and provide guidance and oversight of the project
	AAJ (Airports Authority of Jamaica)	AAJ's involvement in any potential expansions or transportation linkages related to the project, particularly if flood control impacts transportation access.
	MP (Representative Member of Parliament) Anthony Hylton	Represents local government interests and plays a key role in facilitating regulatory approvals and community engagement.
Neighbouring businesses	Kingston Logistics Centre	A key logistics partner involved in supply chain and freight forwarding activities; their operations could be impacted by road and drainage improvements.
	Kingston Wharves Limited	Major logistics operator and port facilities provider; their operations are directly linked to improvements in road infrastructure and flood management along MGD.
	Musson Group	Key commercial player whose businesses may be affected by traffic flow, road infrastructure, and flooding along Marcus Garvey Drive.
SAJ Members	CARIB STAR SHIPPING LTD	Shipping agents, directly impacted by road and flood control infrastructure that affects freight movement and port access.
	CMA CGM JAMAICA LIMITED	Key shipping operator that depends on smooth, flood-free road access for the transport of goods to and from the Port of Kingston.


	Customs Brokers & Freight Forwarders Assoc of Ja	Facilitates cargo movement through customs and logistics networks; directly impacted by infrastructure and flood management improvements.
	HARBOUR COLD STORES LTD	Warehousing and cold storage provider at the Port of Kingston, relies on proper road infrastructure and flood management for the safe transport of goods.
	KINGSTON LOGISTICS CENTER LTD	Critical logistics partner whose operations are reliant on smooth transport corridors; any improvements to road or flood control infrastructure will benefit them.

4.2 Insights from Ongoing Stakeholder Consultations

During the ongoing scoping mission several stakeholders were consulted to determine insight into the proposed development. Their comments and concerns were compiled and are as follows:

Table 5: Summary of Stakeholder Engagement.

Stakeholder	Key Discussion Points
National Works Agency (NWA)	<ol style="list-style-type: none"> 1. Agency Responsibilities: Oversees flood protection, road infrastructure, and shoreline protection. 2. Urban Development Challenges: Rapid urbanization increasing impermeable surfaces, exacerbating flooding. 3. Considerations from Infrastructure Updates: <ul style="list-style-type: none"> - Marcus Garvey Drive: Self-cleaning canal, tidal flow helps sediment removal. - Tinson Pen Aerodrome: Flooding from secondary collector overflow. - Railway Parallel to Gully: Prone to flooding, complicates surrounding infrastructure. 4. Planned Developments: There are proposed developments in wetlands near Newport West. 5. Proposed Solutions: <ul style="list-style-type: none"> - New Road Alignment: Realign Marcus Garvey Drive alongside Tinson Pen. - Diversion to Spanish Town Road: Redirect and widen the road. - Elevated Flyover Corridor: Create direct Port-Tinson Pen connection.
Shipping Association of Jamaica (SAJ)	<p>Expertise Sharing: SAJ connects with Kingston Wharves (KW) and Seaboard Marine. Recommends contacting the engineer for Miami Port's drainage solutions</p> <ol style="list-style-type: none"> A. The proposed alternatives were reviewed. B. Consider landowners, in addition to the shipping members. C. SAJ will identify the affected parties and then coordinate with the Port Authority. D. The owners of the affected areas are impacted by flooding, so they are likely to be willing to collaborate. E. Besides the significant costs of routing the drainage through the port with large pipes, this would also involve crossing private properties.
Kingston and St. Andrew Municipal Corporation (KSAMC)	<ol style="list-style-type: none"> 1. Urban Commuting Patterns: 50,000 people commute daily to downtown Kingston. 2. Considerations for Development: Vendors, trucking operations, informal housing settlements, and environmental challenges such as sea-level rise. 3. Role in Projects: KSAMC ensures access and addresses local community needs. 4. Government Coordination: Desmond McKenzie, Minister of Local Government, is key contact for project alignment.

National Environment and Planning Agency (NEPA)	<ol style="list-style-type: none"> 1. Development Policies: Provides best practices and policy recommendations. 2. Environmental Permitting: Joint or separate permits for road, drainage, and wetland components. 3. Environmental Impact Assessments (EIA): Required for internationally funded projects. 4. Projected Developments: NEPA can provide information on developments that affect traffic and infrastructure planning.
Anthony Hylton and Milton Samuda	<ol style="list-style-type: none"> 1. Wetlands Ownership: Legal representatives for wetlands owners; a master plan for development exists. 2. Challenges: Drainage issues related to Jew Gully, Marcus Garvey Drive, and sedimentation in Hunts Bay. 3. Preservation: Owners wish to retain Tinson Pen Aerodrome and railroad.
Atlantic Council	<ol style="list-style-type: none"> 1. Public-Private Partnerships (PPPs): Challenges with liquidity and currency risks in Jamaican dollars. 2. Funding Opportunities: World Bank supports sustainability in infrastructure, recommends PPPs for long-term maintenance. 3. Innovative Financing: CAF promotes new financing instruments for PPPs to stimulate development.
Airport Authorities	<ol style="list-style-type: none"> 1. Airport Relocation Plans: Study underway for metropolitan airport relocation to the main international airport. 2. Land Use and Zone Development: Zones 1 and 2 identified for operator and hangar development. 3. Marcus Garvey Drive Relocation: Proposed new road alignment north of airport, incorporating logistics zone. 4. Operational Compatibility: Ensuring effective integration with port, logistics zone, and waste management.  <p>Marked areas (in green) are designated for airport expansion.</p>
Port Authority of Jamaica	<ol style="list-style-type: none"> 1. The proposed alternatives were reviewed, and the bypass parallel to the airport runway was identified as the most feasible. 2. The flyover alternative presents security and smuggling concerns due to its passage over the port, as well as clearance issues for port equipment. 3. Impact on navigation was noted due to the discharge of underground drainage in the port area.

5. Activity Timeline and Budget Estimation

5.1. Project Milestones and Key Activities

The project is envisioned to be broken down into 3 stages (Feasibility, Detailed Design and Construction):

Stage	Key Activities	Milestone	Estimated Timeline (months)
1. Feasibility and Preliminary Design (Estimated Timeline 6 Months)	- Stakeholder Engagement: Consult with government agencies, local businesses, and stakeholders to understand project requirements and concerns.	Initial stakeholder consultations complete	2
	- Site Surveys and Data Collection: Conduct surveys of Topography, Bathymetry, Aerial Survey, existing drainage systems, existing road conditions (PCI & IRI), and traffic flow data.	Site surveys and data collection completed	2
	- Environmental Impact Assessment (EIA): Perform an EIA to evaluate the potential environmental impacts and obtain necessary permits from NEPA.	EIA report Started with consultations with NEPA's	4
	- Preliminary Designs: Analyse the existing flood and Roadway infrastructure develop conceptual to preliminary designs inclusive of road alignment, geometry, flood control layout and sizing of relevant components. This stage will also consider the variations of the design to determine the most optimal solutions for all stakeholders.	Preliminary designs	3
	- Preliminary Cost Estimation: Estimate project costs, including construction, materials, and labor, and evaluate the financial feasibility of the project.	Preliminary cost estimates	1
	- Risk Assessment: Identify potential risks (e.g., regulatory, weather-related, social) and develop mitigation strategies.	Risk assessment completed, and mitigation strategies identified	2
2. Detailed Design (Estimated Timeline 12 months)	- Final Design Development: Develop detailed engineering designs for drainage systems, flood control infrastructure, and road improvements. Inclusive but not limited to the structural design of the flood control and roadway, layout of traffic signs and lights, in addition to any details required for construction	Final design for flood control and drainage infrastructure	3
	- Traffic and Flood Management Plans: Finalize traffic management and flood mitigation strategies, including utility relocation, temporary road realignment and diversionary works.	Traffic and flood management plan finalized	3
	- Stakeholder Review and Feedback: Present final designs to stakeholders (e.g., NWA, NEPA, local businesses) for feedback and approval.	Stakeholder review and approval of final designs	1
	- Detailed Cost and Schedule Estimates: Refine the project budget and schedule based on the final designs and construction requirements.	Final cost estimates and project schedule refined and approved	2

	- Tender Document Preparation: Prepare and issue tender documents for construction, ensuring compliance with all regulations and project specifications.	Tender documents issued for contractor bidding	3
	- End of Environmental Impact Assessment (EIA): Complete EIA to evaluate the potential environmental impacts and obtain necessary permits from NEPA.	Final cost estimates and project schedule refined and approved	12
	- Regulatory Submissions: Prepare and issue submit documents for Permitting, consisting of any forms, briefs and design documents	Regulatory Submission to NPEA, Parish Council and NWA, in addition to any stakeholder identified	1
2.1 (Estimated Timeline 8 months)	- Regulatory Reviews and Approvals: Prepare and issue submit documents for Permitting, consisting of any forms, briefs and design documents	Regulatory Approvals form NEPA, Parish Council and NWA, in addition to any stakeholder identified	8
2.2 (Estimated Timeline 6 months)	- Procurement: With produced tender documents the selection process for the relative contractors will begin	Tendering, evaluation and selection, Sector Committee, Cabinet submission, technical committee, approval and contract	6
3. Construction (Estimated Timeline 24 months)	- Site Preparation: Clear the site, relocate utilities, and prepare for construction.	Site preparation and clearing completed	4
	- Flood Control Infrastructure Construction: Begin construction of drainage systems, retention basins, culverts, and other flood mitigation infrastructure.	Flood control infrastructure construction begins	20
	- Road Improvements: Implement Road realignment, dedicated freight lanes, and intersection upgrades to improve traffic flow to the port and adjoining entities.	Road and intersection improvements underway	20
	- Final Testing and Commissioning: Test the flood control systems, drainage capacity, and road improvements to ensure all systems function as designed.	Testing of flood control and drainage systems completed	2
	- Final Inspection and Handover: Conduct a final inspection with stakeholders and hand over the completed infrastructure to the relevant authorities.	Final inspection and handover to authorities	1

5.2. Deliverables

5.2.1. Feasibility and Preliminary Design

The objective of this phase is to assess the feasibility of implementing flood control and drainage improvements along Marcus Garvey Drive, Tinson Pen, and Newport West, and to develop preliminary design concepts that will guide the subsequent detailed design and construction phases. The scope includes site surveys, environmental and structural/civil assessments, stakeholder

consultations, preparation of an environmental impact assessment and the preparation of preliminary designs and cost estimates.

It is envisioned that this phase will be conducted by one company over a period of 6 months.

Table 6: Deliverables of Feasibility and preliminary designs.

No	Deliverable	Requirements of deliverable
D1	Inception report	Outline of the project scope, methodology, timeline, and key milestones to be provided as a report before start of works.
D2	Surveys (Topographic, Aerial, Bathymetry, Road and drainage)	<p>Topographic survey to map existing road conditions, elevations, and infrastructure along Marcus Garvey Drive and surrounding areas, inclusive of Ortho mosaic imagery of the site.</p> <p>Bathymetric survey (if applicable) to assess water depth and underwater features of relevant water bodies such as gullies or drainage channels.</p> <p>Road condition survey, including surface quality, traffic flow data, and current capacity.</p> <p>As-built surveys of Drainage survey to assess the size, condition, and capacity of existing drainage infrastructure along the corridor.</p> <p>As-built surveys of Roadways to be affected by reconstruction noting features inclusive but not limited to kerbs, sidewalk, barriers, stoplights, sign, grades, crossings and cambers.</p>
D3	Preliminary Designs	<p>Development of Initial conceptual designs for flood control and drainage infrastructure, including street level drains, culverts, retention basins, and channels.</p> <p>Preliminary Road design, including potential realignment or widening to improve traffic flow.</p> <p>High-level layout of flood control measures and road infrastructure.</p> <p>Preparation of design Report, drawings, and cost estimates, with design variations</p>
D4	Feasibility Study	<p>Assessment of the technical, financial, environmental, and social feasibility of the proposed flood control and drainage improvements.</p> <p>Identification of potential challenges and risks associated with the project.</p> <p>Evaluation of various flood mitigation options, including cost-benefit analysis and long-term sustainability.</p> <p>Preliminary traffic impact analysis and integration of transport logistics.</p> <p>Recommendations for proceeding to detailed design, including any necessary adjustments to scope or approach.</p>
D5	Environmental impact assessment	<p>Baseline environmental data collection, including water quality, flora, fauna, and any nearby sensitive habitats.</p> <p>Analysis of potential environmental impacts (e.g., soil erosion, water pollution, disruption of local ecosystems) due to the construction and operation of the Road, flood control and drainage systems.</p> <p>Evaluation of social impacts, including effects on local communities, businesses, and traffic.</p> <p>Mitigation measures to minimize adverse environmental and social impacts.</p>

		<p>Proposed environmental management and monitoring plans during and post-construction.</p> <p>Stakeholder consultation process and public disclosure of findings.</p> <p>Identification of applicable permits/no objections to support the designs of the road and drainage infrastructure from the relevant governmental organizations</p>
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5.2.2. Detailed Design

During the Detailed Design Phase, the project team refines all initial design concepts, incorporating technical calculations, environmental considerations, and regulatory compliance into finalized designs. Detailed engineering drawings, construction specifications, and tender documents are to guide the construction team in executing the scope of works.

It is envisioned that this phase will be conducted by one company with sub-consultants over a period of 12 Months. However, approvals and contractor procurement may add an additional 14 months.

No	Deliverable	Requirements of deliverable
D1	Gap analysis	The consultant will review the preliminary designs and identify any additional designs/surveys needed for the construction of the proposed infrastructure
D2	Detailed Engineering Designs	<p>Detailed design for the relocation of utilities (water, sewage, power, telecommunications) affected by the road and flood control works, in addition to identification of area of land acquisition.</p> <p>Roadway and intersection upgrades, including realignment and widening, road surface material specifications, traffic capacity analysis, and road drainage solutions. Inclusive of the design of any civil/structural works</p> <p>Drainage and Flood Control Design: Design of drainage channels, culverts, and retention basins to ensure effective flood mitigation.</p> <p>Design Drawings & Details: Finalized technical drawings with construction details for all infrastructure components.</p> <p>Traffic Management Plan: Detailed strategies to manage traffic during construction, including road closures, detours, access routes for businesses and residents, and coordination with local transportation authorities to ensure smooth traffic flow during construction phases.</p> <p>Construction Environmental Management Plan (CEMP)</p> <p>Final deliverable should include Engineering design report, Drawings, Specifications and a Bill of quantities</p>
D3	Preparation of Tender Documents	<p>Preparation of Tender package which includes:</p> <p>Drawing for Construction</p> <p>Construction specifications</p> <p>Detailed Bill of Quantities (BOQ)</p> <p>Tender documents that outline scope of works, timelines, and bidding requirements for contractors.</p> <p>Quality control and safety standards for construction activities.</p>
D4	Submission of regulatory agencies for approval	Submission of design package to relevant regulatory agencies (e.g., NEPA, NWA, local authorities) for review and approval. address any concerns or requests for changes raised by the regulatory bodies to obtain the necessary permits and approvals.
D5	Environmental Impact Assessment	<p>Baseline environmental data collection, including water quality, flora, fauna, and any nearby sensitive habitats.</p> <p>Analysis of potential environmental impacts (e.g., soil erosion, water pollution, disruption of local ecosystems) due to the construction and operation of the Road, flood control and drainage systems.</p>

		<p>Evaluation of social impacts, including effects on local communities, businesses, and traffic.</p> <p>Mitigation measures to minimize adverse environmental and social impacts.</p> <p>Proposed environmental management and monitoring plans during and post-construction.</p> <p>Stakeholder consultation process and public disclosure of findings.</p> <p>Identification of applicable permits/no objections to support the designs of the road and drainage infrastructure from the relevant governmental organizations</p>
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5.2.3. Construction and Supervision

The Construction Phase is the final stage of the Marcus Garvey Drive Roadway, flood control and drainage work project, where the designs and plans developed in the earlier phases are put into action. The scope of works includes Roadway improvements/realignments, flood mitigation measures, utility relocation, and associated infrastructure.

It is envisioned that this phase will be conducted by two different entities 1) contract administrator and 2) Contractor executing the works over a period of 24 Months.

No	Deliverable	Requirements of deliverable
D1	Contract Administration (to be executed by independent consultant)	<p>Constructability Report</p> <p>Monitoring Reports</p> <p>Certification of works</p> <p>Evaluation of implementation of contractor's quality management plan</p> <p>Inspection reports</p>
D2	Construction of Flood Control Works	Implementation of drainage channels, culverts, retention basins, dredging and outfalls as required by the design documentation
D3	Construction of Road Works	Execution of road resurfacing, widening, and realignment, as per the design specifications and drawing
D4	Defect Liability Period	Post-Construction Monitoring: Monitor the performance of completed works for defects or issues that may arise after construction and Rectification of Said Defects.

5.3. Estimated Budget for Infrastructure Improvements

The following cost estimates were used to determine the approximate cost of each phase of the project.

Stage	Estimated timeline Months	Estimated cost (USD)
1. Feasibility and Preliminary Design	6	380,000
2. Detailed Design	12	1,270,000 (Detailed designs) + 300,000 (EIA)
3. Construction (Estimated Timeline 24 months)	24	140 million - 350 million

The following cost assumptions were used to determine the costs associated with various phases of the project:

1) Feasibility and Preliminary Design

The Professional team will consist of Team Lead, Engineers (Civil and Environmental), surveyors, draft men, and quantity surveyors. The project is assumed to be 0.3 % of the project costs which amounts to ~380,000 USD.

2) Detailed Design

The Professional team will consist of Team Lead, Engineers (Road, Marine, Geo-technical, Civil and Environmental), surveyors, draft men, and quantity surveyors. Estimated work is 45 man months the associated engineering fees for the entire project is assumed to be 1% of the project cost which is approximately 1.27 million USD. Additionally, the EIA which would require approximately 18 months at approximately 0.3 million USD.

3) Construction

A) To determine the range of cost the lowest & highest drainage scenario and roadway scenario added together to determine the maximum and minimum construction costs.

B) The Elevated roadway was based on bridge construction rates at 4500 USD per m2.

C) Land acquisition Rate were based on the property prices along Spanish Town Road which a markup to consider possible demolition, at a rate of 1005 USD per m2.

D) All the proposed options include an additional project management cost assumed to match the detailed design fees.

	Scenario	Construction of new at grade roadway cost (USD)	Elevated Roadway cost (USD)	Land acquisition cost (USD)	Construction of interchange cost (USD)	Total cost (USD)
Drainage Scenario	Drainage 100 RP					\$122,633,372
	Drainage 25 RP					\$114,706,544
Roadway Scenario	1.7 Km Elevated Road Elevated		\$182,772,630			\$182,772,630
	2.7 km Road	\$24,499,783				\$24,499,783
	3 km Spanish town road expansion	\$19,154,852		\$41,372,232		\$60,527,084
	Multi-level interchange			To Be Defined	\$25,980,595	\$25,980,595

5.4 Identification of Project Risks

Phase	Risk Category	Risk Description	Potential Impact	Mitigation Measures
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Preliminary Design and Feasibility	Environmental Risks	Incomplete or inaccurate Environmental Impact Assessments (EIA).	Unforeseen environmental impacts that could halt or delay the project.	Conduct thorough EIA studies and engage stakeholders for input. Monitor environmental conditions regularly.
	Technical Feasibility Risks	Inaccurate site data or failure to account for environmental changes (e.g., increased rainfall).	Design solutions may become inadequate or ineffective over time.	Ensure accurate site surveys and studies. Regularly update design assumptions based on current data.
	Community Risks	Opposition from local communities regarding project impact or land acquisition. This is particularly disruptive in the Spanish Town road realignment option.	Delays due to protests or disputes over land use and displacement of squatters	Engage with the community early, address concerns, and offer fair compensation for land acquisition if necessary. Incorporate local workforce into project wherever possible
Detailed Design	Design Risks	Errors or omissions in the detailed design, including incorrect specifications or calculations.	Project delays, cost overruns, and the need for redesigns.	Implement a rigorous design review process, including cross-checking calculations and ensuring compliance with standards.
	Environmental Compliance Risks	Failure to address environmental concerns adequately in the design phase.	Potential environmental violations, fines, or delays due to non-compliance.	It is imperative the Development Assistance Centre (DAC) be consulted with the preliminary designs to determine permitting requirements and possible objections
	Regulatory Risks	Changes in regulations or guidelines during the design phase. Extended approval timelines	Need for redesigns to meet new requirements, resulting in delays and additional costs.	Regularly monitor updates to regulations, maintain flexibility in designs, and ensure early approval from regulators.
	Stakeholder Risks	Disagreements among stakeholders regarding the design or scope of the project.	Disputes that lead to delays or scope changes.	Maintain clear communication, regular consultations, and align stakeholder interests early in the design process.
Construction	Safety Risks	Accidents or injuries on the construction site due to inadequate safety measures.	Worker injuries, project delays, and potential legal liabilities.	Enforce strict safety protocols, provide regular training, and conduct routine safety inspections.

	Weather Risks	Adverse weather conditions (e.g., heavy rainfall, storms) causing work delays.	Project delays, increased costs, and disruption of the construction schedule.	Include buffer time in the project schedule to accommodate weather-related delays. Plan for weather-resistant solutions.
	Supply Chain Risks	Delays in the delivery of materials or equipment required for construction.	Construction delays and increased costs due to long import times.	Establish reliable suppliers and maintain backup options. Order materials well in advance and monitor delivery schedules.
	Quality Control Risks	Poor workmanship or use of substandard materials during construction.	Failure to meet design standards, requiring rework and additional costs.	Include a third-party contract administrator
	Environmental Risks	Failure to properly manage construction-related environmental impacts (e.g., pollution, soil erosion).	Negative environmental impacts, potential fines, or delays due to non-compliance.	Implement an environmental management plan to monitor and mitigate pollution, erosion, and other impacts.
	Impacts on Traffic	If roadways are not implemented in a systematic way, there may be impacts on existing roadways	Delays on existing roadways due to ongoing road works	Implement a Traffic Management plans
	Community Disruption Risks	Construction activities causing disruptions to local businesses, residents, or traffic.	Negative public perception, protests, or legal actions due to disruptions.	Develop a comprehensive traffic management plan and regularly communicate with the local community to manage disruptions.
	Cost Overrun	Cost of works may increase during implementation due to design gaps, bad quality works and variations	The cost of these additional works may exceed the allocated budget affecting the feasibility of project	Include a third-party contract administrator/supervisor prepare constructability review
Defect Liability Period	Performance Risks	Defects in the completed infrastructure, including drainage or roadworks.	Structural failures or inefficiencies in flood control systems or roads.	Ensure a thorough final inspection and handover process. Address any defects immediately as per the warranty period.

	Contractor Risks	The contractor failing to meet obligations for repairs or corrective actions during the defect liability period.	Delays or additional costs to rectify defects, legal disputes.	Establish clear terms in the contract regarding defect rectification and ensure the contractor's accountability.
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5.5. Project Legal Requirements

All aspects of the project must comply with applicable national legislation and policy requirements, including but not limited to the following:

- 1) Town And Country Planning Act (TcP Act), 1957 (Amended 1987)
- 2) Parish Councils Act 1901 (Amended 2007)
- 3) Land Development and Utilization Act 1966
- 4) Local Improvement Act 1944
- 5) Registration Of Titles Act 1989
- 6) Land Acquisition Act 1947
- 7) Main Roads Act 1932
- 8) Building Act 2016
- 9) Natural Resources Conservation Authority Act 1991
- 10) Water Resources Act 1995
- 11) Draft Policy and Regulation for Mangrove & Coastal Wetlands Protection
- 12) Coastal Management and Beach Restoration Guidelines: Jamaica
- 13) The Flood-Water Control Act 1958

6. Summary and Recommendations

6.1 Summary

Flooding and Drainage Issues: The current drainage infrastructure along Marcus Garvey Drive (MGD) and surrounding areas is inadequate, with many channels undersized and unable to handle even moderate rainfall events (1-year return period). Climate projections indicate that rainfall could increase by 30–35% by 2050–2060, further exacerbating the flooding risks in the area.

Impact of Flooding: Flooding causes significant disruptions, including traffic delays and economic losses. The estimated losses per flood event can reach up to USD 5 million, with an Average Annualized Loss (AAL) of USD 17.5 million. This underscores the critical need for effective flood mitigation measures.

Logistics and Infrastructure Growth: The redevelopment of Tinson Pen Aerodrome into a logistics hub is essential for Jamaica's growing port infrastructure. However, the success of this development is heavily reliant on addressing the current flooding and drainage challenges to ensure smooth transportation and continued economic activity in the region.

Proposed Flood Mitigation Solutions: Several flood mitigation strategies have been recommended, including:

1. For the Tinson Pen Drain, it is proposed that the drainage system be upgraded by:
 - a. Widening 1462 meters of the channel to 18m, and deepening to 3m to carry the flow,
 - b. The crossing at Marcus Garvey Drive is to be upgraded from a 3-cell to a 5-cell culvert, matching the width of the drainage channel.
 - c. The crossing coming from the Stewarts industrial area to the Tinson Pen Drain to be upgraded to a 2-Cell concrete box culvert, measuring 2m deep x 6m wide.
2. For the Jew Gully Drainage channel, it is recommended that:
 - a. The 790 meters of the channel be widened to 14m and deepened to 5.5m to carry the flow for the 100-Yr RP event.
3. For the Marcus Garvey Drive drain, it is recommended that 1661 meters of the drainage channel be upgraded by widening to a width of 6m, and a depth of 1.5m to assist in easing the current flooding situation in the area.
4. The construction of a detention basin and canal to Hunts Bay, where the Tinson Pen drain and Jew Gully intersect. This basin has a proposed functional capacity of approximately 40,000m³ and an invert of -3.0 m, and serves as a debris collection and cleaning point before runoff gets to the harbour.
5. To reduce the instances of flooding in the Newport West area, it is recommended that a large section of the 1120 meters of drainage system, including inlets and the underground pipe network be upgraded to meet the needs of the catchment area.
 - a. Newport West 1 area upgrades existing 900mm culvert to 3.4m *1.2m box culvert
 - b. Newport West 2 area upgrades existing 900mm culvert to 5.5m *1.2m box culvert
 - c. Newport West 3 area upgrades existing 900mm culvert to 3.4m *1.2m box culvert
 - d. Newport West 4 area upgrades existing 900mm culvert to 2.3m *1.2m box culvert

Traffic and Congestion Issues: Marcus Garvey Drive (MGD) is a key arterial roadway in Kingston that faces significant traffic congestion and flooding challenges due to its role as a freight corridor, commuter route, and recreational access point, with over 40,000 vehicles daily. Proposed solutions include:

- a. Constructing a 1.7 km elevated roadway to eliminate flooding and support port logistics at a high cost of \$183 million USD;
- b. Realigning a 2.7 km section north of Tinson Pen aerodrome, integrating it into port operations (\$24 million USD);
- c. Diverting traffic to an expanded Spanish Town Road (3 km), which optimally uses Tinson Pen lands but involves high costs for land acquisition and drainage (~\$61 million USD). Each option addresses congestion and flooding with varying trade-offs in cost, complexity, and impact;

- d. Constructing a multi-level interchange to elevate through traffic while reserving ground level exclusively for port operations (\$26 million USD).

Stakeholder Mapping: The Marcus Garvey Drive improvement project involves extensive stakeholder engagement and consultation to address traffic, flood control, and infrastructure needs. Key stakeholders include government agencies such as NEPA, NWA, PAJ, and AAJ, which oversee environmental compliance, road design, port logistics, and airport access. Local businesses, including logistics centers, shipping companies, and cold storage providers, are directly impacted by the project's outcomes. Insights from consultations highlight concerns such as urban development challenges, flooding impacts, and infrastructure integration. The project will progress through three phases—feasibility, detailed design, and construction.

Project Milestones and Key Activities: The project is divided into three main stages: Feasibility and Preliminary Design, Detailed Design, and Construction.

- ▶ **Feasibility and Preliminary Design (6 months):**
 - ✓ **Key Activities:** Stakeholder consultations, surveys (topography, bathymetry, etc.), Environmental Impact Assessment (EIA), preliminary designs, cost estimation, and risk assessment.
 - ✓ **Deliverables:** Inception report, surveys, preliminary designs, feasibility study, and EIA report.
 - ✓ **Milestones:** Completion of stakeholder consultations, site surveys, EIA, and preliminary designs.
- ▶ **Detailed Design (12 months):**
 - ✓ **Key Activities:** Develop detailed designs, finalize traffic and flood management plans, refine costs, and prepare tender documents.
 - ✓ **Deliverables:** Gap analysis, detailed engineering designs, tender documents, and submission to regulatory agencies.
 - ✓ **Milestones:** Final design approvals, tender issuance, and regulatory submissions.
- ▶ **Regulatory Approvals (8 months)**
- ▶ **Governmental Procurement (6 months)**
- ▶ **Construction (24 months):**
 - ✓ **Key Activities:** Site preparation, construction of flood control infrastructure, roadway improvements, final testing, and inspection.
 - ✓ **Deliverables:** Constructability reports, construction of road and flood control systems, and post-construction monitoring.
 - ✓ **Milestones:** Completion of site preparation, flood infrastructure construction, and final inspections.

6.2 Recommendations

The flooding and drainage issues along Marcus Garvey Drive and the surrounding areas present significant risks to traffic flow, economic activity, and infrastructure growth, particularly with the planned expansion of the Port of Kingston and Tinson Pen Aerodrome. The inadequacy of the current drainage systems is causing frequent flooding that disrupts daily operations and leads to substantial economic losses. Addressing these issues through proposed drainage upgrades, coupled with road realignment or elevated road construction, is crucial to support the region's logistical and economic development.

It is then recommended that the project be implemented in three phases: **Feasibility and Preliminary Design** (6 months, USD 380,000), **Detailed Design** (12 months, USD 1,570,000), and **Construction** (24 months, estimated between USD 140 million and USD 305 million). The recommended flood mitigation and traffic flow solutions will improve infrastructure resilience, reduce congestion, and facilitate continued growth in Kingston's port and logistics sectors. This document can be used to guide the terms of reference to the different stakeholders and guide project implementation.

Stage	Estimated timeline Months	Estimated cost (USD)
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Technical assistance to the Shipping Association of Jamaica
Framework Contract SEA 2023 – INTPA/2022/EA-OP/0102

1. Feasibility and Preliminary Design	6	380,000
2. Detailed Design	12	1,570,000
3. Construction	24	140 million – 305 million

7. Appendix

7.1 Sample table of contents for Environmental Impact Assessment

- 1.0 Introduction
- 2.0 Comprehensive Description of the Proposed Project
 - 2.1 Alignment Alternatives
 - 2.2 Design Concept
 - 2.3 Drainage Study
 - 2.4 Geotechnical Study
 - 2.5 Structural Study
 - 2.6 Traffic Study
 - 2.7 Environmental Report
 - 2.8 Economic Feasibility Report
 - 2.9 Project Criteria and Standards
- 3.0 Description of the Environment
 - 3.1 Physical Environment
 - 3.2 Biological Environment
 - 3.3 Socio-Economic Environment
 - 3.4 Archaeological Environment
- 4.0 Policy, Legal and Administrative Framework
 - 4.1 Environmental Impact Assessment Framework
 - 4.2 Rationale and Basis
 - 4.2 National Legislation
 - 4.3 Regional and International Legislative and Regulatory Considerations
- 5.0 Identification and Assessment of Potential Impacts and Recommended
- 6.0 Environmental Management and Monitoring Programme
- 7.0 Identification and Analysis of Alternatives
- 8.0 Public Sensitization Sessions

7.2 Estimated Budgets for Roads Solutions - Breakdown

Estimated Budgets for Roads Solutions

Alternative 1					
	Unit	Quantity	Unit Price (USD)	Total (USD)	Hypothesis
Structure Area	m2	40.214	4.500	180.963.000	Schematic areas in dwg were considered (approximate length of Structures: 1400m)
Various	Global	1	1.809.630	1.809.630	10%
			TOTAL	182.772.630	

Alternative 2					
	Unit	Quantity	Unit Price (USD)	Total (USD)	Hypothesis
Structure Area	m2	600	4.500	2.700.000	Bridge that does not interfere with roads below
Pavement	m2	59.756	160	9.561.024	
Excavation of Vegetation Cover	m3	29.878	25	746.955	Low area, removal of 0.5m high vegetation material is considered
General Excavation	m3	59.756	25	1.493.910	Low area, average embankments of 1.0m high are considered.
General Fill	m3	99.002	40	3.960.066	Interchange area: Average height of general fill 3.0m (Levels vary from 0m to 6m). Low area: General fill height is considered 1.5m of fill.
Expropriation	m2	0	1.005	0	Public property/port
Light and Water Relocation	m	2.700	390	1.052.487	It is considered per linear meter of work (including branches)
Fiber	m	2.700	137	370.872	
Sanitation	m	2.700	932	2.517.480	
Various	Global	1	2.096.989	2.096.989	10%
			TOTAL	24.499.783	

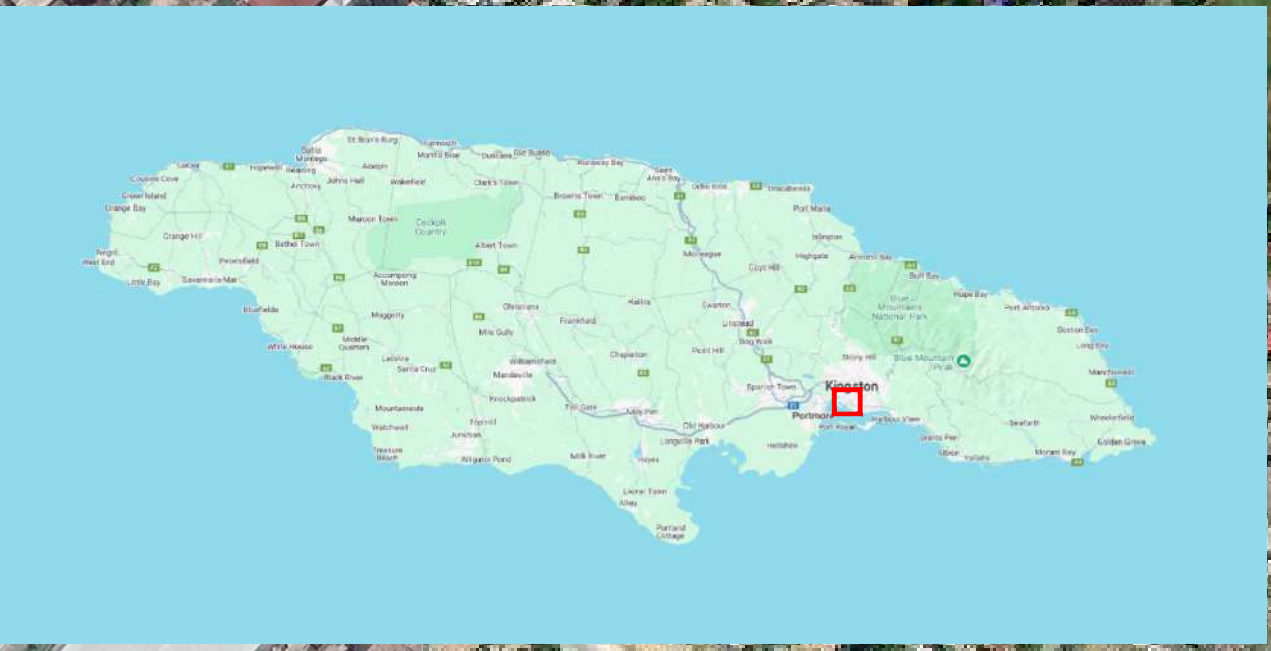
Alternative 3					
	Unit	Quantity	Unit Price (USD)	Total (USD)	Hypothesis
Structure Area	m2	0	4.500	0	
Pavement	m2	92.807	160	14.849.120	
Excavation of Vegetation Cover	m3	0	40	0	
General Excavation	m3	0	40	0	
Expropriation	m2	41.166	1.005	41.372.232	
Light and Water Relocation	m	2.950	390	1.149.940	It is considered per linear meter of work
Fiber	m	2.950	137	405.212	
Sanitation	m	2.950	932	2.750.580	
Various	Global	1	5.541.605	5.541.605	10%
			TOTAL	60.527.084	

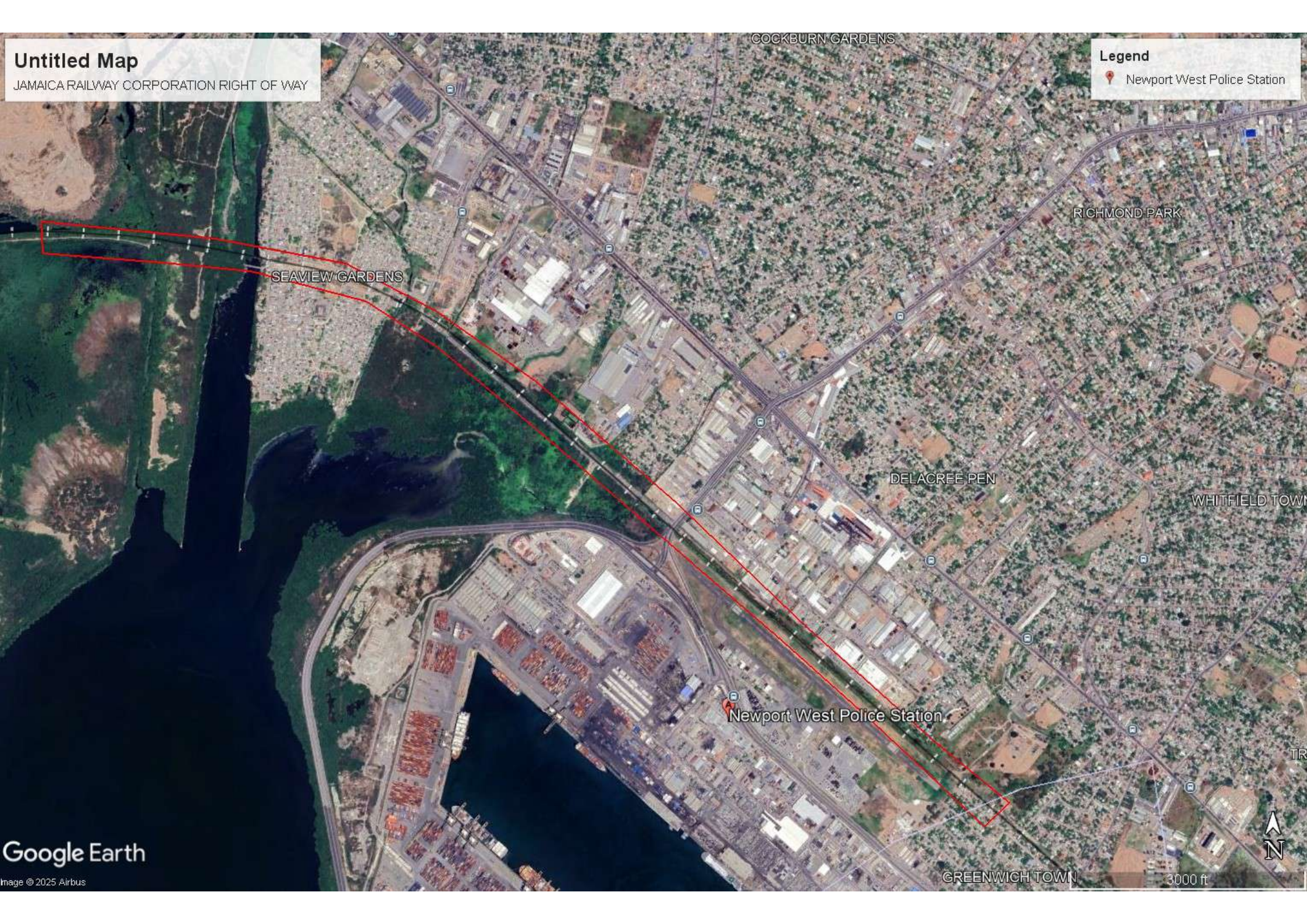
Alternative 4								
Ramp	Connection	Volume of fill (m3)	Cost	Asphalt (m3)	Cost	Reinforced Concrete (m3)	Cost	Total Ramp Cost For Each (USD)
1	On-ramp to Bridge 1 & Bridge 2	3561,6	\$ 92.601,60	222,6	\$ 80.136,00	623,28	\$ 286.708,80	\$ 459.446,40
2	Off-ramp Bridge 2	1872	\$ 48.672,00	117	\$ 42.120,00	771,68	\$ 354.972,80	\$ 445.764,80
3	On-Ramp to Bridge 3	4830	\$ 125.580,00	301,875	\$ 108.675,00	853,3	\$ 392.518,00	\$ 626.773,00
4	Ramp 4 Fixed Height	12600	\$ 327.600,00	393,75	\$ 141.750,00	2784	\$ 1.280.640,00	\$ 1.749.990,00
5	Off-Ramp to Portmore Toll	6006	\$ 156.156,00	375,375	\$ 135.135,00	1061,06	\$ 488.087,60	\$ 779.378,60
6	On-Ramp Crossing Portmore Toll	1600	\$ 41.600,00	100	\$ 36.000,00	371	\$ 170.660,00	\$ 248.260,00
7	Off-Ramp Crossing Portmore Toll	1600	\$ 41.600,00	100	\$ 36.000,00	371	\$ 170.660,00	\$ 248.260,00
8	On-Ramp Crossing Chesterfield	1280	\$ 33.280,00	80	\$ 28.800,00	296,8	\$ 136.528,00	\$ 198.608,00
9	Off-Ramp Crossing Chesterfield	2940	\$ 76.440,00	183,75	\$ 66.150,00	519,4	\$ 238.924,00	\$ 381.514,00
							Total Cost	\$ 5.137.994,80

Bridge	Dimensions (m2)	Cost (USD)
1	2000	\$ 9.062.000,00
2	800	\$ 3.624.800,00
3	500	\$ 2.265.500,00
4	700	\$ 3.171.700,00
5	600	\$ 2.718.600,00
Total Cost		\$ 20.842.600,00

Toal Overall Cost (USD)	\$ 25.980.594,80
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ANNEX 2 – SELECTED LAYOUT TO BE CONSIDERED & RAILWAY CORRIDOR LAYOUT





ANNEX 3 – CEAC FEASIBILITY STUDY

Preliminary Engineering Designs for Storm Drainage and Flood Control for Marcus Garvey Drive and Tinson Pen Zone

Key Drainage Features (D1), Update of Preliminary Master Drainage Plan
(D2) and Hydrological Study (D3) (Revision 1)

Prepared for: National Works Agency



November 2020

Abstract

Flood control and drainage features for Marcus Garvey Drive, Tinson Pen, Shoemaker and Newport West and the associated risks were assessed. The project area is a part of an urban catchment that extends from Half-way Tree and Trafalgar Road in the north to Marcus Garvey Drive in the south. Documented losses of USD5 Million per event and assessed Average Annualized Losses (AAL) of USD\$17.5 Million for direct damages and indirect losses to the Marcus Garvey Drive traffic have been determined for the “do nothing scenario”.

Surveys of existing drain sizes and hydrological analysis suggest that 26km of channels in the project area are undersized with capacities less than the 5-year RP event. Flooding is initiated in the 1-year RP rainfall event, in comparison to desirable frequency of the 100-year RP, in keeping with ODPEM and NWA guidelines. Extreme rainfall is expected to increase between 30 and 35% by 2050 to 2060, when projected peak flows considerably exceed existing channel capacities. Preliminary capacity assessment of Marcus Garvey Drive, Tinson Pen Drain, Jew and Shoemaker gullies confirm the inadequacy of the existing channel sizes due to both the flat slopes of channel and the small dimensions. Newport West four catchments have limited carrying capacity and inadequate street level drainage. Considerable improvement is required for both the flood control and drainage works.


Improvements for 8730 meters of flood control works were proposed. Tinson Pen Drain improvements include a considerable channel from Chesterfield Road to Hunts Bay to lower the hydraulic water surface profile below Marcus Garvey Drive. Jew, Marcus Garvey, Tinson Pen, Oakland, Clifton and Shoemaker Gullies will have to be widened and deepened. Newport West Improvements includes upgrading underground concrete box drains. 24 of the existing crossings in the project area will have to be upgraded to meet the 100-year RP. Flood Plain analysis confirmed the effectiveness of the proposed flood control works to minimize flooding. Minor drainage works consisting of 189 inlets and over 5,578 m of drain pipe are required.

Flood control and drainage works are projected to cost USD\$131.4 Million for the recommended 100-year RP design conditions. The recommended phasing of the works prioritizes the detention basin and canal (USD17.8 Million), then Marcus Garvey Drive, Tinson Pen and Jew Gullies improvements (USD65.4 Million), then Newport West, Shoemaker gully and Jew Gully works.

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Revision Summary

	Review	Submission	Revision 1
Prepared by:	DS/OP	DS/OP/JD	DS/OP/JD
Reviewed by:	CB	CB	CB
Approved by:	CB	CB	CB
Date:	September 2020	October 12 th 2020	October 30 th 2020
Comments:	For internal review	Submitted to client	Comments addressed: i) innovations (data recovery and percolation in catchment); ii) desilting requirements; iii) addition of base flow and SLR considerations; iv) allowance for replacement of sewers and water pipes; v) NWA to approach PAJ for details on berths and implications for Newport West drainage; vi) increased inlet capacity at intersections; vii) Social assessment to inform Jew Gully works. Submitted to client

		DESIGN METHOD STATEMENT, CALCULATION AND DRAWING REVIEW SUMMARY SHEET				
TECHNICAL SERVICES DIRECTORATE 140 Maxfield Ave. Kingston 10		TS-05-DM&CDR / Last Revised: 2020 JUNE 20				
PROJECT TITLE: Flood Control for Marcus Garvey Drive		PROJECT CODE: CEAC-2020-05-01				
CALCULATION TITLE:		SERIAL MARK OR NO.:				
PROJECT MANAGER: Dr. Christopher Burgess		NO. OF SHEETS:				
STATUS		PREPARED BY: David Scott, Odaine Perry				
Schematic <input checked="" type="checkbox"/> Preliminary <input type="checkbox"/>		DATE: November 2, 2020				
Tender <input type="checkbox"/> Other (State) <input type="checkbox"/>		CHECKED BY: Dr. Christopher Burgess				
Final for Construction <input type="checkbox"/>		DATE: November 2, 2020				
		APPROVED BY:				
		DATE:				
LEVELS OF VERIFICATION						
1. Self check by originator <input checked="" type="checkbox"/>		3b. Comparison with similar proven designs check & approval <input type="checkbox"/>		Computer Analysis:		
2. Calculation, review & check <input checked="" type="checkbox"/>				Yes/ No: Yes		
3. Full design check & approval <input type="checkbox"/>		4. External check & internal approval <input type="checkbox"/>		HEC-RAS, HEC-HMS, HY-8, Hydraulic Tool box		
3a. Alternative calculations check & approval <input type="checkbox"/>		5. Other verifications as stated in Management Plan <input type="checkbox"/>		Program(s)		
				Hardware:		
DESIGN METHOD STATEMENT [Describe design philosophy, project description, codes, factors of safety, surcharge loading, etc.]						
The aim was to develop engineering design proposals to address flooding in the project area (of ~3 km ²), defined as Marcus Garvey Drive, Tinson Pen, Shoemaker and Newport West. Existing flood control and drainage works were assessed to determine the causes of flooding in the region and the improvements required. The proposed design improvements take aim to reduce the flooding in the overbank regions of the storm-water drainage system (to regulatory guidelines (NWA)), taking into account a 25% freeboard in drainage channels and crossings to allow for unexpected events during conveyance. Each channel is analyzed using HEC-RAS, to determine hydraulic profile and determine where most of the flooding occurs and determine what hydraulic situation causes the drainage system to fail during heavy rainfall conditions. Peak flows for the respective channels were determined using HEC-HMS taking into account the climate change, approximating future peak flows. The general design philosophy is to produce a robust drainage system that can relieve flooding in the project area, especially in the identified hotspots, while minimizing social impact, environmental damage and cost while taking into account climate change and maintenance.						
THE DESIGNS HAVE BEEN COMPLETED IN ACCORD WITH THE DESIGN METHOD STATEMENT PREVIOUSLY APPROVED		I HAVE COMPLETED THE DESIGN REVIEW AND CONFIRM IT IS IN ACCORD WITH CODE REQUIREMENTS		APPROVED		
David Scott/Odaine Perry	11/2/2020	Christopher Burgess	11/2/2020	Christopher Burgess	11/2/2020	
DESIGN ENGINEER	DATE	REVIEW ENGINEER	DATE	DIRECTOR	DATE	
CONTENTS AMENDMENT RECORD						
Revision# /Page	Status	Date	Description	By	Checked	Approved
1	Complete	2-Nov	Comments addressed: i) innovations (data recovery and percolation in catchment); ii) desilting requirements; iii) addition of base flow and SLR considerations; iv) allowance for replacement of sewers and water pipes;	DS	CB	CB

Executive Summary

Introduction

The aim was to develop flood control and drainage proposals to flooding in the project area ($\sim 3 \text{ km}^2$), defined as Marcus Garvey Drive, Tinson Pen, Shoemaker and Newport West. Existing flood control and drainage works were assessed to determine the causes of flooding and the required improvements. The project area is in the south of Kingston and is at the end of an extensive urban drainage and flood network (for a catchment area $\sim 16 \text{ km}^2$) that stretches from Half-way Tree, Hope Road and Trafalgar Road in the north to the project area in the south.

This report fulfils the requirements of three of the approved deliverables: i) To document the existing key drainage features in the project area (D1); ii) To update the Preliminary Master Drainage Plan (D2) and; iii) To prepare a Hydrologic Study (D3). The remaining tasks are: i) To prepare Preliminary Engineering Designs (D4) and ii) To prepare a Final Report (D5). The investigations, analysis and interpretations are guidelines by NWA Drainage Guidelines, Jamaica's Climate Change Policy Framework and engineering practice.

Flooding from Extreme Events and Risks

The project area has been flood-prone for a number of years and severe flood related losses are documented. Anecdotal surveys suggest persistent flood prone areas and damages in frequent events in excess of USD5 Million. Flood prone area include: Marcus Garvey Drive, Tinson Pen and Jew Gullies, Ashenheim Road, Shoemaker Gully, Whitefield Town and businesses in Newport West.

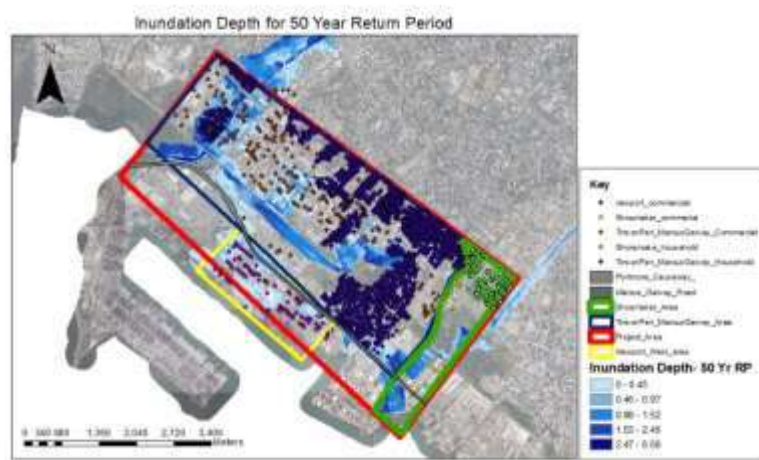
Risk assessment considered both direct damages (for over 3,000 residences and 300 commercial operations) and indirect losses (52,000 vehicles per day). Flood predictions of recent events (September 2019 and October 2020) were used for calibration of a hydraulic and flood plain model. Predictions of the 5 to 100-year Return Period (RP) events were then used to estimate the Average Annualized Losses (AAL). 50-Year RP flood depths of Marcus Garvey, Newport West and Shoemaker Gully are estimated at: 0.8, 0.7 and 1.63 meters respectively, and increase to 1.3, 0.8 and 1.8 meters in the 100-year RP.

Direct and indirect losses (vehicles delay and diversions) are comparable from the 2 to 50-year RP range and vary from USD9 to 35 million in total and suggest that losses from vehicle related losses are not inconsequential. This suggests the possible usefulness of an early warning system to divert traffic from the flood prone area to reduce indirect losses, before a permanent solution is put in place. Catastrophic events (>50 -year RP) would cost in excess of USD \$35 and up to 140 Million and are expected to be dominated by direct losses to residential and commercial properties. The estimated average annualized loss (AAL) is USD\$17.5 Million for the “do nothing scenario” and represents the societal cost of flooding in the project area.

Existing Conditions: Meteorology, topography, watersheds, soils and land use

There is a sparsity of rain gauge data in the project area and over 100 years of data was recovered from 1895 to 1966. No trends were detected in the data for this period and suggest stationarity in the project areas extreme rainfall climate. The data provided greater confidence in the meteorology of the project area. 24-hour rainfall data for Half Way Tree and Cavaliers (Meteorological Service) was used. This speaks to the need for more gauge stations in the KMA, in order to aid in urban planning of infrastructure. 10 to 100-year RP depths of 213 to 401 mm for the 24-hour events were determined for the present climate.

The majority of the catchment areas have slopes of 3 to 5% (hydraulically steep) in the higher reaches and 0.5 to 1.5% (hydraulically mild) in the lowest reaches near the outfalls in the actual project area. Recent LiDAR survey (accuracy of <0.1



meter) collected by CEAC in April 2020 was used. Spatial variations of the slopes across the catchments are conducive for fast runoff from upper reaches and deeper flow depth (synonymous with flooding) in the lower reaches that define the project area.

There are three catchments that correspond to the project area: i) Marcus Garvey, Tinson Pen and Jew Gully (~9.4 km²), ii) Shoemaker (6.3 km²) and Newport West (0.5 km²) with clay loam soil types with high runoff potential. Current and projected land use is predominantly of urban, commercial and industrial areas. Little change in runoff is expected from higher densities and a continuation of the already saturated land use.

Key Drainage Features

The typical drainage features in the project area consists of a network of 26 km of stone wall concrete lined channels that lead to concrete box culverts. Approximately 15 km of this network and 4 culverts are considered major. Both ground (GPS and optical) surveys were conducted to key drainage features (channels and culverts). Hydraulic analysis of the channels suggest that the majority are undersized and can only typically carry the 5-year RP event and even less in some instances. The key drainage and flood control features by catchments are:

1. Marcus Garvey Drive, Tinson Pen Drain, and Jew Gully is made up of three major drainage networks. Tinson Pen Drain serves Richmond Park, Delacree Pen, Payneland, the Stewarts industrial compound and is constructed of concrete (8m W x 2m D) and is a known flooding hot spot. Tinson Pen Drain Crossing/Marcus Garvey Drive crossing is a 3-cell and is a site of several instances of flooding. Marcus Garvey Drive drain is constructed of concrete and is relatively small (0.6m wide and 1m deep). Jew Gully serves Waterloo Road, Eastwood Park, Majestic Gardens, and their surrounding communities and is a stone wall and a concrete base gully (6m W x 2.6m D).
2. Shoemaker Gully serves as far as New Kingston and Trench Town and is constructed of stone wall and a concrete base (10.4m W x 2.6m D). Instances of localized flooding by the Jamaica Coffee Board have been reported. Marcus Garvey Drive Crossing is a 2-cell concrete culvert crossing (4.7m W x 2.6 D).
3. Newport West is an isolated catchment system bordering the sea with sparse drop inlets and a network of underground culvert pipes (900mm to 1200mm in diameter). Newport West is a known hotspot for flooding.

Hydrology

The hydrological regime of the main catchments and the project area were investigated using hydrological tools and recommendations from IPCC (2018) for climate change impacts to extreme rainfall. The 25 and 50-year RP extreme rainfall events are expected to increase between 30 and 35% from current levels when temperatures reach 2°C above pre-industrial levels. Comparison to previous studies present both challenges and confirmation for this study. The Stanley Drainage Master Plan could not be compared to this study given the marginal (if any) overlapping of the study areas. Newport West Engineering Assessment Report for Storm-water Drainage System peak runoffs were comparable and the relatively small differences may be attributed to different rainfall intensities. Peak flows of the catchment areas were determined and considerably exceed the estimated capacities in the respective drains and are presented

Table 0.1. Summary of peak flows (m³/s) for September 2019, 10, 25, 50, and 100-year RP events and capacity (in red if exceeded).

Catchment	Receiving Stream	Isolated Event Sept 2019	10-Yr (m ³ /s)	25-Yr (m ³ /s)	50-Yr (m ³ /s)	100-Yr (m ³ /s)	Capacity (m ³ /s)
Tinson Pen	Jew Gully	65.6	205	270	319	367	49
Jew Gully	Jew Gully (To Outlet)	61	191	251	298	344	114
Jew Gully (Outlet)		129.6	406	534	632	729	
Lower Shoemaker	Lower Shoemaker Gully (Outlet)	81.5	273	361	428	495	147
Newport West 1	NPW Drain 1 (To Outlet)	1.6	4.9	6.4	7.6	8.8	0.9
Newport West 2	NPW Drain 2 (To Outlet)	2.1	6.5	8.6	10.1	11.7	0.9
Newport West 3	NPW Drain 3 (To Outlet)	1.9	5.9	7.7	9.1	10.5	0.9

Newport West 4	NPW Drain 4 (To Outlet)	1.5	4.7	6.2	7.3	8.4	1.9
----------------	-------------------------	-----	-----	-----	-----	-----	-----

Hydraulics and Flood Plain analysis

Flooding is initiated in the 1-year RP rainfall event across the project area. This is in comparison to the desirable limit of frequency of flooding to the 25-year RP or greater, in keeping with the NWA Guidelines. Preliminary capacity assessment of Marcus Garvey Drive, Tinson Pen Drain and Jew Gully confirm the inadequacy of the existing channel sizes due to both the flat slopes of channel and the small dimensions. Shoemaker Gully is also not capable of carrying the flow as its capacity is exceeded relates to the watershed area served. Newport West three major catchments are also served by pipes that have limited carrying capacity when compared to the peak runoff within the catchment area. Additionally, localized flooding in Newport West is also due to inadequate street level drainage

A total of 8730 meters of flood control works will have to be upgraded. See Table 0.2. Marcus Garvey Drive, Tinson Pen, and Jew Gully upgrades include considerable channel widening and deepening to carry the 100-year RP. Tinson Pen Drain improvements include widening the channel to 63m and deepening to 3.4m and upgrading the crossing at the Marcus Garvey Drive from a 3-cell to 5-cell culvert. Jew Gully improvements include widening to 14m and deepened to 5.5m. It is noted that the extent of this improvement is limited by the presence of the residents along the banks of the gully. A detention pond is also required where the Tinson Pen drain and Jew Gully intersect that will allow for the lowering of the outfall level to mean sea level. This basin will have an invert of -3.0 m, and serves as a debris collection and cleaning point before runoff gets to the harbor. Shoemaker Gully improvements (just before the final crossing by Marcus Garvey Drive) will include widening to 18m and deepened to 3m from 50 meters upstream of MGD and dredging the outfall channel be widen to 20 wide and 4.5 meters. Newport West Improvements includes upgrading underground concrete box drains to 5.5m x 1.2m, 3.4m x 1.2m and 1.3m x 1.2 Consultations will be required with Port Authority of Jamaica to fine tune the approach to construction of the drains through Newport West.

Existing crossings in the project area are generally undersized. Upgrading to meet the 100-year RP with future climate will require for 24 crossings (Table 6.18). Flood Plain analysis was used to confirm that both channels and crossings were undersized and also confirmed the effectiveness of the proposed flood control works to minimize flooding.

Proposed minor drainage works are required for all three catchments. 189 Inlets were proposed in the project area, along with 4079 m of 900mm, and 1,499 of 1200mm culverts that conform to the presented NWA Guidelines for inlet sizing, spacing and distance from highpoint requirements.

Cost savings can be realized of USD6.2 Million can be realized with an earth drain at Tinson Pen. An assessment of alternatives suggests that improvements of only the crossings, will not beneficially impact flooding in the project area. Likewise, the detention pond and channel are critical to minimize flooding on Marcus Garvey Drive.

The importance of maintenance was underlined in the assessment of siltation rates from the catchments. Annual desilting of the proposed detention basin, canal to Hunts Bay and flood control channels should be anticipated. The potential for blockage can result in increased flood levels. A routine maintenance program should be implemented and was accounted for the economic analysis.

Table 0.2 Proposed dimensions of the drainage channels for 10 to 100-year return period

Catchment	Improvement Length (m)	10 Year RP		25 Year RP		50 Year RP		100 Year RP	
		Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)
Oaklands	1058	6	4	6	4	8	4	10	4
Clifton	845	6	3	6	3	8	3	10	3
Marcus Garvey Drive	1562	3	1.5	4	1.5	4	1.5	6	1.5

Tinson Pen	1462	18	3	20	3	24	3	26	3
Jew Gully	790	10	4.5	10	5.5	12	5.5	14	5.5
Lower Jews gully (outlet)	To be determined after survey	75	5	75	5	75	5	75	5
Newport West 1	200	3.4	1.2	3.4	1.2	3.4	1.2	3.4	1.2
Newport West 2	460	5.5	1.2	5.5	1.2	5.5	1.2	5.5	1.2
Newport West 3	300	3.4	1.2	3.4	1.2	3.4	1.2	3.4	1.2
Newport West 4	160	1.3	1.2	1.3	1.2	1.3	1.2	1.3	1.2
Upper Shoemaker	897	6	2.5	6	2.5	8	2.5	12	2.5
Mid Shoemaker	480	12	2	14	3	16	3	18	3
Lower Shoemaker	516	20	3	20	4	20	4	20	4.5

Feasibility Assessment and Recommended Phasing

Projected cost of the works is USD\$131.4 Million for the recommended 100-year RP design condition with a BCR of 3.0 and IRR of 11.5%. Additional difficulties with land acquisition and social displacement are anticipated with the 50 -year RP and higher in the Jew Gully sub-catchment. Further consideration should be given to relooking at the implementation of the 100-year RP design after the Environmental Statement exercise.

Limitations were noted and further Investigations are required for the Tinson Pen Detention Basin and Hunts Bay Canal. This channel will necessitate dredging a detention pond and 1,750 meters channel to Hunts Bay that is estimated to cost USD17.8 Million. This cost was considered. Sheet piling and relocation costs in the Jew Gully informal settlement and water and sewage infrastructure replacement throughout the project area are another major cost and was not directly considered.

The recommended phasing of the works is as follows (with 25% for preliminaries and contingencies):

1. Phase 1: The detention basin and canal (USD17.8 Million) should initiate the works.
2. Phase 2: Works relating to minimizing traffic-related losses should be prioritized next with Marcus Garvey Drive, Tinson Pen and Jew Gullies improvements (USD65.4 Million).
3. Phase 3: The importance of Newport West assets (primarily warehouses and office) defines this phase with the construction of four major drains (USD\$10.0 Million).
4. Phases 4 and 5: Shoemaker gully and Jew Gully works (USD\$25.8 Million and USD\$10.0 Million respectively)

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1 Introduction

1.1 Background

1.1.1 Overview and location

The project area (551 hectares) is located along the coast in the parish of Kingston. Figure 1.1.1 shows the location of the project, in relation to the parish of Kingston. Three areas of focus have been identified as hotspots for flooding during heavy rainfall events. Currently, the existing drainage infrastructure in the areas of focus have been deemed inadequate by the National Works Agency. Previous Drainage Reports commissioned by the National Works Agency explored the development of a number of comprehensive drainage and flood control plans, with focus areas that overlap with this assessments' project area. The proposal assesses the implementation of upgrades to the existing drainage infrastructure to alleviate the extensive flooding being experienced in the areas of focus.

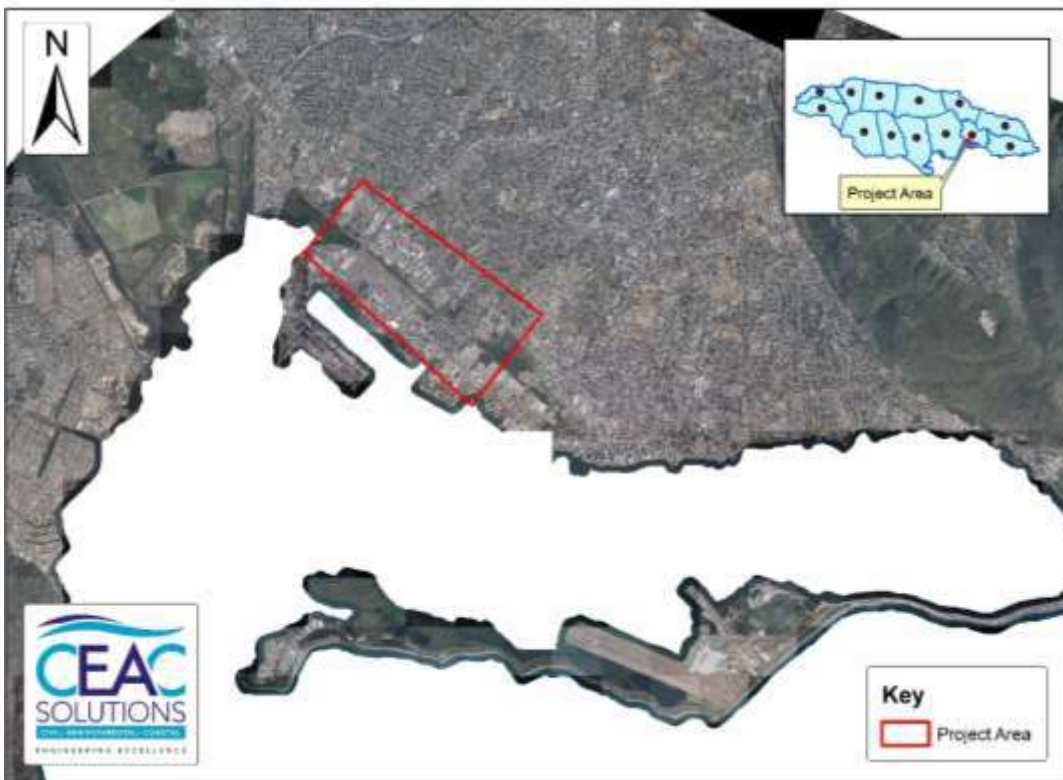


Figure 1.1.1: Location Map of the Project Area

1.1.2 Previous studies

Two previous studies were conducted, each focusing on a separate area of interest identify the historic extent, context and potential causes of localized flooding in the communities of interest. These reports added further context to the assessment, as their findings were compared.

1.1.2.1 Stanley Consultants: Comprehensive Drainage and Flood Control Report

This report focused on developing a number of comprehensive drainage and flood control plans and preliminary designs for several areas around the island. Sections of the Kingston study overlapped with the watershed areas explored in this assessment. Most of the areas are in the upper sections of this project's catchment area.

The study area from Half Way Tree to Marcus Garvey Drive falls well within our study area, corroborated our findings on the causes flooding in the Jew Gully with the following observations:

- Lack of cross slopes on roadway to direct runoff to inlets
- Undersized drainage system
- Inlet grates clogged or not suitably placed to capture runoff

- General lack of inlets and the few observed were clogged or undersized.
- Only one outfall to the Jew Gully

1.1.2.2 Engineering Assessment Report for Storm Water Drainage System (Newport West and Kingston Wharves Ltd.)

This report focused on addressing the flooding situation at Newport West along the Kingston coastline. The reports aim was to provide an overview of the existing drainage systems, and provide recommendations and cost estimates for an improved drainage system. The consultant found that the existing drainage system was incapable of adequately carrying the runoff away from the area during a heavy rainfall event. At the end of the report the consultant presented the following recommendations:

1. The routine maintenance and cleaning of all the drains, gullies, and culverts in the Tinson Pen, Newport West and Marcus Garvey Drive area.
2. Construction of new drainage structures in the Newport West area, providing a reasonable protection for the properties from flooding.
3. Construction of new buildings in the Newport West area with a minimum floor elevation of 2.6m AMSL.
4. Replacing the existing drainage road gratings with more hydrologically efficient gratings, using galvanized steel flats.

1.2 Scope and Terms of Reference

The approved Terms of Reference for this report are shown in Table 1-1.1. It was decided in discussions with the client to consolidate Deliverables 1, 2 and 3 into one report.

Table 1-1.1. TOR for this study

Item	Task	Evidence of Delivery	Anticipated Duration (Subject to Negotiation)
01	Document on existing key drainage features of the study area <ul style="list-style-type: none"> • Within the designated area carry out field investigations and documents on existing available mapping the drainage feature of the study area. • Define the major drainage feature and subcatchments. • Establish the principal flow directions and discharge points in relation to storm flow entering the collected within the development area. • Identify the location of existing historic rain gauge locations and the soils in the area classified in the appropriate hydrogeological soil groups. • Guided by the NWA's Guidelines for preparing Hydrologic and Hydraulic Report for Developments (Drainage Guidelines for Development 2015), carry out analysis of the peak flows expected in the Shoemaker Gully, outfall of Jew Gully into Hunts Bay and Kingston Harbour. 	<p>Available topographical maps identifying with study area the drainage features, sub-catchments, principal flow directions, discharge points in relation to stormwater flow entering and collected within the development area, locations of existing historic rain gauge,</p> <p>Available maps classifying hydrogeological soil groups with study area.</p> <p>Data/recommendations supplemented where necessary by additional mapping and/or survey information.</p> <p>Peak flow analysis in Shoemaker Gully, Jew Gully into Kingston Harbour</p>	Three(3) weeks after the start of the assignment

02	<p>Updating of Preliminary Master Drainage Plan</p> <p>Review the Kingston Development Plan in light of the land use development plan and key reserves for major roads and storm water drainage and prepare an updated guideline for the drainage provision that will necessary to address the development plan needs. This will include identification of options with recommendations for new existing primary and secondary drainage routes, flood regulation areas, and hydrologic features that of the differebr land use areas defined</p>	<p>Available topographical maps outlining existing drainage features and recommendations for new primary and secondary drainage routes, flood regulation areas and hydrologic features.</p>	<p>Five (5) weeks after the start of the assignment</p>
03	<p>Prepare Hydrological Study</p> <p>Prepare a detailed hydrological study that will establish design storm run-off and volumes for the key subcatchments and drainahe channels defined within the Development Plan. This will include recommendation for phasing of project implementation and the indicatibe costing of drainage works defined.</p>	<p>MS Word document suppliened by maps giving the recommended phasing of the project implementation, Maps are also to be provided in soft version.</p> <p>Indicative costing of the drainage works defined in the Drainage and Flood Water Control plan and hydrological study</p>	<p>Eight (8) weeks after the start of assignment</p>

1.3 Regulatory Requirements

1.3.1 NWA

This report was guided by the requirements of the National Works Agency (NWA) Guidelines for Preparing Hydrologic and Hydraulic Design Reports for Drainage Systems of Proposed Developments (2015)¹. In summary:

1. Minor drainage systems that consists of inlets, street and road gutters, roadside ditches, small channels and swales and small underground pipe systems that collect storm water runoff and transport it to structural control facilities, pervious areas, and major drainage systems-which include, but are not limited to, natural waterways, large impoundments, gullies and rivers should be sized to accommodate up to a one (1) in ten (10) year storm event, plus 25% freeboard.
2. Covered drains, such as the ones located in Newport West, should be designed for the 25-year RP with 25% freeboard.

1.3.2 Jamaica Climate Change Policy Framework (2015)²

Principles we have adopted from the climate change policy include:

1. Precautionary Approach: Strategies and methods were recommended to the client based on analysis done on data collected and the existing environs. Such strategies included: i) accommodating land use changes and ii) accommodating high sediment and debris loads, iii) complying with building codes, standards and guidelines.
2. Best Science: Studies were done to ensure that all the information needed is present and credible to make decisions related climate change impacts on the project. These included extreme rainfall change estimates to predict future climate rainfall extremes. The results and conclusions of these studies aid in the design process of the project, as well as aid the client in making decisions.

1.4 Aims and Objectives

The aims and objectives were as follows:

1. To define the existing hydrological setting of the project area. This was achieved by:
 - a. Defining the catchment area and meteorological conditions using both existing and remotely captured data, augmented with field investigations
 - b. Defining the existing flood conditions and experiences in the catchment and runoff
 - c. Estimating peak discharge for both before and existing conditions
2. To explore and define the requirements of the drainage systems in the areas of focus through and around the project area. This was achieved by:
 - a. Estimating the future climate rainfall intensities and corresponding peak discharge.
 - b. Conducting hydraulic analysis to estimate the drain size and slope requirements to alleviate the instances of flooding given the project area layout and terrain.

The approved scope that CEAC was commissioned to undertake is:

1. Develop a drainage master plan for the project area showing:
 - a. Key Primary and Secondary Drainage Features and Routes
 - b. Sub-catchments
 - c. Principle Flow Directions and Discharge Points
 - d. Flood Regulation Areas and Hydrologic Features
2. Conduct a hydrological Study to establish design storm run-off and volumes for the key sub-catchments and drainage channels defined within the project area.

¹ NWA (2015). *Guidelines for Preparing Hydrologic and Hydraulic Design Reports for Drainage Systems*. National Works Agency

² Climate Change Policy Framework for Jamaica, Government of Jamaica, 2015, <http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2016/05/Jamaica-Climate-Change-Policy-fwL-2015.pdf>

3. Prepare preliminary engineering designs for the all drainage and flood control features identified in the project area
4. To prepare and submit a comprehensive drainage report to NWA, consistent with NWA guidelines.

2 Existing Flood Conditions and Risks

The project area is generally flood prone and severe flood related losses have been documented. Upgrading of the Marcus Garvey Drive road works has brought more visibility to the project, with expectations that the associated flood control works will be improved. The reality is that the existing and aged flood control works are undersized, over ½ a century old and require major improvements. For example:

1. The Jew, Tinson Pen and Marcus Garvey gullies and crossings are exceeded in 2-year RP rainfall events and ill-configured, resulting in 0.3 to 1.2 m of flooding in some areas that severely hampers one of the main arterials in the KMA. The landfilling of Newport West and Foreshore Road in 1969-1979³ resulted in the steeper drains being flatten and realigned to an east-west direction.
2. Newport West 600mm drain pipes are severely under sized for the catchments and flood depths of 0.3 to 0.9 meters are common in frequent events. This brings disruption to the major shipping hub of Jamaica.
3. Shoemaker serves a considerable urban catchment that has built out over the years and has crossings and drains are also over ½ century old and crosses Marcus Garvey in the vicinity of PetroJam

It is therefore important to define the past experiences and quantify the economic cost of flooding in the study area

2.1 Anecdotal Evidence

2.1.1 ODPEM flood prone areas

As the area is generally flood prone it was expected that records of historic flooding events would be present. However, available GIS data sets from the Office of Disaster Prevention and Emergency Management (ODPEM) only shows an occurrence of flooding in the Greenwich Town community, and Seaview Gardens which is more than 3km away from the project area. That being said, main discharge points within the project area, namely Jew Gully and the Tinson Pen drain, are known to flood when rainfall events with a return period exceeding 2-Yrs occurs. See Figure 2.1. It is evident that the national disaster database has room for improvement for updating and capturing more flood prone areas.

³ <https://wihcon.com/luxury/1969-1979/>
Prepared by: CEAC Solution Co. Ltd.



Figure 2.1: ODPEM Flood Prone Areas in relation to the project area.

2.1.2 Interviews in project area

2.1.2.1 September 2019

An anecdotal exercise was conducted on September 26, 2019 within areas that are known to experience extreme flooding conditions. Areas that are located relatively close to the key drainage systems were also included. Six (6) persons were interviewed during the anecdotal exercise where two (2) were noted to have been in the area for over 10 years and the others have been in the area for approximately three (3) years, see Figure 2.2.

- Two interviewees have reported to have experience intense flooding at the Tinson Pen Aerodrome and at HEART Trust/NTA (National Tool & Engineering Institute on Ashenheim Road). Both reports stated that the Oakland Gully played a key role the flooding depts. Other interviewees have expressed that the drainage systems along Marcus Garvey Drive is insufficient and has overflowed on many occasions especially during heavy rainfall.
- A search of other events suggests that in the 2016 and 2017 rains that the Jamaica Coffee Board loss over USD8 million in produce. This loss is associated with the Shoemaker Gully.

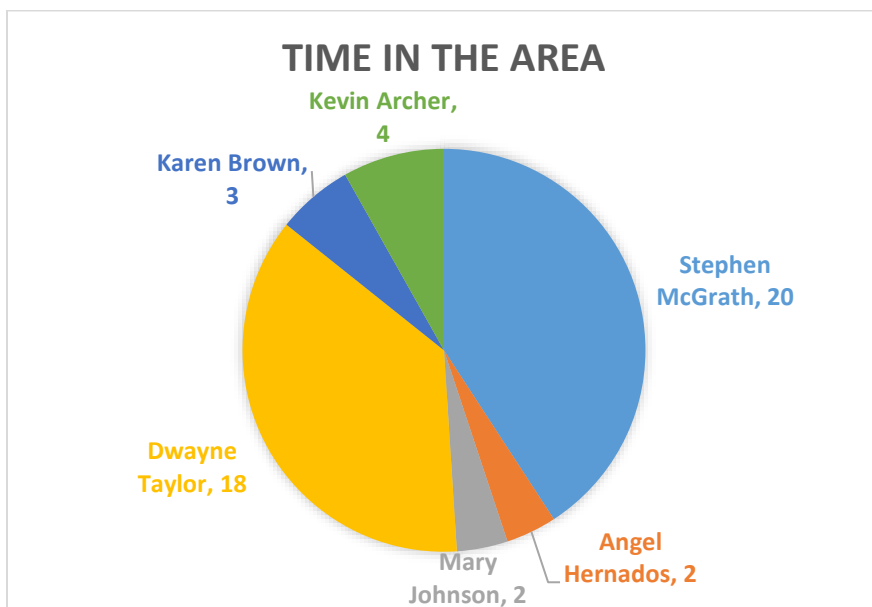


Figure 2.2 Time spent in the area for the interviewees

2.1.2.2 October 2020

An anecdotal survey was conducted on October 6th, 2020 within areas that are known to experience extreme flooding during heavy rainfall events. Areas that are located relatively close to the key drainage systems were also included, see Table 9.1 and Figure 2.3. Nineteen (19) persons were interviewed during the anecdotal exercise where ten (10) were noted to have been in the area for over 10 years and the others have been in the area for approximately three (3) years. Rainfall data from the Meteorological Service (Table 2.1) indicate that 43mm fell at Mona Reservoir that is 7km from the project area. Interestingly 53 mm was recorded the following day at Mico University. This speaks to the dispersion of rainfall patterns around Kingston.

Table 2.1. Meteorological Service data for the period 5th to 7th of October 2020

Parish	Stations	Day 5	Day 6	Day 7
Kingston	Mico University College	1.6	34.6	53.2
Kingston	Mona Reservoir	2.4	43.2	8.6
Portland	Fair Prospect High	13.0	54.2	18.4

Three of the persons interviewed have reported intense flooding at the Tinson Pen Aerodrome and at HEART Trust/NTA (National Tool & Engineering Institute on Ashenheim Road. They went on to state that the crossing and the end of development road is often overtopped by storm water and the manholes along Ashenheim road overflows with water during heavy showers of rain.

The interviewees along the lowers region of Jew gully stated that the gully overtops its banks blaming it on the garbage in the gully and damage to the right bank of the gully close to the temporary. The residence along the trench town gully stated gully does not regularly overtop, the water runs off the road and quickly moves down stream. The residences along Jew gully and trench town however voiced their concerns of inadequate street level drainage, saying the run off ponds along the road way or flows through their residence to get the gully.

The residents along the Shoemaker gully especially in the trench area made note that the gully frequently overflows running against the zinc fence lines of the homes of people living along the gully banks and flooding homes on lower lying areas. They also made note that a backflow from the culverts downstream increase the water level upstream flooding the road

and the homes of residents along the gully. Business owners along the lower shoemaker region stated that flooding in the area has been relatively low with the exception of the major flooding event in 2017.

Other interviewees expressed that the drainage systems along Marcus Garvey Drive is insufficient and has overflowed on many occasions especially during heavy rainfall. A police officer on duty directing traffic away from Marcus Garvey drive identified a major flood hot spot under the overhead pedestrian crossing along Marcus Garvey where waist high water would disable crossing vehicles.

Business owners in Newport West complained of inadequate street level drainage frequently being blocked by debris, causing water to settle in road rendering them impassable to all but the biggest vehicles. Depths of up to 0.77 meters were reported in some areas and water overtopping the curb at 0.3 meters were common throughout Newport west especially along 8th avenue and Newport boulevard.



Figure 2.3: Instances of Flooding in the Tinson Pen/Marcus Garvey Drive areas

2.2 Methodology and Data

A vulnerability and a risk assessment were undertaken to determine the susceptibility of both: i) the operations of road network and ii) existing residential and commercial infrastructure to flooding. The objectives of the assessment were to: i) facilitate risk modelling and ii) to estimate the feasibility of the investment in the proposed flood control and drainage works. The method and associated data for defining the exposure and risk entailed:

1. Estimation of the vehicle operating costs and associated delay costs for interruptions to the traffic flow in the project area (see assumptions in Table 2.2). This approach is in keeping with known relationships between depth-vehicles speed disruption⁴, wherein deeper inundation results in slower speeds to a standstill with 0.15 to 0.3-meter depth of water on roads.
 - o Traffic volumes (52,000 in high periods and 40,000 in non-school periods) and vehicle mix were informed by NWA traffic studies. Vehicle financing, fuel, insurance and maintenance costs were estimated. A residual vehicle life of 10 years and PetroJam fuel prices and typical vehicle consumptions were assumed.
 - o STATIN and World Bank dataset were used to determine population, wages, GDP, and employment data for the period 2000 to 2018.

⁴ Pregolato, Maria, Alistair Ford, Sean M. Wilkinson, and Richard J. Dawson. "The impact of flooding on road transport: A depth-disruption function." Transportation research part D: transport and environment 55 (2017): 67-81.

- Employed population and traffic volumes from NWA (60,000 vehicles per day) were used to estimate the opportunity cost lost for increase delays and additional fuel for using either detours or waiting on the flood waters to subside.
- 2. Estimation of the number, floor area and value of residential and commercial structures in the project site;
 - The number of residential and commercial units for the major catchments in the project area were derived by “heads-up” digitizing of aerial imagery (Figure 2.4). Typical sizes (footprint) were derived by measuring a sample of each type.
 - A structure and content value of USD900 and USD1, 300 per m² was used for the residential and commercial assets and is informed from previous ODPEM studies (Table 2.3).
- 3. Determination of vulnerability of the residential and commercial buildings using damage-flood depth relationships.
 - The vulnerability assessment focused on residential and commercial assets (not the road). The damageability was expressed as a percentage of structure and content replacement cost as a function of the return period.
 - The relationship between damage and depth of water to the residential and commercial assets is shown in Figure 2.5 below. Here: Inundation water depth of 0.5m (4.0m) is expected to damage 10% (100%) of the residential and commercial building stock. This fragility curve is in keeping with those typically found in the literature for immobile residential and commercial settlements⁵.
- 4. Estimation of both direct and indirect flood damage by
 - Applying the hazard magnitude (depth of inundation) to the vulnerability or damageability relationship for the various class of assets to estimate the damage for the 5 to 100 year-RP events.
 - The flooding in the project area was assessed via flood plain maps generated by HEC-RAS 5.0.7 for the 10 to 100 years return period for the present and future climate conditions. The HEC-RAS Model takes into account the topography of the project area, the existing drainage features and the expected peaks flows in the present and future climate condition. The generated flood maps were overlaid onto the residential and commercial asset map in order to assess the potential damage in the project area.
 - Estimating the delay and detour costs for the 5 to 100 year-RP events.
- 5. Determining average annualize lost (AAL) from vehicle delays and direct damages

Table 2.2. Operating costs and mix of vehicles in project area

Delay and diversion Cost Assumptions			Design Mix	
	Rates	Notes		
Wages (USD/hour)	\$3.97	STATIN and WB	SUV	8%
Purchase/financing payments (USD/hour)	\$2.64	av. for veh. mix	cars	80%
Repairs and maintenance (USD/hour)	\$0.15	av. for veh. mix	Trucks	10%
Fuel (USD/mile)	\$0.17	Petrojam USD 0.8/liter	Buses	2%
Insurance (USD/hour)	\$0.19			
Daily traffic volumes	52000	NWA		
Occupancy per vehicle	4.26	from mix		

⁵ de MOEL, Hans, and J. C. J. H. Aerts. "Effect of uncertainty in land use, damage models and inundation depth on flood damage estimates." *Natural Hazards* 58, no. 1 (2011): 407-425.

Daily trip volumes (incl. passengers)	221520			
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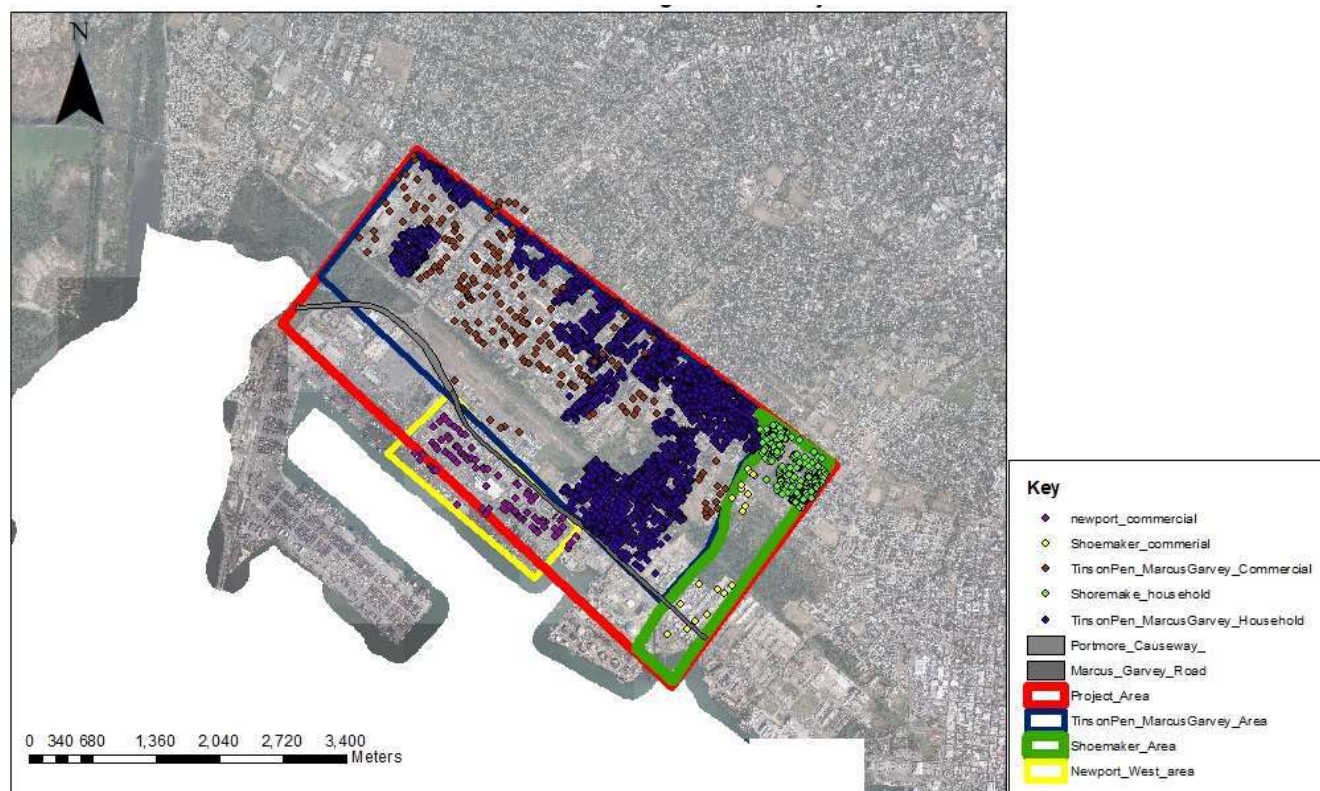


Figure 2.4. Residential and commercial assets in project area.

Table 2.3. Estimated total and vulnerable residential and commercial assets in project area (and catchments)

Total					
	Residential units	Commercial units	Residential floor area (m2)	Commercial floor area (m2)	Estimate value of assets
Tinson Pen/Marcus Garvey/Jew Gully	2434	187	170380	149600	\$347,822,000
Newport West	0	95	0	95000	\$142,500,000
Shoemaker	340	20	23800	14000	\$39,620,000
					\$529,942,000
Vulnerable (10 to 50-year RP flood plain)					
	Residential units	Commercial units	Residential floor area (m2)	Commercial floor area (m2)	Estimate value of assets
Tinson Pen/Marcus Garvey/Jew Gully	500	65	35000	52000	\$99,100,000
Newport West	0	40	0	40000	\$60,000,000
Shoemaker	25	5	1750	3500	\$6,125,000
					\$165,225,000

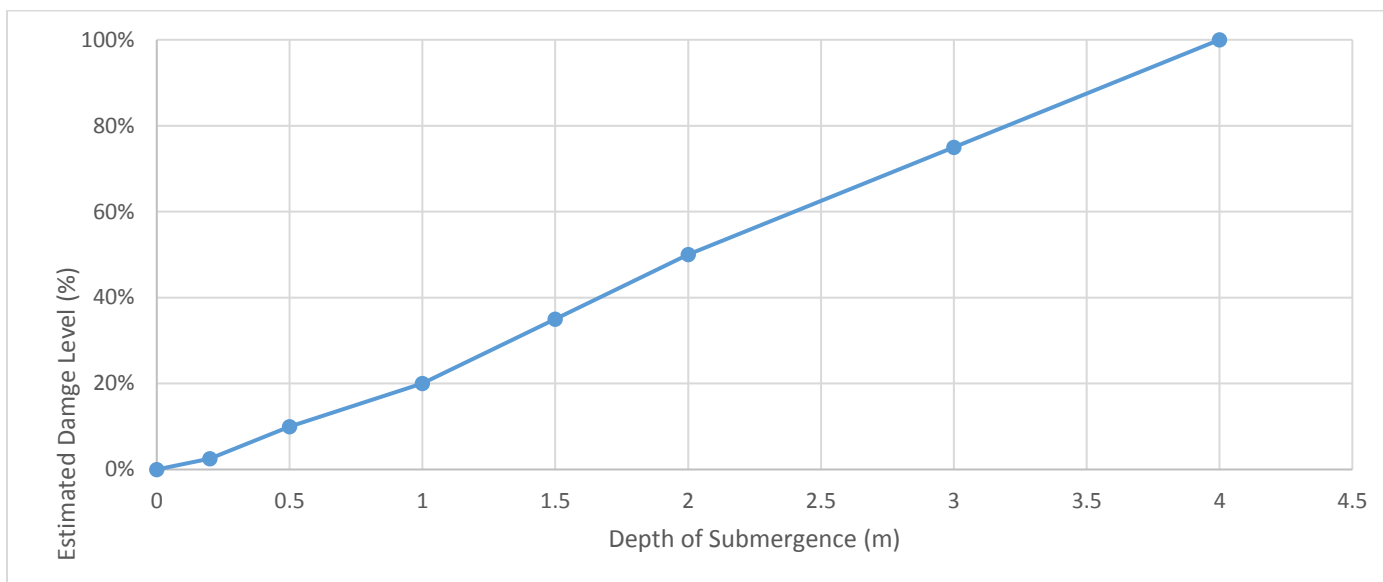


Figure 2.5 Damage curve for commercial and housing infrastructure in project area

2.3 Flood depths: 5 to 100-year RP

Flooding was observed at varying depths throughout the area, in Marcus Garvey, Newport West and Shoemaker Gully, the inundation depths were 0.6, 0.5 and 0.85 (m) respectively for the 10 Year Return Period. While for the 50-Year Future Return Period, at Marcus Garvey, Newport West and Shoemaker Gully, the depth recorded was 0.8, 0.7 and 1.63 (m) respectively. Whereas, for the 100-Year Future Return Period, at Marcus Garvey, Newport West and Shoemaker Gully, the depth recorded was 1.3, 0.8 and 1.8 (m) respectively, see Table 2.4. According to results depicted in Figure 2.6, it was observed Jew's Gully is more prone flooding in the 5-year Return Period in comparison to Shoemaker and Newport West area. 50-Yr Flood Map shows that the flooding becomes more extensive and inundation depth become higher.

Table 2.4 Inundation depth for project area

Area	Inundation Depth (m)					
	2-Return Period	5-Return Period	10- Return Period	25-Return Period	50- Return Period	100-Return Period
Tinson Pen/ Marcus Garvey	0.4	0.5	0.6	0.7	0.8	1.3
Newport West	0.2	0.3	0.5	0.6	0.7	0.8
Shoemaker	0.1	0.2	0.85	0.95	1.63	1.8

The results of the flood plain analysis reveal that short term intense rainfall creates wide spread inundation but with relatively low flood depths with the highest flood depths located in the Shoemaker Gully, in addition to Marcus Garvey.

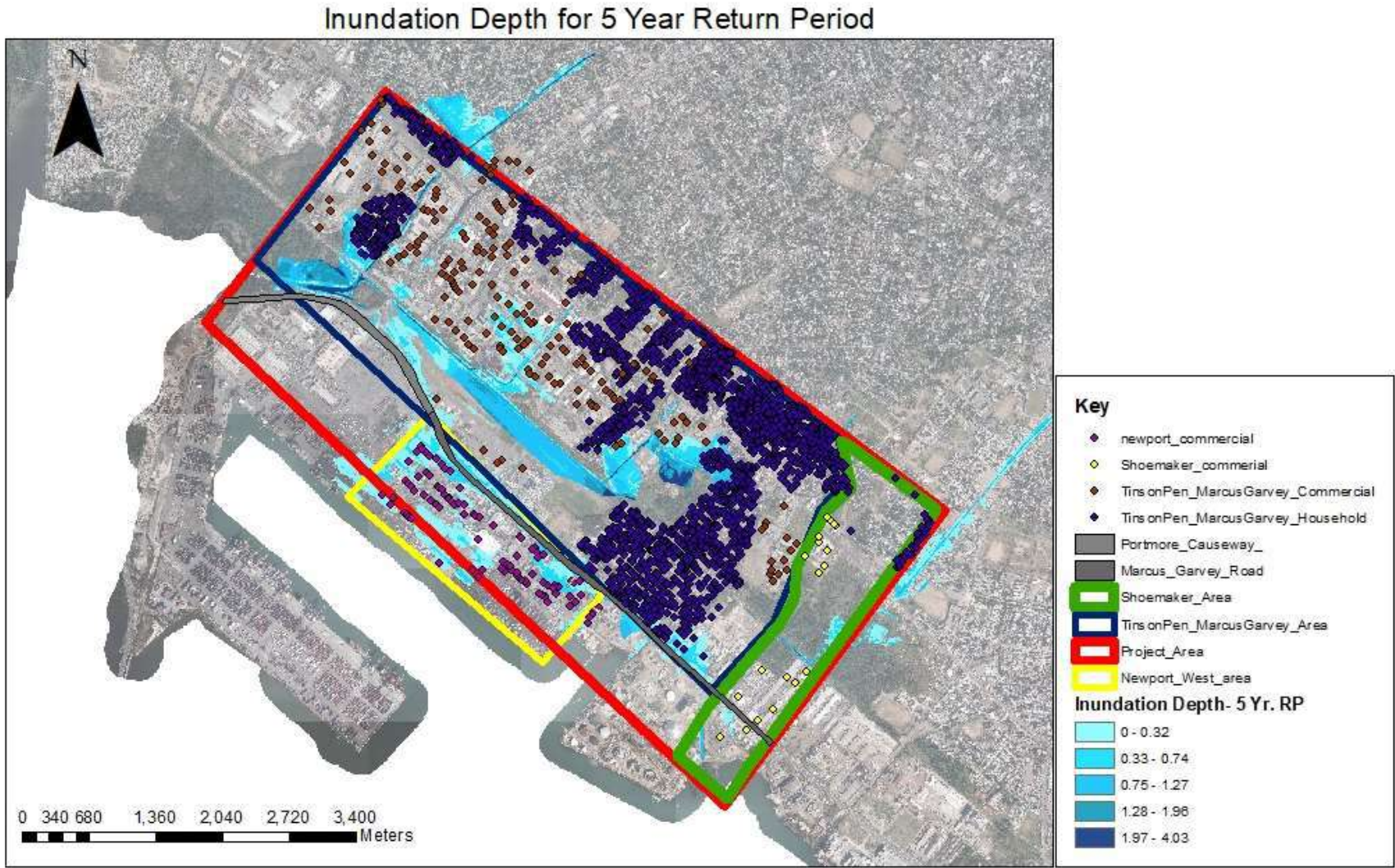


Figure 2.6 Inundation Map for 5 Year Return Period

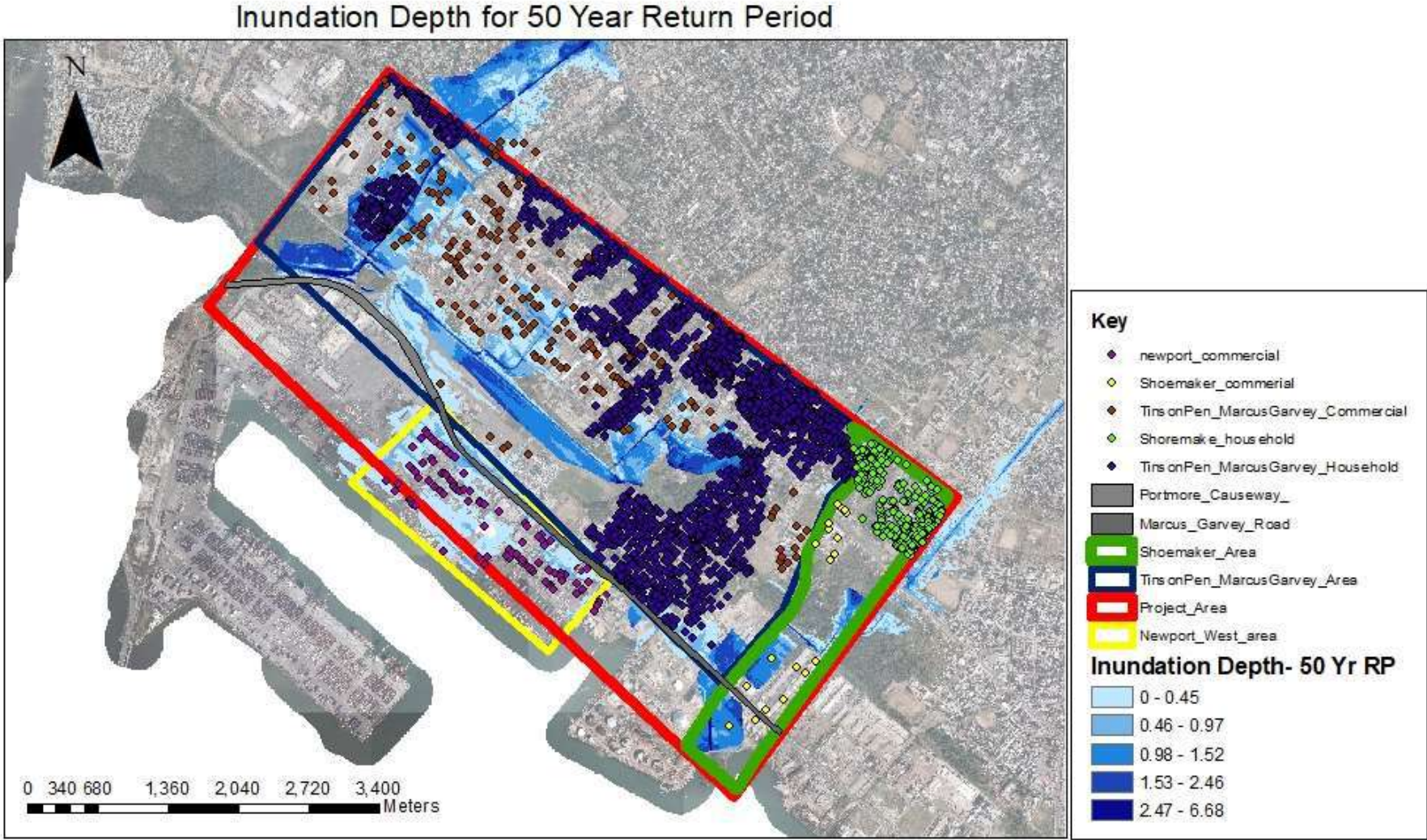


Figure 2.7 Inundation Map for 50 Yr RP

2.4 Risks: Losses

2.4.1 Direct versus Indirect Losses

Both direct and indirect losses (vehicles delay and diversions) are comparable from the 2 to 50-year RP. This suggest that property damages are comparable to vehicle-related losses. Catastrophic events however result in a considerable increase in direct losses and suggest that more severe events (100-year RP) could cost in excess of USD \$35 Million.

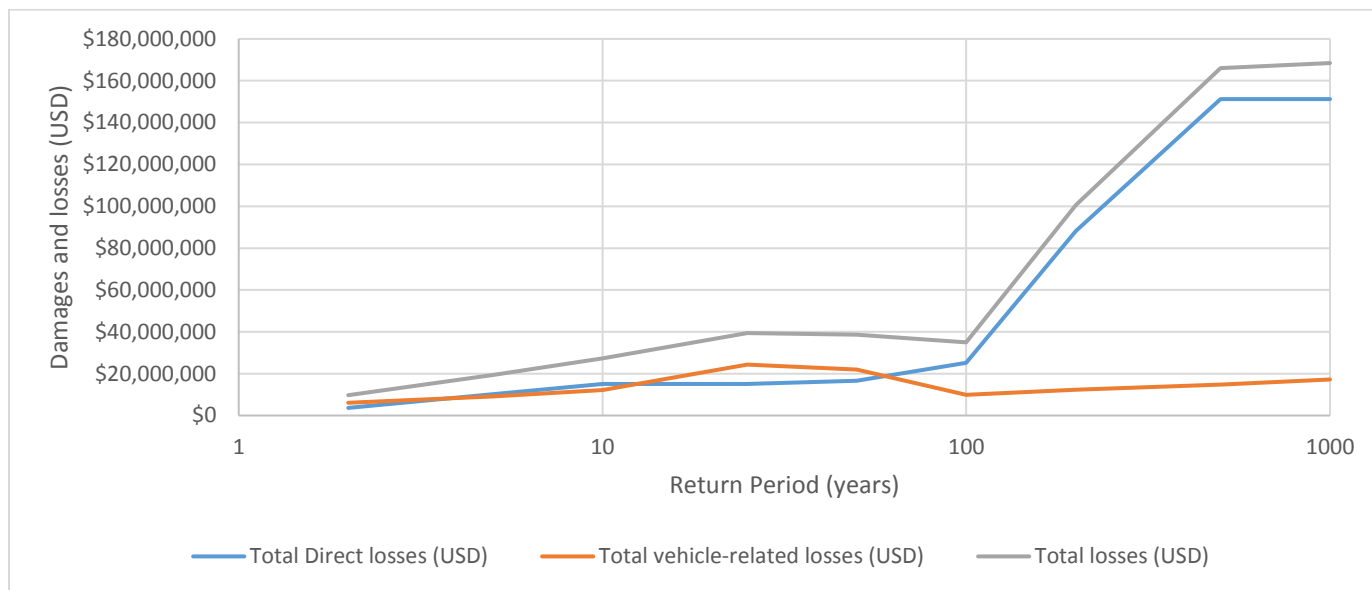


Figure 2.8. Direct and indirect losses flood losses

2.4.2 Average Annualized Loses

An average annualized loss (AAL) is USD\$17,494,576 (Table 2.5) for the “do nothing scenario”. This loss considers the direct losses to commercial assets and indirect cost of delays and added fuel cost of detours/diversions when the project area is impassable for over several hours. Both direct damage to the road way (Marcus Garvey Drive) and residual losses from prolonged business closures were not considered. The estimate is therefore believed to be conservative. Additional estimates for AAL for the project scenario were estimated in the feasibility analysis. The AAL was used to inform the feasibility analysis.

Table 2.5. Annualized losses for project area from direct and indirect losses (delays and diversion costs)

Scenarios (RP)	% Damage	Direct Damages	Indirect Losses (delays and detours)	Total Direct and Indirect Losses (USD)	Probabilistic loss (USD)
2	2%	\$3,627,500	\$6,083,786	\$9,711,286	\$3,641,732
5	7%	\$10,163,125	\$9,125,678	\$19,288,803	\$5,075,016
10	10%	\$15,122,500	\$12,167,571	\$27,290,071	\$3,493,416
25	10%	\$15,122,500	\$24,335,142	\$39,457,642	\$2,336,170
50	11%	\$16,653,750	\$21,943,502	\$38,597,252	\$1,170,823
100	17%	\$25,163,750	\$9,845,720	\$35,009,470	\$552,050
200	58%	\$88,194,375	\$12,307,150	\$100,501,525	\$508,166
500	100%	\$151,225,000	\$14,768,580	\$165,993,580	\$466,366
1000	100%	\$151,225,000	\$17,230,009	\$168,455,009	\$250,836

				AAL (USD)	\$17,494,576
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2.5 Summary

Anecdotal information suggests frequent flood events in the project area. Losses to single entities per event have been documented as high as USD8 million. Hydraulic analysis suggests that the existing drainage networks (Shoemaker, Tinson Pen, Marcus Garvey and Jew Gullies) capacities are less than the 5-year RP and in some instance less than the 2-year RP. It was observed that for the 5-year return period inundation levels varied from 0.1-0.4 m, while for the 100-year return period the inundation depth varied from 0.8-1.8m. The AAL is estimated to be USD \$17,494,576 based on the estimated direct and indirect losses. This represents the societal cost of flooding in the project area.

3 Existing Conditions

3.1 Meteorology

3.1.1 Background and approach

Both recent (1992 to 2013) and historical (1895 to 1966) 24-hour data were available for the project. The recovery, analysis and processing of over 71 years of historical data from National Oceanographic and Atmospheric Administration (NOAA) archives represents an innovation in this project. Depth of rainfall for various return periods was provided by the National Meteorological Service of Jamaica for the two closest gauges (Half Way Tree and Cavaliers). The NOAA data was combined with the recent data and analyzed to determine the rainfall depth for the 2 to 100-year RP. Continuous rain gauge data is absent for the catchment and confirmation of the rainfall hydrographs was not possible. Synthetic mass-curves (SCS type 3) were therefore used. Overall, extreme rainfall data was scarce, until the NOAA rainfall data was recovered.

The overall approach to defining the meteorological conditions was as follows:

1. Evaluate the existing Meteorological Service data
2. Recover and analyze the recovered rainfall data from NOAA.
3. Define the present climate 24-hour rainfall depths for the 2 to 100-year RP
4. An isolated rainfall event that occurred in September 2019 was used to in the calibration of the hydraulic model, with a 24-Hr rainfall depth of 79 mm.

3.1.2 Recent information (1992 to 2013)

The average of two (HWT and Cavalier) rain gauges that are 2.6 km and 6 km from the project area were used in for this assessment. See Table 3.1. Care was taken in the use of the existing information, because of the sparsity and location of the stations, in order to ensure representativeness. Cavaliers is more aligned with (but outside of) the Shoemaker catchment and Half Way Tree with the main (and larger) catchments of Jew and Tinson Pen Gullies and Newport West. Density of the stations is greater than 16km²/gauge and bias greater than 10% was expected and were observed in the data. This is more than likely due to either i) the gauge spacings being greater than the average rainstorm diameter⁶ and therefore sampling the same events historically or ii) errors in the probability distribution model selection and resulting analysis. Use of the average extreme rainfall depth therefore represents a compromise between: i) proximity (Half Way Tree) and ii) higher extremes (Cavaliers). This approach is validated in the rainfall events of October 7th 2020, wherein the differences between the Mico and Mona Reservoir stations was relatively large (44.6mm) on the same day, albeit that the stations are separated by orographic relief and only 4 km. Overall, this challenge speaks to the need for more gauge stations in the KMA, in order to aid in urban planning of infrastructure. See Figure 3.1 for the 24-hour 2 to 100-yr RP rainfall depths.

The project area can be typified as being in an area of moderate extreme rainfall, based on the spatial data for the island (Figure 3.3). 24-hours 100-year RP depths of 492 mm (that are commonly used to mitigate flooding of floor levels) are comparable to the rest of the KSA that have depth of 200 to 300 mm.

Table 3.1 Present climate 24-Hour Rainfall Depths (mm) for Half Way Tree and Cavaliers rain gauge stations (Met. Service/NWA) for the period 1992 to 2015. (Extrapolation for 1 and 2-year RP in red)

Return period (years)	Half Way Tree	Cavaliers	Average	Bias (Cavalier versus HWT)
1-Year			48	
2-Year			114	
5-Year	146	266	206	82%
10-Year	183	346	265	89%

⁶ ALVAREZ, Fernando, and Walter K. HENRY. "Rain gage spacing and reported rainfall." Hydrological Sciences Journal 15, no. 1 (1970): 97-107.

25-Year	230	469	350	104%
50-Year	266	572	419	115%
100-Year	301	682	492	127%

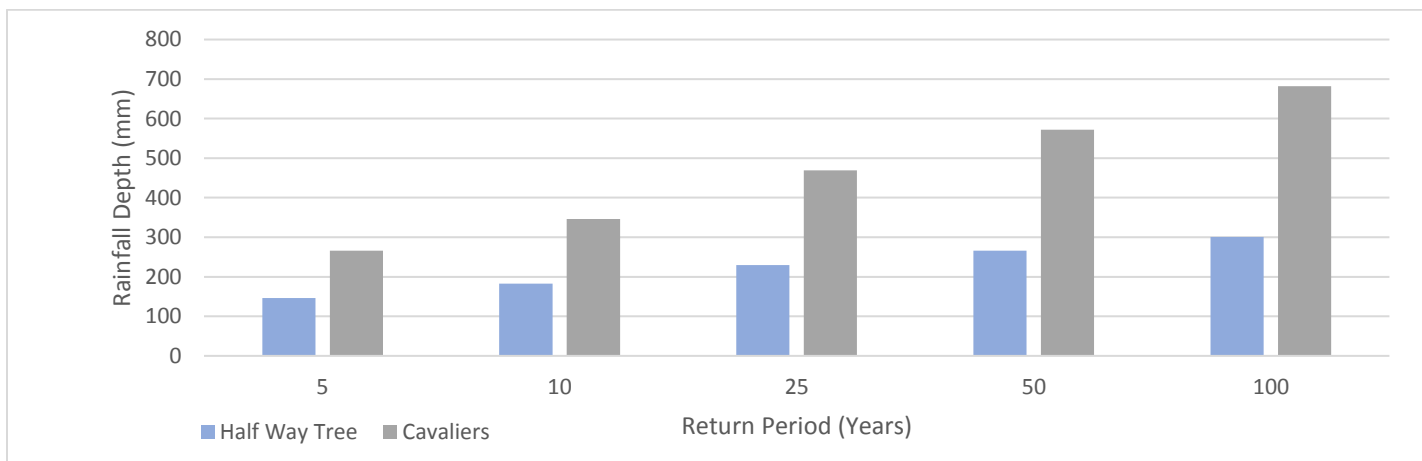


Figure 3.1. Present climate-24 Hour Rainfall Depths (mm) for Half Way Tree and Cavaliers Rain Gauge Stations (1992 to 2013).



Figure 3.2. Location of the Half Way Tree and Cavaliers gauge stations relative to project area.

Prepared by: CEAC Solution Co. Ltd.

Submitted to: National Works Agency

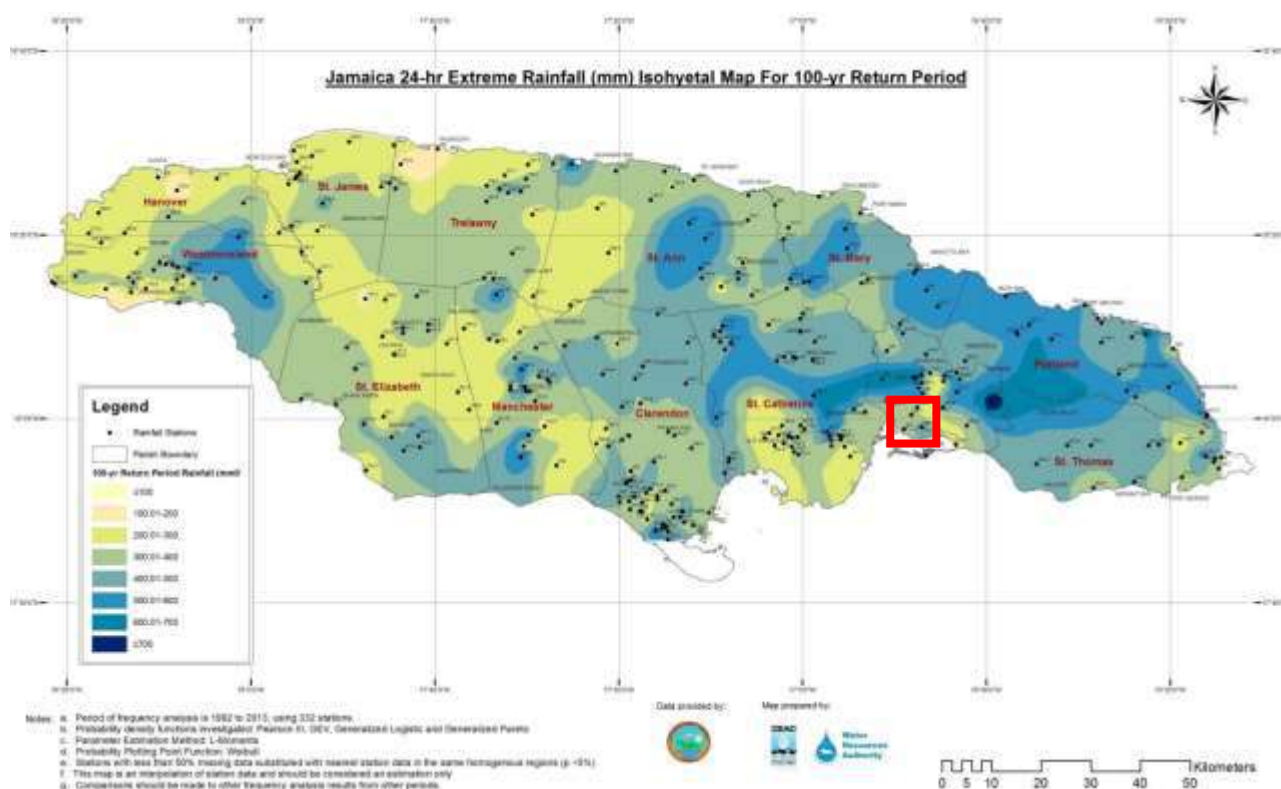


Figure 3.3. 100-year RP Isohyet map of Jamaica, showing project area in red outline

3.1.3 Data Recovery (1895 to 1966), analysis and results

Data recovery improved the samples of extreme events. The highest rainfall depth of 588mm being recorded for HWT in 1963 during Hurricane Flora⁷. Similarly, in 1933 some 261 mm of rainfall from an unnamed hurricane was recorded at HWT. Comparably, Cavalier recorded 346 and 350mm in 1998 and 2005 from a low-pressure system and Hurricane Wilma respectively. This speaks to the importance of understanding the effect of perturbations in hurricane in the future climate. Both HWT and Cavalier are similar and no trends were detected at significant levels in the data. 104 years of station data were recovered in annual maxima information for the HWT and Cavalier stations (Figure 3.4), resulting in an overall period of 118 years of rainfall data. No significant trends (Mann-Kendal test) or breakpoints were detected in the rainfall data for the two periods (@ 95% confidence) and both HWT and Cavalier were determined to be homogenous and similar (Kolmogorov-Smirnov test). It should be noted that Cavalier has an increasing trend in rainfall depths in comparison to HWT, but this is not at significant levels. Homogeneity and stationarity across both stations and periods confirmed that data from both stations could be blended and subjected to further probability analysis.

HWT results were comparable between the shorter and extended period, but Cavalier results were moderately reduced and suggest the benefit of longer data sets. 25, 50 and 100-year RP depths of 350 to 492mm were reduced to 283 to 401mm respectively from the reanalysis (Table 3.2). Distribution fitting for both HWT and Cavalier suggested the suitability of the Log-Normal and Fisher-Tippet distributions at significant levels. Interestingly, the traditional probability distribution methods used in hydrology in Jamaica (Logistic, GEV, Gumbel and Weibull) were as assessed as not being suitable for these stations and suggest the need for reassessing the return period of other stations in Jamaica. Overall, the combined NOAA and MS reanalyzed rainfall depths (1895 to 2013) are approximately 18 to 21% lower than the MS data and represents an innovation in data recovery and analysis.

⁷ Evans, C. J. "Heavy Rainfall in Jamaica Associated with Hurricane Flora 1963 and Tropical Storm Gilda 1973." Weather 30, no. 5 (1975): 157-161.

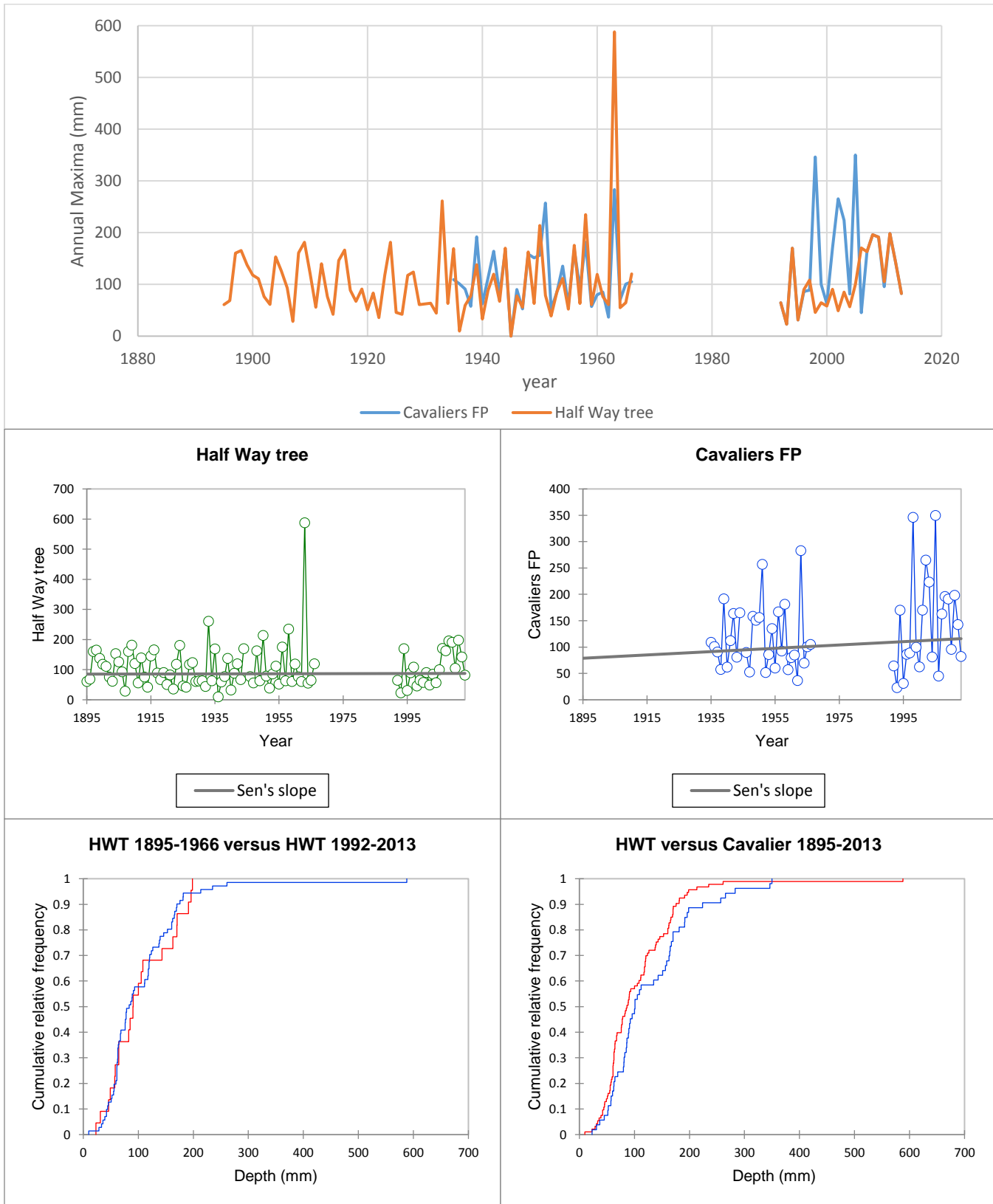


Figure 3.4. Both recent (1992 to 2013) and historical (1895 to 1966), blended meteorological data (top). Trend analysis of HWT and Cavalier (middle) and Homogeneity analysis of HWT 1895-1966 versus 1992-2013 and HWT versus Cavalier (1895 to 2013)(bottom).

Table 3.2. Present climate HWT and Cavalier rainfall (mm) for 2 to 100-year RP from MS (1993 to 2013) and recovered and reanalyzed (1895 to 2013)

RP	HWT		Cavalier		Average		% increase (1895-2013 versus MS)
	MS (1993- 2013)	re-analysis (1895-2013)	MS (1993- 2013)	Re-Analysis (1895-2013)	MS (1993- 2013)	Re-Analysis (1895-2013)	
2		88.3		108		98	
5	146	147.4	266	179	206	163	-21%
10	183	192.8	346	233	265	213	-19%
25	230	256.6	469	309	350	283	-19%
50	266	308.6	572	371	419	340	-19%
100	301	364.4	682	437	492	401	-18%

3.2 Topography and Slopes

Topographic information was sourced from a LiDAR survey conducted by CEAC in April 2020. The LiDAR survey was confirmed to have an accuracy of 0.1m for both vertical and horizontal axes that was deemed more than adequate for the assessment being conducted. The data was analyzed using the ArcGIS, and HEC-RAS software suites which allowed for slope analysis and catchment delineation using supplied tools. The catchments were delineated by both heads-up digitizing using existing data, and then checked with ground truthing.

The majority of the catchment areas have slopes of 3 to 5% (hydraulically steep) in the higher reaches and 0.5 to 1.5% (hydraulically mild) in the lowest reaches near the outfalls in the actual project area. See Figure 3.6 for Slope Map of Project and Catchment Areas. The slope map was generated from the digital elevation model (DEM) on ArcGIS, and was subdivided slope ranges into five classes. In general, the majority of the catchment area (64%) fall within the 1-5% range. Steep catchments result in limited routing, relatively high peak discharges and fast translation of runoff to the outfalls of urban catchments. However, mild slopes result in hydraulic jumps and higher flow depths. Of greater interest are the lateral slopes along which both Tinson Pen and Marcus Garvey drains flow that are in the order of 0.25% and 0.5% and are definitely hydraulically mild slopes. Transmission of high peak flows to these flatter slopes can be expected to result in increased flow depths from hydraulic jumps. Overall, the spatial variation of the slopes across the catchments are conducive for fast runoff from upper reaches and deeper flow depth (synonymous with flooding) in the lower reaches that define the project area.

Table 3.3: Catchment and Project Area slope analysis summary table

Slope Range (%)	Proportion
0-1	9%
1-3	32%
3-5	23%
5-10	23%
>10	13%



Figure 3.5: Topographic Map of Project Area

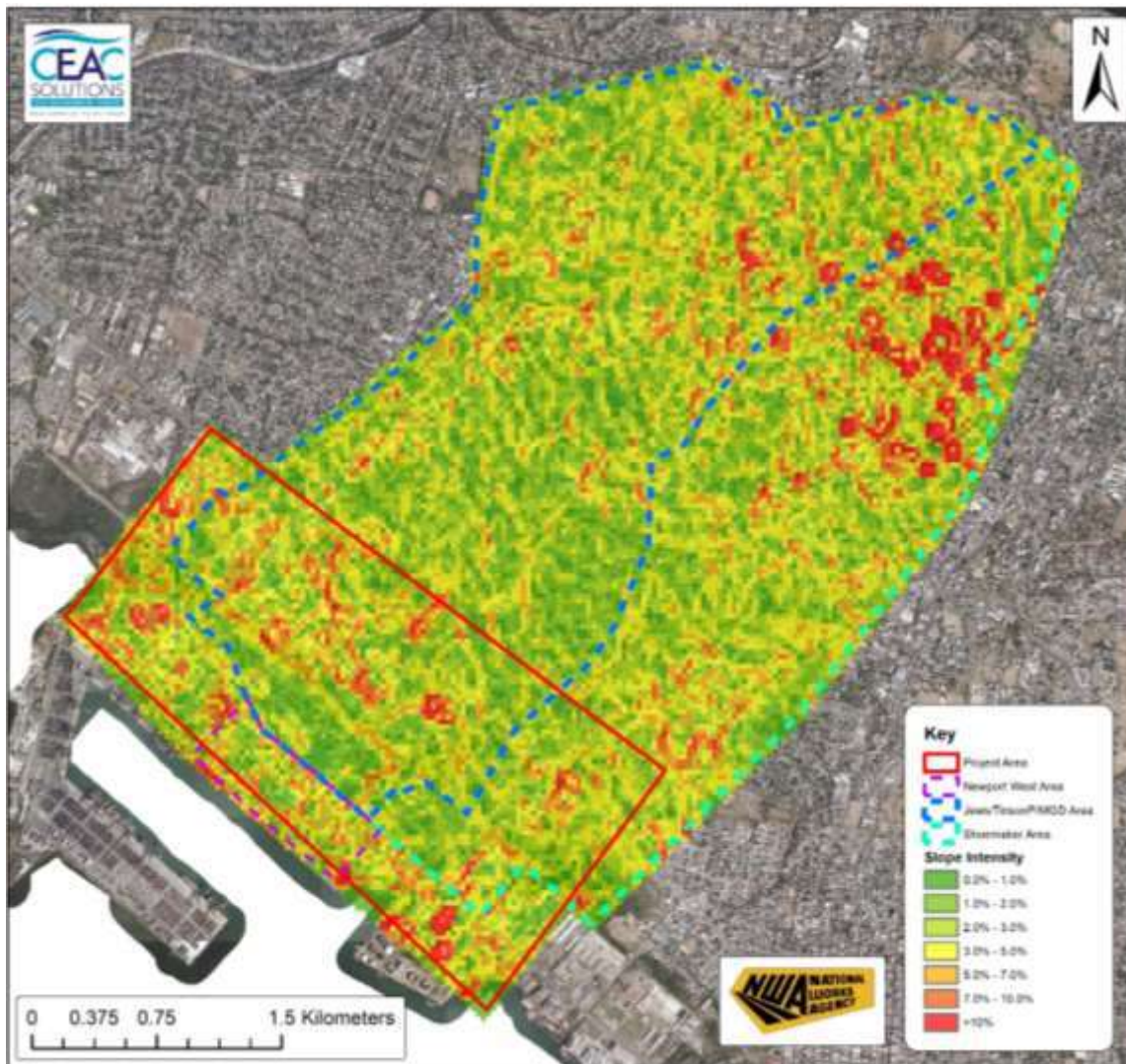


Figure 3.6: Slope map of project and catchment areas

3.3 Watersheds

The assessment was split into the three catchments that correspond to the project area (Figure 3.8). These are: i) Marcus Garvey, Tinson Pen and Jew Gully (~9.4 km²), ii) Shoemaker (6.8 km²) and Newport West (0.5 km²). The major catchments were further broken down to sub-catchments which correspond to the streams identified.

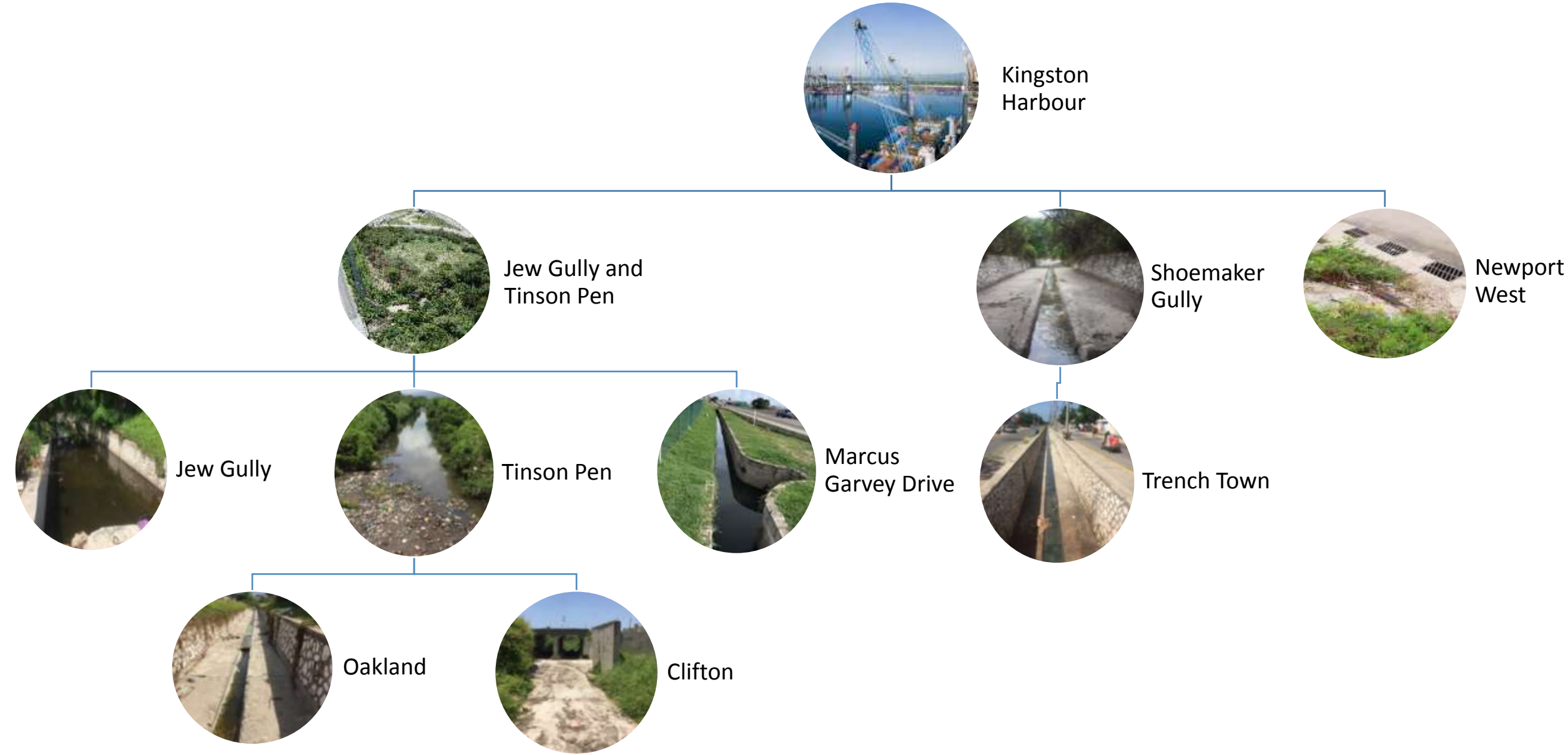


Figure 3.7: Drainage channel connections and flow paths

3.3.1 Marcus Garvey Drive, Tinson Pen and Jew Gullies

The Marcus Garvey Drive, Tinson Pen, Jew catchment is a 940ha large area located to the west of the designated project area, and comprises of 12 sub-catchments and streams. The north-most sub-catchments comprise of areas which carry runoff from northern Kingston to Jew Gully, which terminates to the Kingston Harbor. The sub-catchments to the east of the major catchment comprises of the Stewarts industrial area, Oaklands, and Clifton and its environs. These consists of several major and minor drainage systems which leads to the Tinson Pen Drain. The Tinson Pen drain intersects the Jew Gully before discharging to the Kingston Harbor. The south-most catchments comprise of the drainage system which services the Marcus Garvey Drive roadway, and also lead to the Tinson Pen drain.



Figure 3.8: Jew Gully/Tinson Pen/Marcus Garvey Drive combined catchment with project area

3.3.2 Shoemaker

The Shoemaker catchment is 675 hectares large, and comprises of seven sub-catchments and streams. The sub-catchments comprise of areas to the northeast of project area, including New Kingston, Cross Roads, and Trench Town, which carry runoff to the Shoemaker Gully, and Trench Town Drain which intersects the shoemaker gully before discharging to the ocean. See Figure 3.9 showing combined Shoemaker catchment.



Figure 3.9: Shoemaker combined catchment with project area

3.3.3 Newport West

Newport West catchment is approximately 47ha large, and is located to the south west of the project area and comprises of three sub-catchments. Runoff within these catchments flow to several strategically placed inlets, which then lead to the ocean via underground drainage pipes. See Figure 3.10 showing combined Newport West catchment.



Figure 3.10: Newport West combined catchment.

3.4 Soil types

The catchments' soil types are typified by Clay loams with high runoff potential. Soil data for the catchment and project area was obtained from the Ministry of Agriculture GIS datasets for land use and soil type, as it was required to ascertain the soil texture properties of the land in order to accurately deduce the drainage properties of the in-situ soil. The soil types were separated by their Hydrologic Soil Groups which classify soils based on: i) Intake and transmission of water, ii) Bare soil surface, iii) Maximum Swelling of expansive clays, iv) internal drainage. The catchment primarily comprises of the Cashew Clay Loam soil type. Clay loam soils are hydrologically associated with moderate to high runoff potential as they have very low infiltration rates, and as such typically fall within Hydrological Group D. Figure 3.11 below shows the soil-types present within and surrounding the catchments and project area.

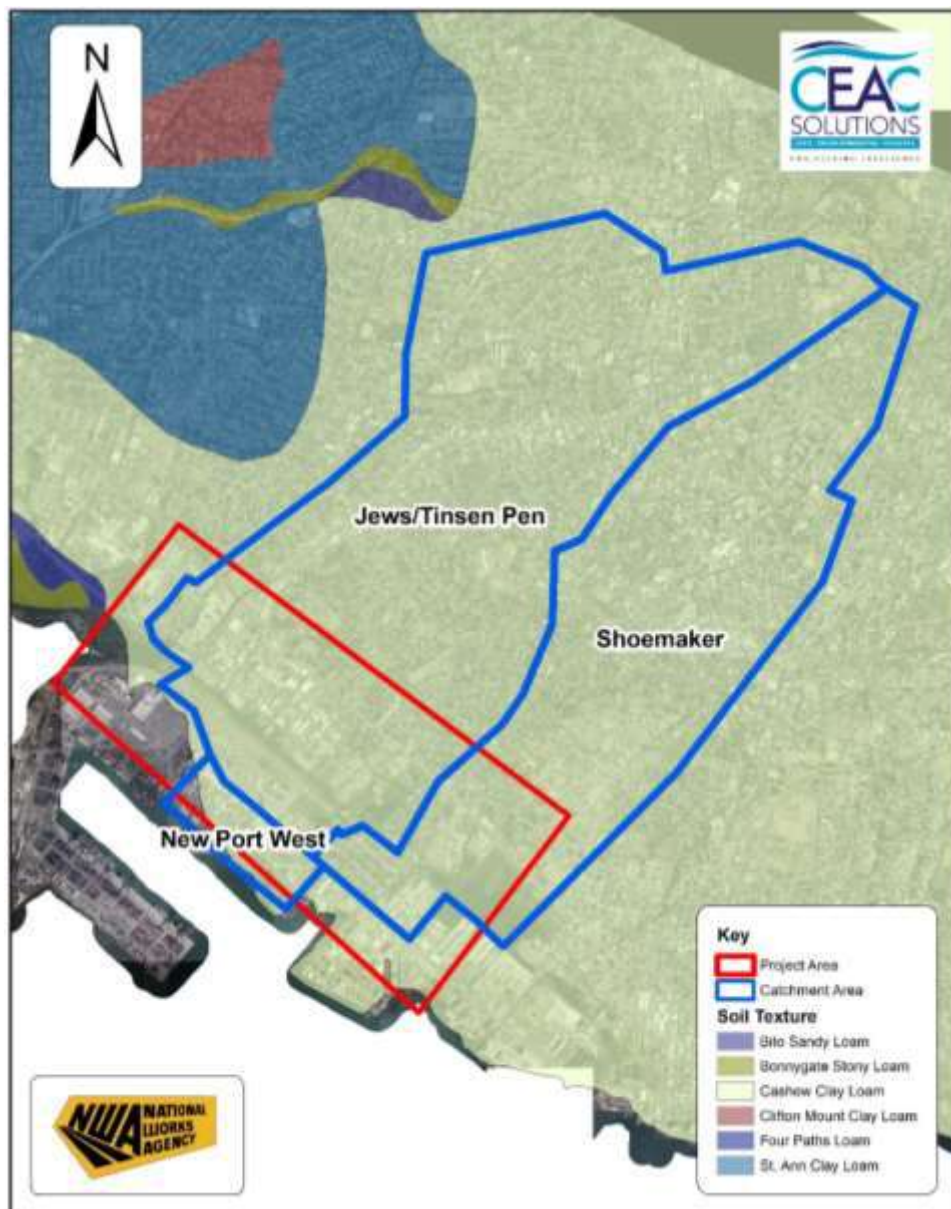


Figure 3.11: Soil types found in the project area

3.5 Land use: Existing and Projected

Currently, the land in and around the watersheds and project area comprises predominantly of urban, commercial and industrial areas. Land Use data was obtained from GIS Datasets provided by the Planning Institute of Jamaica (PIOJ). As the mixture of commercial, industrial and urban areas within and around the watershed and project area is significantly heterogeneous, it was considered that the watersheds are largely impermeable given their developed nature. Land use describes the state of the land as it pertains to the management and modification of the natural environment into built environments. An understanding of the land use of an area provides insight into how runoff behaves within the area of interest. Undeveloped land and land developed for agriculture will have less runoff, as there are generally more permeable than the impermeable surfaces in a developed area.

Higher densities and a continuation of the already saturated land use will result in little significant change in hydrological runoff properties in the future. Under the Town and Country (Kingston and St. Andrew, and the Pedro Cays) Provisional Development Order 2017, several zoning proposals were presented. In its current form the catchment areas are largely residential and commercial, and the project area is a mixture of light industry, heavy industry and Seaport related activity. Though there is potential for change of use, it is unlikely that there is significant change in porosity within the catchment and project area, as the land in its current form is already significantly developed. See Figure 3.12.

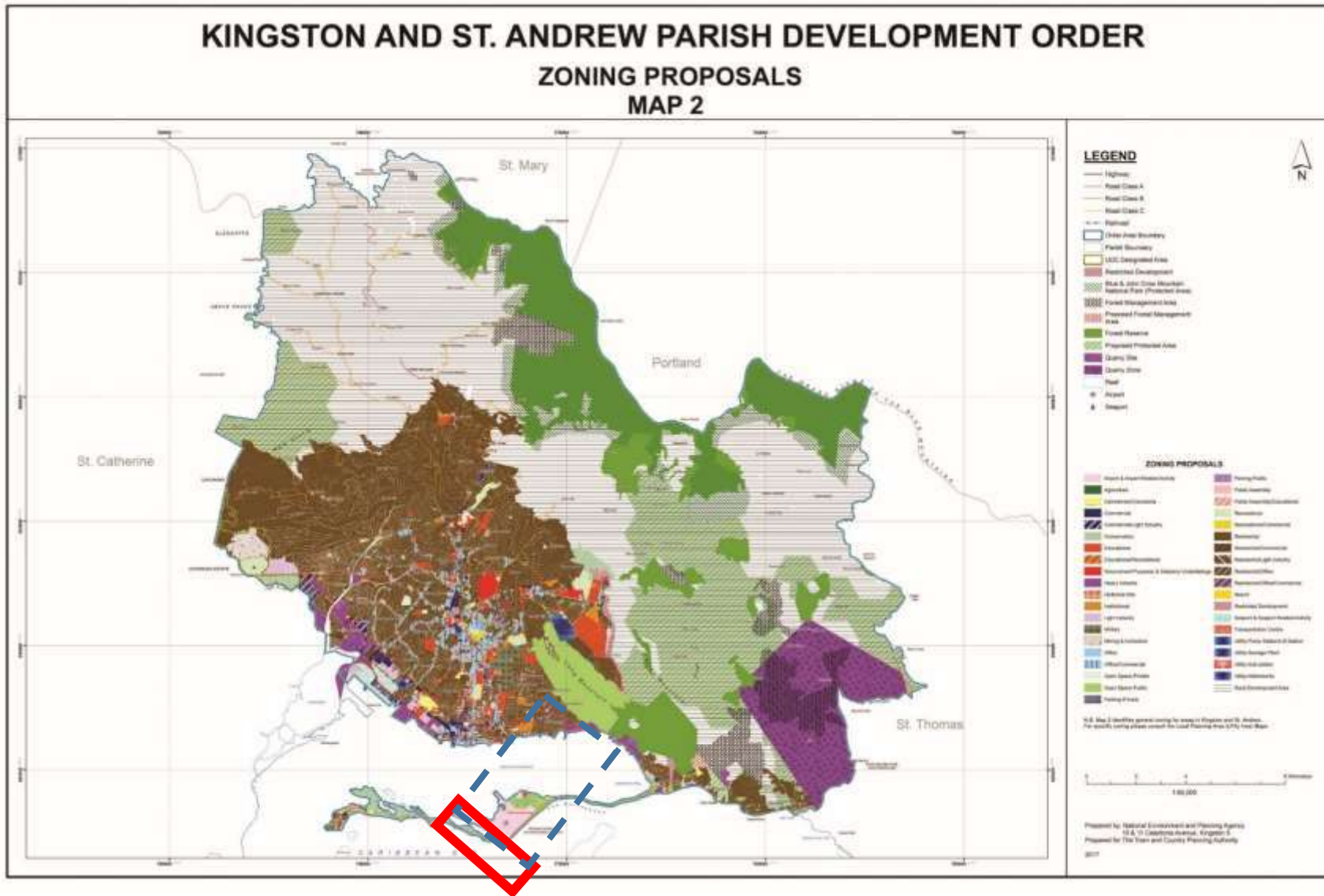


Figure 3.12: Kingston and St. Andrew Parish Development Order (2017): Zoning Proposals

3.6 Summary

Data recovery improved the records (1895 to 2013) of extreme events with a notable storm from Hurricane Flora of 1964 of 588mm for HWT in 1963. Homogeneity and no trends were detected in the data and allowed for the blending of the stations data. 10 to 100-year RP depths of 213 to 401 mm for the 24-hour events were determined for the present climate.

The project area is typified by considerable extreme rainfalls over a steep catchment consisting of relatively impervious soils in a highly developed urban catchment that leads to high peak runoffs. The overall catchment area that directs runoff to through the project area is approximately 16.11 km², and is comprised of 19 sub-catchments. Table 3.4. Summarizes the watershed areas scrutinized in this assessment. The flatter slopes in the lower reaches of the catchments present special hydraulic challenges associated with increased likelihood of flooding.

Table 3.4: Summary of project watershed areas.

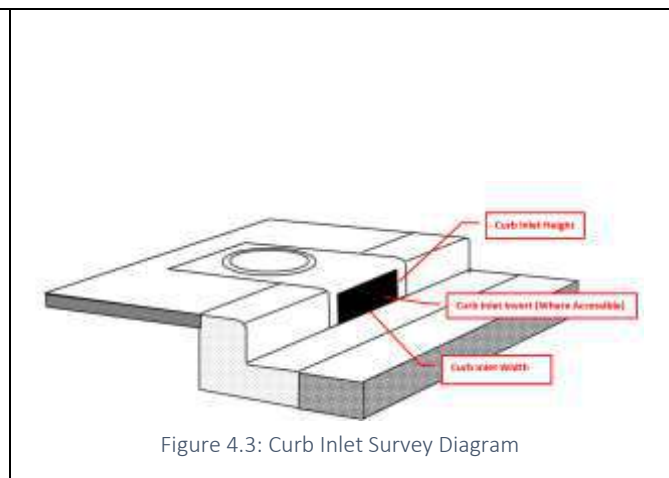
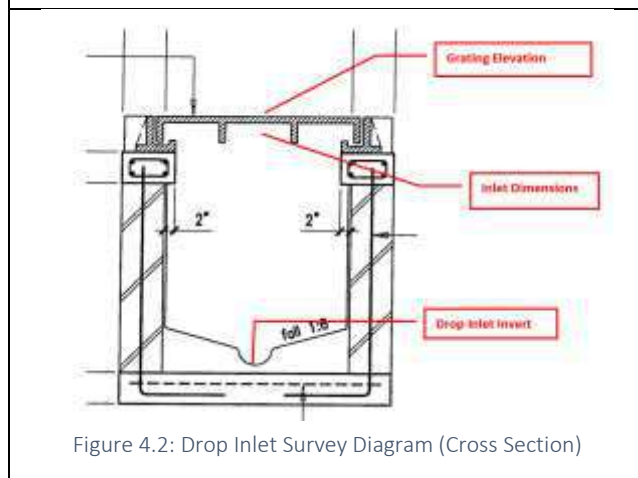
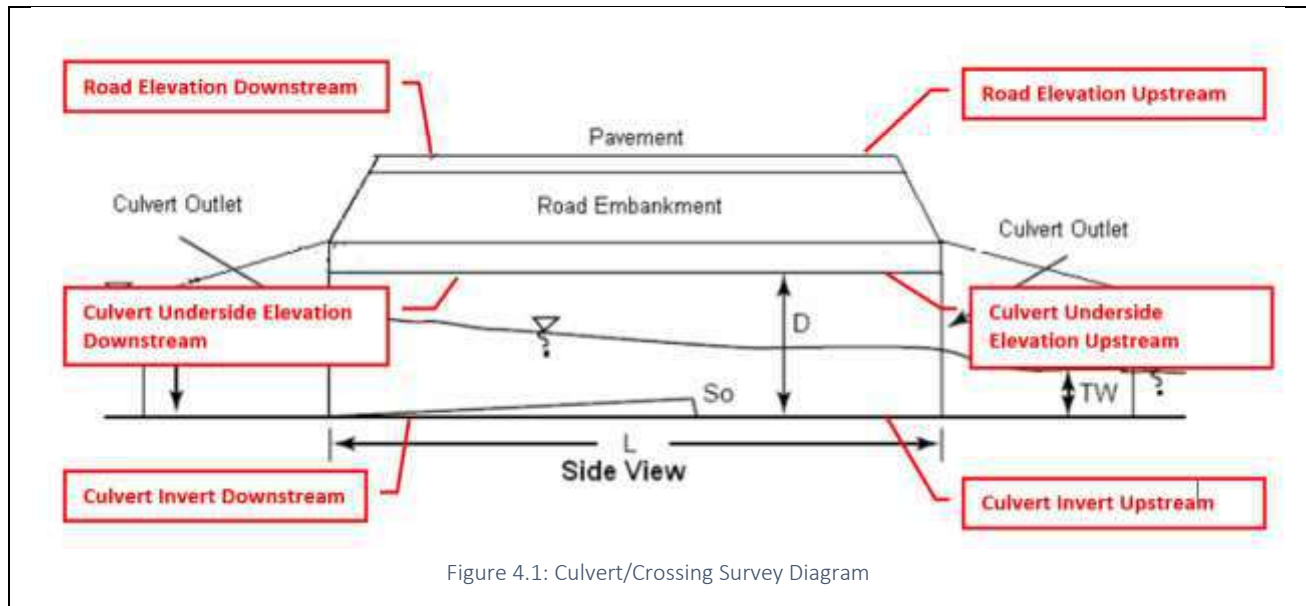
Catchment	Area (ha)	Receiving Stream	Stream Length (m)
Marcus Garvey Drive, Tinson Pen, Jew catchment summary			
Molynes	246	Molynes	2929
Hope Road	129	Hope Road Drain	2568
Upper Oaklands	220	Upper Oaklands	1344
Oaklands	26	Oaklands Drain	721
Clifton	117	Clifton Drain	849
Stewarts	38	Stewarts	300
Marcus Garvey Drive	30	Hunts Bay Drain	1661
Tinson Pen	25	Jew Gully	1610
Jew Gully	109	Jew Gully	2464
Shoemaker Catchment Summary			
Upper Shoemaker	177	Upper Shoemaker Gully	1840
Central Road	14.6	Central Road Drain	766
Mid Shoemaker	67.8	Mid Shoemaker Gully	1378
Sunlight Drive	68.95	Sunlight Drive Drain	1650
Trench Town	154.1	Trench Town Drain	2326
Greenwich Town	34.7	Marcus Garvey Drain	730
Lower Shoemaker	107.3	Lower Shoemaker Gully	1600
Newport West catchment summary			
Newport West 1	9.96	NPW Drain 1 (To Outlet)	200
Newport West 2	13.35	NPW Drain 2 (To Outlet)	460
Newport West 3	11.95	NPW Drain 3 (To Outlet)	300
Newport West 4	9.58	NPW Drain 4 (To Outlet)	160

There were few limitations in the definition of the existing conditions in the catchments. The most important of which was that there were only 2 rain gauges with limited rainfall intensity data were in proximity of the project area and watersheds. Notwithstanding, a conservative approach was adopted to partially mitigate potential issues.

4 Key Flood Control and Drainage Features

4.1 Methodology

Surveys were conducted in the project area to capture the key drainage features, including minor and major drains that carry runoff from the upper catchments, through the project area to the Kingston Harbor. This was conducted using a team of surveyors and engineers to locate, survey and assess each feature to be accurately represented in the hydrological model. The surveyors used a combination GPS and Optical survey equipment to properly geolocate the drains, crossings and other appropriate drainage features. The engineers assessed the drains from a qualitative point of view noting the construction, shape and other parameters. Figure 4.1, Figure 4.2, and Figure 4.3 detail the dimensions and parameters collected by the team.



Hydraulic capacities were estimated by taking the current geometry of the channels and NWA guidelines into account. First the flow regime (steep versus mild) was determined by comparing normal depths to critical depths. Then allowable discharge to yield a 25% freeboard (in keeping with NWA guidelines) were determined. It was then possible to compare the capacity to the 25-year RP flows in subsequent sections of this report.

4.2 Marcus Garvey Drive, Tinson Pen Drain, and Jew Gully

4.2.1 Tinson Pen Drain

The Tinson Pen Drain is located in the western segment of the project area and carries runoff from Richmond Park, Delacree Pen, Payneland, the Stewarts industrial compound, and their surrounding communities. The drain is constructed of concrete with measurements 8m wide and 2m deep and vertical side walls. A major crossing was identified at the end of the drain, just before its intersection with Jew Gully. This crossing is a known flooding hot spot, with several occurrences of flooding as a result of its inadequacy during heavy rainfall events. See appendices 9.1.

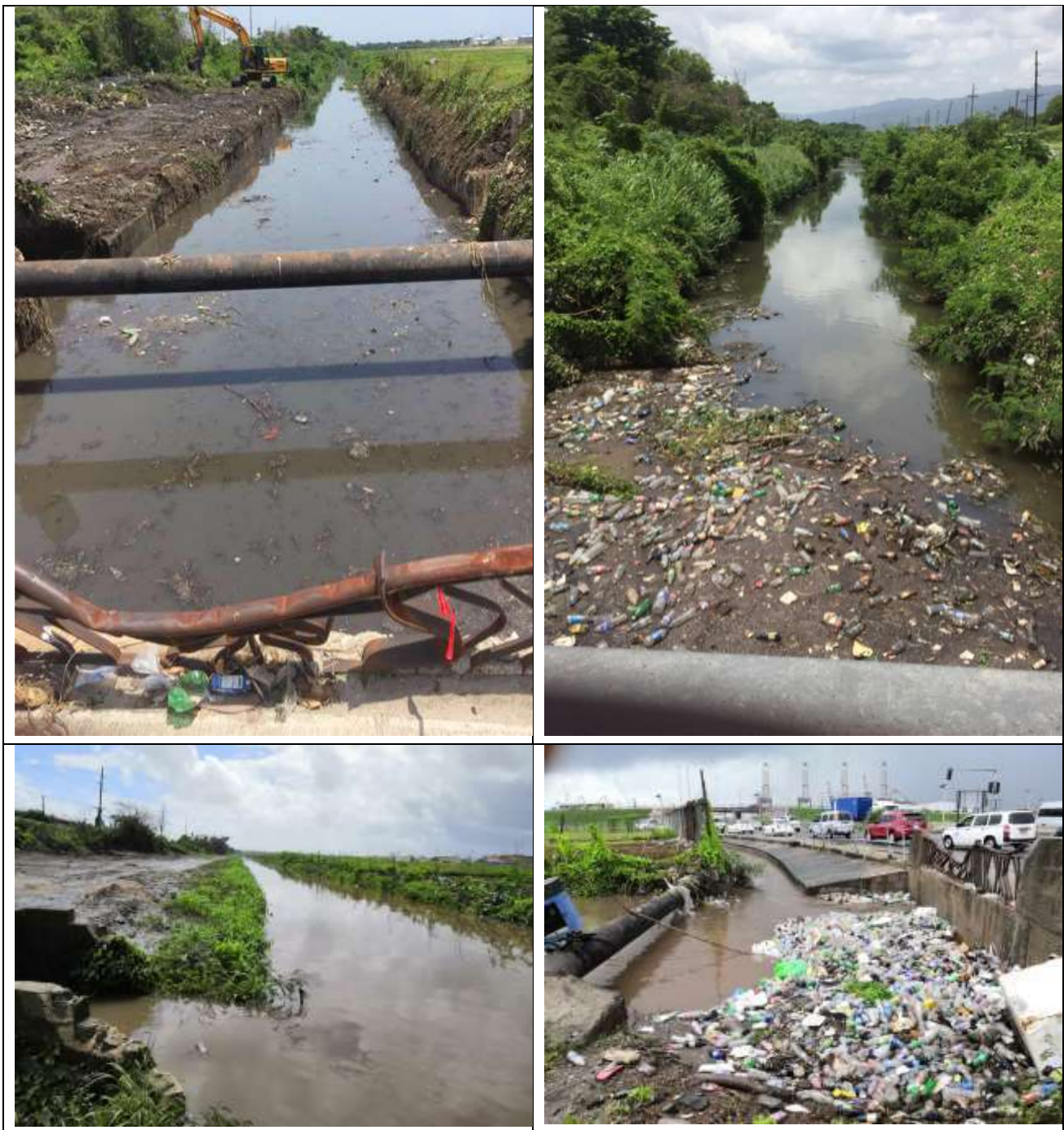


Figure 4.4: Photos of Tinson Pen drain at Marcus Garvey Drive

4.2.1.1 Tinson Pen Drain Crossing

The Marcus Garvey Drive crossing for the Tinson Pen Drain is a 3-cell concrete culvert crossing with dimensions 2.5m wide and 2m deep for each cell. It is the final crossing along the Tinson Pen drainage channel before intersecting the Jew Gully and flowing outward to the sea. This is the site of several instances of flooding, as it appears the capacity of the crossing does not meet the requirements for a heavy rainfall event. Photos of the crossing can be seen in Figure 4.5.



Figure 4.5: Photos Tinson Pen culvert crossing at Marcus Garvey Drive

4.2.2 Marcus Garvey Drive

The Marcus Garvey Drive drainage system runs parallel to the recently constructed (2016) Marcus Garvey Drive Roadway, and carries runoff from the roadway and its surrounding properties to the Tinson Pen Drain. The drain is constructed of concrete and is relatively small with measurements of 0.6m wide and 1m deep, with vertical sidewalls. See Figure 4.6.



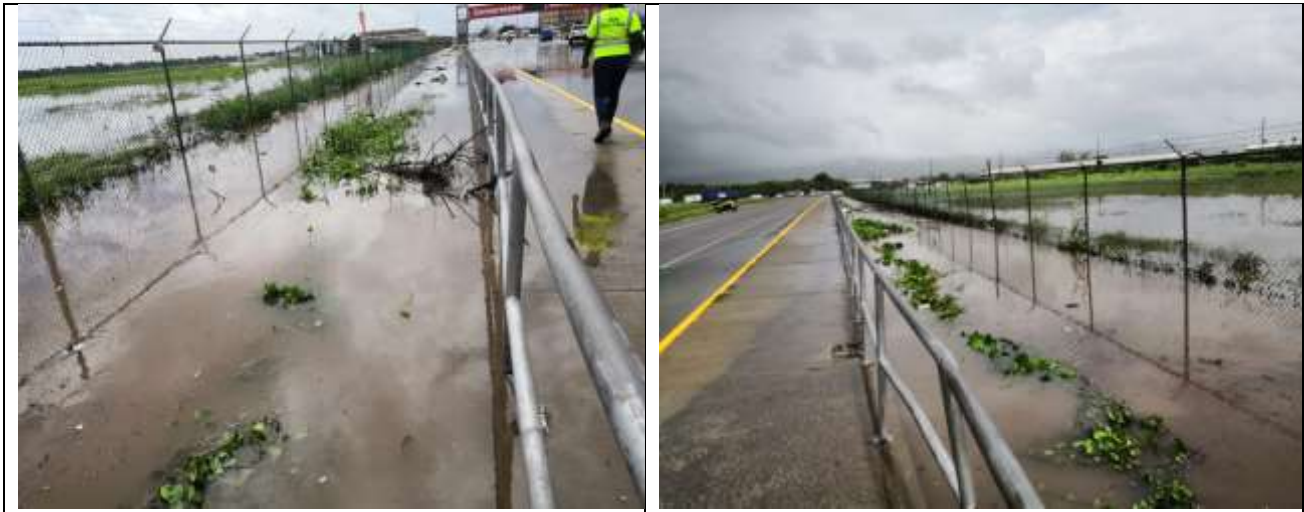


Figure 4.6: Photos of Marcus Garvey Drive drainage channel

4.2.3 Jew Gully

Jew Gully is located on the western boundary of the project area and carries runoff from as far as Waterloo Road, Eastwood Park, Majestic Gardens, and their surrounding communities. The gully is generally with a combination of stone wall and a concrete base with measurements 6m wide and 2.6m deep, with vertical side slopes and a low flow channel. A temporary major crossing has been identified in the project area, which is located just before the drainage channel is intersected by the Tinson Pen Drain. See Figure 4.7.





Figure 4.7: Photos of Jew Gully drainage channel

4.2.3.1 Jew Gully Temporary Crossing

The crossing as it exists is a temporary steel frame crossing, located where the drain crosses the Chesterfield main road. The crossing measures 6m wide and 2.6m deep, and was placed during the Marcus Garvey Drive Roadworks project. It is also the final crossing along the drainage channel before runoff enters the sea. Photos of the crossing can be seen in Figure 4.8.



Figure 4.8: Photos of Jew Gully temporary crossing at Chesterfield main road

Drainage Channel	Stream Length (m)	Width (m)	Depth (m)	Capacity (m ³ /s) @25% Freeboard
Molynes Drain	2929	4	1.5	32.2
Hope Road Drain	2568	7.5	2	105.0
Upper Oaklands Drain	1344	3	1.5	9.8
Oaklands Drain	721	3	1.5	21.8
Clifton Drain	849	5	2	32.5
Stewarts Drain	300	1	1	4.8
Hunts Bay Drain	1661	0.6	1	0.4
Tinson Pen Drain	1610	7.5	2	48.8
Jew Gully	2464	7.5	2	114.1

Table 4.1: Summary of Major Drainage Channels for Jew, Tinson Pen, Marcus Garvey Drive, Stewarts, Oaklands Area

4.3 Shoemaker Gully

Shoemaker Gully is located on the eastern boundary of the project area and carries runoff from as far as New Kingston, and sections of Trench Town. The gully is generally constructed with a combination of stone wall sides, and a concrete base with measurements 10.4m wide and 2.6m deep at the final crossing. The drain also includes a low flow channel to maintain flow during normal or low runoff conditions. Two major crossings have been identified in the project area. The first is located where the drain crosses Spanish Town Road, and the other is located where it crosses the Marcus Garvey Drive. Instances of localized flooding by the Jamaica Coffee Board have been reported during heavy rainfall events. See Figure 4.9.



Figure 4.9: Photos showing Shoemaker Gully

4.3.1 Spanish Town Road Crossing

The Spanish Town Road crossing is a large single cell concrete culvert crossing, with dimensions 9.1m wide by 1.8m deep. No instance of flooding has been reported in this location; however, it must be noted that a section of the drain just downstream is in significant disrepair. Photos of the crossing can be seen in Figure 4.10.



Figure 4.10: Photos Shoemaker Culvert Crossing at Spanish Town Road

4.3.2 Marcus Garvey Drive Crossing

The Marcus Garvey Drive crossing for the Shoemaker Gully is a 2-cell concrete culvert crossing with dimensions 4.7m wide and 2.6 deep for each cell. It was constructed in 2016 as a part of the Marcus Garvey Drive Roadworks project, and is the final crossing along the drainage channel before runoff enters the Kingston Harbor. Photos of the crossing can be seen in Figure 4.11.



Figure 4.11: Photos Shoemaker Culvert Crossing at Marcus Garvey Drive

Receiving Stream	Stream Length (m)	Width (m)	Depth (m)	Capacity (m ³ /s) @25% Freeboard
Upper Shoemaker Gully	1840	4	1.5	31.9
Central Road Drain	766	2.5	1.2	17.3
Mid Shoemaker Gully	1378	5	1.5	56.0
Sunlight Drive Drain	1650	2.5	1	14.0
Trench Town Drain	2326	3	1.3	22.7
Marcus Garvey Drain	730	1	0.6	0.8
Lower Shoemaker Gully	1600	10	1.8	147.1

Table 4.2: Summary of Major Drainage Channels for Shoemaker Area

4.4 Newport West

The Newport West drainage system is located along the southwestern boundary of the project area and carries runoff from the from the general Newport West catchment area to the bordering sea. The system consists of an array of strategically located drop inlets and a network of underground culvert pipes which measure from 900mm to 1200mm in diameter, and conveys the water away from the low-lying area. Newport West is a known hotspot for flooding as the drainage system as it exists currently does not have the capacity to relieve the area during a high intensity rainfall event. See Figure 4.12.



Figure 4.12: Photos of Newport West inlet during normal conditions, and during heavy rainfall (same location)

Drainage Channel	Stream Length (m)	Pipe Diameter (m)	Capacity (m ³ /s) @25% Freeboard
NPW Drain 1	200	0.9	0.9
NPW Drain 2	460	0.9	0.9
NPW Drain 3	300	0.9	0.9
NPW Drain 4	160	1.2	1.9

Table 4.3: Summary of Major Drainage Pipes for Newport West Area

4.5 Minor Drainage

The project area consists of roads with mild slopes drained by a network of gutters, inlets and culverts that run to their respective major drainage channel. Some of the areas identified lack crucial or have undersize drainage infrastructure, and as such experience extensive flooding during heavy rainfall events.

4.5.1 Jew Gully

Tinson Pen and Marcus Garvey Drive

The Tinson Pen/ Marcus Garvey Drive area is generally very mildly sloped, with an array of inlets, gutters and culverts which serves to drain the area. However, this does not prevent flooding in the area as any rainfall event exceeding 1 – 2 years results in significant localized flooding. Analysis of the topographic data revealed that the roads within the area have slopes generally ranging from 0.07% to 0.6%, and a general area slope of 0.15% towards the north. Field Reconnaissance accounted for 12 Inlets within the area which included drop inlets, curb inlets and combination inlets. When compared to the NWA Guidelines, the inlets in the area conform to the size requirements however do not adhere to the spacing and distance from high point requirements as the inlets appear to be strategically placed to drain the flat areas. See MAP for layout of existing drainage system



Figure 4.13: Photo of Inlet on Marcus Garvey Drive



Figure 4.14: Photo indicating flood heights at the Tinson Pen Aerodrome during heavy rainfall (1-2yr RP)



Figure 4.15: Photo of vehicle substantially damaged by flooding along Marcus Garvey Drive



Figure 4.16: Photo of flooding along Marcus Garvey Drive during heavy rainfall event (1-2yr RP)

Stewarts Industrial

The Stewarts area is generally very mildly sloped, with an array of inlets, gutters and culverts which drain to the Tinson Pen Drain. Analysis of the topographic data revealed that the roads within the area have slopes generally

ranging from 0.15% to 0.67%, and a general area slope of 0.24% towards the south. Field Reconnaissance accounted for 9 Inlets within the area which included drop inlets, curb inlets and combination inlets.

When compared to the NWA Guidelines, the area had a general lack of sufficiently sized and placed inlets which would allow sufficient drainage. The inlets that were actually present did not conform to spacing requirements, but generally conformed to the distance from the highpoint. See 9.9.1.



Figure 4.17: Photo of inlet in the Stewarts industrial area



Figure 4.18: Photo of flooding along Ashenheim Road in the Stewarts industrial area

Clifton and Oakland

Both the Clifton and Oakland for areas are similarly sloped ranging from 0.7% to 1.7% and a general slope of 1.3% towards the south to the Tinson Pen Gully. Field Reconnaissance revealed 46 inlets in the area. When compared to the NWA Guidelines, the communities that contribute to the runoff to the main drainage channel generally conform to both spacing and highpoint requirements, with a few being not meeting the size requirements. See 9.9.1 for map of Existing Flood Control and Drainage System.



Figure 4.19: Photo of curb inlet leading to the gully servicing the Oakland catchment area



Figure 4.20: Photo of runoff sheet flowing from the road to the gully servicing the Clifton cathcment area.

4.5.2 Shoemaker Gully

The Shoemaker Gully area consists of generally mildly sloped terrain serviced by strategically placed gutters, inlets and culverts which discharge to the Shoemaker Gully main drainage channel. Analysis of the topographic data revealed that the roads within the area have slopes generally ranging from 0.2% to 2%, and a general slope of 3% towards the south. After field reconnaissance and ground truthing a total of 22 inlets were surveyed and accounted for.

When compared to the NWA Guidelines, several inlets within the area did not conform to the spacing requirements as in several instances the spacing exceeded the maximum distance of 80m by as much as 25m. The inlets' distance from the highpoints conformed as the maximum of 200m was not exceeded in any instance. The minimum length of the inlets did not conform to the guidelines as they were generally 0.9m, which is half of the 1.8m length required. See 9.9.1 for map of Existing Flood Control and Drainage System.



Figure 4.21: Photo of inlet that services the Shoemaker catchment area



Figure 4.22: Photo of residential area damaged by flooding along Shoemaker Gully

4.5.3 Newport West

The Newport West area is predominantly flat terrain serviced by a drainage system that consists of network of strategically placed gutters, inlets and culverts, which discharge to the neighboring harbor. Analysis of the topographic data revealed that the roads within the area have slopes ranging from 0.16% to 0.6%, and a general slope of 0.15% towards the harbor. After field reconnaissance a total of 96 inlets consisting of curb inlets, drop inlets and combination inlets were surveyed and accounted for.

When compared to the NWA Guidelines, several inlets within the area did not conform to the spacing requirements as in several instances the spacing exceeded the maximum distance of 80m by as much as 25m. The inlets' distance from the highpoints conformed as the maximum of 200m was not exceeded in any instance. The minimum length of the inlets did not conform to the guidelines as they were generally 0.9m, which is half of the 1.8m length required. See 9.9.1 for map of Existing Flood Control and Drainage System. See 9.9.1.



Figure 4.23: Photos of localized flooding in the Newport West area due to inadequate drainage infrastructure

4.6 Summary

15 major flood control channels and 44 crossings were surveyed. Four of these crossings were considered as being major crossings as they cross major intersections. The major streams and crossings are summarized in Table 4.4 and Table 4.5. The major channels have an estimated total length of 15 km and represent 60% of the total length of the channels in the project area.

A total of 405 inlets were surveyed in the project area during field reconnaissance. They are mostly effective in draining their respective areas; however, it was observed some areas could greatly benefit from the incorporation of inlets. It was also observed that several of the inlets did not conform to the size requirements outlined by the NWA, which can also be said about the spacing and distance from highpoint requirements.

Table 4.4. Summary of major streams and crossings in project area

Catchment	Major Flood control channels	Major crossings (culverts)
Marcus Garvey Drive, Tinson Pen and Jew Gully	<ol style="list-style-type: none"> 1. Oakland gully 2. Clifton gully 3. Tinson Pen gully 4. Jew Gully 5. Marcus Garvey Drive drain 	<ol style="list-style-type: none"> 1. Tinson Pen Drain crossing Marcus Garvey Drive 2. Jew Gully temporary crossing Chesterfield Road
Shoemaker Gully	<ol style="list-style-type: none"> 1. Shoemaker gully 2. Trench town drain 3. Sunlight drain 4. Marcus Garvey Drive drain 	<ol style="list-style-type: none"> 1. Shoemaker Gully crossing Spanish Town Road 2. Shoemaker Gully crossing Marcus Garvey Drive
Newport West	(900 and 1,200 drain pipes)	N/A

Table 4.5. Summary of all and major stream lengths in the project area.

Catchments	Receiving Stream	Drains and gullies stream lengths (m)	Major drains and gullies stream lengths (m)
Marcus Garvey Drive, Tinson Pen, Jew catchment	Molynes	2929	
	Hope Road Drain	2568	
	Upper Oaklands	1344	
	Oaklands Drain	721	721
	Clifton Drain	849	849
	Stewarts	300	300
	Hunts Bay Drain	1661	1661
	Jew Gully-upper	1610	1610
	Jew Gully-lower	2464	2464
	sub-total	14446	7605
Shoemaker Catchment	Upper Shoemaker Gully	1840	
	Central Road Drain	766	
	Mid Shoemaker Gully	1378	1378
	Sunlight Drive Drain	1650	
	Trench Town Drain	2326	2326
	Marcus Garvey Drain	730	730
	Lower Shoemaker Gully	1600	1600
	sub-total	10290	6034
Newport West catchment	NPW Drain 1 (To Outlet)	200	200
	NPW Drain 2 (To Outlet)	460	460
	NPW Drain 3 (To Outlet)	300	300
	NPW Drain 4 (To Outlet)	160	160
	sub-total	1380	1380
	Total	26116	15019

5 Hydrology

The hydrological regime of the main catchments and the project area were investigated to determine the runoff flow rate and velocities to aid in determining the adequacy of the existing drainage system and to assist in developing solutions at the identified areas within the project area. Once potential drainage or flooding hazards were identified appropriate mitigation measures were implemented in the design to prevent storm-water accumulation or overflow.

5.1 Methodology and Data

The methodology entailed hydrological analysis of the sub-catchments under present conditions, and post-improvement (future climate) conditions. Runoffs were calculated using the US Soil Conservation Service (SCS) method using HEC-HMS and confirmed with WinTR-55. The SCS method was used to estimate the runoff hydrograph. This method required the assignment of curve number (CN) for sub-catchments based on soil types and land use. See Table 5.2 for sub-catchment CN assignment. The peak runoffs are generally calculated using the Type III rainfall distribution for catchments in Jamaica and was used for this project. This approach is believed to be conservative as the Type III mass distribution curve is suspected to be more peaked than the extreme rainfall in Jamaica that is also suspected to be bi-modal, versus the SCS curve that is mono-peaked. The approach follows engineering practice with modern hydrological tools.

5.1.1 Process Flow

Both the WinTR-55 and HEC-HMS software uses the SCS method to estimate the runoff hydrograph. To conduct the hydrological assessment, several input parameters were required to determine runoff. These parameters are determined by the area and conditions of the catchments. The parameters required and process (Figure 5.1) are as follows:

Parameter	Description
Watershed Area	Area contributing flow to outlet
Reach Data	This details the parameters for the reaches in the assessment area. This includes length, Manning's Coefficient, slope, channel width, and side slopes.
Design 24-Hour Rainfall (Storm Data)	The 24-Hr Rainfall and their corresponding return period for the assessment area. Rainfall Distribution Type is also selected.
Runoff Curve Number	Roughness factor dependent on Land Use and Soil Type
Manning's Coefficient	Roughness value for watershed area
Elevations	Upper and lower elevations for watercourse and watershed area.

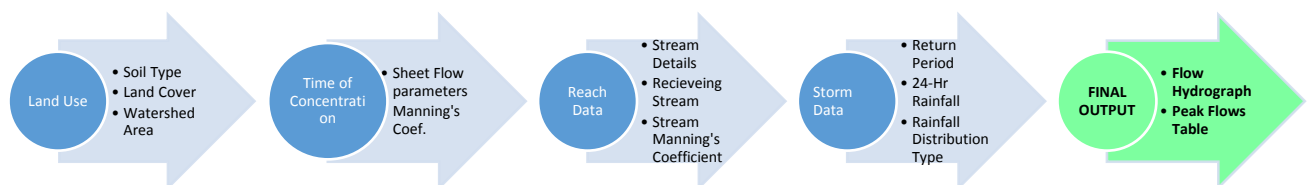


Figure 5.1. TR-55 Process flow chart

5.1.2 Climate change

Future climate extreme rainfall was estimated based on the findings and recommendations of IPCC (2018)⁸ (Figure 5.2). This estimation is based on the probability ratio of heavy precipitation as a function of global warming and event probability. Climate change factors for the 2 to 100-yr were determined to 1.2 to 1.45 for the

⁸ Masson-Delmotte, Valérie, Panmao Zhai, Hans-Otto Pörtner, Debra Roberts, Jim Skea, Priyadarshi R. Shukla, Anna Pirani et al. "Global warming of 1.5 C." An IPCC Special Report on the impacts of global warming of 1 (2018).

2°C above pre-industrial levels conditions. We believe these conditions to be robust to 2050 to 2060 period in the RCP8.5 scenario when Sea Level Rise is estimated to be about 0.4 meters above present levels. Change factors (CCF) were applied to the present climate 24-hour rainfall depth extremes to determine the estimated future climate rainfall extremes (Table5.1).

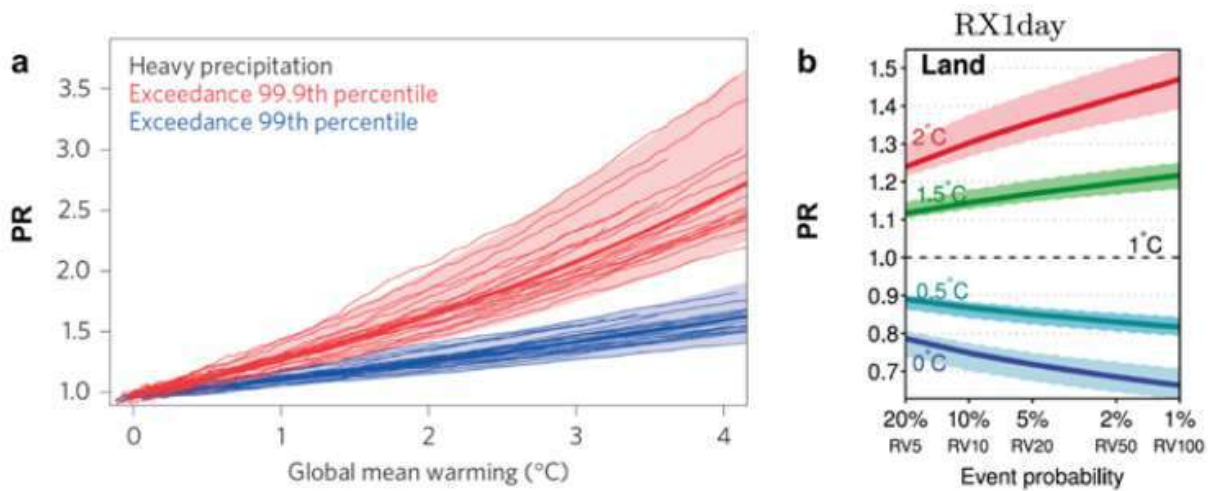


Figure 3.10 | Probability ratio (PR) of exceeding (heavy precipitation) thresholds. (a) PR of exceeding the 99th (blue) and 99.9th (red) percentile of pre-industrial daily precipitation at a given warming level, averaged across land (from Fischer and Knutti, 2015). (b) PR for precipitation extremes (RX1day) for different event probabilities (with RV indicating return values) in the current climate (1°C of global warming). Shading shows the interquartile (25–75%) range (from Kharin et al., 2018).

Figure 5.2: Probably ratio of heavy precipitation as a function of global warming and event probability (IPCC 2018)

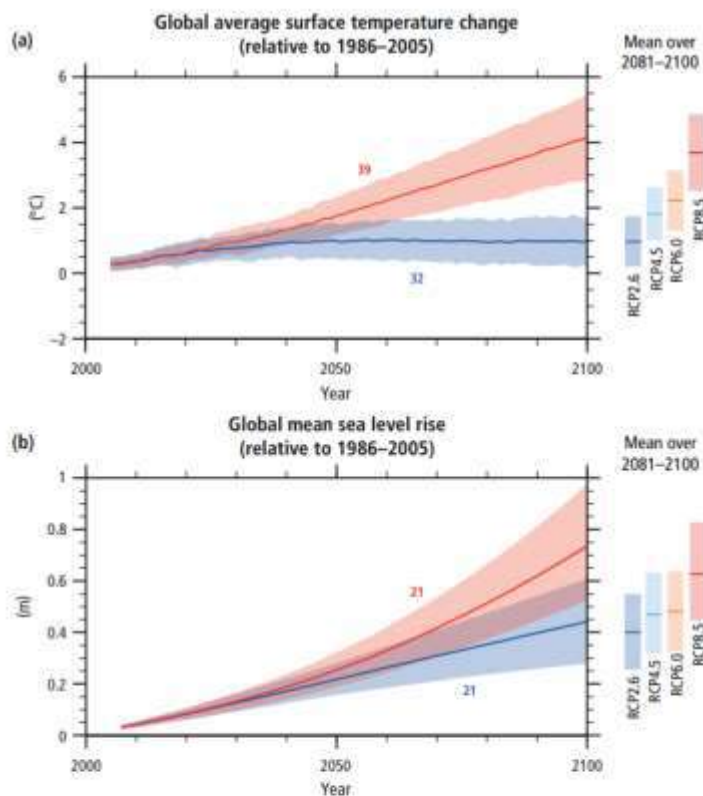


Figure SPM.6 | Global average surface temperature change (a) and global mean sea level rise (b) from 2006 to 2100 as determined by multi-model simulations. All changes are relative to 1986–2005. Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP2.6 (blue) and RCP8.5 (red). The mean and associated uncertainties averaged over 2081–2100 are given for all RCP scenarios as coloured vertical bars at the right hand side of each panel. The number of Coupled Model Intercomparison Project Phase 5 (CMIP5) models used to calculate the multi-model mean is indicated. (2.2, Figure 2.1)

Figure 5.3. IPCC⁹ Global Mean Surface temperatures and Sea Level Rise (SLR) for RCP 8.5

⁹ Change, IPCC Climate. "Synthesis Report. Contribution of working groups I." II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change 151, no. 10.1017 (2014).

Table 5.1: Present climate HWT/Cavalier, CCF (IPCC 2018) and estimated future climate 24-hour rainfall depths at 2C.

Return Period	Present Climate Extreme Rainfall (mm)	Future Climate Change Factors (CCF) (2°C increase)	Future Climate Extreme Rainfall (mm) at 2C	% increase
2	98	1.2	108	10%
5	163	1.25	182	12%
10	213	1.3	238	12%
25	283	1.35	312	10%
50	340	1.4	368	8%
100	401	1.45	424	6%

5.1.3 Rainfall Hyetograph

A hyetograph is the distribution of rainfall intensity over time. For example, in the 24-hour rainfall distributions as developed by the Soil Conservation Service rainfall intensity progressively increases until it reaches a maximum and then gradually decreases. Where this maximum occurs and how fast the maximum is reached is what differentiates one distribution from another. The Type III rainfall distribution curve was used for this assessment as it most accurately reflects the 24-hour rainfall distribution experienced by the island. The SCS distribution curves can be seen in Figure 5.4. Rainfall Hyetographs were generated using the present and future climate condition extreme rainfall and can be seen in Figure 5.4 and Figure 5.5.

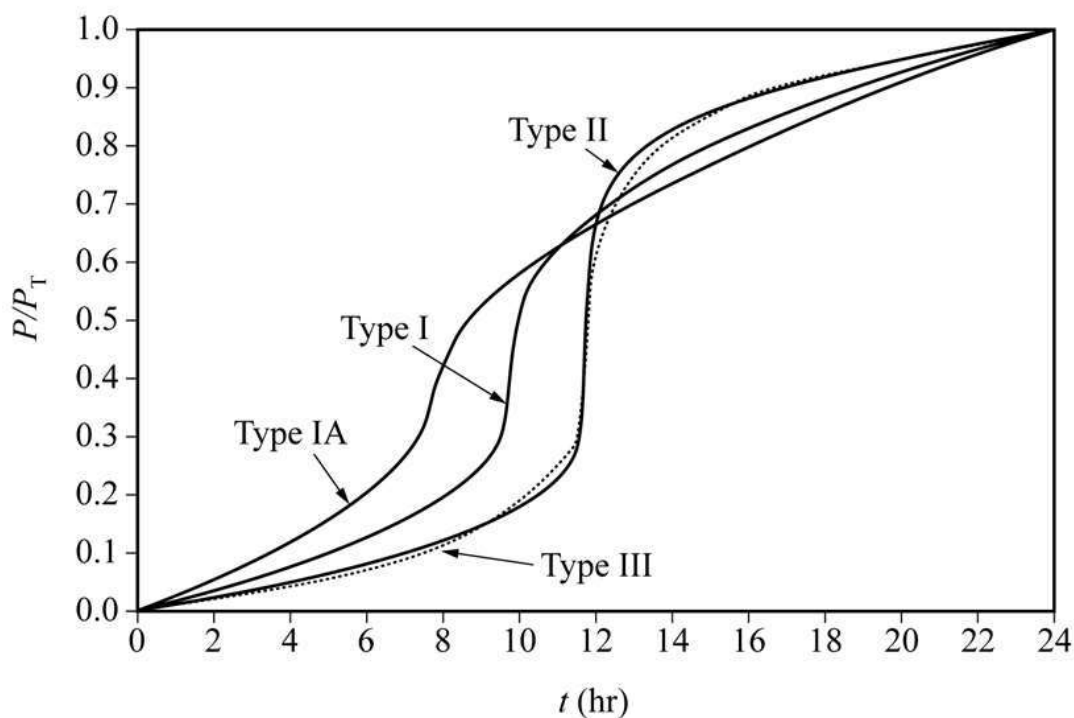


Figure 5.4: SCS Rainfall Distribution Curves

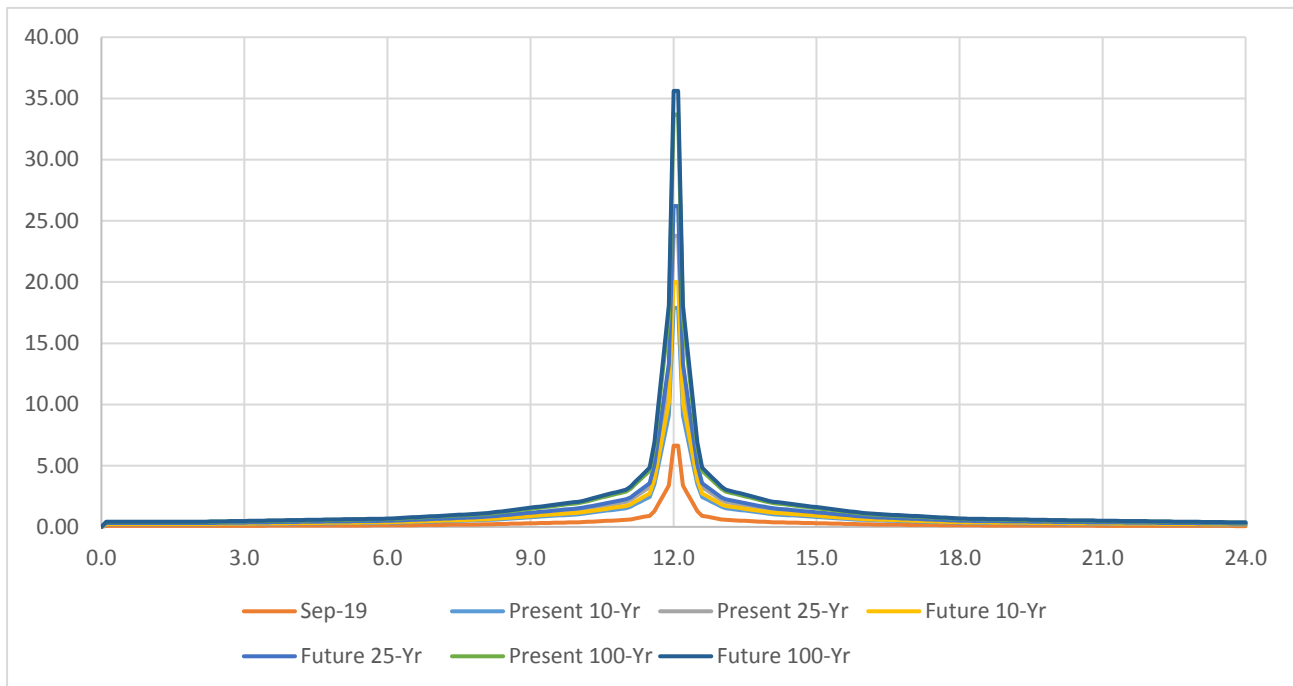


Figure 5.5: Iso-Hyetograph of average Sept. 2019 Event, 10-Yr, 25-Yr, and 100-Yr RP Rainfall Intensities - Present Climate and Future Climate

5.1.4 Routing

Kinematic Routing was used in the hydrological model to account for the diffusion of the runoff wave throughout the catchments. This led to the most realistic (versus more peaked and less practical) flows. A reach element conceptually represents a segment of river or stream. HEC-HMS provided nine routing methods, but not all methods are equally adept at representing a particular stream. For this hydrologic model, the Muskingum-Cunge routing method was used. This method is based on the combination of the conservation of mass and the diffusion representation of the conservation of momentum. It is sometimes referred to as a variable coefficient method because the routing parameters are recalculated every time step based on channel properties and the flow depth. It represents attenuation of flood waves and can be used in reaches with a small slope. The most realistic peak flows were anticipated from the analysis taking channel properties into account.

5.1.5 Hydrological Models

The hydrological models setup in HEC-HMS were created to represent the conditions existing within the watershed area. All the basin models presented consist of combination of several basins, reaches, and junctions to determine the peak flow through each node. Table 5.2 summarizes the components within each basin model and Figure 5.6 shows the spatial relationship of the sub-catchments and reaches.

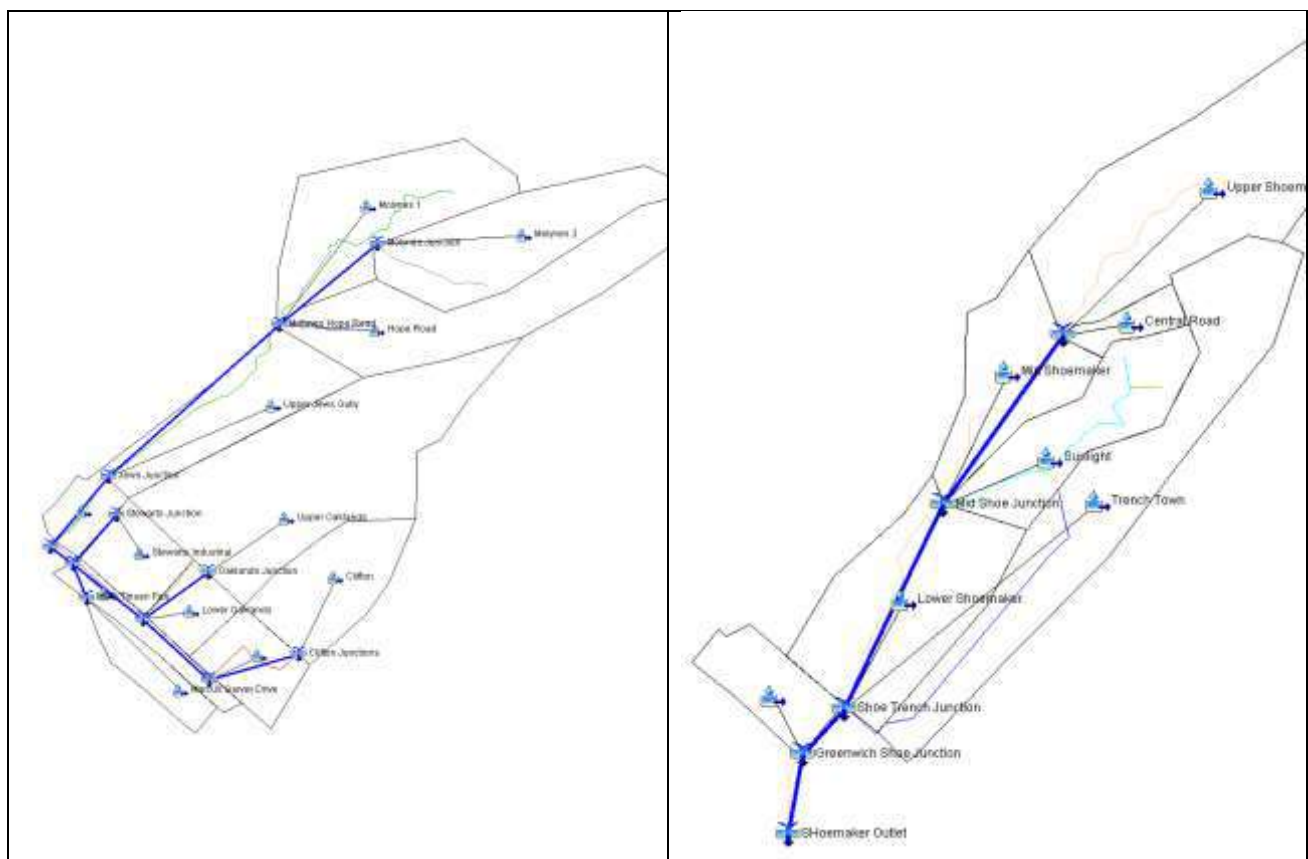
Table 5.2: Summary of basin model components.

Jew, Tinson, MGD Basin Model			
Element Name	Element Type		Downstream Element
		Curve Number	
Marcus Garvey Drive	Sub-Basin	93	MGD Tinson Pen
Clifton	Sub-Basin	91	Clifton Junctions
Lower Clifton	Sub-Basin	92	Clifton Tinson Pen
Upper Oaklands	Sub-Basin	93	Oaklands Junction
Lower Oaklands	Sub-Basin	93	Oaklands Tinson Pen
Stewarts Industrial	Sub-Basin	93	Stewarts Junction
Tinson Pen Aerodrome	Sub-Basin	93	Stewarts, Tinson Pen, MGD

Hope Road	Sub-Basin	94	Molynes Hope Road
Molynes 1	Sub-Basin	93	Molynes Hope Road
Molynes 2	Sub-Basin	93	Molynes Junction
Upper Jew Gully	Sub-Basin	93	Jew Junction
Lower Jew Gully	Sub-Basin	93	Jew Tinson Pen (Outlet)
Clifton to Tinson Pen	Reach		Clifton Tinson Pen
Oaklands	Reach		Oaklands Tinson Pen
Tinson Pen Upper	Reach		Oaklands Tinson Pen
Tinson Pen Lower	Reach		Stewarts, Tinson Pen, MGD
Stewarts Drain	Reach		Stewarts, Tinson Pen, MGD
Marcus Garvey Drain	Reach		Stewarts, Tinson Pen, MGD
Molynes Drain	Reach		Molynes Hope Road
Upper Jew to Lower Jew	Reach		Jew Junction
Lower Jew	Reach		Jew Tinson Pen (Outlet)
Tinson Pen to Jew	Reach		Jew Tinson Pen (Outlet)

Element Name	Element Type		Downstream Element
		Curve Number	
Element Name	Element Type	Curve Number	Downstream
Upper Shoemaker	Sub-Basin	92	Upper Shoe Junction
Central Road	Sub-Basin	92	Upper Shoe Junction
Sunlight	Sub-Basin	92	Mid Shoe Junction
Mid Shoemaker	Sub-Basin	92	Mid Shoe Junction
Trench Town	Sub-Basin	90	Shoe Trench Junction
Lower Shoemaker	Sub-Basin	85	Shoe Trench Junction
Greenwich Town	Sub-Basin	92	Greenwich Shoe Junction
Mid Shoemaker Reach	Reach		Mid Shoe Junction
Mid Shoe Reach	Reach		Shoe Trench Junction
Shoe (before crossing) Reach	Reach		Greenwich Shoe Junction
Shoe to outlet reach	Reach		Shoemaker Outlet

Shoemaker Basin Model			
Element Name	Element Type	Curve Number	Downstream
NPW 1	Sub-Basin	94	NPW 1 Outlet
NPW 2	Sub-Basin	94	NPW 2 Outlet
NPW 3	Sub-Basin	94	NPW 3 Outlet
NPW 4	Sub-Basin	94	NPW 4 Outlet



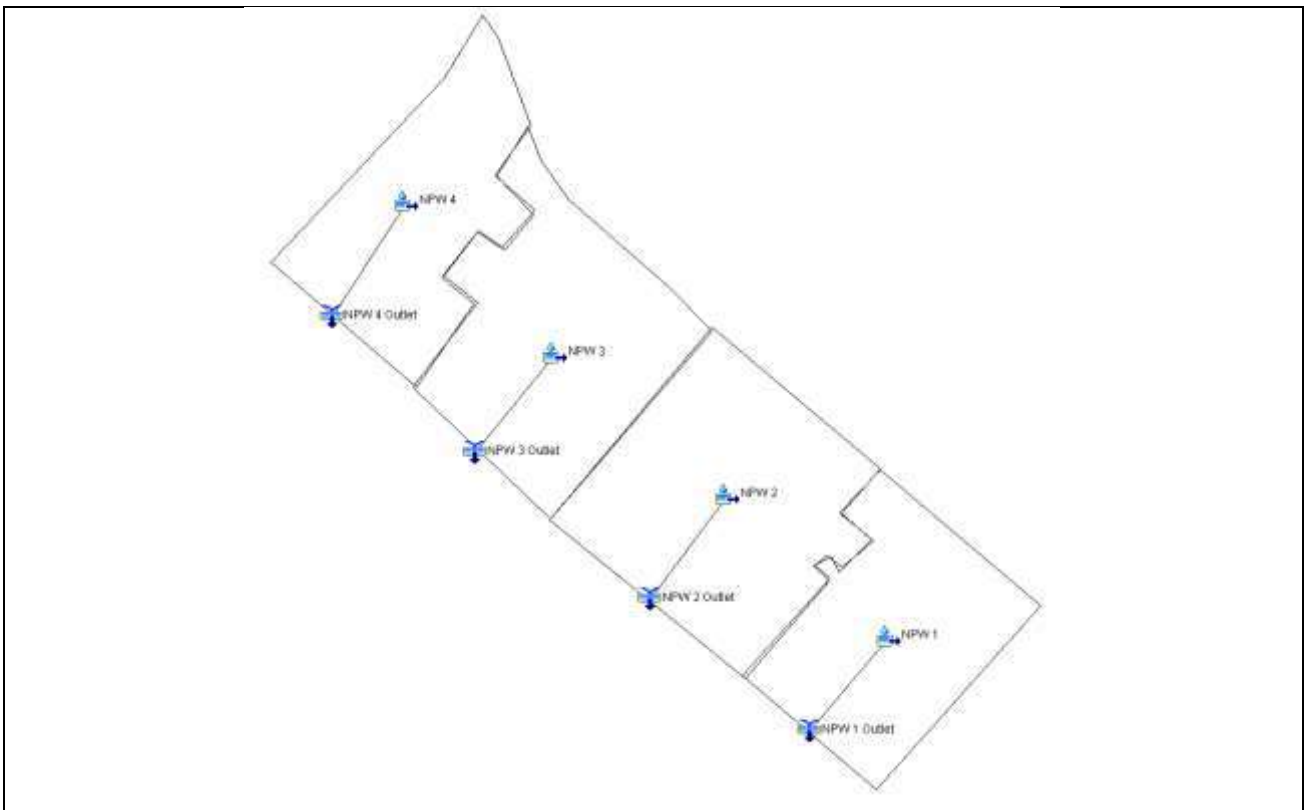


Figure 5.6: HEC-HMS Basin Model setup for Marcus Garvey, Tinson Pen and Jew Gully (top left), Shoemaker Gully (top right) and Newport West (bottom)

5.2 Peak flows: Present and Future Climate

The project area is located at the lowest points of the three main catchments in focus, where the flows within the catchments concentrates in the Jew and Tinson Pen Gullies, Shoemaker Gully and Newport West Drains, where they run to the ocean. The catchment area contains mostly developed land with a homogenous mixture of commercial, industrial and residential spaces, though dominated by residential. Two rainfall stations were used to conduct the analysis as their proximity to the assessment area gave a good representation of the rainfall in the project area, and the catchments leading to it. Modelling was conducted using a combination of the HEC-HMS and WinTR-55 hydrologic modelling software to determine the flows, and isolate the areas of concern, to efficiently determine and address the issues faced.

5.2.1 Marcus Garvey, Tinson Pen and Jew Gullies

The Jew Gully/Tinson Pen catchment comprises of two drains which converge before flowing to the ocean. This is a known hotspot for flooding and as such is an area of interest. At the end of the Tinson Pen drain, before converging with runoff from the Jew Gully, the estimated peak flows for the Isolated event (September 2019), the 10-Yr Return Period, 25-Yr Return Period and 100-Yr Return Period were 66 m³/s, 205 m³/s, 270 m³/s and 367 m³/s respectively. The combined flow for the Jew Gully and Tinson Pen drains for the same return periods were 130 m³/s, 406 m³/s, 632 m³/s and 729 m³/s. See Table 5.3 that details the peak runoff expected.

Table 5.3: Peak Runoff Analysis Pre-Improvement within the Marcus Garvey, Tinson Pen and Jew Gullies catchment (areas of focus highlighted in Bold). Existing capacity also shown in red when exceeded by 25-year RP

Catchment	Catchment Area (ha)	Receiving Stream	Current Drainage Capacity (m ³ /s) @ 25% freeboard	Present Climate Peak Flow Through Stream (m ³ /s)				Future Climate Peak Flow Through Stream (m ³ /s)			
				10-Yr	25-Yr	50-Yr	100-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Molynes	246	Molynes	32.2	147.3	196.7	236.9	279.9	164.9	217.2	256.6	296.1
Hope Road	129	Hope Road Drain	105	54.3	72.5	87.3	103.1	60.8	80	94.5	109
Upper Oaklands	220	Upper Oaklands	9.8	101.2	135.3	162.9	192.4	113.4	149.4	176.5	203.6
Oaklands	26	Oaklands Drain	21.8	149.2	200.7	242.6	287.4	167.6	222.1	263.2	304.4
Clifton	117	Clifton Drain	32.5	47.4	63.8	77.2	91.4	53.3	70.6	83.7	96.8
Stewarts	38	Stewarts	4.8	16.1	21.5	25.9	30.5	18	23.7	28	32.3
Marcus Garvey Drive	30	Hunts Bay Drain	0.4	10.5	12.8	15.4	18.2	10.7	14.1	16.6	19.2
Tinson Pen	25	Jew Gully	48.8	183.2	244.6	294.4	374.4	205.2	270	318.8	367.4
Jew Gully	109	Jew Gully (To Outlet)	79.9	170.1	227.4	274.4	324.8	190.6	251.3	297.5	343.9
Jew Gully (Outlet)				362	483.9	583.2	689.2	405.6	534.4	631.8	729.2

5.2.2 Shoemaker Gully

Pre-development in the context of this assessment describes the condition of the project area prior to improvements. The hydrological model was used to determine the pre-improvement peak flow for current conditions for the 10-yr - 100-yr return period events. Additionally, an isolated rainfall event that occurred in September 2019 was used as a means to calibrate the model. At the end of Shoemaker Gully, the estimated peak flows for the Isolated event (September 2019), the 10-Yr Return Period, 25-Yr Return Period, and 100-Yr Return Period were 81.5 m³/s, 243 m³/s, 326 m³/s and 467 m³/s respectively. See Table 5.4 that details the peak runoff expected.

Table 5.4: Peak Runoff Analysis Pre-Improvement within the Shoemaker Gully associated catchment and project area (Area of focus highlighted in Bold). Existing capacity also shown in red when exceeded by 25-year RP

Catchment	Catchment Area (ha)	Receiving Stream	Current Drainage Capacity (m ³ /s) @ 25% freeboard	Present Climate Peak Flow Through Stream (m ³ /s)				Future Climate Peak Flow Through Stream (m ³ /s)			
				10-Yr	25-Yr	50-Yr	100-Yr	10 Yr	25 Yr	50 Yr	100-Yr
Upper Shoemaker	177	Upper Shoemaker Gully	32	84.4	112.9	136.1	160.8	94.6	124.7	147.5	170.2
Central Road	14.6	Central Road Drain	17	6.5	8.7	10.5	12.4	7.3	9.6	11.3	13.1
Mid Shoemaker	67.8	Mid Shoemaker Gully	56	137.7	184.8	223.1	264	154.6	204.3	241.9	279.4
Sunlight Drive	68.95	Sunlight Drive Drain	14	30.7	41.1	49.6	58.6	34.4	45.4	53.7	62
Trench Town	154.1	Trench Town Drain	23	59.5	80	96.7	114.5	66.8	88.5	104.9	121.2
Greenwich Town	34.7	Marcus Garvey Drain	1	15.2	20.3	24.4	28.9	17	22.4	26.5	30.6

Lower Shoemaker	107.3	Lower Shoemaker Gully (Outlet)	147	242.6	326.4	394.5	467.2	272.5	361.1	427.9	494.6
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5.2.3 Newport West

Newport west consists of underground drains that carry runoff from the roads within that area to the ocean via underground pipes. The drop inlets that service these underground pipes are strategically placed to correspond to three separate catchments. See Table 5.5 that details the flow through each underground pipe for the corresponding return period.

Table 5.5: Peak Runoff Analysis: Pre-Improvement within the Newport West associated catchments. Existing capacity also shown in red when exceeded by 25-year RP

Catchment	Catchment Area (ha)	Receiving Stream	Current Drainage Capacity (m ³ /s) @ 25% freeboard	Present Climate Peak Flow Through Stream (m ³ /s)				Future Climate Peak Flow Through Stream (m ³ /s)			
				10-Yr	25-Yr	50-Yr	100-Yr	10 Yr	25 Yr	50 Yr	100-Yr
Newport West 1	9.96	NPW Drain 1 (To Outlet)	0.9	4.4	5.8	7	8.3	4.9	6.4	7.6	8.8
Newport West 2	13.35	NPW Drain 2 (To Outlet)	0.9	5.8	7.8	9.3	11	6.5	8.6	10.1	11.7
Newport West 3	11.95	NPW Drain 3 (To Outlet)	0.9	5.3	7	8.4	9.9	5.9	7.7	9.1	10.5
Newport West 4	9.58	NPW Drain 4 (To Outlet)	1.9	4.2	5.6	6.7	8	4.7	6.2	7.3	8.4

5.3 Comparison to Previous studies

5.3.1 Stanley Drainage Report Master Plan

The Stanley Drainage Master Plan Report was conducted before the Hagley Park Road Improvement Project in 2019, and identified several project study areas located within the Kingston Metropolitan area. There included: Constant Spring Road, Hagley Park Road, Mid-Town Kingston and Mona Road. The Stanley report investigated the instances and causes of flooding in the areas mentioned, and proposes solutions to alleviate said issues. For the purposes of this report it was intended to compare the infrastructure and corresponding flows of Hagley Park Road to the peak flows entering the project area through the Jew Gully watershed. However, the report focused on the instances of flooding and mitigation techniques for the street level drainage north of this report's project area, while this report focuses on addressing issues within the main drainage channels along Jew Gully, Tinson Pen, Marcus Garvey Drive and Shoemaker Gully. It was not possible to compare the results of both studies given that there was marginal overlapping of the study areas.

5.3.2 Newport West Engineering Assessment Report for Storm-water Drainage System

This report focused on the Newport West drainage system which southwest of our project area. It explores the existing drainage system and its ability to carry ease localized flooding in the area. For the purposes of this report, the infrastructure and its corresponding flows were compared to the peak flows through the project area. When compared to the NOWAL report, this reports peak flows for Drainage Area 1 were noticeably higher, with an average difference of 17% across the return periods. This trend continues with Drainage Area 3, with peak flows being an average of 26% higher across the return periods. Peak Flows for Drainage Area 2 were lower with an average difference of -9% across the Return Periods. Drainage Area 4 presented the least difference with an average of 3% higher across the return periods. These differences may be attributed to different rainfall intensities used for the calculations, as they were not presented in the report.

Table 5-5.6: Comparison Table between NOWAL's and CEAC's Peak Flows for Newport West study area.

Drainage Area	NOWAL			CEAC		
	10-Yr	25-Yr	50-Yr	10-Yr	25-Yr	50-Yr
Newport West 1	4.35	5.53	6.26	4.9	6.4	7.6
Newport West 2	7.43	9.54	10.53	6.5	8.6	10.1
Newport West 3	4.84	6.15	6.88	5.9	7.7	9.1
Newport West 4	4.58	6.1	6.98	4.7	6.2	7.3

5.4 Summary

Peak flows of the catchment areas were determined. At the end of the Tinson Pen drain, before converging with runoff from the Jew Gully, the estimated peak flows for the Isolated event (September 2019), the 10, 25, 50 and 100-Yr Return Period were 66 m³/s, 183 m³/s, 245 m³/s, 294 m³/s and 374 m³/s respectively. The combined flow for the Jew Gully and Tinson Pen drains for the same return periods were 130 m³/s, 362 m³/s, 284 m³/s, 583 m³/s and 689 m³/s. At the end of Shoemaker Gully, the estimated peak flows for the same event and RP were 81.5 m³/s, 243 m³/s, 326 m³/s, 394 m³/s and 467 m³/s respectively. These flows (Table 5.7) considerably exceed the estimated capacities in the respective drains. The results are comparable to previous studies, were overlap of the study areas allowed for a comparison.

Table 5.7. Summary of peak flows (m³/s) for September 2019, 10, 25, 50 and 100-year RP events

Catchment	Receiving Stream	Isolated Event Sept 2019	10-Yr	25-Yr	50-Yr	100-Yr
Tinson Pen	Jew Gully	65.6	183	245	294	374
Jew Gully	Jew Gully (To Outlet)	61	170	227	274	325
Jew Gully (Outlet)		129.6	362	284	583	689
Lower Shoemaker	Lower Shoemaker Gully (Outlet)	81.5	243	326	394	467
Newport West 1	NPW Drain 1 (To Outlet)	1.6	4.4	5.8	7	8.3
Newport West 2	NPW Drain 2 (To Outlet)	2.1	5.8	7.8	9.3	11
Newport West 3	NPW Drain 3 (To Outlet)	1.9	5.3	7	8.4	9.9
Newport West 4	NPW Drain 4 (To Outlet)	1.5	4.2	5.6	6.7	8

6 Hydraulics and Flood Plain analysis

6.1 Method

Both a preliminary and detailed hydraulic analysis were undertaken. Firstly, to gain an understanding of deficiencies and then to develop a detailed understanding of water surface profiles and flooding issues. Preliminary hydraulic capacity assessment was undertaken to develop an understanding of the existing flood control channels and the requirements for improvement works. The methodology adopted was as follows:

1. Each catchment area is identified and delineated, and their associated slopes determined by evaluating the elevations of the upper and lower points of the catchment.
2. The receiving reach was identified and its dimensions (length, width, depth, side slopes and channel slopes) evaluated.
3. Determination of each reach's normal and critical depth flow regime
4. Determination of each reach's flow regime (super or sub-critical)
5. The flow depth for each reach is estimated for present climate and existing dimensions.
6. An evaluation of the dimensions required for future peak flows with 25% freeboard conducted to determine potential solution for current flooding issue.

HEC-RAS was used to model the flood plain analysis and flood control works in both present (existing conditions) and future climate (with improvements). Future climate Sea Level Rise (SLR) was directly considered by ensuring that the end of the flood control system was above the anticipated MSL of 0.4 meter in 2050-2060. This approach allowed for an examination of the water surface profile, transition between super-critical and sub-critical flow and to estimate flood inundation depth over the terrain methodology is as follows:

1. Each drain defined as a reach with bank lines.
2. Cross sections were defined based on LiDAR data and in the field surveys
3. The culverts in each drain were defined in the project area
4. Peak flows were set at the top of each reach
5. Boundary Conditions were set at the out fall of each reach

The hydraulic capacity of the culverts in the project area were also assessed and presented in section 6.5. The culverts were assessed using the HY-8 culvert analysis US DOT in conjunction with HEC-RAS. The method used to evaluate the effect of the culverts on the flood plain entailed the following steps.

1. Existing crossings were digitized and modelled in HEC-RAS to determine the areas worst affected
2. The proposed culverts were tested in HY8 to ensure that there is no overtopping during peak flow
3. The proposed crossings were digitized in the HECRAS model in order to evaluate the reduction in flooding around the gullies

Assessment of minor or road drainage was guided by the requirements of the National Works Agency (NWA) Guidelines for Preparing Hydrologic and Hydraulic Design Reports for Drainage Systems of Proposed Developments (2015)¹⁰. In summary, collector drains/sewers are to be constructed from any high point on the road for a distance not exceeding that as set out in Table 6.1.

Table 6.1. Maximum inlet distance from highpoint and corresponding gradients

Road Gradient (%)	Distance from high point (m)
<1.0	200.00
to 4.9	160.00
5.0 to 10.0	120.00
>10	60.00

Maximum allowable length of storm sewer inlets shall be 80m and the minimum length of inlets shall be 1.8m. Where inlets are located at a low point, a minimum length of 1.0m is recommended.

¹⁰ NWA (2015). *Guidelines for Preparing Hydrologic and Hydraulic Design Reports for Drainage Systems*. National Works Agency

The drainage was design to the NWA Guidelines (2015)¹¹. Compliance with NWA guidelines were first explored. Where deficiencies were found then recommendations for additional inlets were made. Given the difficulties in observing the drainage pipes it was assumed that these would be exposed and if needs be replaced. Conceptual design was based on the likely range of longitudinal profile slopes in the project area and application of typical sewer sizes and slopes in keeping with the guidelines. For instance:

1. A return period of 5 year was used with a time of concentration based on typical lot dimensions and slopes and the corresponding road profiles for each of the sub-catchments. This allow for some hydrological routing to be accounted for and more economical designs
2. Given the relatively flat terrain, 1.8 L x 0.3 W combination side inlet (typically referred to as “double inlet”) and gratings (with P1-7/8 grating) on grade (with 75mm suppression) were assumed in the estimation of the capacities. 25% clogging was assumed as well to take into account maintenance and debris issues. It was intended not to exceed the typical 150 to 200mm curb height at peak flow and to remove the said flow at the recommended spacing of less than 200 meters. Care was taken to place inlet at intersection in particular, to remove by-pass flows accumulating at critical locations.
3. Sewer sizes were match to correspond to the areas of the urban catchment estimated from the uppermost extremes to the corresponding flood control works.

6.2 Preliminary Capacity Assessment

6.2.1 Marcus Garvey Drive, Tinson Pen Drain and Jew Gully

6.2.1.1 Marcus Garvey Drive

Several instances of isolated flooding have occurred along the Marcus Garvey Drive, which evidence suggests is a result of inadequate drainage. The key drainage channel along Marcus Garvey Drive 0.6m x 1m channel with a slope of 0.1%, and runs parallel to the roadway. As it exists currently, the channel has a capacity of 0.4m³/s which is woefully inadequate for carrying flows for runoff corresponding to any storm event exceeding September 2019 event. The inadequacy of this Marcus Garvey Drive drain can be attributed to both the flat slope of channel and the small dimensions relative to the area to be drained.

6.2.1.2 Tinson Pen Drain

The Tinson Pen Drain carries runoff from a relatively large catchment area from north of the project area and eventually to the Kingston Harbor. Instances of flooding during heavy rainfall events suggest inadequacy of the channel to carry the required capacity to mitigate against flooding. The channel is 8m x 2m with a slope of 0.2%, and a carrying capacity of 49m³/s. As with the Marcus Garvey Drive Drain, the inadequacy of the drain can be attributed to both the flat slope of the channel and the small dimensions of the channel relative to catchment area being relieved.

6.2.1.3 Jew Gully

Instances of flooding of the Jew Gully during heavy rainfall events suggest inadequacy of the channel to carry the flow from the catchments upstream of the project area. The channel as it exists is 5.6m x 2.6m with an average slope of 1.3%, which results in a carrying capacity of 79m³/s. When compared to the peak runoff during several return periods, it was observed that the channel is incapable of carrying the flow as it exceeds when it experiences any return period events exceeding 2-5 years. As with the afore mentioned channels, the inadequacy of Jew Gully can be attributed to the small dimensions of the channel relative to the watershed area being serviced.

Table 6.2: Summary of Peak Flows through catchments and reaches for the Jew Gully catchment (red highlight means undersized and green highlights mean sufficiently sized)

Catchment	Area (ha)	Receiving Stream	Stream Length (m)	Capacity (m ³ /s) @25% freeboard	Peak Flow Through Stream (m ³ /s)					
					Isolated Event Sept 2019	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Molynes	246	Molynes	2929	32.2	53	125	165	217	257	296

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Hope Road	129	Hope Road Drain	2568	105	20	46	61	80	95	109
Upper Oaklands	220	Upper Oaklands	1344	9.8	37	86	113	149	177	204
Oaklands	26	Oaklands Drain	721	21.8	53	126	168	222	263	304
Clifton	117	Clifton Drain	849	32.5	17	40	53	71	84	97
Stewarts	38	Stewarts	300	4.8	6	14	18	24	28	32
Marcus Garvey Drive	30	Hunts Bay Drain	1661	0.4	4	8	11	14	17	19
Tinson Pen	25	Jew Gully	1610	48.8	66	156	205	270	319	367
Jew Gully	109	Jew Gully (To Outlet)	2464	79.9	61	145	191	251	298	344
Jew Gully (Outlet)					130	308	406	534	632	729

6.2.2 Shoemaker Gully

The shoemaker gully is a 10m x 2.6m channel with a slope of 1.5%, which results in a carrying capacity of 147m³/s. When compared to the peak runoff during several return periods, it was observed that the channel is incapable of carrying the flow as it exceeds when it experiences any return period events exceeding 2-5 years. The inadequacy of the channel can be attributed to the dimension of the channel as it relates to its ability to service its watershed area.

Table 6.3: Summary of Peak Flows through catchments and reaches for the Shoemaker Gully catchments

Catchment	Area (ha)	Receiving Stream	Stream Length (m)	Capacity (m ³ /s) @25% freeboard	Peak Flow Through Stream (m ³ /s)					
					Isolated Event Sept 2019	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Upper Shoemaker	177	Upper Shoemaker Gully	1840	31.9	29.3	81.5	108.5	140.2	168	198
Central Road	14.6	Central Road Drain	766	17.3	2.3	6.3	8.3	10.8	13	15.2
Mid Shoemaker	67.8	Mid Shoemaker Gully	1378	56	47.5	133	177.5	229.8	276	325
Sunlight Drive	68.95	Sunlight Drive Drain	1650	14	10.7	29.7	39.5	51	61	72
Trench Town	154.1	Trench Town Drain	2326	22.7	19.8	57.4	76.9	99.7	120	141
Greenwich Town	34.7	Marcus Garvey Drain	730	0.8	5.3	14.7	19.5	25.2	30	36
Lower Shoemaker	107.3	Lower Shoemaker Gully	1600	147.1	81.5	234.2	313.5	406.5	489	576

6.2.3 Newport West

The Newport West drainage system comprises of a network of inlets and underground pipes ranging from 0.9m-1.2m in diameter which carry runoff from within the catchment to the Kingston Harbor. The 0.9m pipes have a carrying capacity of 0.9m³/s, while the 1.2m pipe has a carrying capacity of 1.9m³/s. When compared to the peak runoff within the catchment area, the drainage system within the Newport West 1, 2 and 3 drainage areas are incapable of carrying flows for when faced with any return period events exceeding 1 to 2-Yr. The drainage system servicing Newport West 4 failed to carry flows up to and exceeding any event surpassing 2 to 5-Yr. As several instances of localized flooding has occurred in the Newport West area, it corroborates the findings of inadequacy of the drainage system.

Table 6.4: Summary of Peak Flows through catchments and reaches for the Newport West catchments

Catchment	Area (ha)	Receiving Stream	Stream Length (m)	Pipe Diameter (m)	Capacity (m ³ /s) @25% Freeboard	Peak Flow Through Stream (m ³ /s)					
						Isolated Event Sept 2019	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Newport West 1	9.96	NPW Drain 1 (To Outlet)	200	900	0.9	1.6	3.8	4.9	6.4	7.6	8.8
Newport West 2	13.35	NPW Drain 2 (To Outlet)	460	900	0.9	2.1	5	6.5	8.6	10.1	11.7
Newport West 3	11.95	NPW Drain 3 (To Outlet)	300	900	0.9	1.9	4.5	5.9	7.7	9.1	10.5
Newport West 4	9.58	NPW Drain 4 (To Outlet)	160	1200	1.9	1.5	3.6	4.7	6.2	7.3	8.4

6.3 Flood Control Works

See appendices 9.9.2 for the conceptual design of the proposed flood control and drainage solutions

6.3.1 Marcus Garvey Drive, Tinson Pen, and Jew Gully Improvements

6.3.1.1 Marcus Garvey Drive and Tinson Pen Drain Improvements

It is proposed that the Marcus Garvey Drive drainage system be upgraded by widening to a width of 3m and a depth of 1.5m to assist in easing the current flooding situation in the area for a 10-Yr RP event. The resulting drain has a capacity of 24 m³/s, which exceeds the peak flow of the future 10-Yr RP event of 10.7m³/s. However, the modelling conducted indicate that the improvement of the Tinson Pen and Jew Gully Drains will significantly reduce the instances of flooding along the Marcus Garvey Drive area.

For the Tinson Pen Drain, it is proposed that the drainage system be upgraded by widening the channel to 18m, and deepening to 3m to carry the flow. The result is a drain with a capacity of 257m³/s, which exceeds the future 10-Yr RP event of 205.2m³/s. In addition to the drain, the crossing at Marcus Garvey Drive is to be upgraded from a 3-cell to 5-cell culvert, matching the width of the drainage channel.

Both seepage and SLR were directly considered. High groundwater levels (0.5 to 1.5 m above MSL) in this area will make construction challenging. However, seepage rates of 0.13 m³/s are relatively small in comparison to peak flows and are not expected to compete with hydraulic capacity. The invert of the most downstream channel (0.65m) is above the anticipated MSL (0.4m) at the end of the 2050-2060 period and the flood control works are expected to be resilient providing that they are built to the required grades.

6.3.1.2 Jew Gully Improvements

It is proposed that the Jew Gully Drainage channel be widened to 10m and deepened to 4.5m to carry the flow for the 10-Yr RP event. The result is a drain with a capacity of 257 m³/s, which exceeds the 10-Yr RP peak flow of 190m³/s. It must be noted that the extent of this improvement is limited by the presence of the residents along the banks of the gully, in the 10- and 25-year return period deepening of the channel was prioritized rather than widening to reduce impact. However, in the higher return periods it becomes unavoidable as the base elevation of the channel falls below sea level.

Table 6.5: Summary of Improvements capacities for Marcus Garvey, Tinson Pen and Jew Gullies, along with design Capacity for the 10-Yr, 25-Yr, 50-Yr and 100 Yr. (yellow highlights mean channel to be upgraded)

Catchment	Receiving stream	10 RP		25 RP		50 RP		100 RP		Slope (%)	Design Capacity for respective return periods (25% free board)			
		Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)		10 YR FC	25 YR FC	50 YR FC	100 YR FC
Oaklands	Oaklands Drain	6	4	6	4	8	4	10	4	1.0	187	251	303	359
Clifton	Clifton Drain	6	3	6	3	8	3	10	3	0.9	67	88	105	121
Marcus Garvey Drive	Hunts Bay Drain	3	1.5	4	1.5	4	1.5	6	1.5	0.4	13	18	21	24
Tinson Pen	Jew Gully	18	3	20	3	24	3	26	3	0.2	257	338	399	459
Jew Gully	Jew Gully	10	4.5	10	5.5	12	5.5	14	5.5	0.4	238	314	372	430
Lower Jews gully	Lower Jews gully	75	5	75	5	75	5	75	5	0.1	912	912	912	912

6.3.1.3 Detention Pond

Another proposed upgrade to the drainage channel is the inclusion of detention basin where the Tinson Pen drain and Jew Gully intersect. This basin has a capacity of approximately 40,000m³ and an invert of -3.0 m, and serves as a debris collection and cleaning point before runoff gets to the harbor.

6.3.2 Shoemaker Gully Improvement

Flooding along the Shoemaker Gully occurs primarily just before the final crossing by Marcus Garvey Drive. To reduce the instances of flooding in this area, it is proposed that the channel be widened to 12m and deepened to 3m from 50 meters upstream the junction between trench town and Shoemaker to about 50 meter before the final crossing. This results in a capacity of 193 m³/s, which exceeds the peak flow during a future 10-Yr RP rainfall event of 154m³/s, which should significantly reduce the instances of localized flooding in the area. In addition, from the last crossing the outfall the channel be widened to 20 meters and deepened to -3.0 meters in order to reduce the localized flooding upstream with the hydraulic jump. The carrying capacity of 340 m³/s, which exceeds the 10-Yr RP peak flow of 272.5 m³/s, which can more than handle any flows through the gully. Both seepage and SLR were directly considered. Groundwater levels (0.5 to 1.5 m above MSL) in the lowest reaches will make construction challenging. However, seepage rates of 0.08 m³/s are relatively small in comparison to peak flows and are not expected to compete with hydraulic capacity. The invert of the most downstream channel (0.45m) is above the anticipated MSL (0.4m) at the end of the 2050-2060 period and the flood control works are expected to be resilient providing that they are built to the required grades.

Table 6.6. Summary of Improvements for Shoemaker Gully, along with design Capacity for the 10-Yr, 25-Yr, 50-Yr and 100 Yr. (yellow highlights mean channel to be upgraded)

Catchment	Receiving stream	10 RP		25 RP		50 RP		100 RP		Slope (%)	Design Capacity for respective return periods (25% free board)			
		Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)		10 YR FC @25 %	25 YR FC @25 %	50 YR FC @25 %	100 YR FC @25 %
Upper Shoemaker	Upper Shoemaker Gully	6	2.5	6	2.5	8	2.5	12	2.5	1.5	221	221	300	363
Mid Shoemaker	Mid Shoemaker Gully	12	2	14	3	16	3	18	3	0.3	193	255	302	349
Lower Shoemaker	Lower Shoemaker Gully	20	3	20	4	20	4	20	4.5	0.3	340	451	534	618

6.3.3 Newport West Improvements

To reduce the instances of flooding in the Newport West area, it is proposed that a large section of the drainage system, including inlets and the underground pipe network be upgraded to meet the needs of the catchment area. The improvement includes the strategic upgrade of key inlets, and upgrading the underground piping to underground concrete box drains measuring 5.5m x 1.2m, 3.4m x 1.2m, and 1.3m x 1.2, with an increased capacity of 22 m³/s, 16 m³/s and 8 m³/s respectively, for Newport West 1 -4.

Alignment and construction of the revetment under the berths is uncertain at this time. NWA is advised to consult with Port Authority on the feasibility of the proposed construction and the details of the shoreline under the berths. Both concrete and armour stone revetment works are anticipated under the berth. This has to be combined with the operational nature of the port and the phasing of these works with the use of the berths.

Both seepage and SLR were directly considered. High groundwater levels (0.5 to 1.5 m above MSL) in this area will make construction challenging. However, seepage rates of 0.01 m³/s are relatively small in comparison to peak flows and are not expected to compete with hydraulic capacity. The invert of the most downstream channel (0.5m) is above the anticipated MSL (0.4m) at the end of the 2050-2060 period and the flood control works are expected to be resilient providing that they are built to the required grades.

Table 6.7: Summary of Improvements capacities for Newport West, along with design Capacity for the 10-Yr, 25-Yr, 50-Yr and 100 Yr.
(yellow highlights mean channel to be upgraded)

Catchment	Receiving stream	10 RP		25 RP		50 RP		100 RP		Slope (m/m)	Design Capacity for respective return periods (25% free board)			
		Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)	Width (m)	Depth (m)		10 YR FC @25 %	25 YR FC @25 %	50 YR FC @25 %	100 YR FC @25 %
Newport West 1	NPW Drain 1 (To Outlet)	3.4	1.2	3.4	1.2	3.4	1.2	3.4	1.2	0.003	15.2	15.2	15.2	15.2
Newport West 2	NPW Drain 2 (To Outlet)	5.5	1.2	5.5	1.2	5.5	1.2	5.5	1.2	0.004	27.6	27.60	27.60	27.60
Newport West 3	NPW Drain 3 (To Outlet)	3.4	1.2	3.4	1.2	3.4	1.2	3.4	1.2	0.002	15.2	15.2	15.2	15.2
Newport West 4	NPW Drain 4 (To Outlet)	1.3	1.2	1.3	1.2	1.3	1.2	1.3	1.2	0.015	12.1	12.1	12.1	12.1

6.4 Minor Drainage Works

6.4.1 Capacities

6.4.1.1 Peak flow

Peak design flow of 0.3 m³/s·ha for the 5-yr RP was determined and is comparable to the 10-year RP flow. This is based on a rainfall intensity of 95mm/hr. Variations in sub-catchment slopes of 0.25% to 1.5% did not affect the estimate much and we believe this peak flow per hectare to be robust, given the nature of the urban catchment.

6.4.1.2 Gutter capacity

Gutter flow and inlet capacities of 0.24 to 0.4 m³/s were determined for the range of road profiles in the project area. These gutter flows will necessitate the use of inlets approximately every 0.7 to 1.3 hectares. The capacity of each inlet corresponds to a 600mm (0.25%) interconnecting pipe for double camber cross sections with inlets on either side.

6.4.1.3 Combination Inlets

Combination inlets measuring 1.8m x 0.3m were modelled for two longitudinal slope conditions, these being 0.25% and 0.75%. These correspond to capacities of 0.23 m³/s and 0.41 m³/s respectively.

6.4.1.4 Storm Sewers

Two variations in storm sewer capacity were explored and suggest the wide spread use of 900 - and 1200-mm diameter pipes as feasible options. Slopes of 0.25% to 0.75% can carry 0.6 to 1.4 and 1.1 to 2.45 m³/s respectively. These largely correspond to 1 to 3 hectares of the 900mm and 2 to 7 hectares of each 1200mm for the range of slopes likely in the project area.

6.4.2 Conceptual Drainage Plan

The proposed improvements for the project area consist of upgraded drainage systems consisting of inlets, gutters and culverts adequately sized and spaced in accordance with the presented NWA Guidelines for sizing, spacing and distance from highpoint.

6.4.2.1 Jew Gully/Marcus Garvey Drive/ Tinson Pen/Oaklands

Forty-Two (42) additional inlets were proposed to the area, along with 1,082 m of 900mm diameter culverts, and 931m of 1200mm culverts. This should great improve street drainage in the area, as the frequency and effectiveness of the drainage inlets would have been greatly improved. See 9.9.2.

6.4.2.2 Shoemaker Gully

Twenty-Four (24) additional inlets were proposed to the area, along with 149 m of 900mm diameter culverts, and 403m of 1200mm culverts. This should great improve street drainage in the area, as the frequency and effectiveness of the drainage inlets would have been improved, as well as runoff to the gully would. See 9.9.2.

6.4.2.3 Newport West

This area suffers from significant flooding as a result of an inadequate drainage system. It is proposed that 123 inlets be added to replace some of the inlets and place some where none existed, along with 2848 m of 900mm diameter culverts, and 165m of 1200mm culverts. This should great improve street drainage in the area, as the frequency and effectiveness of the drainage inlets would have been greatly improved. See 9.9.2.

6.4.2.4 Summary

Overall, 189 Inlets were proposed in the project area, along with 146m of 900mm, and 967 of 1200mm culverts which conform to the presented NWA Guidelines for inlet sizing, spacing and distance from highpoint requirements. This should great improve street drainage in these areas, as the frequency and effectiveness of the drainage inlets and culverts would have been greatly improved. See Table 6.8.

Table 6.8. Summary of proposed minor (street) drainage infrastructure for the project area

Item	Quantity
Combination Inlets	189
900mm	4,079 m
1200mm	1,499 m

6.5 Crossings

6.5.1 Capacity of Existing Culverts

Undersized Crossings in the project area restrict flow going down stream and causes the storm water in the drainage channel to the water level upstream to rise overtopping the road way and onto the over bank region. Table 6.9 lists the crossing in the project area and the highlighted rows are crossings recommended to be improved based on the capacity of the drains or the head water in the channel upstream the channel.

Table 6.9 Summary table of existing culverts (highlight rows channel recommended for immediate improvement)

Gullies	Crossing Code	Type	Culvert Length (m)	Depth (m)	Span (m)	Invert Elevation (m)	Outlet Elevation (m)	Capacity (m ³ /s)
/Trench Town	TT-01	single cell concrete box culvert	10.00	1.61	2.40	22.47	22.20	24.7
	TT-02	single cell concrete box culvert	9.00	1.60	2.40	20.68	20.55	24.4
	TT-03	single cell concrete box culvert	20.00	1.47	2.40	19.24	18.65	21.8
	TT-04	single cell concrete box culvert	24.00	1.50	2.40	13.24	12.82	22.5
	TT-05	single cell concrete box culvert	7.00	1.60	3.40	12.13	12.04	39.0
	TT-06	single cell concrete box culvert	10.00	1.25	2.72	12.20	12.11	20.9
	TT-07	single cell concrete box culvert	9.00	1.26	2.39	7.74	7.60	17.8
	TT-08	single cell concrete box culvert	10.00	1.99	2.97	5.22	5.21	43.3
Shoemaker Gully	SM-8	2 cell box culverts	30.00	2.57	4.60	0.90	0.40	109.8
	SM-07	single cell concrete box culvert	10.00	2.30	5.30	6.77	6.57	114.3
	SM-06	single cell concrete box culvert	10.00	1.87	9.11	14.00	13.74	167.9
	SM-05	single cell concrete box culvert	7.00	2.40	5.69	15.31	15.11	132.9
	SM-04	single cell concrete box culvert	7.00	2.93	5.58	16.50	16.21	169.4
	SM-03	single cell concrete box culvert	10.00	2.31	10.00	18.75	18.70	255.9
	SM-02	semi-circular CSV	29.00	2.45		19.47	19.30	44.0
	SM-01	single cell concrete box culvert	26.00	2.74	5.86	19.47	19.30	165.3
Clifton	CL-01	pipe culvert	7.00	0.60		12.39	12.35	2.1
	CL-02	2 cell box culverts	35.00	2.20	2.02	11.00	10.40	28.4
	CL-03	single cell concrete box culvert	9.00	0.80	2.96	13.35	13.15	12.5
Oaklands	OK-05	single cell concrete box culvert	5.00	1.18	3.01	4.27	3.87	22.0
	OK-04	single cell concrete box culvert	20.00	1.17	3.04	9.50	8.50	21.9
	OK-03	single cell concrete box culvert	6.00	2.20	2.60	8.91	8.78	40.8

	OK-02	single cell concrete box culvert	14.00	2.34	3.03	7.57	7.25	54.8
	OK-01	dual pipe culvert	8.00	1.35		5.00	4.90	18.0
Stewarts	ST-01	single cell concrete box culvert	10.00	1.00	1.00	7.30	7.26	3.9
	ST-02	single cell concrete box culvert	12.00	0.80	0.80	6.60	6.57	2.2
	ST-03	conc pipe culvert	7.00	0.90		5.05	4.95	6.1
	ST-04	single cell concrete box culvert	12.00	1.17	3.04	3.45	3.35	21.9
Tinson Pen	TP-01	three cell concrete box culvert	30.00	2.5	2	1.55	1.52	70
	TP-02	single cell concrete box culvert	20.00	0.60	2.07	3.50	2.00	5.3
Marcus Garvey Drive	MG-01	concrete arch culvert	6.00	0.90		1.30	1.20	6.1
	MG-02	single cell concrete box culvert	5.00	0.80	1.63	0.93	0.85	5.8
	MG-03	concrete arch culvert	7.00	0.90		1.00	0.42	6.1
	MG-04	single cell concrete box culvert	10.00	1.30	1.76	0.37	-0.14	12.2
	MG-05	single cell concrete box culvert	20.00	0.84	0.50	1.50	0.50	1.1
Jew's Gully	JG-04	single cell concrete box culvert	15.00	2.00	5.99	1.60	1.55	110.3
	JG-03	single cell concrete box culvert	8.00	2.04	5.97	2.60	2.55	113.0
	JG-02	corrugated Semi circle	21.00	2.62	2.40	8.50	7.50	45.1
	JG-01	single cell concrete box culvert	9.00	2.80	6.41	11.54	10.90	191.6

6.5.2 Required Improvements

The proposed culverts were analyzed and redesigned taking into account: i) the head water, ii) tail water, iii) height of the embankment and iv) flow requirements. HY-8 was used to test and optimize culvert dimension for a 10 to 100-year return periods with future climate condition period design flow, the output of this exercise can be found in chapter 9.5. The results were summarized placed in Table 6.10 with highlighted culverts to be upgraded.

Table 6.10 Summary table of proposed culverts

10 FC RP Improved							
Drain/Gully	Crossing Code	Total Span	Depth	Invert Elevation:	Outlet Elevation:	notes	Capacity
Shoemaker Gully	SM-8	20	3	0.47	0.3	bridge single span	361.1
	SM-07	12	2	7.07	6.87	2 cells recommended or removal	193.25
	SM-06	9.11	1.87	6.76	6.5		
	SM-05	5.69	2.4	12.02	11.82		
	SM-04	5.58	2.93	13.85	13.56		
	SM-03	10	2.31	11.06	11.01		
	SM-02	6	2.5	19.42	19.25	Single cell concrete box culvert	193.25
	SM-01	5.86	2.74	16.35	16.18		
Clifton	CL-01	6	3	9.99	9.95	Single cell concrete box culvert	53.3
	CL-02	6	3	10.2	9.6	Two cell concrete box culvert	53.3
Oaklands	OK-05	6	4	1.453	1.05	Single cell concrete box culvert	149.2
	OK-04	6	4	6.665	5.665	Single cell concrete box culvert	149.2
	OK-03	6	4	7.11	6.98	Single cell concrete box culvert	149.2
	OK-02	6	4	5.91	5.59	Single cell concrete box culvert	149.2
	OK-01	6	4	2.35	2.25	Single cell concrete box culvert	149.2
Tinson Pen	TP-01	18	3	0.1	0.07	Three cell box culvert	205.2
	TP-02	6	2	2.1	0.5	Single cell concrete box culvert	28
Marcus Garvey Drive	MG-01	4	1.5	0.7	0.6	Single cell concrete box culvert	24
	MG-02	3.5	1	0.73	0.65	Single cell concrete box culvert	15.8
	MG-03	3.5	1	0.9	0.32	Single cell concrete box culvert	15.8
	MG-04			1.67	1.16		
	MG-05	3.5	1	1.34	0.34	Single cell concrete box culvert	15.8
Jew Gully	JG-04	10	4.5	-0.9	-0.95	Two cell concrete box culvert	190.6
	JG-03	10	4.5	0.14	0.09	Two cell concrete box culvert	190.6
	JG-02	10	4.5	11.12	10.12	Two cell concrete box culvert	190.6
	JG-01	10	4.5	9.84	9.2	Two cell concrete box culvert	190.6

25 FC RP Improved							
Drain/Gully	Crossing Code	Total Span	Depth	Invert Elevation:	Outlet Elevation:	notes	Capacity
Shoemaker Gully	SM-8	20	3	0.47	0.3	bridge single span	361.1
	SM-07	14	3	6.07	5.87	2 cells recommended or removal	255.375
	SM-06	6	2.5	9.11	1.87		
	SM-05	6	2.5	5.69	2.4		
	SM-04	6	2.5	5.58	2.93		
	SM-03	6	2.5	10	2.31		
	SM-02	6	2.5	19.42	19.25	Single cell concrete box culvert	255.375
	SM-01	6	2.5	5.86	2.74		
Clifton	CL-01	6	3	9.99	9.95	Single cell concrete box culvert	70.6
	CL-02	6	3	10.2	9.6	Two cell concrete box culvert	70.6
Oaklands	OK-05	6	4	1.453	1.05	Single cell concrete box culvert	200.7
	OK-04	6	4	6.665	5.665	Single cell concrete box culvert	200.7
	OK-03	6	4	7.11	6.98	Single cell concrete box culvert	200.7
	OK-02	6	4	5.91	5.59	Single cell concrete box culvert	200.7
	OK-01	6	4	2.35	2.25	Single cell concrete box culvert	200.7
Tinson Pen	TP-01	20	3	0.1	0.07	Four cell box culvert	270
	TP-02	6	2	2.1	0.6	Single cell concrete box culvert	28
Marcus Garvey Drive	MG-01	4	1.5	0.7	0.6	Single cell concrete box culvert	24
	MG-02	3.5	1	0.73	0.65	Single cell concrete box culvert	15.8
	MG-03	3.5	1	0.9	0.32	Single cell concrete box culvert	15.8
	MG-04			1.67	1.16		
	MG-05	3.5	1	1.34	0.34	Single cell concrete box culvert	15.8
Jew Gully	JG-04	10	5.5	-1.9	-1.95	Two cell concrete box culvert	251.3
	JG-03	10	5.5	-0.86	-0.91	Two cell concrete box culvert	251.3
	JG-02	10	5.5	11.12	10.12	Two cell concrete box culvert	251.3
	JG-01	10	5.5	8.84	8.2	Two cell concrete box culvert	251.3

50 FC RP Improved							
Drain/Gully	Crossing Code	Total Span	Depth	Invert Elevation:	Outlet Elevation:	notes	Capacity
Shoemaker Gully	SM-8	20	3.3	0.17	0	bridge single span	427.9
	SM-07	16	3	6.07	5.87	3 cell concrete box culvert or removal	302.375
	SM-06	8	2.5	13.37	13.11	Two cell concrete box culvert	302.375
	SM-05	8	2.5	15.21	15.01	Two cell concrete box culvert	302.375
	SM-04	8	2.5	16.93	16.64	Two cell concrete box culvert	302.375
	SM-03	8	2.5	18.56	18.51	Two cell concrete box culvert	302.375
	SM-02	8	2.5	21.92	21.75	Two cell concrete box culvert	302.375
	SM-01	8	2.5	19.71	19.54	Two cell concrete box culvert	302.375
Clifton	CL-01	8	3	9.99	9.95	Single cell concrete box culvert	83.7
	CL-02	8	3	10.2	9.6	Two cell concrete box culvert	83.7
Oaklands	OK-05	8	4	1.453	1.05	Two cell concrete box culvert	242.6
	OK-04	8	4	6.665	5.665	Two cell concrete box culvert	242.6
	OK-03	8	4	7.11	6.98	Two cell concrete box culvert	242.6
	OK-02	8	4	5.91	5.59	Two cell concrete box culvert	242.6
	OK-01	8	4	6.35	6.25	Two cell concrete box culvert	242.6
Tinson Pen	TP-01	24	3	0.1	0.07	five cell concrete box culvert	318.8
	TP-02	6	2.5	1.6	0.1	Single cell concrete box culvert	28
Marcus Garvey Drive	MG-01	4	1.5	0.7	0.6	Single cell concrete box culvert	24
	MG-02	4	1	0.23	0.15	Single cell concrete box culvert	17.6
	MG-03	4	1	0.9	0.32	Single cell concrete box culvert	17.6
	MG-04			1.67	1.16		
	MG-05	4	1	1.34	0.34	Single cell concrete box culvert	17.6
Jew Gully	JG-04	12	5.5	-1.9	-1.95	Two cell concrete box culvert	297.5
	JG-03	12	5.5	-0.86	-0.91	Two cell concrete box culvert	297.5
	JG-02	12	5.5	11.12	10.12	Two cell concrete box culvert	297.5
	JG-01	12	5.5	8.84	8.2	Two cell concrete box culvert	297.5

100 FC RP Improved							
Drain/Gully	Crossing Code	Total Span	Depth	Invert Elevation:	Outlet Elevation:	notes	Capacity
Shoemaker Gully	SM-8	20	3.5	0.07	-0.01	bridge single span	494.6
	SM-07	18	4	5.07	4.87	3 cell concrete box culvert or removal	349.25
	SM-06	12	2.5	13.37	13.11	Two cell concrete box culvert	349.25
	SM-05	12	2.5	15.21	15.01	Two cell concrete box culvert	349.25
	SM-04	12	2.5	16.93	16.64	Two cell concrete box culvert	349.25
	SM-03	12	2.5	18.56	18.51	Two cell concrete box culvert	349.25
	SM-02	12	2.5	21.92	21.75	Two cell concrete box culvert	349.25
	SM-01	10.5	2.5	19.71	19.54	Two cell concrete box culvert	349.25
Clifton	CL-01	10	3	9.99	9.95	Single cell concrete box culvert	96.8
	CL-02	10	3	10.2	9.6	Two cell concrete box culvert	96.8
Oaklands	OK-05	10	6	0.453	0.4	Two cell concrete box culvert	287.4
	OK-04	10	6	4.665	3.665	Two cell concrete box culvert	287.4
	OK-03	10	6	5.11	4.98	Two cell concrete box culvert	287.4
	OK-02	10	6	3.91	3.59	Two cell concrete box culvert	287.4
	OK-01	10	4	2.35	2.25	Two cell concrete box culvert	
Tinson Pen	TP-01	26	3.8	0.1	0.07	five cell culvert	366.92
	TP-02	7	2.5	1.6	0.1	Single cell concrete box culvert	32.3
Marcus Garvey Drive	MG-01	4	1.5	0.7	0.6	Single cell concrete box culvert	24
	MG-02	4.5	1	0.73	0.65	Single cell concrete box culvert	19.8
	MG-03	4.5	1	0.9	0.32	Single cell concrete box culvert	19.8
	MG-04			1.67	1.16		
	MG-05	4.5	1	1.34	0.34	Single cell concrete box culvert	19.8
Jew Gully	JG-04	14	5.5	-1.9	-1.95	Two cell concrete box culvert	343.9
	JG-03	14	4.5	0.14	0.09	Two cell concrete box culvert	343.9
	JG-02	14	4.5	6.62	5.62	Two cell concrete box culvert	343.9
	JG-01	14	4.5	9.84	9.2	Two cell concrete box culvert	343.9

6.5.3 Summary

The culverts in Table 6.11 are proposed to be improved in order to reduce the localized flooding around crossings in the project area.

Table 6.11 Culverts Proposed to be improved with the project area

Drain/Gully	Crossing Code	Description	Existing Type	10-Yr RP				25-Yr RP				50-Yr RP				100-Yr RP			
				Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity
Jew Gully/Tinson Pen/Marcus Garvey Drive																			
Clifton	CL-01	Road Crossing/ Culvert Pipe Crossing	pipe culvert	6	3	Single cell concrete box culvert	53.3	6	3	Single cell concrete box culvert	70.6	8	3	Single cell concrete box culvert	83.7	10	3	Single cell concrete box culvert	96.8
Clifton	CL-02	Earth Drain/Culvert	2 cell box culverts	6	3	Two cell concrete box culvert	53.3	6	3	Two cell concrete box culvert	70.6	8	3	Two cell concrete box culvert	83.7	10	3	Two cell concrete box culvert	96.8
Oaklands	OK-05	Road Crossing	single cell concrete box culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	6	Two cell concrete box culvert	287.4
Oaklands	OK-04	Road Crossing	single cell concrete box culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	6	Two cell concrete box culvert	287.4
Oaklands	OK-03	Concrete Slab Crossing	single cell concrete box culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	6	Two cell concrete box culvert	287.4
Oaklands	OK-02	Road Crossing	single cell concrete box culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	6	Two cell concrete box culvert	287.4
Oaklands	OK-01	Culvert Crossing (two 3’ pipes)	dual pipe culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	4	Two cell concrete box culvert	
Tinson Pen	TP-01	Major Road Crossing	three cell concrete box culvert	18	3	Three cell box culvert	205.2	20	3	Four cell box culvert	270	24	3	five cell culvert	318.8	26	3.8	five cell culvert	366.92
Tinson Pen	TP-02	Drainage structure (Stewarts Drain to Tinson Pen Gully)	single cell concrete box culvert	6	2	Single cell concrete box culvert	28	6	2	Single cell concrete box culvert	28	6	2.5	Single cell concrete box culvert	28	7	2.5	Single cell concrete box culvert	32.3
Marcus Garvey Drive	MG-01	Along Marcus Garvey Drive	concrete arch culvert	4	1.5	Single cell concrete box culvert	24	4	1.5	Single cell concrete box culvert	24	4	1.5	Single cell concrete box culvert	24	4	1.5	Single cell concrete box culvert	24
Marcus Garvey Drive	MG-02	Along Marcus Garvey Drive	single cell concrete box culvert	3.5	1	Single cell concrete box culvert	15.8	3.5	1	Single cell concrete box culvert	15.8	4	1	Single cell concrete box culvert	17.6	4.5	1	Single cell concrete box culvert	19.8
Marcus Garvey Drive	MG-03	Along Marcus Garvey Drive	concrete arch culvert	3.5	1	Single cell concrete box culvert	15.8	3.5	1	Single cell concrete box culvert	15.8	4	1	Single cell concrete box culvert	17.6	4.5	1	Single cell concrete box culvert	19.8
Marcus Garvey Drive	MG-05	Crosses Marcus Garvey Drive	single cell concrete box culvert	3.5	1	Single cell concrete box culvert	15.8	3.5	1	Single cell concrete box culvert	15.8	4	1	Single cell concrete box culvert	17.6	4.5	1	Single cell concrete box culvert	19.8
Jew Gully	JG-04	Temporary Crossing Structure	single cell concrete box culvert	10	4.5	Two cell concrete box culvert	190.6	10	5.5	Two cell concrete box culvert	251.3	12	5.5	Two cell concrete box culvert	297.5	14	5.5	Two cell concrete box culvert	343.9
Jew’s Gully	JG-03	Road Crossing	single cell concrete box culvert	10	4.5	Two cell concrete box culvert	190.6	10	5.5	Two cell concrete box culvert	251.3	12	5.5	Two cell concrete box culvert	297.5	14	4.5	Two cell concrete box culvert	343.9
Jew’s Gully	JG-02	Very High Drop/ Main Road (Drain is corrugated Semi circle)	corrugated Semi circle	10	4.5	Two cell concrete box culvert	190.6	10	5.5	Two cell concrete box culvert	251.3	12	5.5	Two cell concrete box culvert	297.5	14	4.5	Two cell concrete box culvert	343.9
Jew’s Gully	JG-01	Road Crossing	single cell concrete box culvert	10	4.5	Two cell concrete box culvert	190.6	10	5.5	Two cell concrete box culvert	251.3	12	5.5	Two cell concrete box culvert	297.5	14	4.5	Two cell concrete box culvert	343.9

Drain/Gully	Crossing Code	Description	Existing Type	10-Yr RP				25-Yr RP				50-Yr RP				100-Yr RP			
				Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity
Shoemaker Gully	SM-8	Main Road Crossing	2 cell box culvert	20	3	bridge single span	361.1	20	3	bridge single span	361.1	20	3.3	bridge single span	427.9	20	3.5	bridge single span	494.6
Shoemaker Gully	SM-07	Foot Crossing	single cell concrete box culvert	12	2	2 cells recommended or removal	193.25	14	3	2 cells recommended or removal	255.375	16	3	3cells recommended or removal	302.375	18	4	3cells recommended or removal	349.25
Shoemaker Gully	SM-06	Main Road Crossing	single cell concrete box culvert	No improvement necessary				No improvement necessary				8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-05	Road Crossing	single cell concrete box culvert									8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-04	Road Crossing	single cell concrete box culvert									8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-03	Road Crossing	single cell concrete box culvert									8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-02	Drain is corrugated Semi circle	semi-circular CSV	6	2.5	Single cell concrete box culvert	193.25	6	2.5	Single cell concrete box culvert	255.375	8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-01	Road Crossing	single cell concrete box culvert	No improvement necessary				No improvement necessary				8	2.5	Two cell concrete box culvert	302.375	10.5	2.5	Two cell concrete box culvert	349.25

6.6 Flood Plain Analysis

6.6.1 Calibration and Simulations

6.6.1.1 October 6th 2020 Event

The October 6th, 2020 event with 50mm of rainfall (from forecasts) was modelled and compared with anecdotal data collected in the project area see in order to evaluate the flood plain model. Extrapolation of the design rainfall curves (Table 3.1) suggest that the event is 1-year RP event and can be expected annually. See Figure 6.1. The Modelled and anecdotal flood depths are compared in Table 6.12 with an average difference of 0.17 m, indicating the model slightly underestimating the flooding depths in the study area. This validates the results of the model and the results can be extrapolated for higher return period events.

Table 6.12 Comparison between October 6th 2020 Extreme Rainfall event anecdotal and modeled flood depth

Record ID	Observed Flood Depth (m)	Modelled Depth (m)	Difference (m)
1	0.4	0.15	0.25
2	0.4	0.3	0.1
3	0.31	0.29	0.02
4	0	0	0
5	0.3	0.23	0.07
6	0.4	0	0.4
7	0.15	0.23	0.08
8	0.3	0.45	0.15
9	0.45	0.62	0.17
10	0.77	0.44	0.33
11	0.61	0.42	0.19
12	0.6	0.37	0.23
13	0.9	0.4	0.5
14	0.1	0	0.1
15	0.05	0	0.05
16	0.1	0.11	0.01
17	0	0.1	0.1
18	0.4	0.21	0.19
19	0.7	0.36	0.34

Anecdotal Flood Map for 2020 Rainfall Event



Figure 6.1 October 6th 2020 event modeled vs anecdotal map

6.6.1.2 Flood Depths versus Return Periods

Flooding is initiated in the project area for less than the 1-year RP and increases with severity of events for existing conditions. See Figure 6.2 and Table 2.4. Generally speaking, 100% vehicle disruption is widespread across the project area from the 1-year RP and upwards. Damage is initiated for minor rainfall events in Marcus Garvey/Tinson Pen area and for the less frequent events (around the 5-year RP) in Newport West and Shoemaker. This later point suggests that far more serious damage to the commercial and residential building stock is plausible in the near future and should therefore be seen as a matter of urgency.

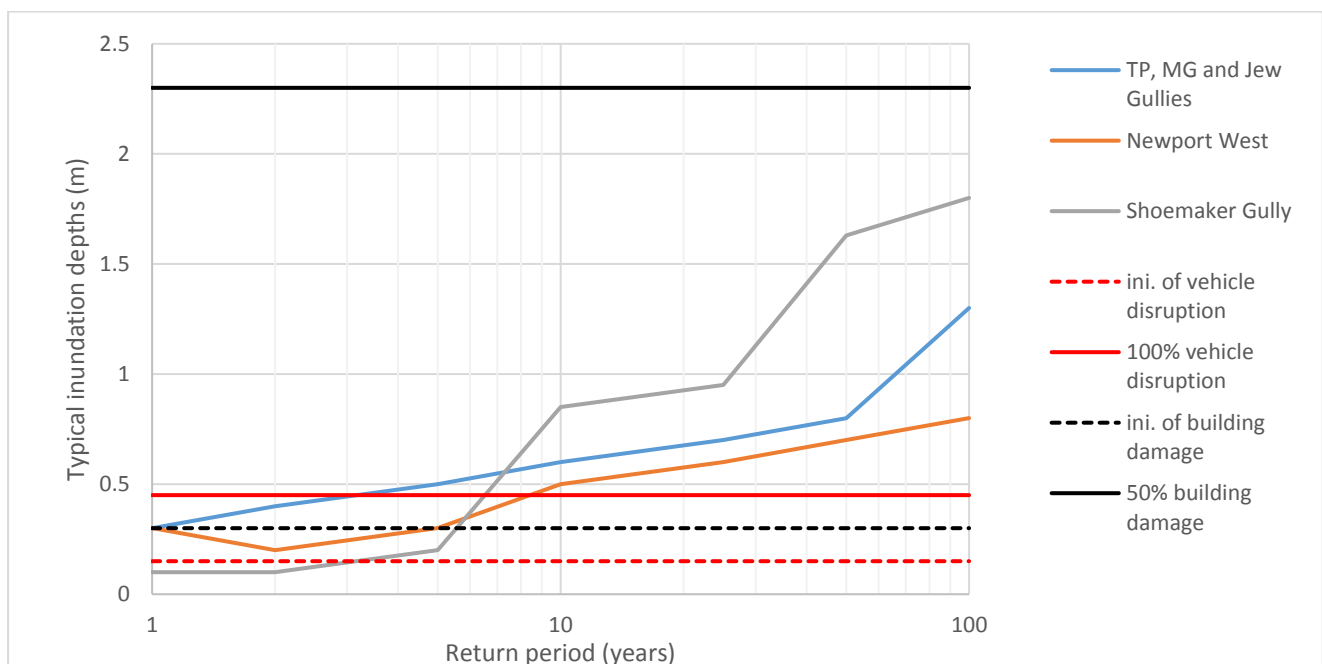


Figure 6.2. Typical flood inundation depths for project area with return periods and depths for initiation and near complete vehicle disruption and damage of residential and commercial building stock.

6.6.2 Jew Gully/Tinson Pen

6.6.2.1 Existing Conditions (25-year RP)

Upper Jew gully is a major drain for the western region of the corporate area receiving flow from the Hope road drain and the Molynees road gully, in addition connecting to Upper Oaklands, Oaklands, Clifton, Stewarts, Marcus Garvey Drive and Tinson Pen at the downstream end about 500 m from the outfall. The upper Jew gully has an average slope of 0.45% with the water in the channel flowing supercritical (average Froude number of 1.3) for most of the conveyance until the super critical flow meets the subcritical slow-moving water down stream, this sudden change in velocity causes the water levels to rise downstream likely being the cause of the cause the flooding downstream particularly in the 25 year return period. This can be seen in the hydraulic profile Figure 6.3 whereas channel slope moves from steep to mild there is a rise in water surface elevation causing flooding the lower regions of upper Jew gully. Further upstream the under capacity of the drains becomes apparent as the drains cannot contain the increased flow and overflow its banks.

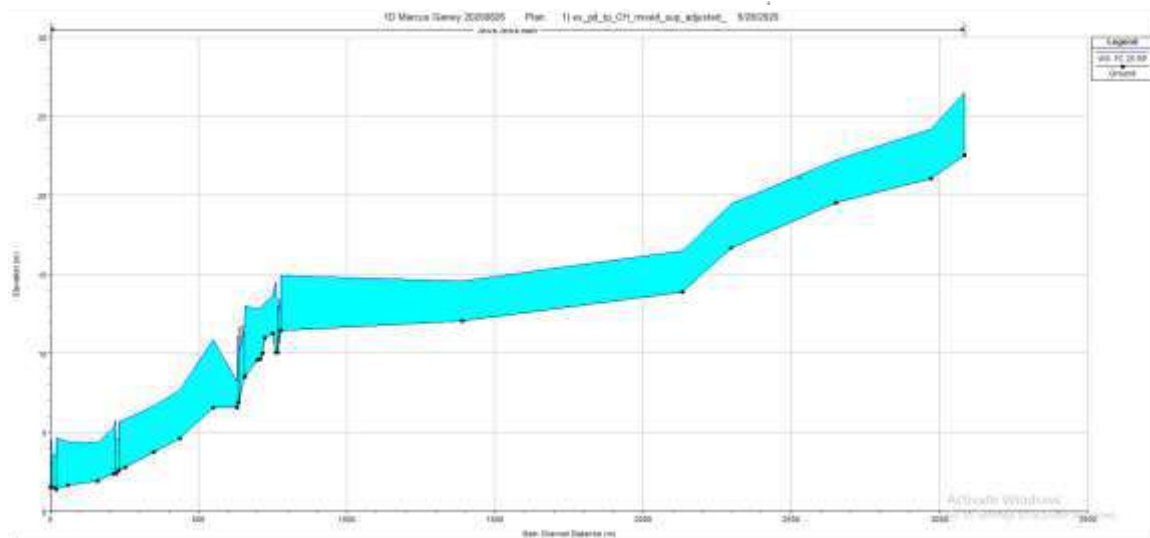


Figure 6.3 Upper Jew gully Hydraulic Profile

The Lower Jew gully starts at the junction of the Jew drain and the Tinson pen drain, this earth drain conveys a flow of 546.6 cubic meters per second to the outfall (the sea). As the upstream drains join the lower Jew gully there is a back flow effect where the water levels at the ends of upper Jew gully and the Tinson pen gully increases sharply this can as seen in the hydraulic profiles at the end of the Tinson pen gully where the back flow overtops the culvert under the Marcus Garvey drive and the temporary crossing at the end of upper Jew gully see .

The Tinson pen drain is feed by both the Oaklands and Clifton drains, the upstream profile of the Tinson pen drain is relatively steep (1.7% slope) then transitions into a gentler (0.2% slope) in the lower sections of the Tinson pen gully. This relatively sudden change in slope causes a hydraulic jump in the Tinson pen region running parallel to the airfield, causing the water level in the drain to increase rapidly overflowing its channel. The increased water level in this channel also reduces the ability of the Marcus Garvey drain from flowing into the Tinson pen gully as the channel has exceeded its flow capacity.

The Marcus Garvey drain collects runoff from Marcus Garvey drive and carries the water to Tinson pen, Shoemaker in addition to the major drains running though Newport West. Based on anecdotal studies and literature reviews significant flooding is observed on the road way especially in areas to the west of the air field, in the Tinson pen's parking lot/ neighboring car depot. This has also been reflected in the flood model see Figure 6.5 predicting sporadic flooding along the Marcus Garvey drive. The flooding appears most intense in areas where the runoff enters the culverts to cross into Newport west and drain into the major Tinson pen drain. The sudden jumps in the hydraulic profile in Figure 6.6 indicates the water is not flowing into the out flow as expected and is increasing the water level in area in which the water should be draining which indicates the drains are under sized or the slopes are irregular.

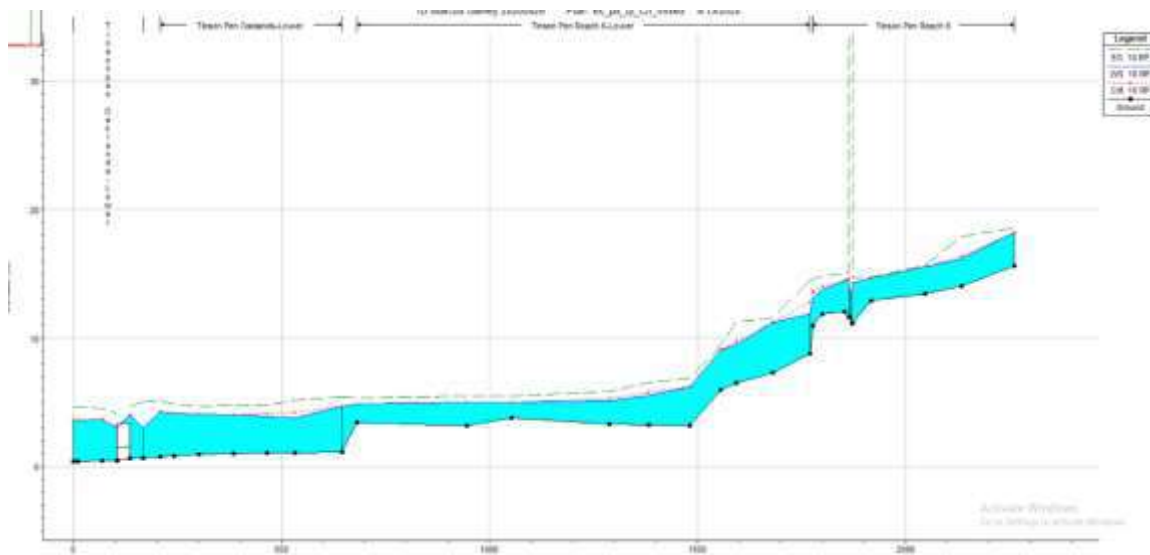


Figure 6.4 Hydraulic profile of Tinson pen gully during a future 25-year rainfall event

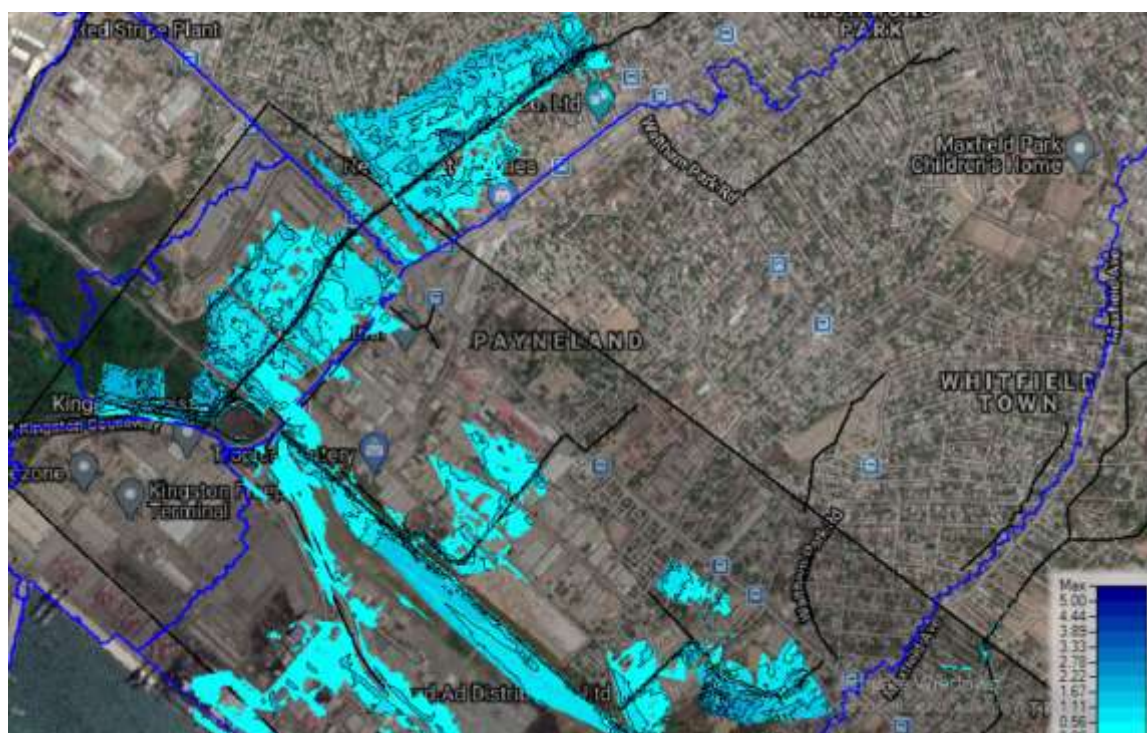


Figure 6.5 Flood map of highlighting flooding the Jew/Tinson pen and Marcus Garvey drains 25-year rainfall event

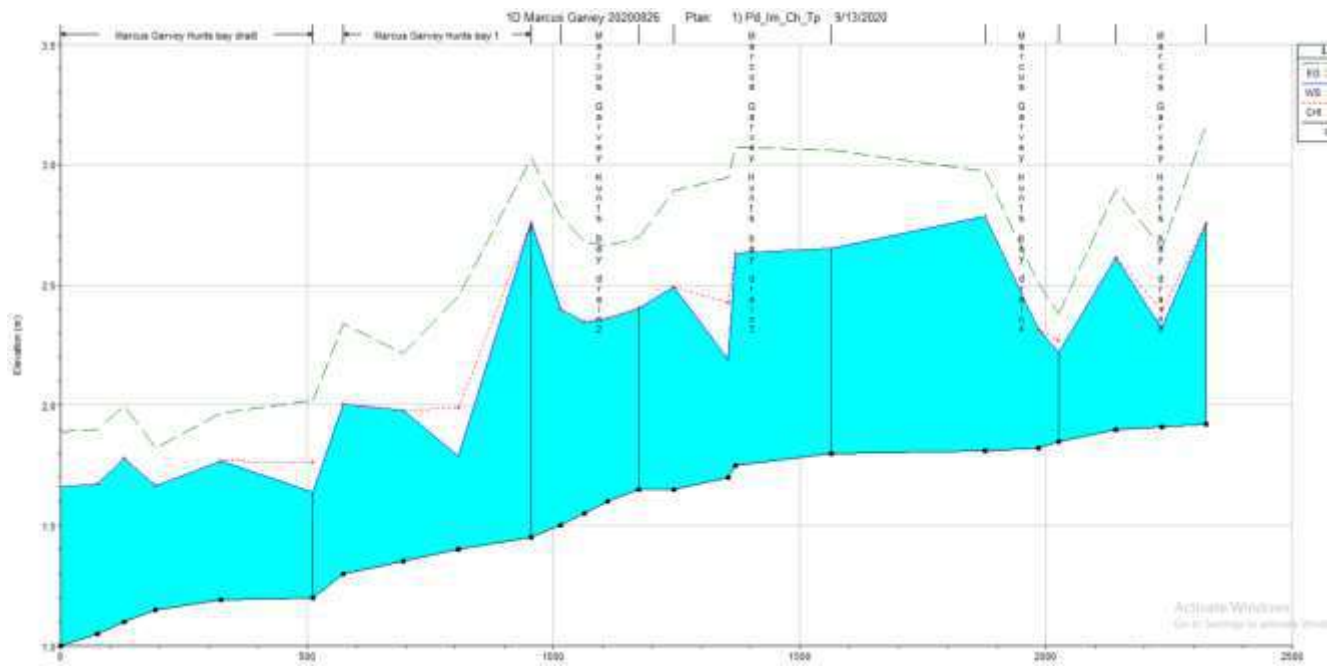


Figure 6.6 Marcus Garvey drain hydraulic profile 25-year rainfall event

6.6.2.2 Post-Improvement (25-year RP + Future Climate)

The following improvements are recommended in keeping with the summary in

Table 6.17:

1. Detention basin with a hydraulic connection to Hunts Bay to make the end of this system outfall at mean sea level. This detention basin will also provide debris removal and minimize maintenance requirements to the proposed channel to Hunt Bay
2. Widen and deepen the Lower Jew gully channel leading to the outfall to Hunts Bay to prevent upstream backflow.
3. Widen and deepen the channel width and depth in addition to sizing up culverts for
 - a. Jew gully to allow for increased capacity for future events
 - b. Tinson pen drain in addition to sizing up major culverts along the drain
 - c. Marcus Garvey drain to increase its capacity to convey flood water away from the road way

Less flooding is predicted for the same 25-year return period rainfall event see Figure 6.7.



Figure 6.7 . 25-year RP Flood map highlighting the effects of drainage

6.6.3 Shoemaker Gully

6.6.3.1 Existing Conditions (25-year RP)

The Shoemaker drain can be broken down into the upper Shoemaker section, the mid Shoemaker section and the lower Shoemaker region. The upper Shoemaker section is relatively steep (approximately 1% slope) takes flow from Sunlight Street gully and Central gully, the flow in the drain at this point it's relatively low and fast moving at a relatively low super-critical depth. This results in relatively little flooding in the upstream regions of shoemaker. As Shoe marker drain joins the Trench Town gully, known as the Mid Shoemaker gully, the volume of water flowing in the channel increases and the slope of the channel decreases, this causes the water level in the channel to begin to increase downstream as seen in Figure 6.8. As the water in Lower Shoemaker approaches the outfall a hydraulic jump occurs about 20 meters before the major bridge crossing under Marcus Garvey Drive. This causes the water level to rise sharply and over flow the channel and move into the over bank region, the impacts can be seen in (Figure 6.8). Based on the flow conditions and dimensions of the as built shoemaker channel the HECRAS model shows the impact of the flooding mainly concentrated in the lower Shoemaker region for a 25-year future scenario.

The occurrence of hydraulic jump in the lower shoe marker region matches with a flood event in the area during 2016 where business owners described the nature of the inundation in areas around the gully seen in Figure 6.10. A Witness of the flooding stated "It is clear the water levels rose above the gully banks. This led to significant

volumes of water, in a very short period of time, almost totally engulfing the surrounding areas” this phenomenon being described lines up with a hydraulic jump occurring in the shoe marker gully upstream from the culvert on Marcus Garvey drive. Based on the flow conditions and dimensions of the as built Shoemaker channel the HECRAS model (Figure 6.9) shows the impact of the flooding mainly concentrated in the lower Shoemaker region, for a 25-year future scenario.

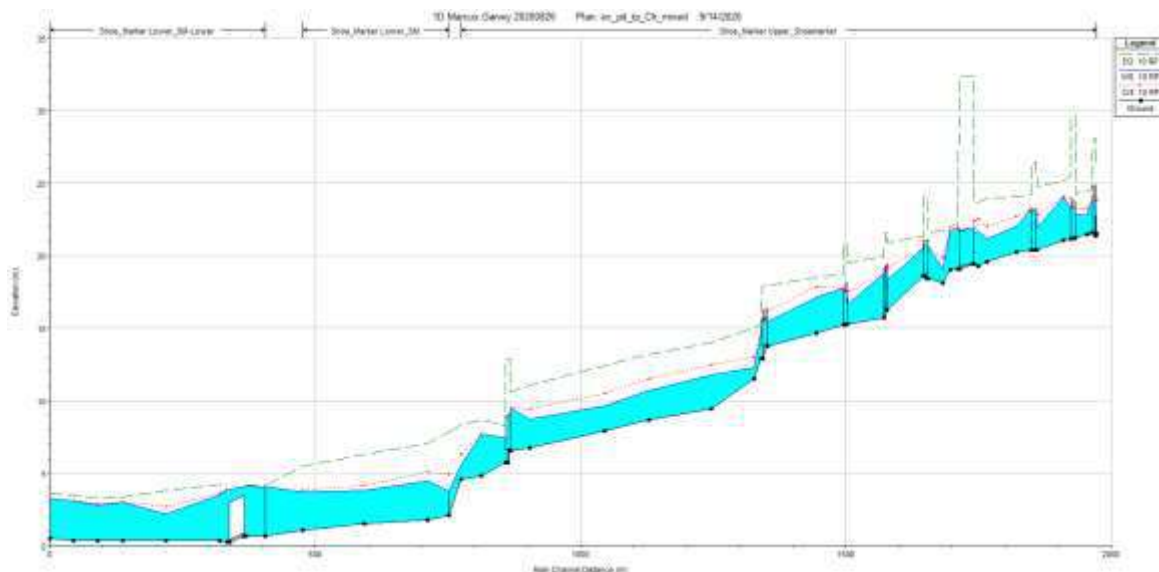


Figure 6.8 Hydraulic Profile of the Shoemaker Gully

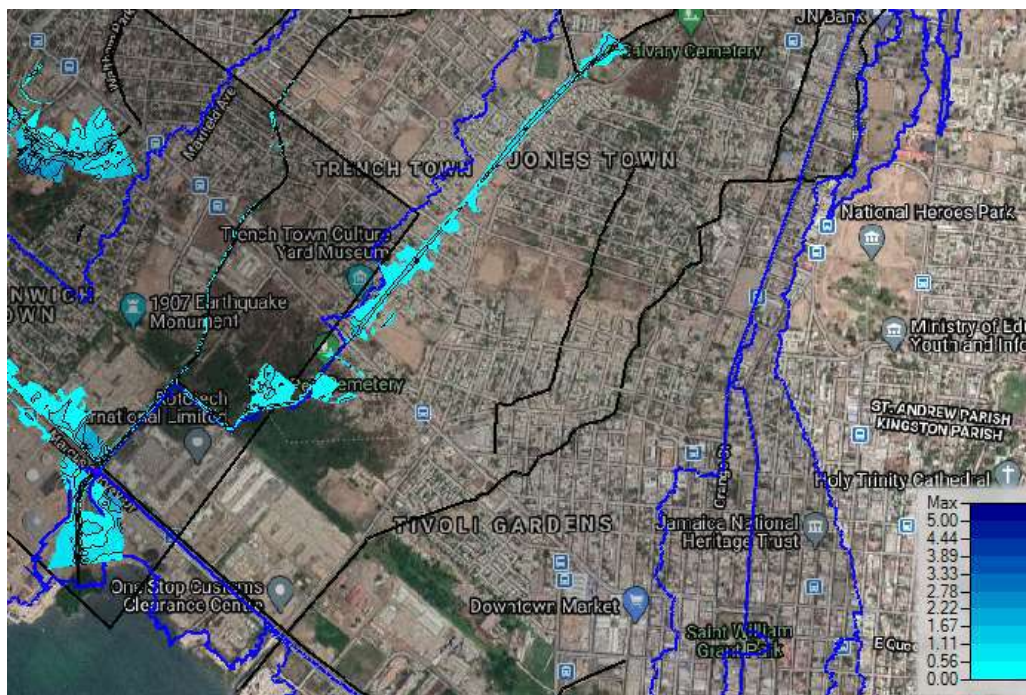


Figure 6.9 Flood Map Showing Shoemaker Gully



Figure 6.10 Possible impact of a hydraulic jump in the Shoemaker Gully

6.6.3.2 Post-Improvement (25-year RP + Future Climate)

The major flooding issues within Shoemaker gully lays within the mid and lower regions of the channel where the fast-moving water from upstream (super-critical) meets the slower moving water in lower Shoemaker (sub-critical) causing the water level in the channel to increase sharply. Note as well that the channel also has insufficient capacity. The following improvements are recommended in keeping with the summary in

Table 6.17:

1. Increasing the width and depth of the channel in order to prevent flood water from overflowing into the over bank region
2. Converting the existing lower-Shoemaker to a submerged canal that leads to the retention pond to drop the existing invert from +1.7 meters to -2.0 below Mean Sea Level and widening the outfall.
3. Adjust the profile of the downstream region of the channel allowing the hydraulic jump to occur further downstream in the gully closer to the outfall.

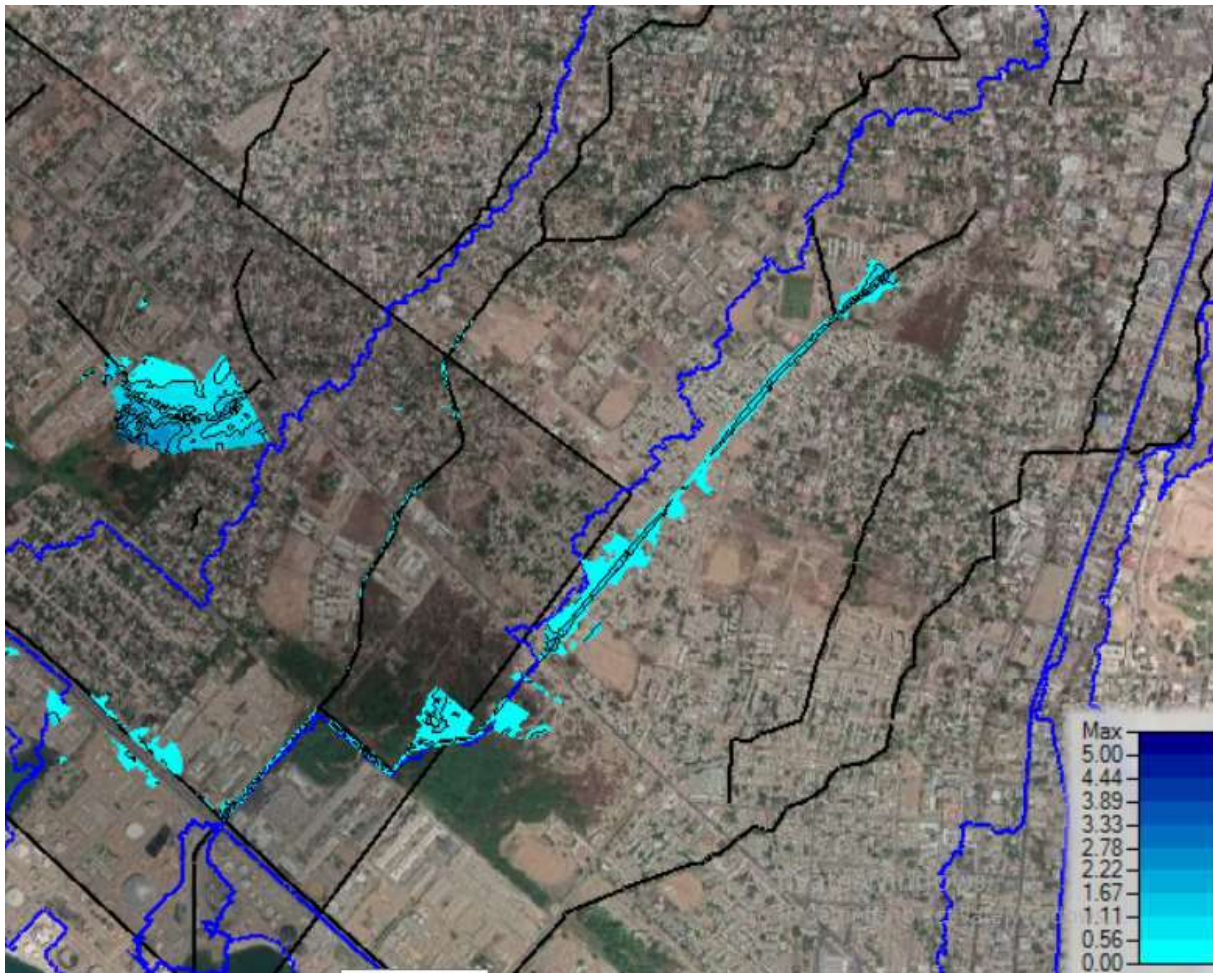


Figure 6.9. 25-year RP Flood map showing the effects of the improvements in the drainage system

6.6.4 Newport West

6.6.4.1 Existing Conditions (25-year RP)

Newport west collects runoff from the drains on Marcus Garvey drive and from several drop inlets placed strategically along the road way in Newport west. The layout for the underground area drainage facilities are represented in Figure 6.11



Figure 6.11 Layout of drainage system in Newport west

Major flooding was predicted along the Newport west 1 and Newport west 2 (Figure 6.12) resulting in storm water not being drained away fast enough from Marcus Garvey Drive and affecting commercial property in Newport west. Under-ground drainage are overwhelmed because of their limited capacity resulting run off not being able to enter the drainage system and flooding.

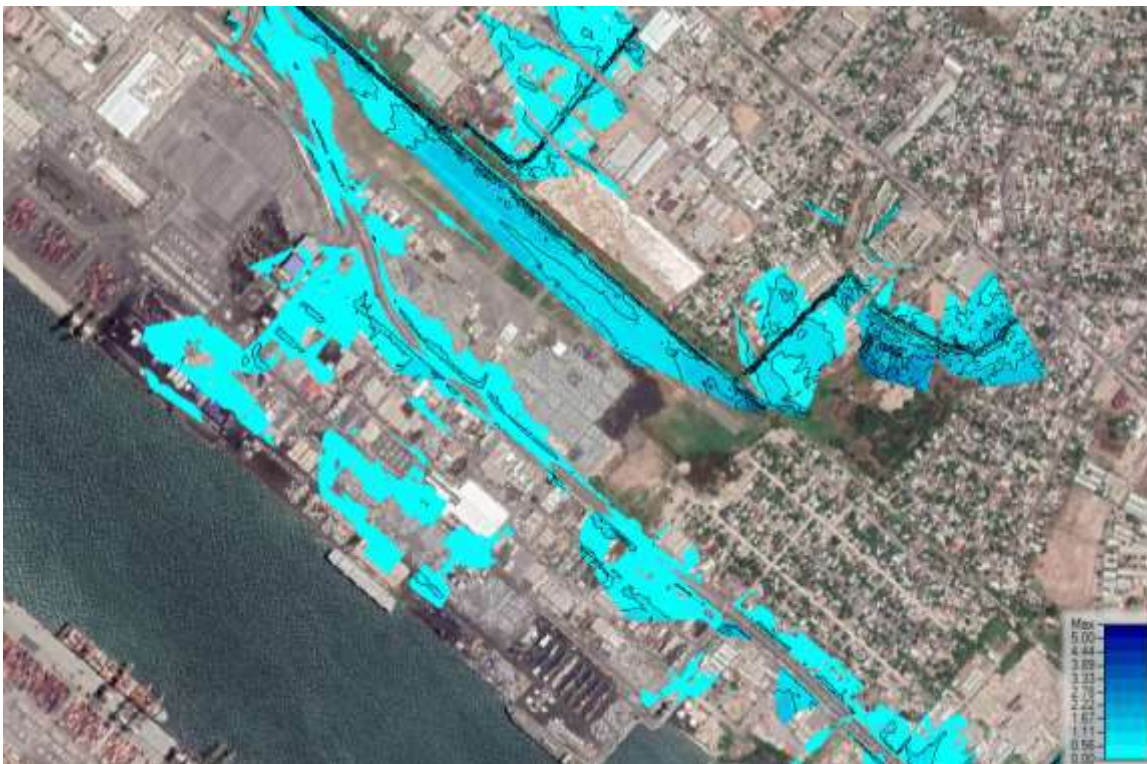


Figure 6.12 Flood map of the Newport west Marcus Garvey Drains

6.6.4.2 Post-Improvement (25-year RP + Future Climate)

Replacement of the existing drainage network is recommended in keeping with the summary in

Table 6.17. Improvement to the capacity of the drainage system will significantly reduce the extents of the flooding in the Newport west area and the likely damage (see Figure 6.13).



Figure 6.13 25-year RP flood map showing the effects of the improvements in the drainage system

6.7 Assessment of Alternatives

6.7.1 Crossings Improvement only

An alternative considered in this study is the improvement of the crossing in regions with relatively high inundation depths without improving the connecting drainage channel or constructing a detention pond. This approach in general slightly reduced the flooding the areas in near proximity to said crossings however the flood levels both upstream and downstream from the crossing remain consisting to not implementing any changes. These results reflect the nature of the drainage system where the changes though the upstream and downstream of the channel affect the properties of the crossings in the case of the show marker crossing SM-08 the culvert where the crossing are submerged in the 25 year return period, in this case a change in the sizing of the culvert will not affect the amount of flooding in the area. Similar results can be seen in the Tinson and Jew gully drains indicating that only upgrading the crossing are not a feasible solution to relieve flooding in the project area.



Figure 6.14 Impacts of implementing a crossing only strategy during a 25-year return period flood

6.7.2 Detention pond and Lower Jew Gully canal

The possibility of not incorporating the construction of the detention pond and 75mx-3.0 meters channel (connecting the flood control system to Hunts Bay) was explored. This alternative envisaged avoiding the relatively large amounts of excavation and associated costs (USD15.4 Million). Hydraulic analysis suggests that without dropping the outfall from +1.3 m at present to MSL in the lower regions of the Tinson pen gully and Jew gully, a tailwater effect persists in Jew gully and Tinson pen gully resulting in flooding, highlighted in Figure 6.15. This effect is due to the higher (+1.3 m) and undersized earthen channel outfall exceeding its capacity and increases the water level upstream. Whereas, deepening and widening of the Lower Jew gully channel (75m W x -3.0m D) invoke critical depth at the outfall of Tinson Pen, Marcus Garvey and Jew Gully that decreases surface water levels. Not implementing the detention pond and channel will cause the continued flooding of Marcus Garvey (+0.1 to 0.6 meters) and discharge of waste collected upstream to be deposited into the harbor causing continued damage to the local ecosystem. The channel and detention pond are important for the desired performance of the proposed flood control system.

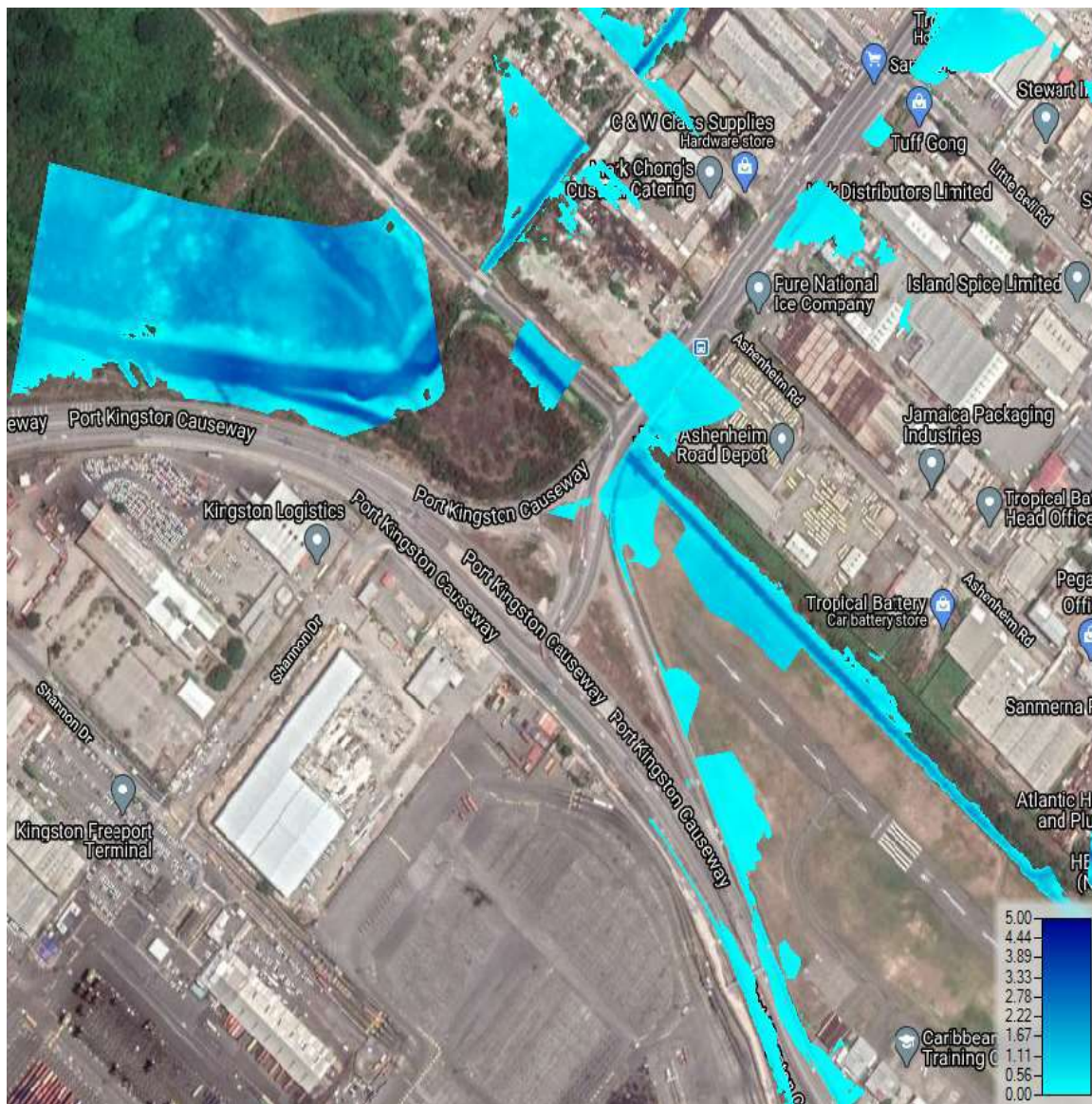


Figure 6.15 Flood map of Jew Gully with no detention pond and no improvement to Lower Jew gully for

6.7.3 Point Source Containment and Storm Water Management

Containment at both the sub-catchment and lot scale levels are not feasible alternatives for mitigating the peak flows from the design events. The volume of runoff in the 10-year RP for example would require a number of detention basins with areas of 0.6 to 6.8 hectares at the sub-catchment levels (Table 6.13). These areas are not available and therefore this approach is not feasible with great relocation costs. On-site mitigation through stipulation of a 5% increase in effective permeable area throughout the catchments is also expected to be ineffective. Reductions in peak flows of near zero to 0.25% might be plausible but not significant (Table 6.13). Large scale hydraulic improvements are required to safely conduct the anticipated flood water.

Table 6.13. Storm water management using detention basins and on-site mitigation

Hypothetical Detention basins			On-site mitigation		
Catchment	Average size (hectares)	# of basins required	Current conditions (m ³ /s)	5% red. in impervious surfaces (m ³ /s)	Reduction (%)
Lower Shoemaker	2.2	7	242.6	242	-0.25%
Jew Gully (Outlet)	6.8	9	362.0	361.6	-0.11%
Newport West 3	0.6	4	5.3	5.3	0.00%

6.8 Maintenance

6.8.1 Siltation of detention basin

The siltation rate of the detention basin was determined using the Universal Soil Loss Equation, developed by the National Resources Conservation Service. The Universal Soil Loss Equation (USLE) predicts the long-term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, vegetation and land management practices. USLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might occur from gully, wind or tillage erosion. This erosion model was created for use in selected cropping and management systems, but is also applicable to non-agricultural conditions such as construction sites.

*Universal Soil Loss Equation: $A = R * k * LS * C * P$*

Parameter	Description
A	Potential long-term average annual soil loss in tonnes per hectare (tons per acre) per year
R	Rainfall and runoff factor by geographic location
K	Soil erodibility factor
LS	Slope length-gradient factor
C	Crop/vegetation and management factor
P	Support practice factor

For this assessment, the Universal Soil Loss Erosion was used estimate the siltation rate of the proposed detention basin at the junction of the Tinson Pen Drain and Jew Gully. The estimation was conducted assuming erosion within the Jew Gully combined contributing watershed (Figure 6.16) would be the primary factor to the siltation of the basin. The equation yielded an average Soil Loss in the catchment Area of 19.76 Tons/Acre per year. As the area of the combined catchment is approximately 2,411 Acres, the average estimated loss per year is approximately 17,645 m³/year (see Table 6.14).

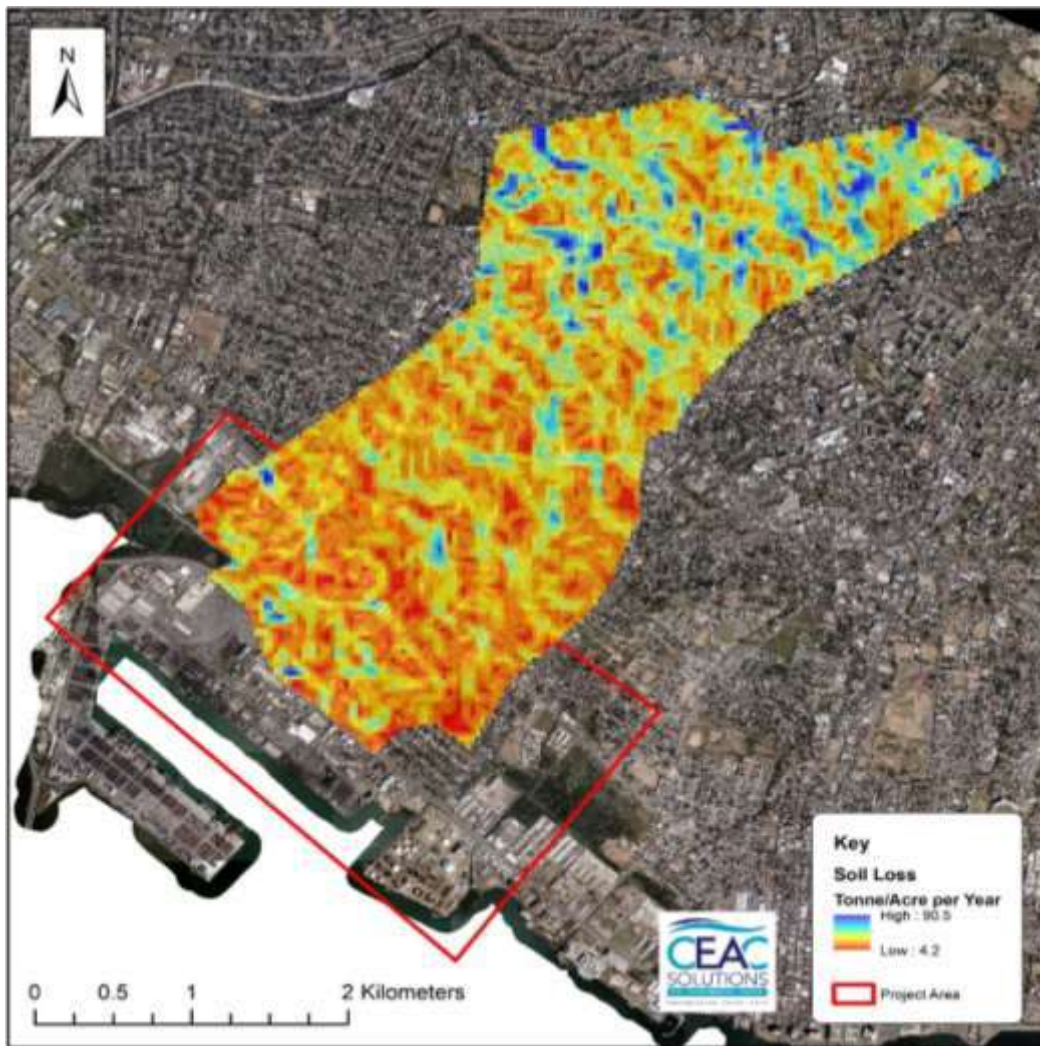


Figure 6.16: Soil Loss Map (Siltation Rate of Detention Basin) over Jew catchment area

Assuming that the all of the material lost within the combined Jew Gully catchment moves downstream to the detention basin it can deduced that the detention basin with a capacity of 40,000m³ would be filled within 2.3 years under typical conditions. As such a minimum maintenance schedule of once every year is recommended and is expected to cost between USD0.3 and 1.0 Million.

Table 6.14. Soil loss analysis used in the estimation of maintenance requirements for detention pond.

Average Soil Loss in catchment area (Tons/Acre per year)	19.8
Combined Catchment Area (m²)	9,758,790 (2,411.45 Acres)
Soil Density (kg/m³)	2,450.0
Soil Loss in catchment area (Ton/year)	47,655.5
Soil Loss in catchment area (kg/year)	43,232,334
Soil Loss in catchment area (m³/year)	17,645.9
Detention Basin Fill Rate years to fill (40,000m³ Detention Basin Capacity)	2.3
Recommended Maintenance Schedule	Annually

6.8.2 Blockage

Blockage was investigated in 3 major culverts in the project area. Namely: i) Marcus Garvey drive culvert along the Shoemaker gully, ii) Marcus Garvey drive culvert along the Tinson pen gully, iii) Spanish Town Road Temporary crossing along Jew gully (Table 6.16). Blockage due to derris and siltation in the gully and culverts can reduce the capacity and cause increased flooding in the surrounding areas. A Debris Potential at Structure of 25% for a 25 to 50-year RP (Syme, 2016) was investigated (Table 6.15 and Table 6.16). The improved drainage

features take into account not only present and future flood condition but also a freeboard of 25% therefore if there is blockage of 25% there should be minimal increased flooding to the areas surrounding the channel. Blockage is anticipated to increase water surface profiles 0.25 to 0.75 meter. Tinson Pen gully is the most vulnerable and expected to increase the flood levels to +0.2 meter above road levels. This speaks clearly to the need for maintenance of both the channels and culverts, and regular removal of debris.

Table 6.15 Blockage potential for drainage structure

AEP [ARI]	Debris Potential at Structure		
	High	Medium	Low
>5% [<20yr]	50%	25%	25%
5%-0.5% [20yr-200yr]	100%	50%	25%
<0.5% [>200yr]	100%	100%	50%

Table 6.16 The effects of blockage on the proposed major crossings in the project area

Drainage feature	Upstream water surface elevation with blockage 25 RP (m)	Upstream water surface elevation without blockage 25 RP (m)	Increase in water level (m) due to blockage	Bank Elevation (m)
Jew Gully	0.77	0.42	0.25	2
Tinson pen	3.66	2.91	0.75	3.4
Show marker	1.97	1.66	0.33	3.6

6.9 Summary

Flooding of the project area is initiated in the 1-year RP rainfall event and hydraulic and flood plain analysis confirmed and explain flooding in all 3 of the major catchments in the project area. Flooding hot spots were confirmed in: Marcus Garvey Drive, Newport Boulevard and Eight avenue in Newport west, the west airfield and parking lots of the Tinson pen aerodrome, Ashenheim Road, the lower region of Jew gully and the lower reaches of the shoe marker gully. The cause of the flooding can be attributed to the inadequate capacity of major flood control and minor street level drainage features. These flood control and drainage features will be further overwhelmed with increases in extreme rainfall, expected with climate change.

Upgrades to the major drains and crossings are summarized in the

Table 6.17 and Table 6.18. Further details from and consultations with Port Authority of Jamaica will be required to fine tune the approach to construction of the drains through the port. The proposed street level drainage plan consists of 189 combination inlets to be installed in the project area, along with 146m of 900mm, and 967 of 1200mm culverts. These improvements along with the regular maintenance plan of the culvert, drains and detention basin will reduce flooding in the project area to tolerable levels.

Alternatives were evaluated and confirm the need for major flood control and drainage improvements. Improvement of crossings only resulted in considerable flooding on Marcus Garvey Drive. Likewise, need for a detention pond and canal to Hunts Bay was shown to alleviate the flooding on Marcus Garvey Drive by up to 0.6 meters. Point source containment is also not expected to be beneficial in mitigating the peak flow rates.

Siltation can be expected in the detention basin annually and a 1 to 2.3-year maintenance cycle will be required to maintain its efficiency at a recurring cost of up to USD1.0 million. The importance of continue maintenance is underlined in an assessment of blockage of the culverts where in increased flooding of up to 0.75 meters can be expected with the openings are not cleared routinely.

Table 6.17 Proposed improvements to the drainage channels within the project area for the 10 – 100Yr Return Period.

Catchment	Receiveing stream	Channel Slope	Improvement Length (m)	10 RP			25 RP			50 RP			100 RP		
				Width (m)	Depth (m)	Capacity (25% Freeboard) m³/s	Width (m)	Depth (m)	Capacity (25% Freeboard) m³/s	Width (m)	Depth (m)	Capacity (25% Freeboard) m³/s	Width (m)	Depth (m)	Capacity (25% Freeboard) m³/s
Jew Gully/Tinson Pen/Marcus Garvey Drive															
Oaklands	Oaklands Drain	1.00%	1058	6	4	186.5	6	4	250.875	8	4	303.25	10	4	359.25
Clifton	Clifton Drain	0.90%	845	6	3	66.625	6	3	88.25	8	3	104.625	10	3	121
Marcus Garvey Drive	Hunts Bay Drain	0.40%	1562	3	1.5	13.375	4	1.5	17.625	4	1.5	20.75	6	1.5	24
Tinson Pen	Jew Gully	0.20%	1462	18	3	256.5	20	3	337.5	24	3	398.5	26	3	459.25
Jew Gully	Jew Gully	0.40%	790	10	4.5	238.25	10	5.5	314.125	12	5.5	371.875	14	5.5	429.875
Lower Jews gully	Lower Jews gully	0.10%	To be determined after survey	75	5	911.5	75	5	911.5	75	5	911.5	75	5	911.5
Newport West															
Newport West 1	NPW Drain 1 (To Outlet)	0.30%	200	3.4	1.2	11	3.4	1.2	11	3.4	1.2	11	3.4	1.2	11
Newport West 2	NPW Drain 2 (To Outlet)	0.40%		460	5.5	1.2	14.625	5.5	1.2	14.625	5.5	1.2	14.625	5.5	1.2
Newport West 3	NPW Drain 3 (To Outlet)	0.20%	300	3.4	1.2	13.125	3.4	1.2	13.125	3.4	1.2	13.125	3.4	1.2	13.125
Newport West 4	NPW Drain 4 (To Outlet)	4.30%	160	1.3	1.2	10.5	1.3	1.2	10.5	1.3	1.2	10.5	1.3	1.2	10.5
Shoemaker Gully															
Upper Shoemaker	Upper Shoemaker Gully	1.50%	897	6	2.5	221.2	6	2.5	221.23	8	2.5	300	12	2.5	363
Mid Shoemaker	Mid Shoemaker Gully	0.30%	480	12	2	193.25	14	3	255.375	16	3	302.375	18	3	349.25
Lower Shoemaker	Lower Shoemaker Gully	0.30%	516	20	3	340.625	20	4	451.375	20	4	534.875	20	4.5	618.25

Table 6.18 Proposed improvements to the crossings within the Jew Gully/Tinson Pen/Marcus Garvey Drive area for the 10 – 100Yr Return Period.

Drain/Gully	Crossing Code	Description	Existing Type	10-Yr RP				25-Yr RP				50-Yr RP				100-Yr RP			
				Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity
Jew Gully/Tinson Pen/Marcus Garvey Drive																			
Clifton	CL-01	Road Crossing/ Culvert Pipe Crossing	pipe culvert	6	3	Single cell concrete box culvert	53.3	6	3	Single cell concrete box culvert	70.6	8	3	Single cell concrete box culvert	83.7	10	3	Single cell concrete box culvert	96.8
Clifton	CL-02	Earth Drain/Culvert	2 cell box culverts	6	3	Two cell concrete box culvert	53.3	6	3	Two cell concrete box culvert	70.6	8	3	Two cell concrete box culvert	83.7	10	3	Two cell concrete box culvert	96.8
Oaklands	OK-05	Road Crossing	single cell concrete box culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	6	Two cell concrete box culvert	287.4
Oaklands	OK-04	Road Crossing	single cell concrete box culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	6	Two cell concrete box culvert	287.4
Oaklands	OK-03	Concrete Slab Crossing	single cell concrete box culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	6	Two cell concrete box culvert	287.4
Oaklands	OK-02	Road Crossing	single cell concrete box culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	6	Two cell concrete box culvert	287.4
Oaklands	OK-01	Culvert Crossing (two 3’ pipes)	dual pipe culvert	6	4	Single cell concrete box culvert	149.2	6	4	Single cell concrete box culvert	200.7	8	4	Two cell concrete box culvert	242.6	10	4	Two cell concrete box culvert	
Tinson Pen	TP-01	Major Road Crossing (Measuring Apparatus Required for depth)	three cell concrete box culvert	18	3	Three cell box culvert	205.2	20	3	Four cell box culvert	270	24	3	five cell culvert	318.8	26	3.8	five cell culvert	366.92
Tinson Pen	TP-02	Drainage structure (Stewarts Drain to Tinson Pen Gully)	single cell concrete box culvert	6	2	Single cell concrete box culvert	28	6	2	Single cell concrete box culvert	28	6	2.5	Single cell concrete box culvert	28	7	2.5	Single cell concrete box culvert	32.3
Marcus Garvey Drive	MG-01	Along Marcus Garvey Drive	concrete arch culvert	4	1.5	Single cell concrete box culvert	24	4	1.5	Single cell concrete box culvert	24	4	1.5	Single cell concrete box culvert	24	4	1.5	Single cell concrete box culvert	24
Marcus Garvey Drive	MG-02	Along Marcus Garvey Drive	single cell concrete box culvert	3.5	1	Single cell concrete box culvert	15.8	3.5	1	Single cell concrete box culvert	15.8	4	1	Single cell concrete box culvert	17.6	4.5	1	Single cell concrete box culvert	19.8
Marcus Garvey Drive	MG-03	Along Marcus Garvey Drive	concrete arch culvert	3.5	1	Single cell concrete box culvert	15.8	3.5	1	Single cell concrete box culvert	15.8	4	1	Single cell concrete box culvert	17.6	4.5	1	Single cell concrete box culvert	19.8
Marcus Garvey Drive	MG-05	Crosses Marcus Garvey Drive	single cell concrete box culvert	3.5	1	Single cell concrete box culvert	15.8	3.5	1	Single cell concrete box culvert	15.8	4	1	Single cell concrete box culvert	17.6	4.5	1	Single cell concrete box culvert	19.8
Jew Gully	JG-04	Temporary Crossing Structure	single cell concrete box culvert	10	4.5	Two cell concrete box culvert	190.6	10	5.5	Two cell concrete box culvert	251.3	12	5.5	Two cell concrete box culvert	297.5	14	5.5	Two cell concrete box culvert	343.9
Jew’s Gully	JG-03	Road Crossing	single cell concrete box culvert	10	4.5	Two cell concrete box culvert	190.6	10	5.5	Two cell concrete box culvert	251.3	12	5.5	Two cell concrete box culvert	297.5	14	4.5	Two cell concrete box culvert	343.9
Jew’s Gully	JG-02	Very High Drop/ Main Road (Drain is corrugated Semi circle)	corrugated Semi circle	10	4.5	Two cell concrete box culvert	190.6	10	5.5	Two cell concrete box culvert	251.3	12	5.5	Two cell concrete box culvert	297.5	14	4.5	Two cell concrete box culvert	343.9

Jew's Gully	JG-01	Road Crossing	single cell concrete box culvert	10	4.5	Two cell concrete box culvert	190.6	10	5.5	Two cell concrete box culvert	251.3	12	5.5	Two cell concrete box culvert	297.5	14	4.5	Two cell concrete box culvert	343.9
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Table 6.19: Proposed improvements to the crossings within the Shoemaker Gully area for the 10 – 100Yr Return Period.

Drain/Gully	Crossing Code	Description	Existing Type	10-Yr RP				25-Yr RP				50-Yr RP				100-Yr RP			
				Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity	Total Span	Depth	Improvement Note	Capacity
Shoemaker Gully	SM-8	Main Road Crossing	2 cell box culvert	20	3	bridge single span	361.1	20	3	bridge single span	361.1	20	3.3	bridge single span	427.9	20	3.5	bridge single span	494.6
Shoemaker Gully	SM-07	Foot Crossing	single cell concrete box culvert	12	2	2 cells recommended or removal	193.25	14	3	2 cells recommended or removal	255.375	16	3	3cells recommended or removal	302.375	18	4	3cells recommended or removal	349.25
Shoemaker Gully	SM-06	Main Road Crossing	single cell concrete box culvert	No improvement necessary				No improvement necessary				8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-05	Road Crossing	single cell concrete box culvert									8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-04	Road Crossing	single cell concrete box culvert									8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-03	Road Crossing	single cell concrete box culvert									8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-02	Drain is corrugated Semi circle	semi-circular CSV	6	2.5	Single cell concrete box culvert	193.25	6	2.5	Single cell concrete box culvert	255.375	8	2.5	Two cell concrete box culvert	302.375	12	2.5	Two cell concrete box culvert	349.25
Shoemaker Gully	SM-01	Road Crossing	single cell concrete box culvert	No improvement necessary				No improvement necessary				8	2.5	Two cell concrete box culvert	302.375	10.5	2.5	Two cell concrete box culvert	349.25

7 Feasibility Assessment

7.1 Methodology and Data

7.1.1 Cost estimate

Cost estimates were derived for the required flood control and drainage works for the 10, 25, 50 and 100--year RP events, using industrial average rates from a combination of NWA and other national projects (NHT and JSIF). See Table 7.1. Preliminaries and contingencies were accounted for at a rate of 10% and 15% respectively. A higher rate for contingencies was used because of the preponderance of several unknowns. These were discussed separately. Drain lengths and cross section dimensions were used to derive quantities for grubbing, excavation, soil stabilization, filling and concrete works. Several exigencies of the proposed works were considered to factor up the prevailing rates, including:

1. Excavation in high water tables conditions. It is estimated that extensive dewatering will be required given the high ground water.
2. Demolition and removal of existing concrete channel sections where they exist
3. Use of geogrid to stabilize the inverts is advisable to minimize movement of the sections.
4. An all-in rate for formwork, steel and concrete to account for variability across the various sections.
5. Culvert costs and diversions were nominally estimated to be 10% of the associated flood control works

Table 7.1. Flood control BQ items and rates in USD and JMD.

	Items	Units	USD	JMD
1	Drainage works: Including, inlet, 900mm, 1200mm drain pipes	m	\$869	\$130,362
2	Water and sewage: Including 100mm water pipes 200 and 250mm sewer pipes and manholes	m	\$300	\$45,000
3	Road reinstatement works: Including 200mm base course, 75mm asphaltic concrete and sidewalks	m	\$617	\$92,489
4	Grubbing, including clear site of vegetation and whole trees and dispose	m2	\$1.5	\$230
5	Demolition and removal of concrete structures and disposal	m3	\$33.3	\$5,000
6	Excavation in water + dewater including dredging	m3	\$20.0	\$3,000
7	Geogrid: including 2 layers, supplied and laid	m2	\$10.0	\$1,500
8	Engineered fill , including selected, placed and compacted in layers	m3	\$23.3	\$3,500
9	Concrete works, including allowance for formwork, reinforcement and 31MPa concrete	m3	\$500.0	\$75,000

7.1.2 Economic Analysis

Cost–benefit analysis (CBA) was used to estimate and compare the costs and benefits of implementing the flood control works with that of a ‘do nothing’ approach. This approach represents a continuation of current conditions under which the proposed project/ policy is not implemented. The following methods were used to evaluate the project’s feasibility:

- i. Calculate the Net Present Value (NPV) - Calculating present value (PV) involved discounting values that occur in future years. Net Present Value (NPV) is the value of all future cash flows (positive and negative) over the entire life of an investment discounted to the present. It is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. A positive net present value indicates that the projected earnings generated by a project or investment (in present dollars) exceeds the anticipated costs, also in present dollars. In addition to factoring all revenues and costs, it also takes into the account the timing of each cash flow that can result in a large impact on the present value an investment. The following formula was

used to calculate the Net Present Values (NPV): $NPV = \sum_{t=1}^n \frac{R_t}{(1+i)^t}$. Where, R_t = net cash inflow-outflow during the period (t), i = the discount rate or potential returns from alternative investments, t = the number of time periods. The design life and an interest rate of 3.0% for this project. This percentage represents the discount rate which can be used to account for the time value of the money (climate-related damages) in the present. Costs and benefits occur in different amounts and at different time periods during the project, so in order to compare these costs and benefits, both costs and benefits have to be discounted (against a certain interest rate). This is required because due to inflation, interest rates, and opportunity costs, money is more valuable the sooner it is received.

- ii. Calculate the Benefit Cost Ratio (BCR) - The BCR is the ratio of the benefits of a project or proposal relative to its costs, expressed in monetary terms. This indicator should be higher than 1 for a project to be acceptable. For the purpose of this project, the benefits and costs are represented by the Average Annualized Loss (AAL), which can be defined as the expected loss per year averaged over the design life period. The AAL is the amount of money the public loses each year in direct and indirect costs. The benefit-cost ratio formula is the discounted value of the project's benefits divided by the discounted value of the project's costs, $BCR = \frac{\text{Value of Benefits}_{DISCOUNTED}}{\text{Value of Costs}_{DISCOUNTED}}$. The primary limitation of the BCR is that it reduces a project to a simple number, when the success or failure of an investment or expansion relies on many factors and can be undermined by unforeseen events. Essentially, the BCR is the fact that different classifications of costs will ultimately lead to different outcomes. The BCR must be used as a tool in conjunction with other types of analysis to make a well-informed decision as previously stated. Another type of analysis employed within this study is discussed below.
- iii. If projects are to be compared that are not mutually exclusive, the Internal rate of return (IRR) is a better indicator than the BCR, because IRR is independent of external discount rates and independent of the way associated costs are dealt with. IRR was also used to define the feasibility of the project proposals.

7.1.3 Phasing

Losses emanate from both vehicle-related delay losses and direct damages to both residential and commercial properties. The value of both exposed assets and deferred social losses were compared to the estimated cost of the flood control. Deferred social losses were valued using NPV over a 50-year period. An examination of the assets exposed on a sub-catchment level allowed for the closer examination of the benefits of focusing the works on either: i) assets (mitigations of direct losses) or ii) vehicle related losses (indirect losses).

7.2 Cost Estimate

The projected cost of the works across the project area is USD\$143,290,388 for the recommended 100-year RP design condition. B:C ratio for the five options exceed 2.0 and are therefore beneficial. The 100-year RP had a lower rate of IRR (10.4%) than the 25 and 50-year (~10.5%), but higher than the 10-year RP (7.4%), and suggest that higher benefits could be derived from some modifications to the initial proposal. A 100-year RP with some revisions was contemplated and discuss in further details in Section 7.4.1, with the highest IRR of 11.5% that is higher than the discount rate, and possibly a favorable investment for social goods/infrastructure. Additional requirements of land acquisition and social displacement are anticipated with the 50 and 100-year RP in the Jew Gully sub-catchment. These will have to be better defined in the design stage. See Table 7.2 for a summary of options 10, 25, 50 and 100-year RP, break-down by the various flood control areas in Table 7.3 for the 100-year RP (Revised) option and appendices for the detailed cost break down. Overall, there is improved benefits from the 100-year RP options with considerably greater benefits, for marginally more costs. The 100-year RP (Revised) design is therefore recommended as the most feasible and justifiable option at this time.

Due consideration should be given in the design phase and after the environmental impacts are estimated to relook at the implementation of the 100-year RP design. It may be plausible to use differential RP for solutions across the project area. This would allow for the most practical cross sections that can be implemented to be utilized, where social and space constraints exist, to minimize social disruptions.

Table 7.2. Cost estimate, benefits, NPV, B:C ratio and IRR for Marcus Garvey/Tinson Pen flood control works for the 10 to 100-year RP event.

	10- year RP	25- year RP	50- year RP	100- year RP	100- year RP (REV)
Cost estimate/CAPEX (USD)	-\$128,903,893	-	-	-	-
Average Annualized Loss (AAL)	\$6,432,302	\$2,124,990	\$1,353,044	\$1,002,950	\$1,002,950
Benefit/deferred costs (USD) per year	\$11,062,274	\$15,369,587	\$16,141,532	\$16,491,626	\$16,491,626
Maintenance cost (USD) @ 1.0% per year	-\$1,289,039	-\$1,334,110	-\$1,394,094	-\$1,432,904	-\$1,313,166
Discount rate	3%	3%	3%	3%	3%
Project life (year)	50	50	50	50	50
NPV (USD)	\$251,463,027	\$361,129,506	\$379,448,081	\$387,457,376	\$390,538,193
Benefit:Cost	2.0	2.7	2.7	2.7	3.0
IRR	7.4%	10.4%	10.5%	10.4%	11.5%

Table 7.3. Cost estimate of proposed drainage works for the 10, 25, 50 and 100-year RP options

Breakdown	10-year RP	25-year RP	50-year RP	100-year RP	100-year RP (Revised)
Preliminaries	\$10,133,419	\$10,672,879	\$11,152,755	\$11,463,231	\$10,505,331
Marcus Garvey, Tinson Pen and Jew Gullies	\$75,285,529	\$77,890,928	\$81,630,763	\$84,036,825	\$74,457,826
Shoemaker	\$15,468,467	\$18,704,440	\$19,763,368	\$20,657,016	\$20,657,016
Newport West	\$10,133,419	\$10,133,419	\$10,133,419	\$9,938,469	\$9,938,469
Contingencies	\$15,468,467	\$16,009,318	\$19,763,368	\$17,194,847	\$15,757,997
GRAND TOTAL	\$128,903,893	\$133,410,984	\$139,409,437	\$143,290,388	\$131,316,639

7.3 Cost Benefit and Internal Rate of Return

Average Annualized Loses are expected to be reduced to USD\$ \$1,002,950 (from \$17,494,576) as a result of the proposed flood control works. The benefit-cost ratio for the upgrading the flood control is 3.0 with an NPV of USD \$390,538,193. An internal rate of return of 11.5% was determined and is above prevailing sovereign bond rate of ~3% and below international norms of 12 to 18%¹² for disaster mitigation projects, therefore suggest that the infrastructure works are economically feasible, but has room for improvements¹³. See Table 7.2.

7.4 Limitations and Further Investigations Required

Several items of the proposed works are difficult to verify at this time and require further investigations. These were discussed as follows:

7.4.1 Tinson Pen Earth Drain

An earth drain 63 meters wide earth drain at 0.25% slope and with 2:1 side slopes could be used to substituted for the initially proposed W 26 m x D 3 m reinforced concrete channel. This saves \$6,189,523 and results in less turbulent flows, with Froude number (F) ~0.7 < 1 versus concrete option F = 1.2. However, this alternative requires additional land space. This alternative should be considered.

7.4.2 Tinson Pen Detention Basin and Hunts Bay Canal

Lowering of the water surface profile is key to preventing flooding in the project area. The confluence of Tinson Pen (mild), Marcus Garvey (mild) and Jew Gullies (steep) in an environment of relatively low road levels, will necessitate the dropping of the invert of the outfall profiles from 1.4 to 0.4 meters. This will reduce the water surface profile to below the Marcus Garvey Drive road elevation of 3.4 meters. Achieving this requirement, will necessitate: i) dredging a 12

¹² <http://documents1.worldbank.org/curated/en/552201468145748680/pdf/31771.pdf>

¹³ Shyam, K. C. "Cost benefit studies on disaster risk reduction in developing countries." (2015).

hectares detention pond and ii) creating a 75 meters wide x 3 meters deep x1,750 meters long deep channel that leads to Hunts Bay. The works in this area are estimated to cost USD\$15,368,880 and are subject to the sparsity of information and limitations at this time. Land acquisition, topographic, bathymetric and geotechnical conditions are uncertain in the Hunts Bay to Chesterfield area of the project. The proposed detention basin will require land acquisition of two parcels (Figure 7.1) off Chesterfield Road. It is our understanding that these parcels (discussions with JSEZA) were assigned to KW Ltd. Notwithstanding, the nominal cost for acquiring these parcels was not accounted for at this time. Topographic information in the mangroves and the bathymetric survey information in the Hunts Bay is described on the charts as “un-surveyed” (Figure 7.2). The quantity of material in this area is therefore uncertain and average case scenario was used as it relates to the cost of dredging. Shallower depths and more extensive dredging could impact the cost by USD2 to 5 million. Geotechnical information is also lacking and could impact the cost of dredging. Stiffer sediments are more expensive to dredge. Ecological conditions are also unknown in the adjacent mangroves and some may need to be cleared. Additionally, NEPA could require compensation costs for removal of mangroves. It is therefore important to determine the extent of works and ecological setting in the mangrove to better estimate these works.

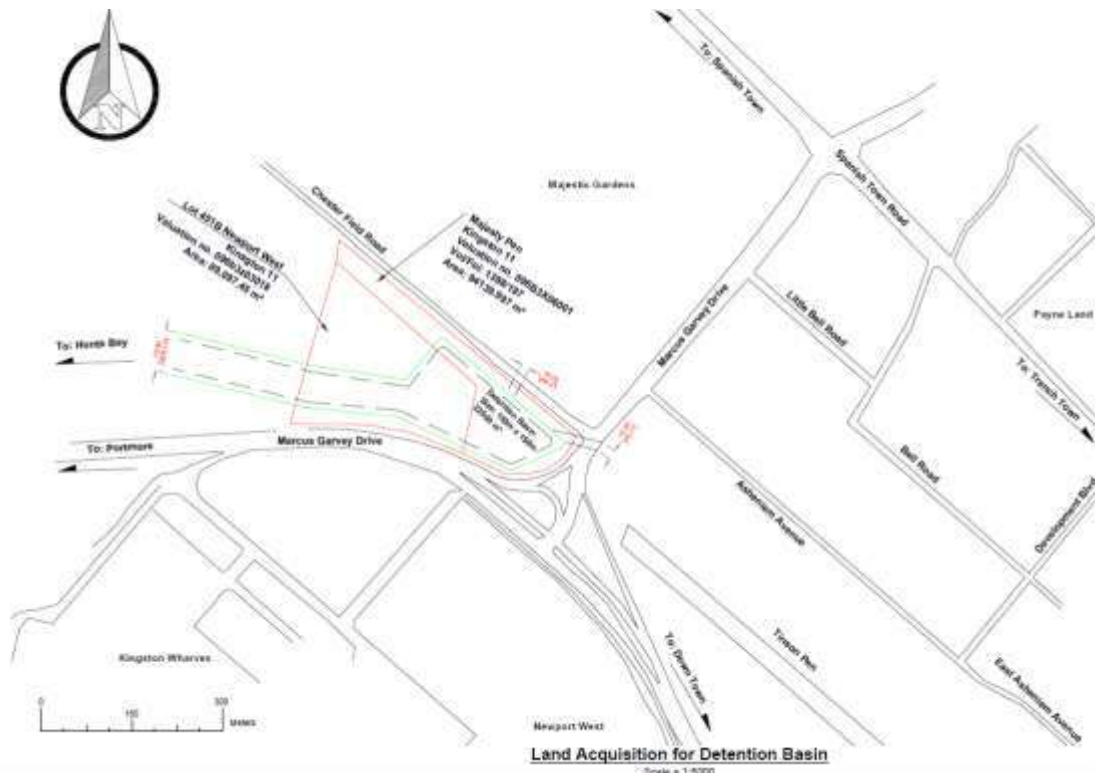


Figure 7.1. Land acquisition required for Tinson Pen Detention Basin



Figure 7.2. Proposed Hunts Bay and wetland survey areas south of Chesterfield Road

7.4.3 Sheet piling and relocation costs

Informal settlement along the banks of the Jew Gully (Figure 7.3) makes widening of the existing gully (7.5 mx 2 m) challenging without either relocation costs or sheet piling. Relocation would be necessary for the widening option and would entail social disruption. An alternative to this would entail deepening the channel by sheet piling a channel in the invert to increase the hydraulic capacity. This approach would entail: i) demolishing the invert of the channel, sheet piling and sealing the new and deeper invert. The cost of the relocation in the first approach and the cost of sheeting in the second approach was not considered at this time. Further guidance from NWA is sought to finalize the approach.



Figure 7.3. Jew Gully in Majestic Gardens.

7.4.4 Water and Sewage infrastructure replacement

Allowances for replacement of sewer and water utilities were made. An all-in rate of USD300,000 per km rates for water and sewer and USD500,000 for two lift stations and force main were used per sub-catchment. Information on the water and sewer network in the project area can help to guide the costs associated with these assets in the design phase in any additional effort.

7.5 Recommended Phasing

Five phases are recommended as follows:

1. Phase 1: The detention basin and canal (USD17.8 Million) should initiate the works. this is crucial to the overall success of the project and is highlighted in Table 7.4. Its importance stems from the fact that the remaining elements of the Tinson Pen, Marcus Garvey and Jew Gullies works cannot function adequately without these works being in place first.
2. Phase 2: Works relating to minimizing traffic-related losses should be prioritized with Marcus Garvey Drive and Tinson Pen Gullies improvements (USD65 Million).
3. Phase 3: The importance of Newport West assets (primarily warehouses and office) is justified in this phase. Four major drains are required for these works (USD\$10.0 Million).
4. Phases 4 and 5: Shoemaker gully and Jew Gully works have high capital requirements (USD\$25.8 Million and USD10 Million) in comparison to the estimated assets and benefits (USD23 Million). A caveat is suggested here, wherein the overtopping of the intersection of Shoemaker and Marcus Garvey does impede the flow of traffic, but is not fully understood at this time. Further investigations are required into both the exposed assets and the nature of the flooding at this point in the flood control works.

Table 7.4. Recommended phasing of flood control works

Catchments	Value of assets at risk	Cost of flood control works (100-year RP revised)	Ratio of Assets at risk: Cost of works
Tinson Pen/Marcus Garvey/Jews Gully	\$339,946,058	\$93,072,282	3.65
<i>Detention basin, canal +</i>	\$339,946,058	<i>\$17,786,680</i>	<i>19.11</i>
<i>Tinson Pen (commercial)+ Marcus Garvey (veh. delays)</i>	\$322,446,058	<i>\$65,351,484</i>	<i>4.93</i>
<i>Jews Gully (residential)</i>	\$17,500,000	<i>\$9,934,118</i>	<i>1.76</i>
New Port West	\$60,000,000	\$12,423,087	4.83
Shoemaker	\$6,125,000	\$25,821,270	0.24

7.6 Summary

The flood control works are expected to cost USD \$131,316,639 with preliminaries and contingencies for the 100-year RP event. The recommended phasing prioritizes: i) Detention basin and Hunts Bay Canal, Marcus Garvey, Tinson Pen, followed by ii) Newport West and then iii) Shoemaker and Jew Gully. The works are expected to considerably reduce the AAL from USD17.5 million to USD1.0 Million and are expected to be economically feasible with a BCR of ~3.0 and IRR of ~11.5%. Several limitations were noted that should be considered.

8 Summary, Conclusions and Recommendations

8.1 Summary and Conclusions

The following are concluded based on the field observations, hydrological, hydraulic and flood plain analysis:

1. The project area serves 3 major catchments: i) Marcus Garvey Drive and the Tinson Pen and Jew's Gully catchment, ii) Shoe marker catchment and iii) the New Port west catchment. All have a general slope of 1 to 3% leading to the Kingston harbor, except in the lower reaches where the catchments flatten to 0.5 to 1.5% in the project area. The project area is typified by considerable extreme rainfalls over a steep catchment consisting of relatively impervious soils in a highly developed urban catchment that leads to high peak runoffs. The overall catchment area that directs runoff to through the project area is approximately 16.11 km², and is comprised of 19 sub-catchments. The most important limitation was that there were only 2 rain gauges in proximity of the project area. The project area consists of 15 major flood control channels and 44 crossings.
2. Anecdotal information suggests frequent flood events in the project area with losses to single entities per event as high as USD8 million. 5 to 100-year RP inundation levels varied from 0.4 to 1.8m. The AAL is estimated to be USD \$17,494,576 based on the estimated direct and indirect losses.
3. Flooding is initiated in the 1-year RP event across the project area. Flood map assessment confirmed several flood hot spots along all 3 of the major catchments within the project area. The most notable areas are: New port boulevard and Eight avenue in Newport west with (max flood depths of 0.8 m), the west airfield and the parking lots of the Tinson pen aerodrome (max flood depths of 0.9 m), Ashenheim Road (max flood depths of 1.0 m), the lower region of Jew gully (max flood depths of 1.2m) and the lower reaches of the Shoemaker gully (max flood depths of 1.7 m) for a 25 year rainfall event present climate condition.
4. A combination of channel and crossing improvements, improving and lowering the hydraulic connection to Hunts Bay and extensive street level drainage improvements will alleviate flooding for up to the 100-year RP. Detailed investigations in the Environmental Statement exercise and further hydraulic investigations are required, given space limitations and social variables. Of the existing 9337 m of drainage system studied 8730 m would have to be improved to be resilient to flood events to a 100-year return period (Table 8.1).

Table 8.1. Channel improvement lengths (m) in sub-catchments

	Jew, Marcus Garvey, Tinson, Oakland and Clifton Gullies	NPW	Shoemaker Gully	Total (m)
Total Drainage channel in project area existing	6320	1120	1897	9337
Total Improvement	5717	1120	1893	8730

5. Investigation of alternatives confirm that improvement of crossings only will be ineffective in mitigating flooding on Marcus Garvey Drive. A detention pond and canal to Hunts Bay are required to alleviate the flooding. Routine maintenance will be required to ensure the efficiency of the proposed flood control works to mitigate the effects of siltation and blockage of culverts. This programme is expected to cost up to USD1.0 million annually.
6. The flood control works are expected to cost USD\$131.4 Million with preliminaries and contingencies for the revised option to address the 100-year RP event. The proposed solutions included: i) 7610 km of widening and deepening the major drainage channels, ii) improvements to the Newport West underground drainage system, iii) improvements to 14 crossings and iv) constructing a detention basin and canal to Hunt Bay. Extensive street level drainage will be required as well and will consists of 189 combination inlets and almost 1200 meters of 900 and 1200 drain pipes. These improvements along with the regular maintenance plan of the culvert, drains and dentation basin will reduce flooding in the project area to tolerable levels.

8.2 Recommendations

8.2.1 Infrastructure Improvements

The following are the recommendations to alleviate flooding in the project area:

Tinson Pen, Jew Gully, Marcus Garvey Drive

1. For the Tinson Pen Drain, it is proposed that the drainage system be upgraded by:
 - a. Widening 1462 meters of the channel to 18m, and deepening to 3m to carry the flow, which results in the drain having a capacity of 459m³/s, which exceeds the future 100-Yr RP event of 367m³/s.
 - b. The crossing at Marcus Garvey Drive is to be upgraded from a 3-cell to a 5-cell culvert, matching the width of the drainage channel.
 - c. The crossing coming from the Stewarts industrial area to the Tinson Pen Drain to be upgraded to a 2-Cell concrete box culvert, measuring 2m deep x 6m wide.
2. For the Jew Gully Drainage channel, it is recommended that:
 - a. The 790 meters of the channel be widened to 14m and deepened to 5.5m to carry the flow for the 100-Yr RP event. The result is a drain with a capacity of 430 m³/s, which exceeds the 100-Yr RP peak flow of 367 m³/s.
3. For the Marcus Garvey Drive drain, it is recommended that 1661 meters of the drainage channel be upgraded by widening to a width of 6m, and a depth of 1.5m to assist in easing the current flooding situation in the area. The resulting drain will have a capacity of 24m³/s, which does not exceed the peak flow of the future 100-Yr RP event of 19m³/s. However, the modelling conducted indicates that the improvement of the Tinson Pen and Jew Gully Drains will significantly reduce the instances of flooding along the Marcus Garvey Drive area.
4. The construction of a detention basin and canal to Hunts Bay, where the Tinson Pen drain and Jew Gully intersect. This basin has a proposed functional capacity of approximately 40,000m³ and an invert of -3.0 m, and serves as a debris collection and cleaning point before runoff gets to the harbor.

Newport West

To reduce the instances of flooding in the Newport West area, it is recommended that a large section of the 1120 meters of drainage system, including inlets and the underground pipe network be upgraded to meet the needs of the catchment area. The improvement includes the strategic upgrade of key inlets, and upgrading the underground piping to underground concrete box drains. The Newport West 1 drainage area does not require any improvement.

1. Newport West 1 area upgrades existing 900mm culvert to 3.4m *1.2m box culvert with a capacity of 15.5m³/s, which exceeds the 100-Yr RP event of 8.8 m³/s.
2. Newport West 2 area upgrades existing 900mm culvert to 5.5m *1.2m box culvert with a capacity of 22.5m³/s, which exceeds the 100-Yr RP event of 12.5 m³/s.
3. Newport West 3 area upgrades existing 900mm culvert to 3.4m *1.2m box culvert with a capacity of 15.5m³/s, which exceeds the 100-Yr RP event of 11.3 m³/s.
4. Newport West 4 area upgrades existing 900mm culvert to 1.3m *1.2m box culvert with a capacity of 8.4m³/s, which exceeds the 100-Yr RP event of 8.4 m³/s.

Shoemaker Gully

1. Approximately 480 meters of the channel to be widened to 20m and deepened to 4.5m before the final crossing at Marcus Garvey Drive. This results in a capacity of 349 m³/s, which exceeds the peak flow during a future 100-Yr RP rainfall event of 279 m³/s, which should significantly reduce the instances of localized flooding in the area.
2. Approximately 516 meters of the drainage channel after the Marcus Garvey Drive crossing be upgraded with a maintained width of 20m, but an upgraded depth of 4.5m, which results in a capacity of 618m³/s, which exceeds the 100-Yr RP peak flow of 495m³/s, and should assist in reducing the localized flooding upstream.
3. Crossing at Marcus Garvey Drive be upgraded to a single span bridge measuring 16m wide and 6m deep.

Culvert Crossings and Street Drainage

In addition to the upgrading of the drainage channels, it is also recommended that some of the existing culvert crossings be upgraded, as in several instances they significantly reduce the capacity of the channel. As such, 14 culvert crossings have been identified for upgrade. Street drainage in several identified areas were found to be lacking, as such it is recommended that upgrades be implemented to assist with carrying runoff from identified areas to their associated drains efficiently. A total of 189 combination inlets, along with approximately 4km of 900mm culverts, and 1.5km 1200mm culverts were recommended to assist with drainage of the study area.

8.2.2 Feasibility and Phasing

The probabilistic loss estimate shows that the losses emanate from delay related losses in vehicle operating losses, and direct damages to both residential and commercial properties. As such, the following phasing is recommended:

1. Phase 1: The detention basin and canal (USD17.8 Million) should initiate the works. This is crucial to the overall success of the project and is highlighted in Table 7.4. Its importance stems from the fact that the remaining elements of the Tinson Pen, Marcus Garvey and Jew Gullies works cannot function adequately without these works being in place first.
2. Phase 2: Works relating to minimizing traffic-related losses should be prioritized with Marcus Garvey Drive and Tinson Pen Gullies improvements (USD65.4 Million).
3. Phase 3: The importance of Newport West assets (primarily warehouses and offices) is justified in this phase. Three major drains are required for these works (USD\$12.0 Million).
4. Phases 4 and 5: Shoemaker gully and Jew Gully works have high capital requirements (USD\$25 and 10.0 Million) in comparison to the assets and benefits (USD23 Million). A caveat is suggested here, wherein the overtopping of the intersection of Shoemaker and Marcus Garvey does impede the flow of traffic, but is not fully understood at this time. Further investigations are required into both the estimated exposed assets and the nature of the flooding at this point in the flood control works.

9 Appendix

9.1 Photos



Figure 9.1: Shoemaker Gully (Upstream View) during 1-2Yr RP rainfall event



Figure 9.2: Shoemaker Gully (Downstream View) during 1-2Yr RP rainfall event



Figure 9.3: Flooding along Marcus Garvey Drive during 1-2Yr RP rainfall event



Figure 9.4: Flooding in the Newport West area during 1-2Yr RP rainfall event



Figure 9.5: Flooding at Tinson Pen Aerodrome



Figure 9.6: Flooding in the Newport West area during 1-2Yr RP rainfall event



Figure 9.7: Respondent showing flood depth in hanger, Tinson Pen Aerodrome during 1-2Yr RP rainfall event



Figure 9.8: Flooding in the Newport West area during 1-2Yr RP rainfall event



Figure 9.9: Flooding along Marcus Garvey Drive during 1-2Yr RP rainfall event



Figure 9.10: Flooding along Marcus Garvey Drive during 1-2Yr RP rainfall event



Figure 9.11: Flooding along Marcus Garvey Drive during 1-2Yr RP rainfall event



Figure 9.12: Tinson Pen drain during 1-2yr RP rainfall event



Figure 9.13: Marcus Garvey Drive drain during 1-2yr RP rainfall event



Figure 9.14: Marcus Garvey Drive drain during 1-2yr RP rainfall event



Figure 9.15: Flooding along Marcus Garvey Drive during 1-2Yr RP rainfall event



Figure 9.16: Temporary Crossing at Jew Gully during 1-2yr RP rainfall event

9.2 Aerial Photos



Figure 9.17: Aerial Photos of Tinson Pen culvert crossing and proposed detention basin location

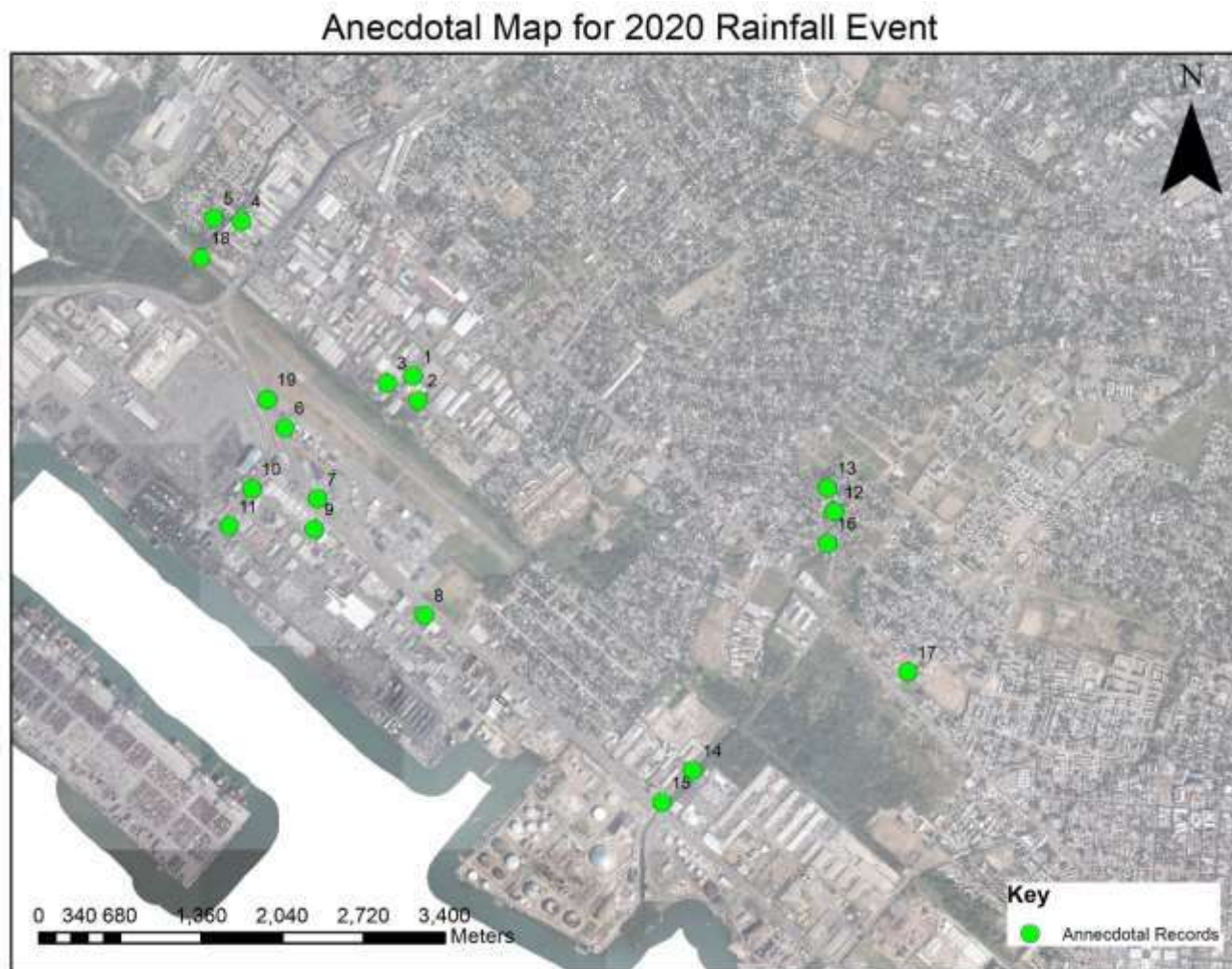
9.3 Anecdotal Interview Summary

Table 9.1 Summary of anecdotal interviews conducted on October 6th 2020.

No.	Time in area (years)	Location interviewed	Depth of water 2020 event (m)	Notes
1	10	Ashenheim Road	0.4	The water covers Ashenheim Road and also the man holes spill water
2	60	Bank of the Oakland gully	0.4	The crossing close to heart trust gets blocks and overtops the road
3	2	Heart Trust NTA	0.31	Experienced 3 inches of rainfall in the guard house
4	50	Majestic garden	0	No flooding upstream but inadequate street level drainage ponding in the roadway
5	5	Majestic garden	0.3	Flooding increased recently as left gully bank downstream damaged
6	20	Tara, Tinson pen	0.4	6 inches of rainfall within hanger, 0.4m in front the Tara front office
7	3	Car lot close to Tinson pen	0.15	Floods at least twice yearly

8	2	New Port West	0.3	2020 event worse seen
9	5	New Port West	0.45	2020 event worse seen
10	10	New Port West	0.77	Water settled in the middle of the road and rose entering the property
11	5	New Port West	0.61	The water level rise to about half a truck tire and comes up two flight of stairs
12	36	Trench town	0.6	The gully over tops the lower bank and flows against the property fence
13	10	Trench town	0.9	The gully over flows the left bank and heavy floods the residence
14	15	coffee board	0.1	Flooding on the banks reduced after the completion of the road, gully has been recently cleaned minor/no flooding from the gully
15	3	Marcus Garvey	0.05	Minor flooding close to the gully
16	10	Trench town	0.1	The gully slightly over tops and flows against property boundary
17	30	Trench town	0	The water level increases to mid-way the gully and moves fast
18	65	Temporary crossing on Chester field drive	0.4	Gully overflow s on the right bank more frequently recently due to damage to drain
19	5	Marcus Garvey	0.7	Police officer on duty reported waist height water in the road, vehicles stalled in the water, area under the overhead pedestrian crossing particularly badly flooded

Figure 9-9.18 Anecdotal Records Map



9.4 Hydraulic Report for Drainage Design

9.4.1 Hydrograph - Rational Method Analysis_5yr RP - Rational Hydrograph Method

5 year recurrence Interval, Peak Discharge: 0.287 cms, Time to Peak: 12.00 (min), Total Volume: 203.91 m³

Time (minutes)	Flow cms
0.00	0.00
1.00	0.02
2.00	0.05
3.00	0.07
4.00	0.09
5.00	0.12
6.00	0.14
7.00	0.16
8.00	0.19
9.00	0.21
10.00	0.23
11.00	0.26
12.00	0.29
13.00	0.26
14.00	0.24
15.00	0.22
16.00	0.19
17.00	0.17
18.00	0.14
19.00	0.12
20.00	0.10
21.00	0.07
22.00	0.05
23.00	0.02
24.00	0.00

9.4.2 Rational Analysis: Rational Method Analysis_10yr RP

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.95

Basin Area: 1.0000 hectares

Rainfall Intensity: 122.08 mm/hr

Time of Concentration: 13.87 minutes

Recurrence Year: 10 year

Rational Method Results

Flowrate: 0.3 cms

IDF Input Parameters

User Supplied Data

5 year Recurrence, 5 min duration: 170 mm/hr

5 year Recurrence, 10 min duration: 120 mm/hr

5 year Recurrence, 15 min duration: 100 mm/hr

5 year Recurrence, 30 min duration: 70 mm/hr

5 year Recurrence, 60 min duration: 50 mm/hr

10 year Recurrence, 5 min duration: 200 mm/hr

10 year Recurrence, 10 min duration: 150 mm/hr

10 year Recurrence, 15 min duration: 120 mm/hr

10 year Recurrence, 30 min duration: 70 mm/hr

10 year Recurrence, 60 min duration: 60 mm/hr

25 year Recurrence, 5 min duration: 250 mm/hr

25 year Recurrence, 10 min duration: 170 mm/hr

25 year Recurrence, 15 min duration: 120 mm/hr

25 year Recurrence, 30 min duration: 90 mm/hr

25 year Recurrence, 60 min duration: 70 mm/hr

IDF Results

10 year IDF equation: $i = 22.8406 / (T_c + 1.45692)^{0.570984}$

Intensity: 122.0760 mm/hr

Time of Concentration Input Parameters

Minimum Time of Concentration: 5.00 min

Computed Time of Concentration

Time of Concentration: 13.87 min

Sheet Flow Input Parameters

Top Elevation: 2.40 m

Bottom Elevation: 2.30 m

Length: 30.00 m

Recommended length not to exceed 30 m. Maximum length is 90 m

Manning's n: 0.0150

See HDS-2 Table 2.1

2 yr, 24 hr precip: 80.0000 mm

Sheet Flow Results

Slope: 0.0010 m/m

Time of Concentration: 0.96 min

Shallow Concentrated Flow Input Parameters

Top Elevation: 2.30 m

Bottom Elevation: 1.80 m

Length: 200.00 m

k: 0.6190

See HDS-2 Table 2.2

Shallow Concentrated Flow Results

Slope: 0.0025 m/m

Velocity: 0.3113 m/s

HDS-2 equation 2.7

Time of Concentration: 10.71 min

Total Time of Concentration

Time of Concentration: 13.87 min

9.4.3 Rational Analysis: Rational Method Analysis_5yr RP

Notes:

Rational Method Input Parameters

Runoff Coefficient: 0.95

Basin Area: 1.0000 hectares

Rainfall Intensity: 108.80 mm/hr

Time of Concentration: 12.37 minutes

Recurrence Year: 5 year

Rational Method Results

Flowrate: 0.3 cms

IDF Input Parameters

User Supplied Data

5 year Recurrence, 5 min duration: 170 mm/hr

5 year Recurrence, 10 min duration: 120 mm/hr

5 year Recurrence, 15 min duration: 100 mm/hr

5 year Recurrence, 30 min duration: 70 mm/hr

5 year Recurrence, 60 min duration: 50 mm/hr

10 year Recurrence, 5 min duration: 200 mm/hr

10 year Recurrence, 10 min duration: 150 mm/hr

10 year Recurrence, 15 min duration: 120 mm/hr

10 year Recurrence, 30 min duration: 70 mm/hr

10 year Recurrence, 60 min duration: 60 mm/hr

25 year Recurrence, 5 min duration: 250 mm/hr

25 year Recurrence, 10 min duration: 170 mm/hr

25 year Recurrence, 15 min duration: 120 mm/hr

25 year Recurrence, 30 min duration: 90 mm/hr

25 year Recurrence, 60 min duration: 70 mm/hr

IDF Results

5 year IDF equation: $i = 14.7663 / (T_c + -0.00972333)^{0.492256}$

Intensity: 108.7974 mm/hr

Time of Concentration Input Parameters

Minimum Time of Concentration: 5.00 min

Computed Time of Concentration

Time of Concentration: 12.37 min

Sheet Flow Input Parameters

Top Elevation: 2.80 m

Bottom Elevation: 2.30 m

Length: 30.00 m

Recommended length not to exceed 30 m. Maximum length is 90 m

Manning's n: 0.0150

See HDS-2 Table 2.1

2 yr, 24 hr precip: 80.0000 mm

Sheet Flow Results

Slope: 0.0051 m/m

Time of Concentration: 0.51 min

Shallow Concentrated Flow Input Parameters

Top Elevation: 2.30 m

Bottom Elevation: 1.80 m

Length: 200.00 m

k: 0.6190

See HDS-2 Table 2.2

Shallow Concentrated Flow Results

Slope: 0.0025 m/m

Velocity: 0.3113 m/s

HDS-2 equation 2.7

Time of Concentration: 10.71 min

Total Time of Concentration

Time of Concentration: 12.37 min

9.4.4 Curb and Gutter Analysis: Longitudinal Slope of 0.25% (W: 0.3m*L: 1.8m)

Gutter Input Parameters

Longitudinal Slope of Road: 0.0025 m/m Cross-Slope of Pavement: 0.0200 m/m Uniform
Gutter Geometry
Manning's n: 0.0150
Gutter Width: 0.6096 m
Width of Spread: 6.1000 m

Gutter Result Parameters Design Flow:
0.2300 cms Gutter Depression:
0.0000 mm Area of Flow: 0.3721 m²
Eo (Gutter Flow to Total Flow): 0.2451
Gutter Depth at Curb: 122.0000 mm

Inlet Input Parameters

Inlet Location: Inlet in Sag Percent Clogging: 25.0000 % Inlet Type: Sweeper Combo Grate
Type: P - 1-7/8
Grate Width: 0.3000 m Grate Length: 1.8000 m Length of Inlet: 1.8000 m
Curb opening height: 150.0000 mm
Local Depression: 75.0000 mm

Inlet Result Parameters

Perimeter: 2.4000 m
Effective Perimeter: 1.8000 m
Area: 0.8910 m²
Effective Area: 0.6683 m²
Depth at curb face (upstream of local depression): 0.1812 m
Computed Width of Spread at Sag: 9.0604 m
Flow type: Weir Flow
Efficiency: 1.0000

9.4.5 Curb and Gutter Analysis: Longitudinal Slope of 0.75% (W: 0.3m*L: 1.8m)

Gutter Input Parameters

Longitudinal Slope of Road: 0.0080 m/m Cross-Slope of Pavement: 0.0200 m/m Uniform
Gutter Geometry
Manning's n: 0.0150
Gutter Width: 0.6096 m
Width of Spread: 6.1000 m

Gutter Result Parameters

Design Flow: 0.4114 cms Gutter
Depression: 0.0000 mm Area of
Flow: 0.3721 m²
Eo (Gutter Flow to Total Flow): 0.2451
Gutter Depth at Curb: 122.0000 mm

Inlet Input Parameters

Inlet Location: Inlet in Sag Percent
Clogging: 25.0000 % Inlet Type:
Sweeper Combo Grate Type: P - 1-
7/8
Grate Width: 0.3000 m Grate
Length: 1.3000 m Length of
Inlet: 1.3000 m
Curb opening height: 150.0000 mm
Local Depression: 50.0000 mm

Inlet Result Parameters

Perimeter: 1.9000 m
Effective Perimeter: 1.4250 m
Area: 0.6110 m²
Effective Area: 0.4583 m²
Depth at curb face (upstream of local depression): 0.3120 m
Computed Width of Spread at Sag: 15.6016 m
Flow type: Weir Flow
Efficiency: 1.0000

9.4.6 Channel Analysis: Channel Analysis_450mmO_0.25%_75%

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 0.4500 m

Longitudinal Slope: 0.0025 m/m

Manning's n: 0.0150

Depth: 0.3400 m

Result Parameters

Flow: 0.1136 cms

Area of Flow: 0.1289 m²

Wetted Perimeter: 0.9483 m

Hydraulic Radius: 0.1360 m

Average Velocity: 0.8814 m/s

Top Width: 0.3868 m

Froude Number: 0.4873

Critical Depth: 0.2349 m

Critical Velocity: 1.3532 m/s

Critical Slope: 0.0073 m/m

Critical Top Width: 0.45 m

Calculated Max Shear Stress: 8.3319 N/m²

Calculated Avg Shear Stress: 3.3316 N/m²

9.4.7 Channel Analysis: Channel Analysis_600mmO_0.25%_75%

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 0.6000 m

Longitudinal Slope: 0.0025 m/m

Manning's n: 0.0150

Depth: 0.4200 m

Result Parameters

Flow: 0.2228 cms

Area of Flow: 0.2114 m²

Wetted Perimeter: 1.1894 m

Hydraulic Radius: 0.1777 m

Average Velocity: 1.0538 m/s

Top Width: 0.5499 m

Froude Number: 0.5425

Critical Depth: 0.3056 m

Critical Velocity: 1.5395 m/s

Critical Slope: 0.0066 m/m

Critical Top Width: 0.60 m

Calculated Max Shear Stress: 10.2923 N/m²

Calculated Avg Shear Stress: 4.3556 N/m²

9.4.8 Channel Analysis: Channel Analysis_900mmO_0.25%_75%

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 0.9000 m

Longitudinal Slope: 0.0025 m/m

Manning's n: 0.0150

Depth: 0.6300 m

Result Parameters

Flow: 0.6568 cms

Area of Flow: 0.4757 m²

Wetted Perimeter: 1.7841 m

Hydraulic Radius: 0.2666 m

Average Velocity: 1.3809 m/s

Top Width: 0.8249 m

Froude Number: 0.5804

Critical Depth: 0.4750 m

Critical Velocity: 1.9283 m/s

Critical Slope: 0.0058 m/m

Critical Top Width: 0.90 m

Calculated Max Shear Stress: 15.4385 N/m²

Calculated Avg Shear Stress: 6.5334 N/m²

9.4.9 Channel Analysis: Channel Analysis_1200mmO_0.25%_75%

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.2000 m

Longitudinal Slope: 0.0025 m/m

Manning's n: 0.0150

Depth: 0.8400 m

Result Parameters

Flow: 1.4145 cms

Area of Flow: 0.8456 m²

Wetted Perimeter: 2.3788 m

Hydraulic Radius: 0.3555 m

Average Velocity: 1.6728 m/s

Top Width: 1.0998 m

Froude Number: 0.6090

Critical Depth: 0.6492 m

Critical Velocity: 2.2652 m/s

Critical Slope: 0.0054 m/m

Critical Top Width: 1.20 m

Calculated Max Shear Stress: 20.5846 N/m²

Calculated Avg Shear Stress: 8.7113 N/m²

9.4.10 Channel Analysis: Channel Analysis_900mmO_0.75%_75%

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 0.9000 m

Longitudinal Slope: 0.0075 m/m

Manning's n: 0.0150

Depth: 0.6300 m

Result Parameters

Flow: 1.1376 cms

Area of Flow: 0.4757 m²

Wetted Perimeter: 1.7841 m

Hydraulic Radius: 0.2666 m

Average Velocity: 2.3917 m/s

Top Width: 0.8249 m

Froude Number: 1.0054

Critical Depth: 0.6319 m

Critical Velocity: 2.3838 m/s

Critical Slope: 0.0074 m/m

Critical Top Width: 0.82 m

Calculated Max Shear Stress: 46.3154 N/m²

Calculated Avg Shear Stress: 19.6003 N/m²

9.4.11 Channel Analysis: Channel Analysis_1200mmO_0.75%_75%

Notes:

Input Parameters

Channel Type: Circular

Pipe Diameter: 1.2000 m

Longitudinal Slope: 0.0075 m/m

Manning's n: 0.0150

Depth: 0.8400 m

Result Parameters

Flow: 2.4501 cms

Area of Flow: 0.8456 m²

Wetted Perimeter: 2.3788 m

Hydraulic Radius: 0.3555 m

Average Velocity: 2.8974 m/s

Top Width: 1.0998 m

Froude Number: 1.0547

Critical Depth: 0.8625 m

Critical Velocity: 2.8158 m/s

Critical Slope: 0.0070 m/m

Critical Top Width: 1.08 m

Calculated Max Shear Stress: 61.7539 N/m²

Calculated Avg Shear Stress: 26.1338 N/m²

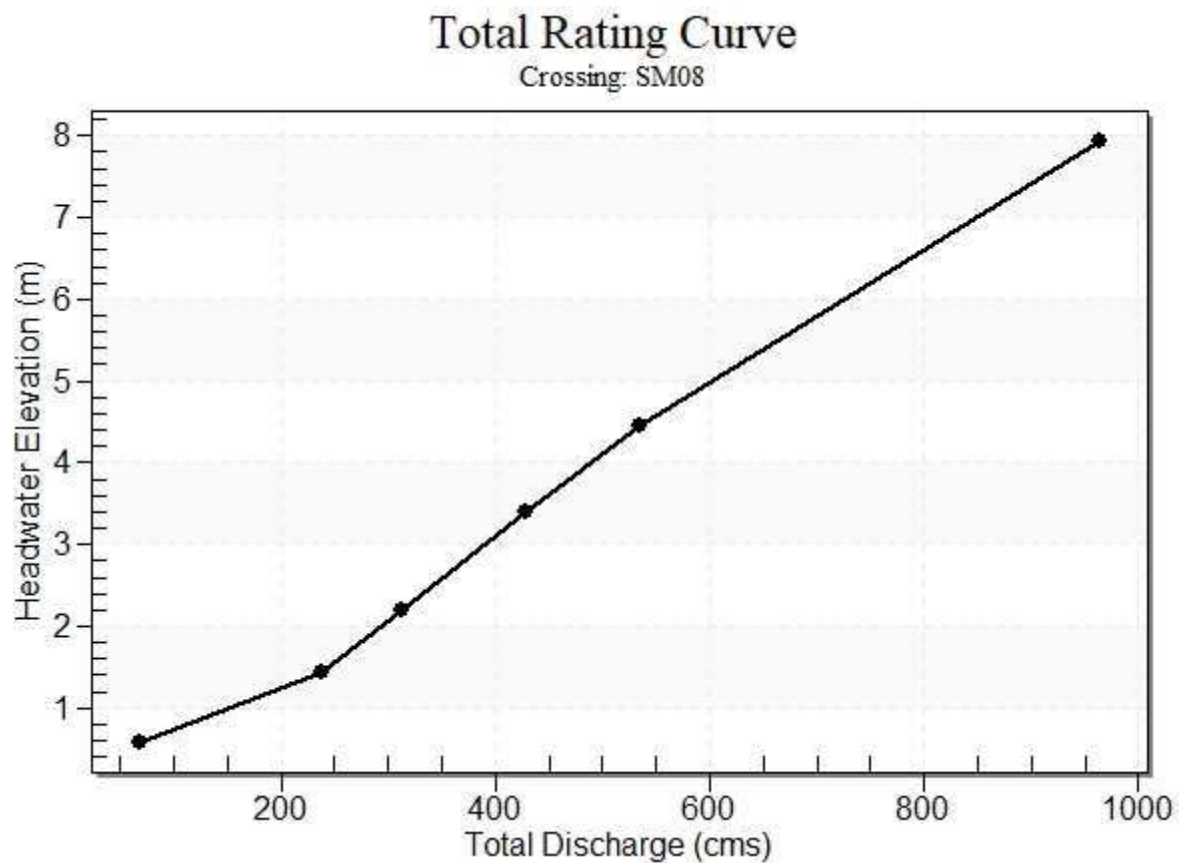
9.5 Culvert Analysis: HY-8 Culvert Analysis Report

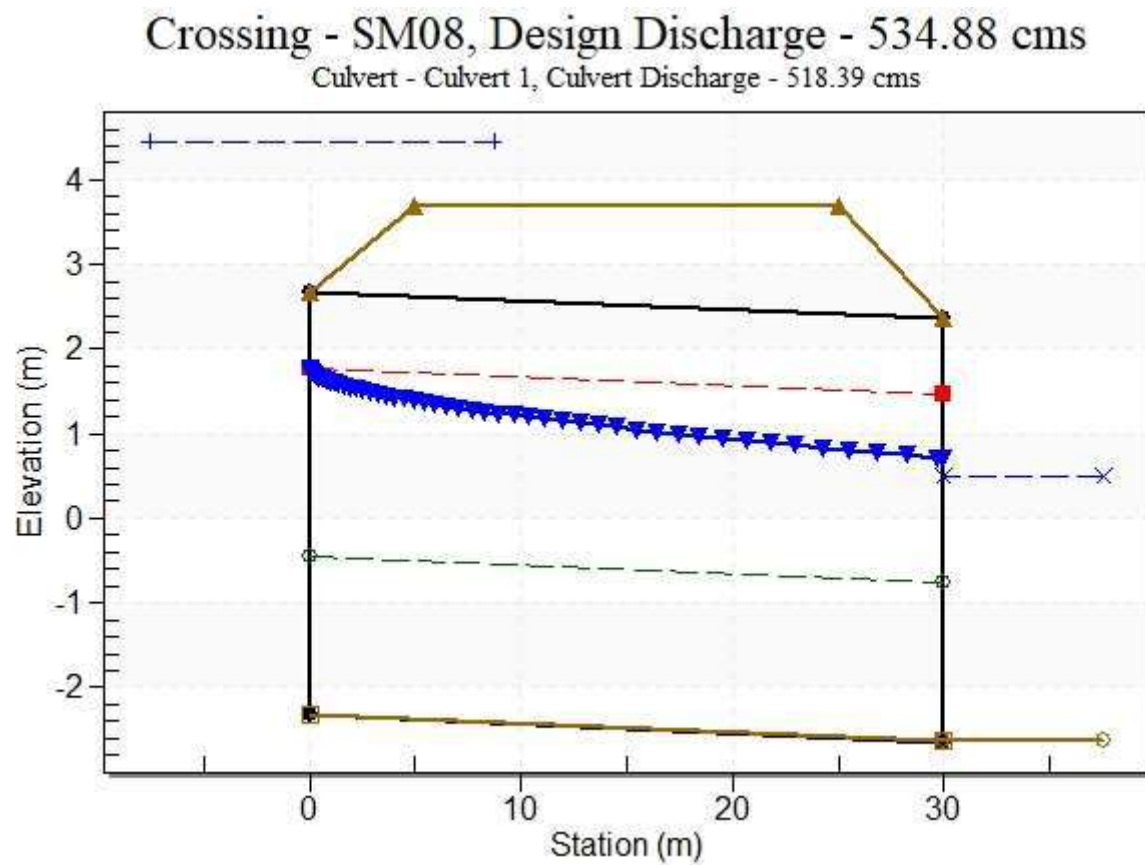
The HY-8 software was used to analyze the purposed design of the improved culverts to meet to the present and future climate scenarios. The results from the software were summarized in to a crossing summary table, rating curve of the crossing and a water surface profile of the crossing. These results can be used to predict how the proposed crossings will perform under the required design conditions.

Table 1 - Summary of Culvert Flows at Crossing: SM08

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert Discharge (cms)	Roadway Discharge (cms)	Iterations
0.59	2019	67.51	67.51	0.00	1
1.44	5 RP	239.00	239.00	0.00	1
2.20	10 RP	313.50	313.50	0.00	1
3.39	25 RP	427.90	427.90	0.00	1
4.46	50 RP	534.88	518.39	16.48	6
3.70	Overtopping	455.24	455.24	0.00	Overtopping

Rating Curve Plot for Crossing: SM08



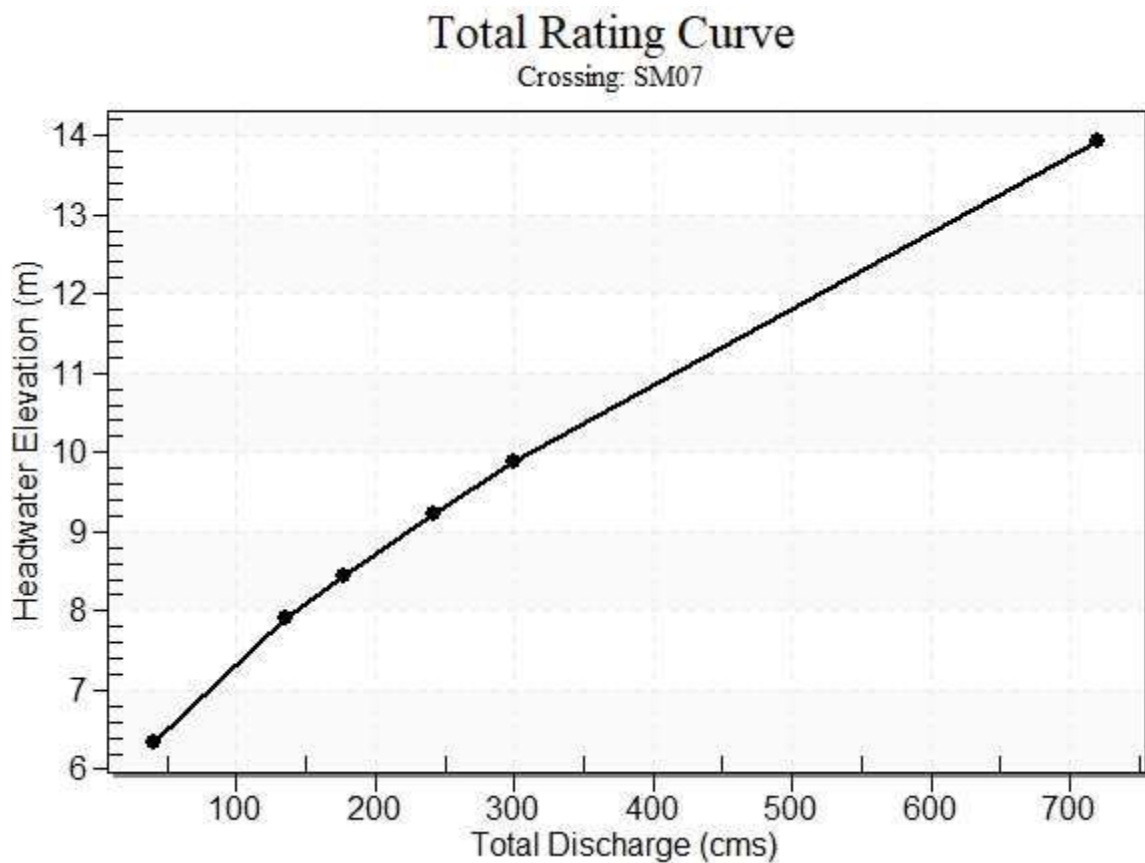


Water Surface Profile Plot for Culvert: Culvert

Table 2 - Summary of Culvert Flows at Crossing: SM07

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	SM07 Discharge (cms)	Roadway Discharge (cms)	Iterations
6.35	2019	40.46	40.46	0.00	1
7.90	10 RP	135.70	135.70	0.00	1
8.44	10 RP	177.50	177.50	0.00	1
9.21	25 RP	241.90	241.90	0.00	1
9.89	50 RP	300.00	299.33	0.67	5
9.77	Overtopping	289.39	289.39	0.00	Overtopping

Rating Curve Plot for Crossing: SM07



Water Surface Profile Plot for Culvert: SM07

Crossing - SM07, Design Discharge - 300.00 cms

Culvert - SM07, Culvert Discharge - 299.33 cms

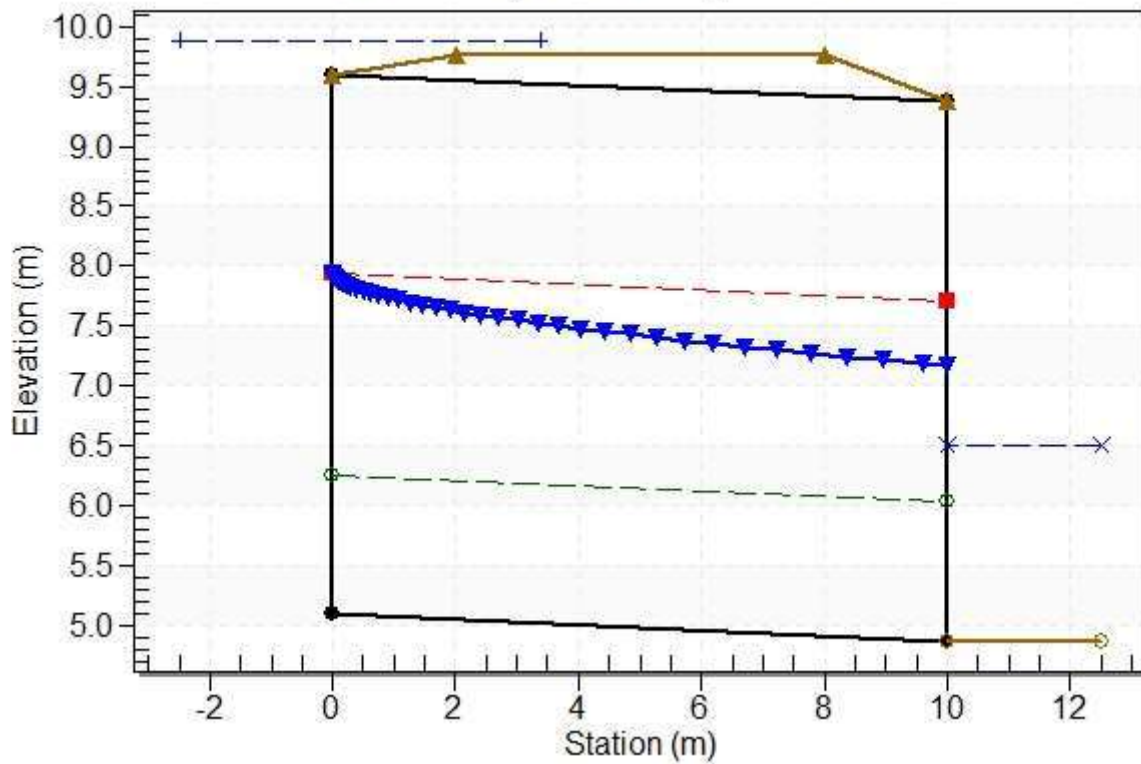
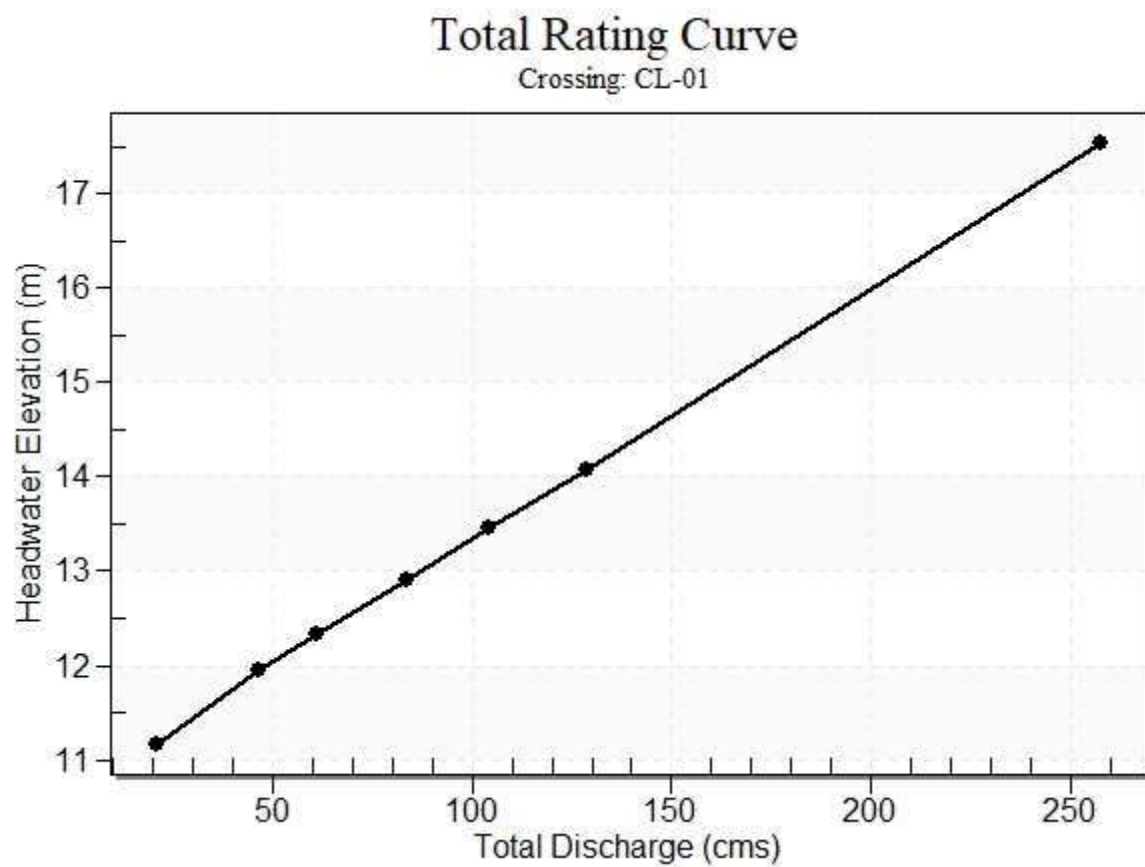
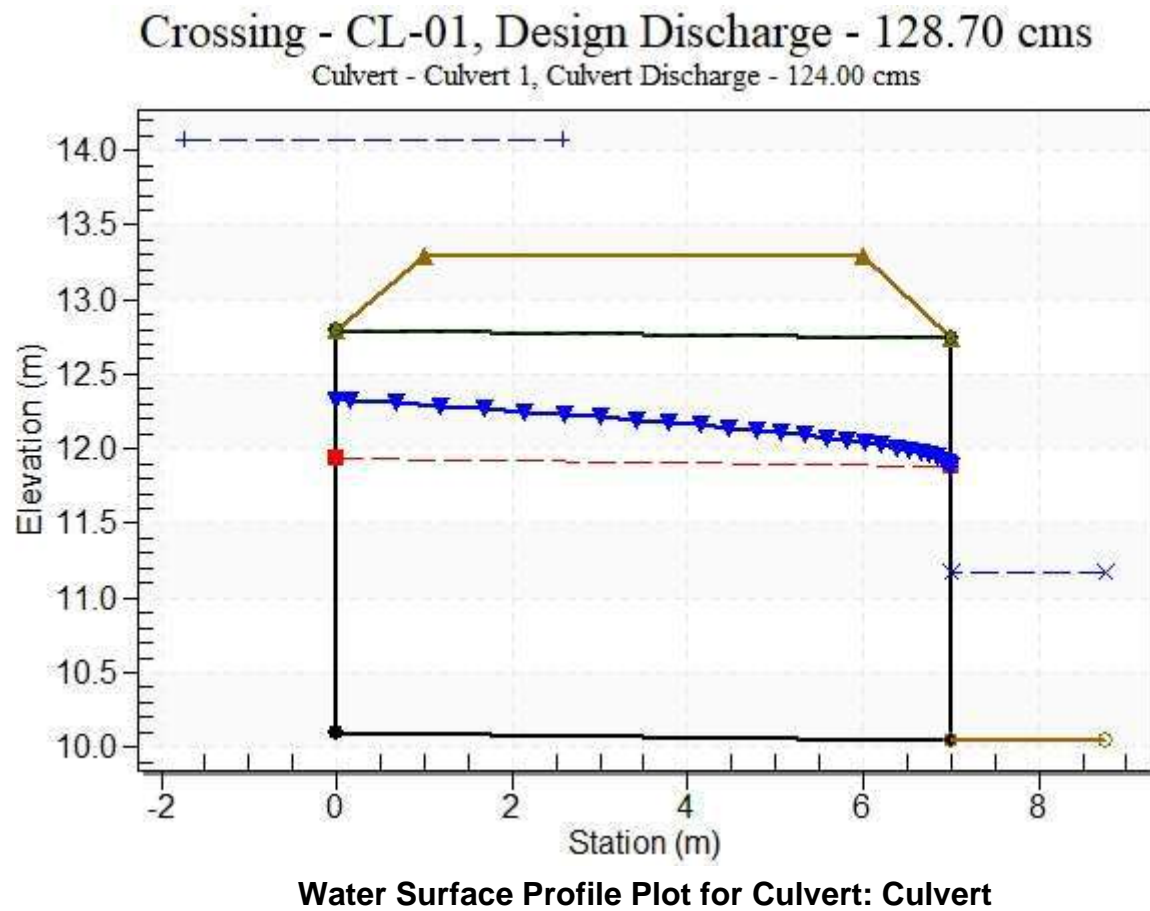


Table 3 - Summary of Culvert Flows at Crossing: CL-01

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert Discharge (cms)	Roadway Discharge (cms)	Iterations
11.17	2019	21.11	21.11	0.00	1
11.95	RP 5	46.70	46.70	0.00	1
12.34	RP 10	61.30	61.30	0.00	1
12.91	RP 25	83.70	83.70	0.00	1
13.46	RP 50	104.00	103.52	0.48	4
14.08	RP 100	128.70	124.00	4.70	4
13.29	Overtopping	97.35	97.35	0.00	Overtopping

Rating Curve Plot for Crossing: CL-01





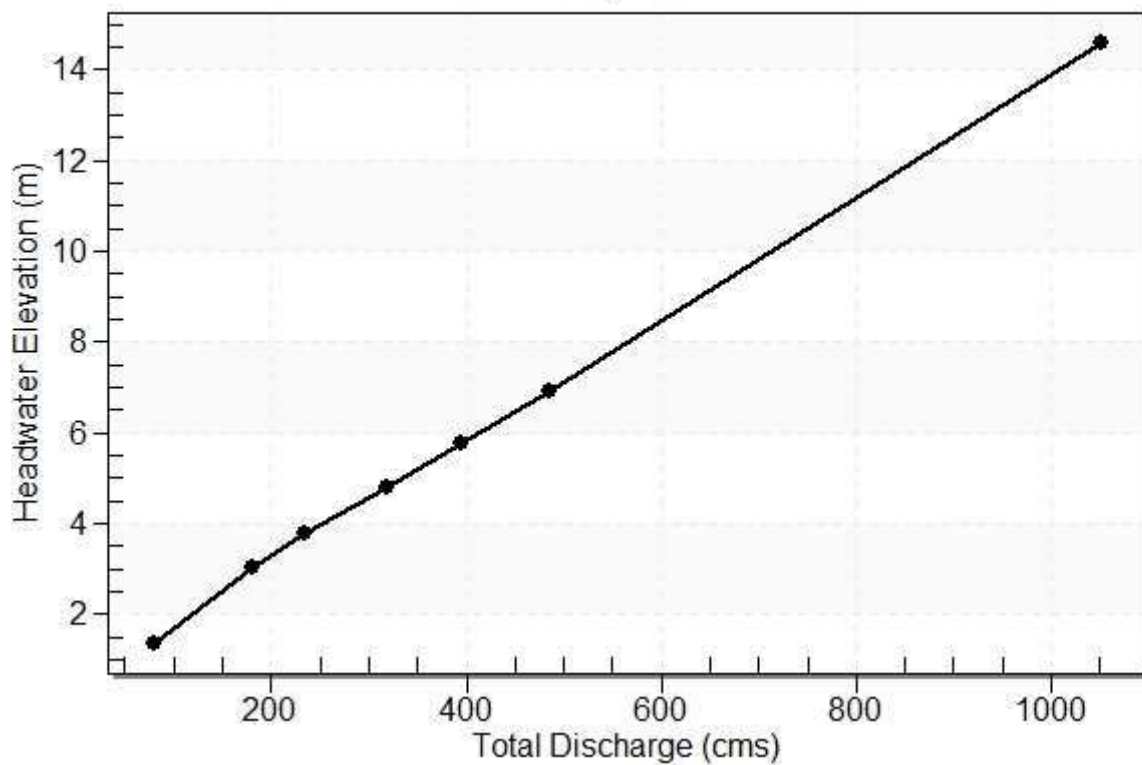
Crossing Discharge Data

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert Discharge (cms)	Roadway Discharge (cms)	Iterations
1.38	2019	80.11	80.11	0.00	1
3.01	5	180.60	180.60	0.00	1
3.76	10	235.10	235.10	0.00	1
4.81	25	318.80	318.80	0.00	1
5.77	50	394.00	391.31	2.69	6
6.93	100	485.20	467.77	17.43	6
5.30	Overtopping	357.36	357.36	0.00	Overtopping

Table 4 - Summary of Culvert Flows at Crossing: TP-01

Total Rating Curve

Crossing: TP-01



Rating Curve Plot for Crossing: TP-

Water Surface Profile Plot for Culvert: Culvert

Crossing - TP-01, Design Discharge - 485.20 cms

Culvert - Culvert 1, Culvert Discharge - 467.77 cms

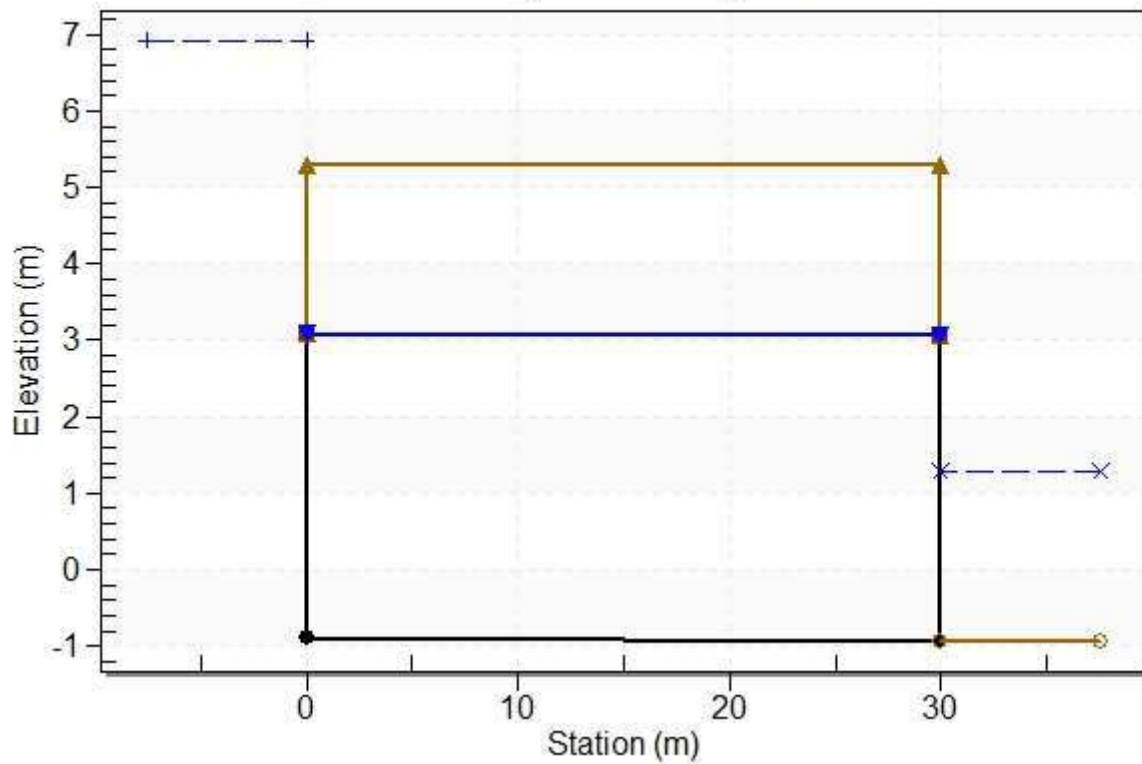
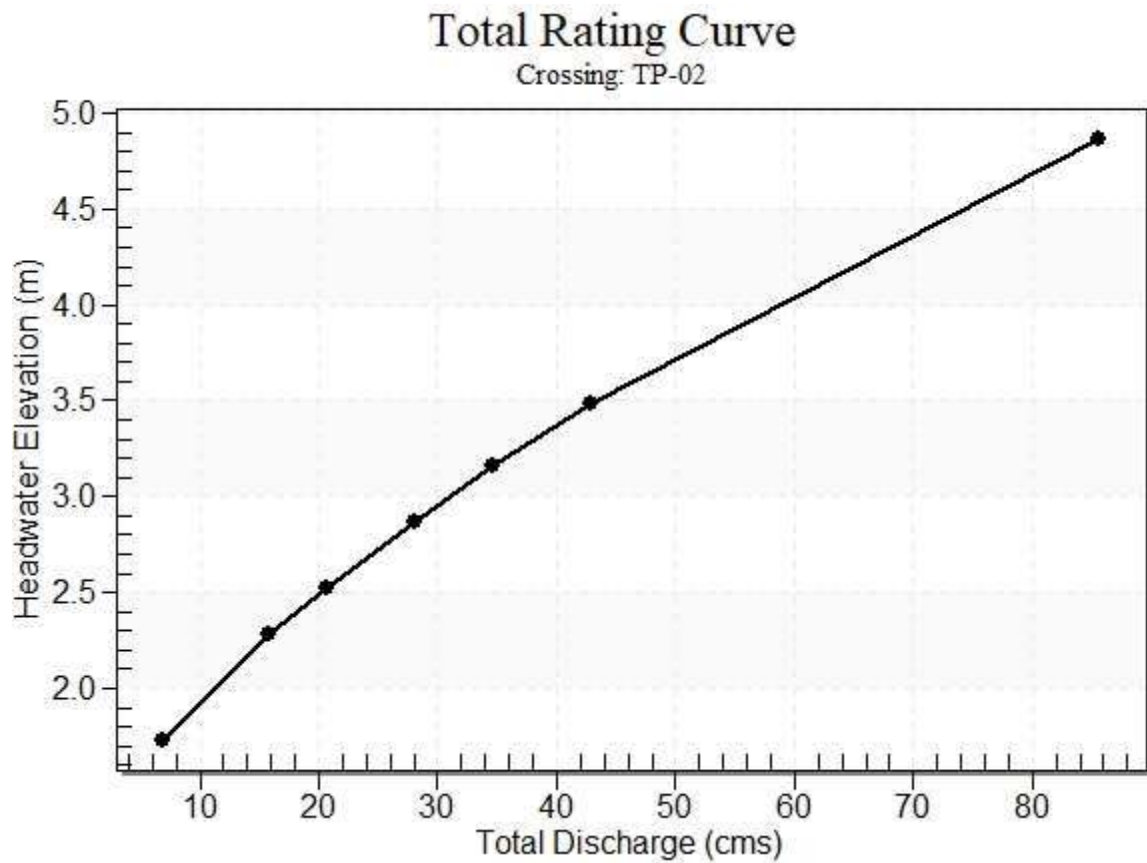


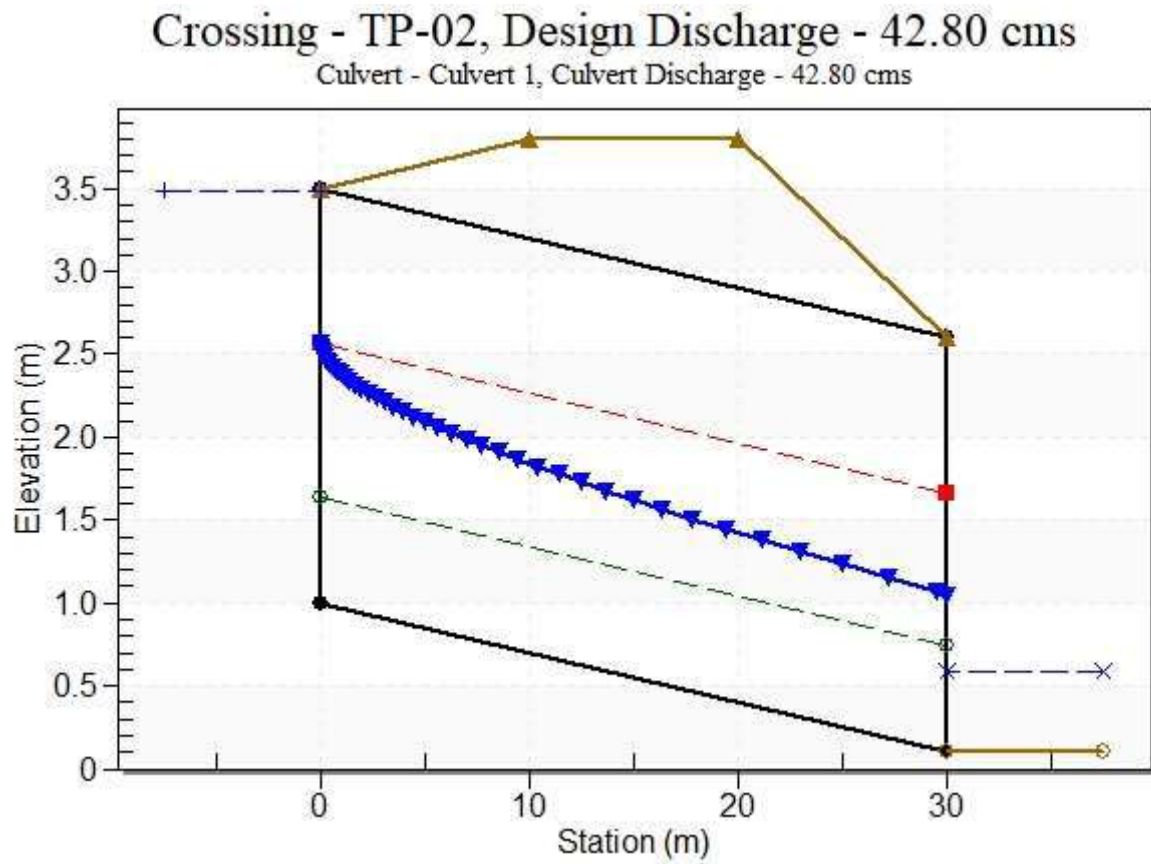
Table 5 - Summary of Culvert Flows at Crossing: TP-02

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert Discharge (cms)	Roadway Discharge (cms)	Iterations
1.73	2019	6.86	6.86	0.00	1
2.28	5	15.80	15.80	0.00	1
2.53	10	20.60	20.60	0.00	1
2.87	25	28.00	28.00	0.00	1
3.16	50	34.70	34.70	0.00	1
3.48	100	42.80	42.80	0.00	1
3.80	Overtopping	50.12	50.12	0.00	Overtopping

Rating Curve Plot for Crossing: TP-02



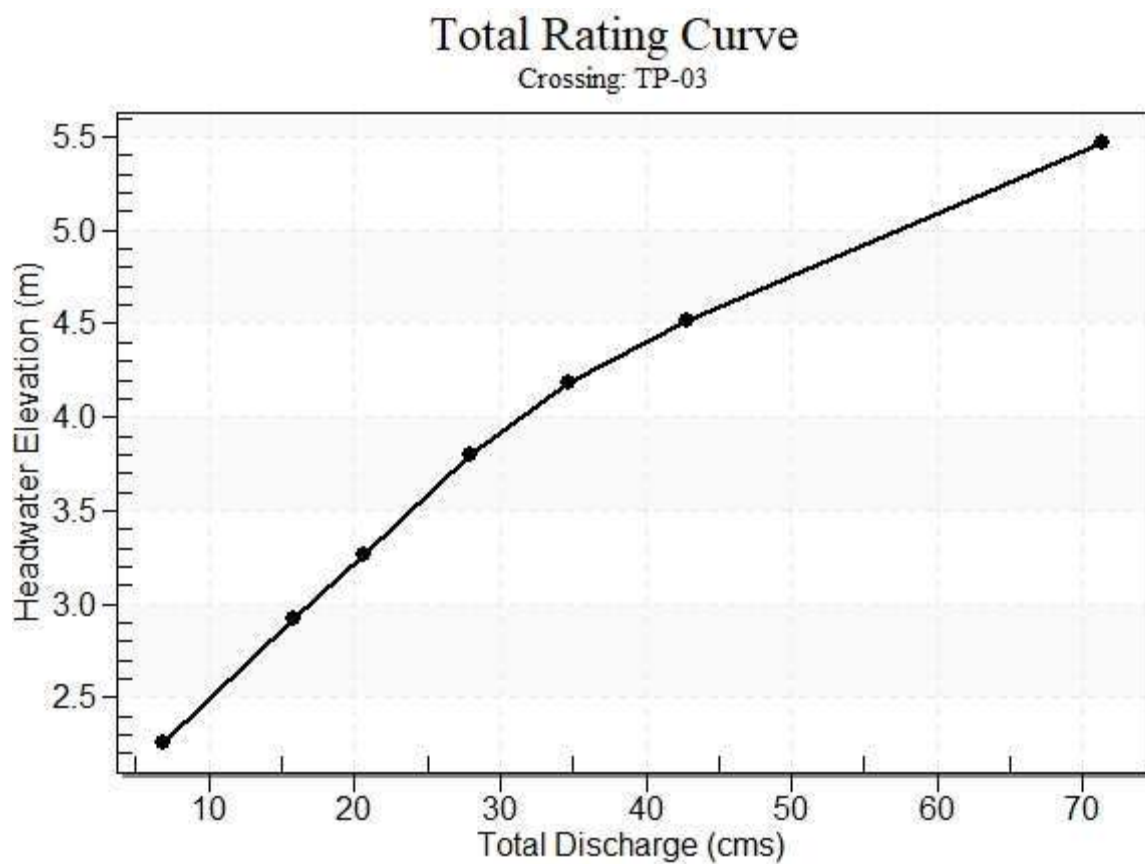
Water Surface Profile Plot for Culvert: Culvert



Crossing Discharge Data

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	Culvert Discharge (cms)	Roadway Discharge (cms)	Iterations
2.26	2019	6.86	6.86	0.00	1
2.92	5	15.80	15.80	0.00	1
3.26	10	20.60	20.60	0.00	1
3.79	25	28.00	28.00	0.00	1
4.18	50	34.70	33.93	0.77	5
4.52	100	42.80	39.06	3.74	4
4.00	Overtopping	31.15	31.15	0.00	Overtopping

Table 6 - Summary of Culvert Flows at Crossing: TP-03



Rating Curve Plot for Crossing: TP-03

Water Surface Profile Plot for Culvert: Culvert

Crossing - TP-03, Design Discharge - 42.80 cms

Culvert - Culvert 1, Culvert Discharge - 39.06 cms

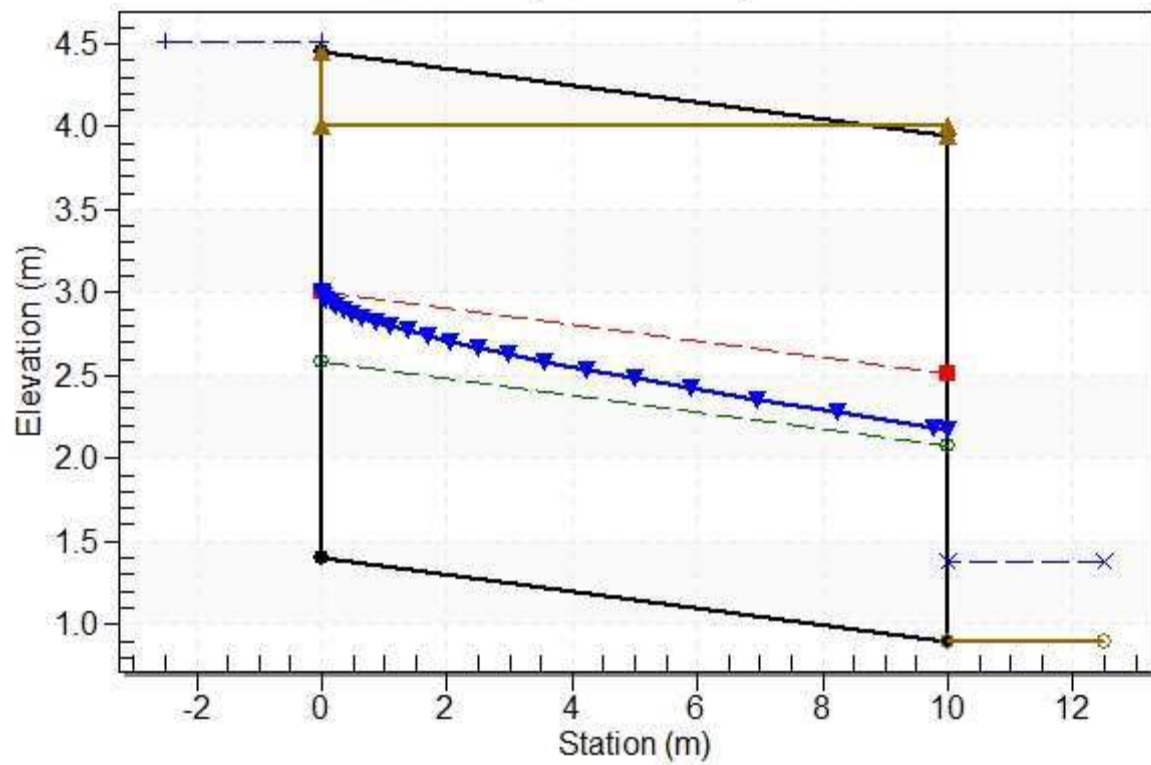
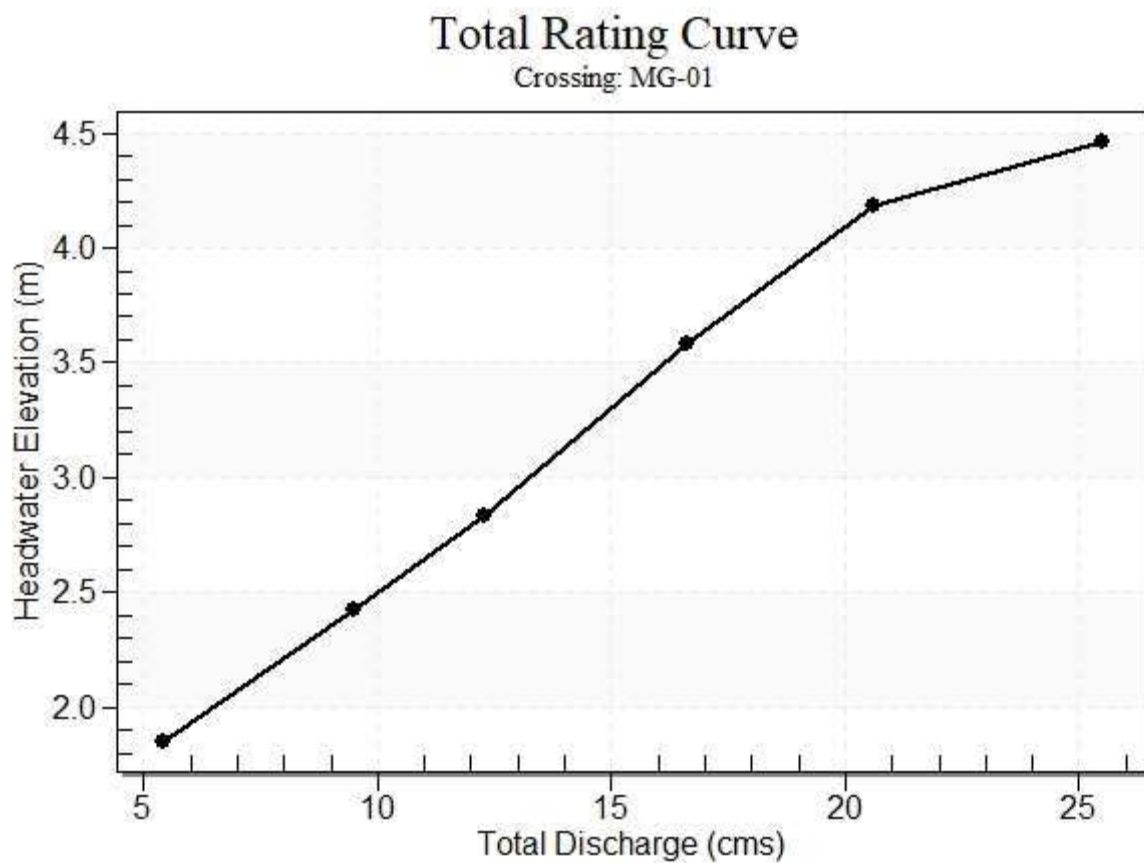


Table 7 - Summary of Culvert Flows at Crossing: MG-01

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	MG-01 Discharge (cms)	Roadway Discharge (cms)	Iterations
1.85	2019	5.41	5.41	0.00	1
2.42	10 RP	9.50	9.50	0.00	1
2.83	10 RP	12.30	12.30	0.00	1
3.58	25 RP	16.60	16.60	0.00	1
4.18	50 RP	20.60	19.46	1.14	4
4.47	100 RP	25.50	20.70	4.80	3
4.00	Overtopping	18.65	18.65	0.00	Overtopping

Rating Curve Plot for Crossing: MG-01



Water Surface Profile Plot for Culvert: MG-01

Crossing - MG-01, Design Discharge - 25.50 cms

Culvert - MG-01, Culvert Discharge - 20.70 cms

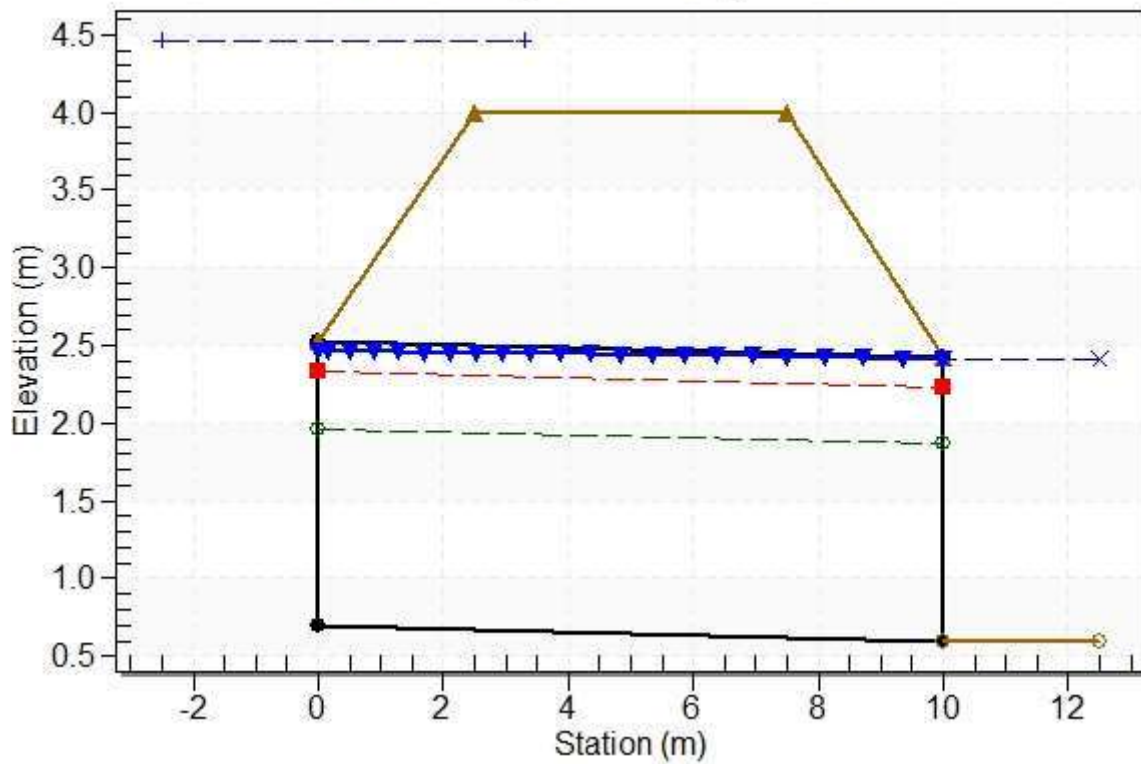
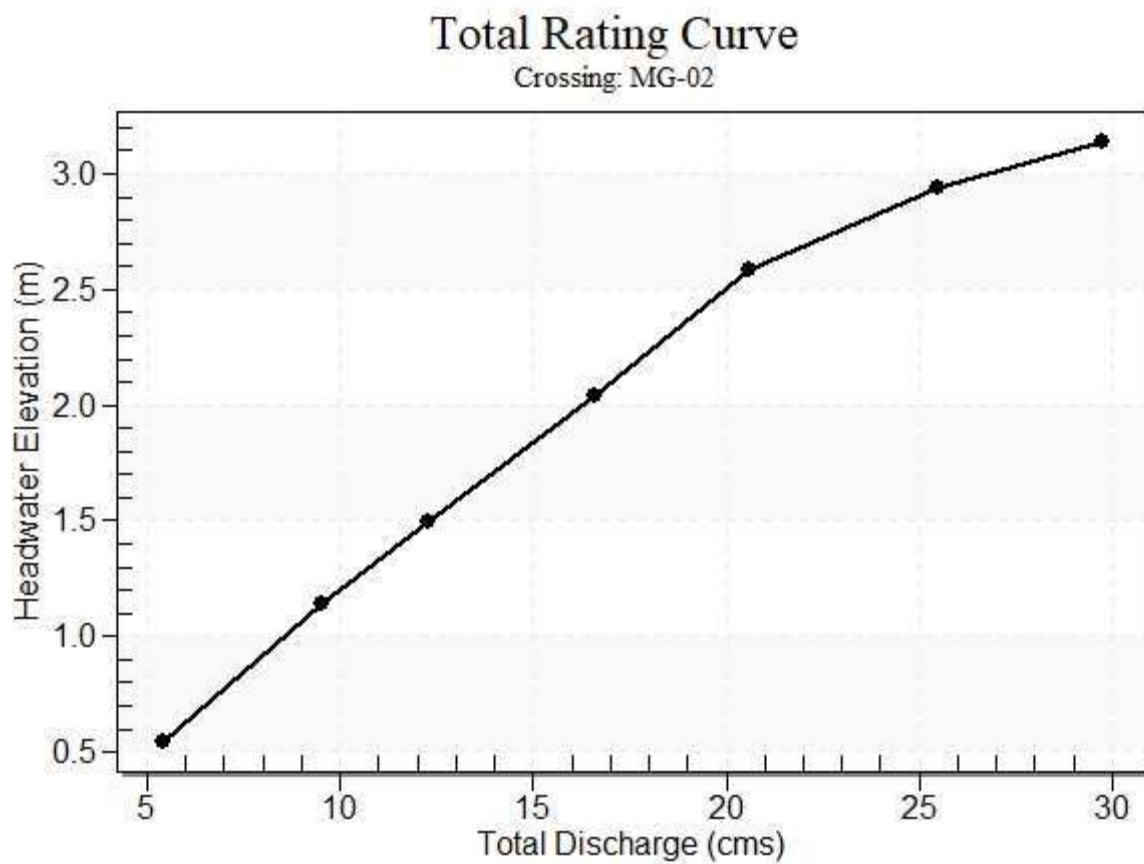


Table 8 - Summary of Culvert Flows at Crossing: MG-02

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	MG-02 Discharge (cms)	Roadway Discharge (cms)	Iterations
0.55	2019	5.41	5.41	0.00	1
1.14	10 RP	9.50	9.50	0.00	1
1.50	10 RP	12.30	12.30	0.00	1
2.04	25 RP	16.60	16.60	0.00	1
2.59	50 RP	20.60	20.60	0.00	1
2.94	100 RP	25.50	22.94	2.56	5
2.63	Overtopping	20.91	20.91	0.00	Overtopping

Rating Curve Plot for Crossing: MG-02



Water Surface Profile Plot for Culvert: MG-02

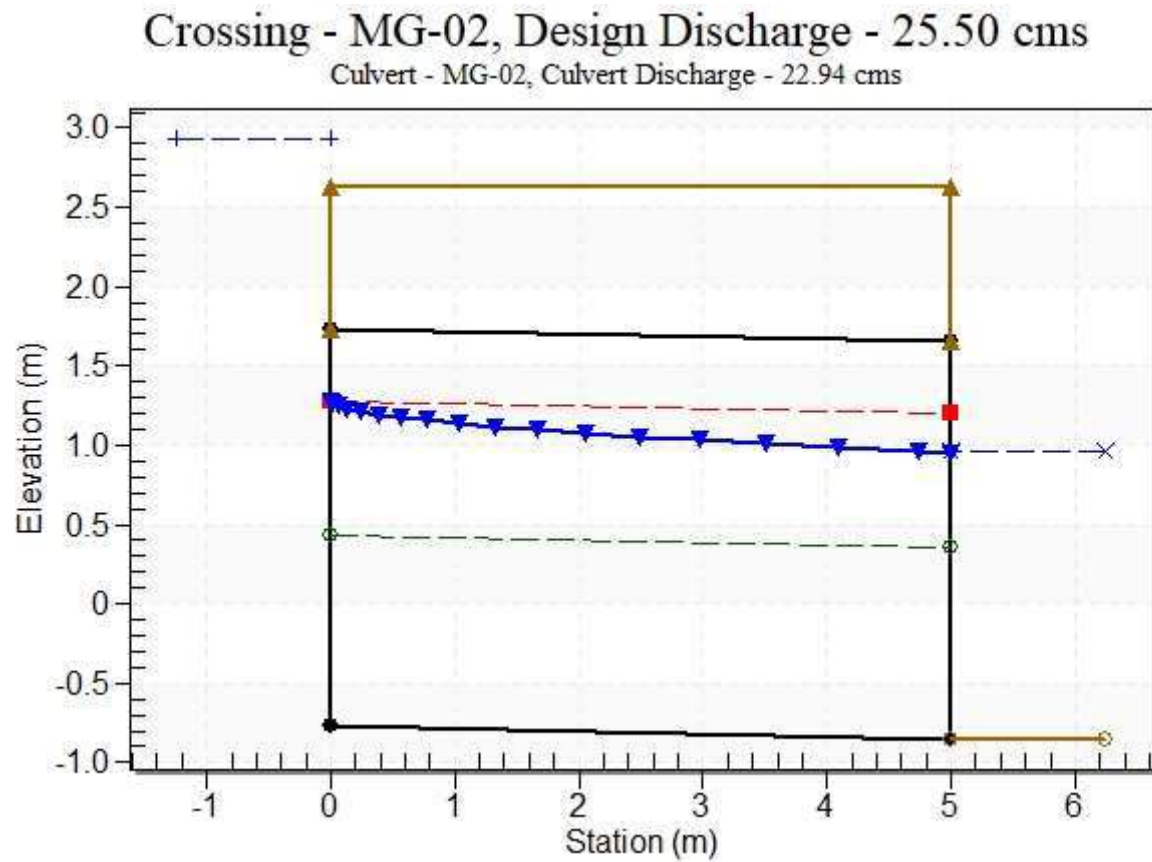
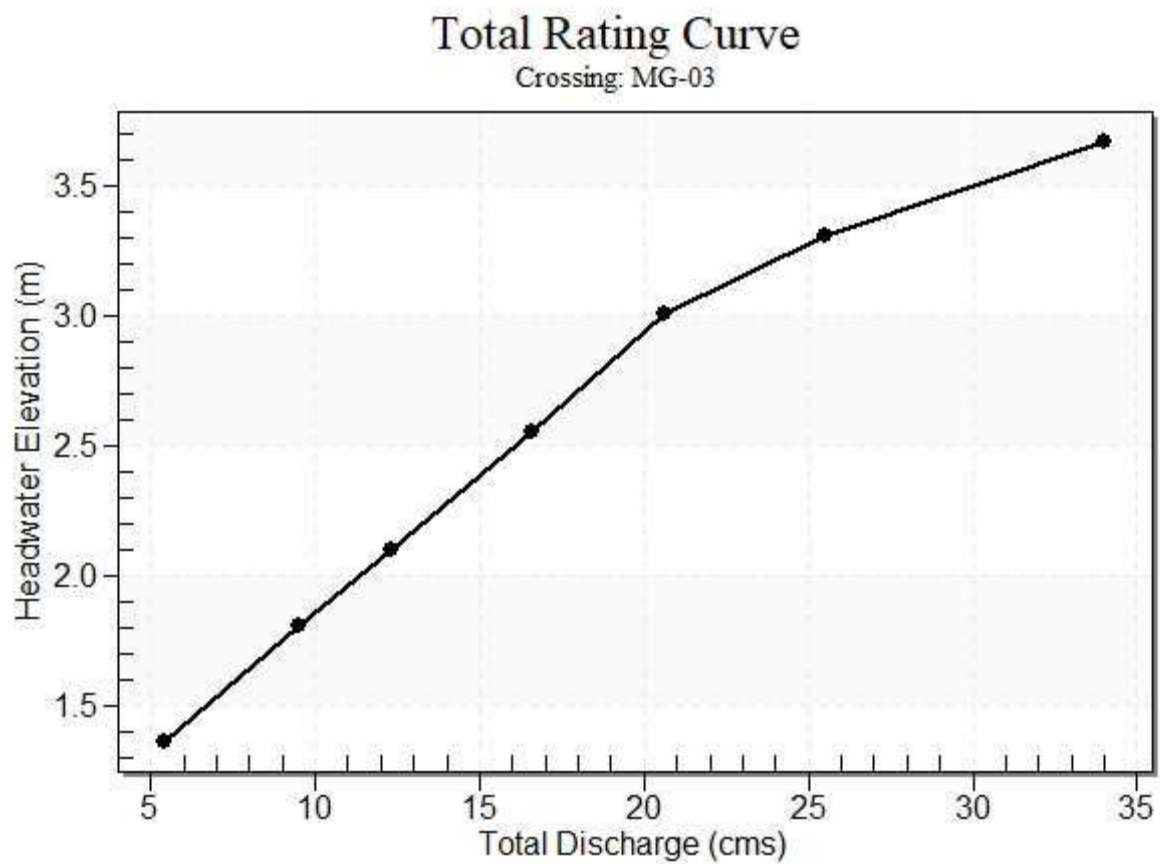


Table 9 - Summary of Culvert Flows at Crossing: MG-03

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	MG-03 Discharge (cms)	Roadway Discharge (cms)	Iterations
1.36	2019	5.41	5.41	0.00	1
1.81	10 RP	9.50	9.50	0.00	1
2.10	10 RP	12.30	12.30	0.00	1
2.56	25 RP	16.60	16.60	0.00	1
3.01	50 RP	20.60	20.58	0.02	7
3.31	100 RP	25.50	22.93	2.57	3
3.00	Overtopping	20.48	20.48	0.00	Overtopping

Rating Curve Plot for Crossing: MG-03



Water Surface Profile Plot for Culvert: MG-03

Crossing - MG-03, Design Discharge - 25.50 cms

Culvert - MG-03, Culvert Discharge - 22.93 cms

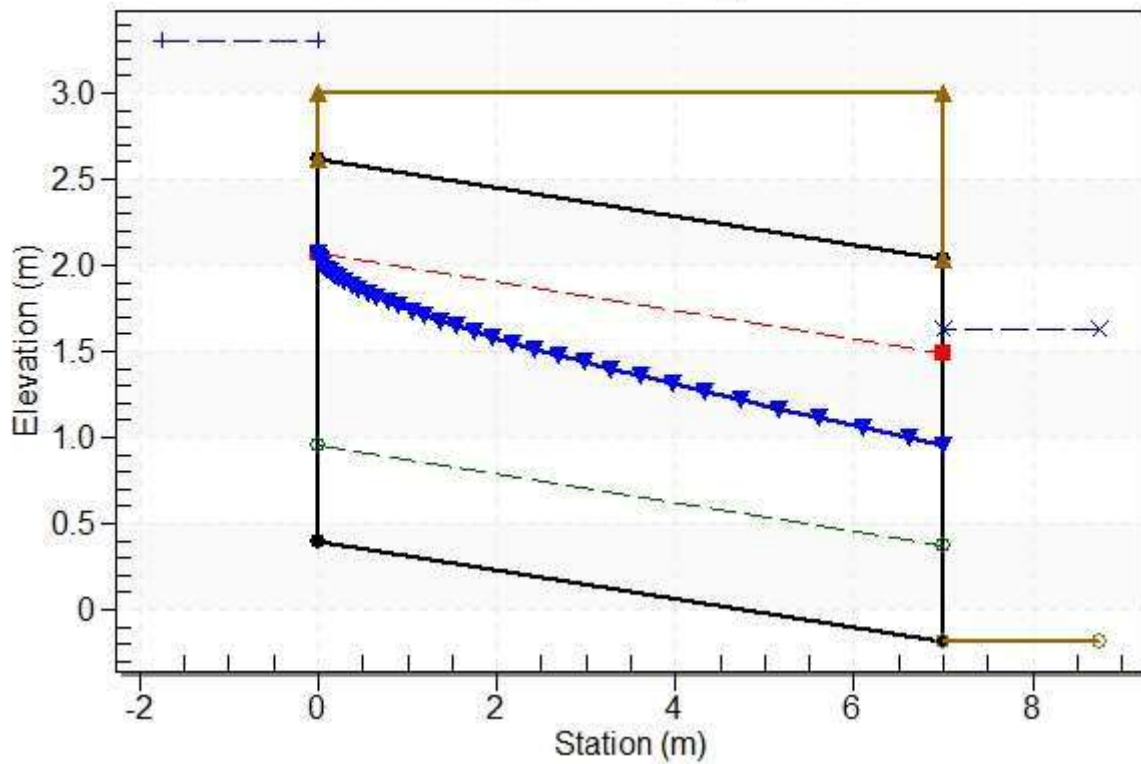
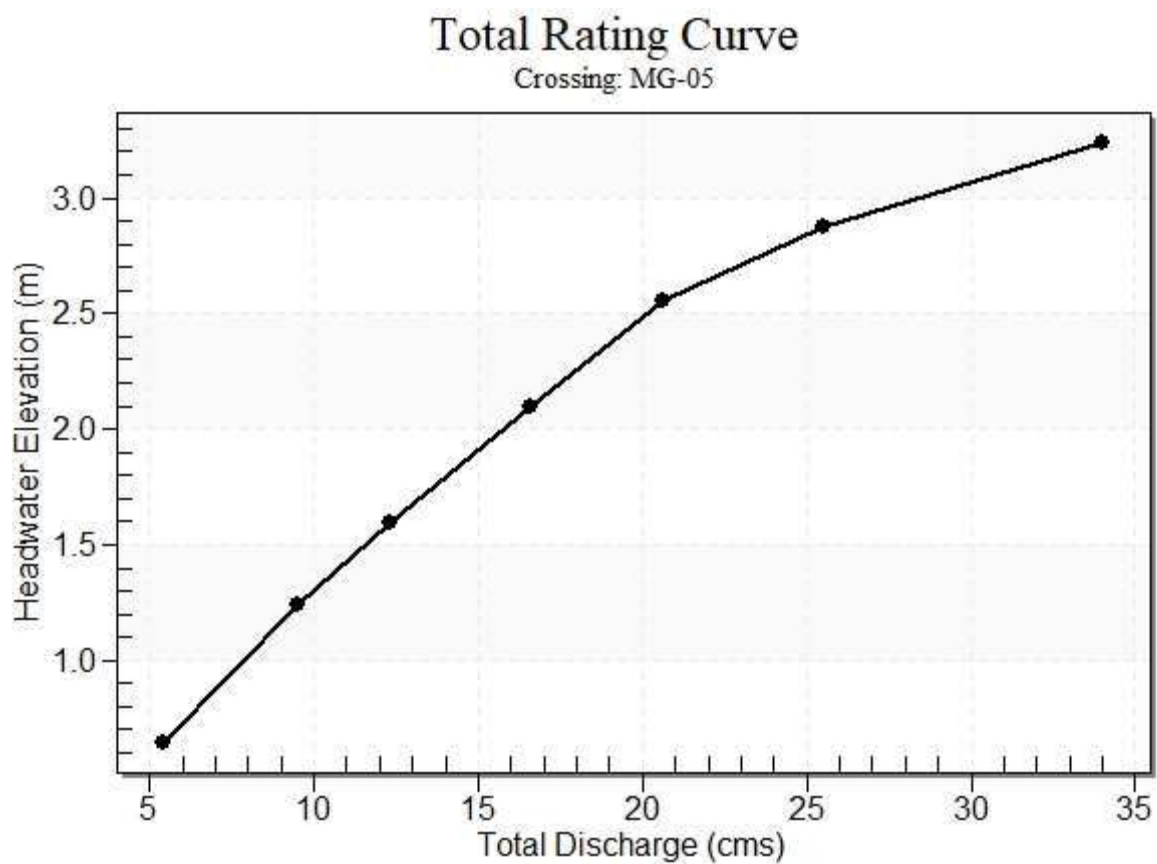


Table 10 - Summary of Culvert Flows at Crossing: MG-05

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	MG-05 Discharge (cms)	Roadway Discharge (cms)	Iterations
0.65	2019	5.41	5.41	0.00	1
1.24	10 RP	9.50	9.50	0.00	1
1.59	10 RP	12.30	12.30	0.00	1
2.10	25 RP	16.60	16.60	0.00	1
2.56	50 RP	20.60	20.60	0.00	1
2.88	100 RP	25.50	23.31	2.19	4
2.60	Overtopping	20.98	20.98	0.00	Overtopping

Rating Curve Plot for Crossing: MG-05



Water Surface Profile Plot for Culvert: MG-05

Crossing - MG-05, Design Discharge - 25.50 cms

Culvert - MG-05, Culvert Discharge - 23.31 cms

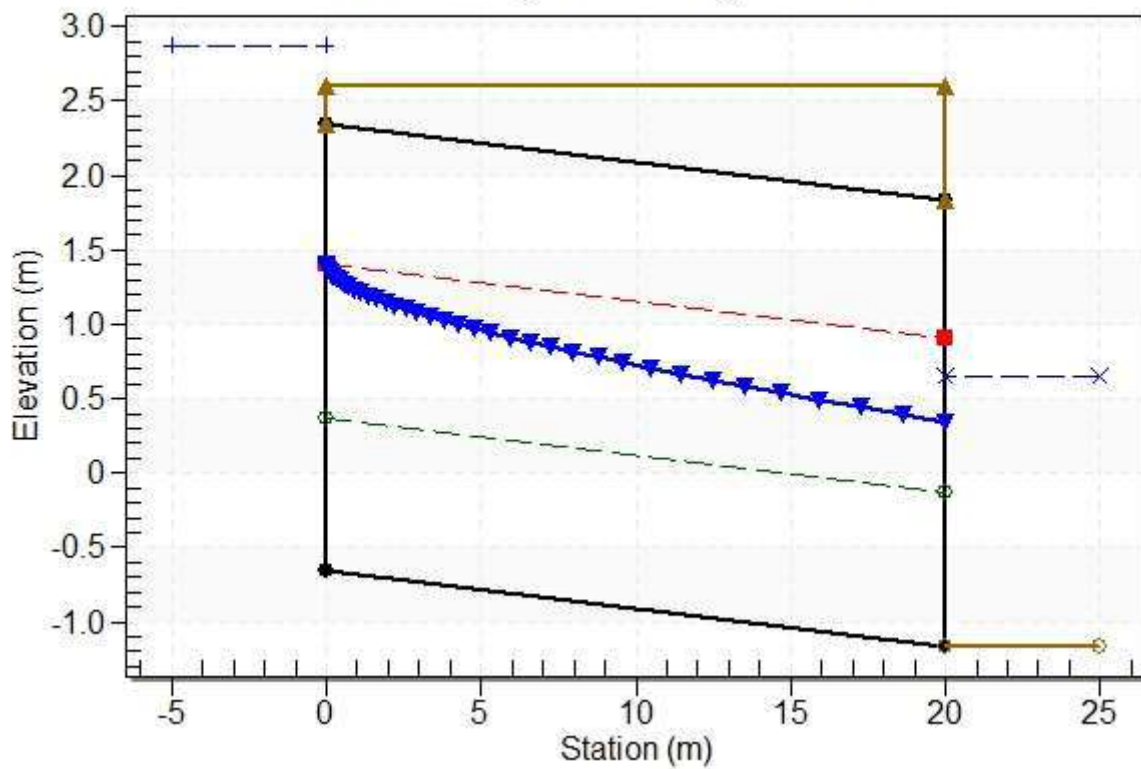
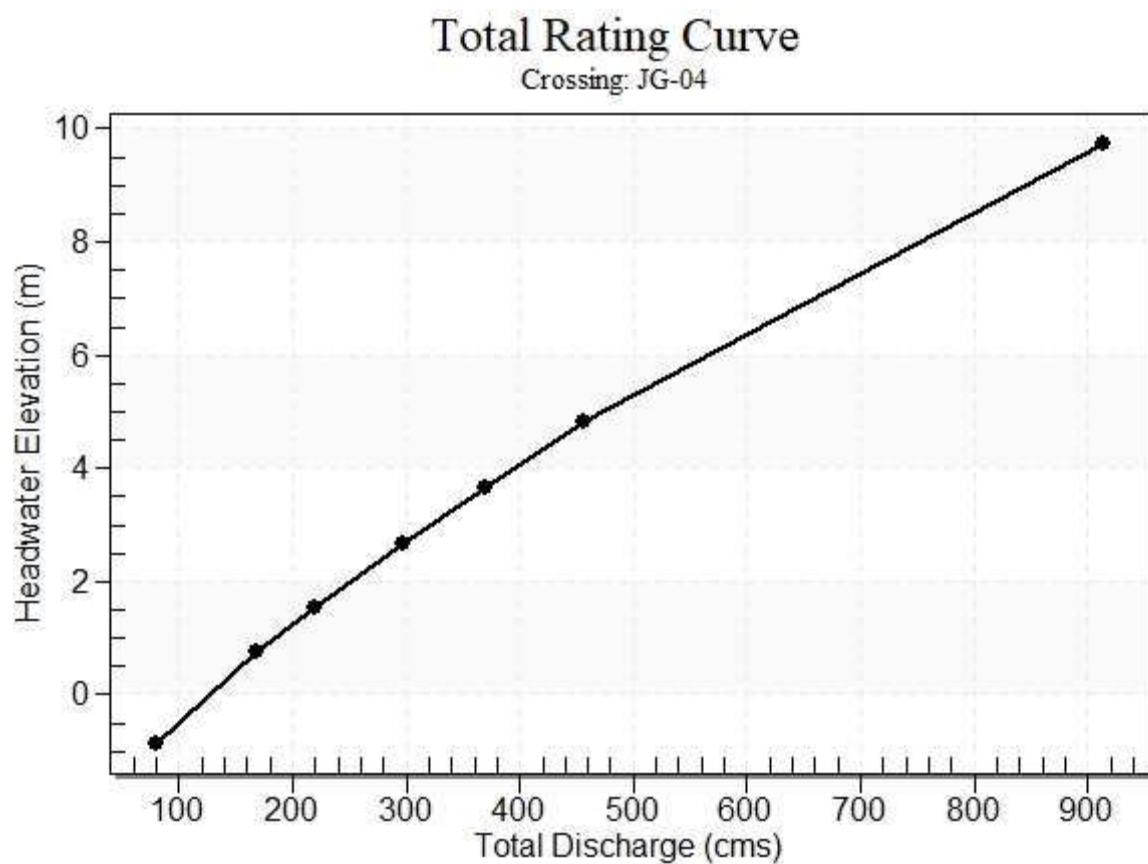


Table 11 - Summary of Culvert Flows at Crossing: JG-04

Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	JG-04 Discharge (cms)	Roadway Discharge (cms)	Iterations
-0.85	2019	80.00	80.00	0.00	1
0.75	10 RP	167.60	167.60	0.00	1
1.53	10 RP	218.60	218.60	0.00	1
2.65	25 RP	297.50	297.50	0.00	1
3.65	50 RP	369.30	369.30	0.00	1
4.82	100 RP	456.80	449.37	7.43	6
4.20	Overtopping	407.53	407.53	0.00	Overtopping

Rating Curve Plot for Crossing: JG-04



Water Surface Profile Plot for Culvert: JG-04

Crossing - JG-04, Design Discharge - 456.80 cms

Culvert - JG-04, Culvert Discharge - 449.37 cms

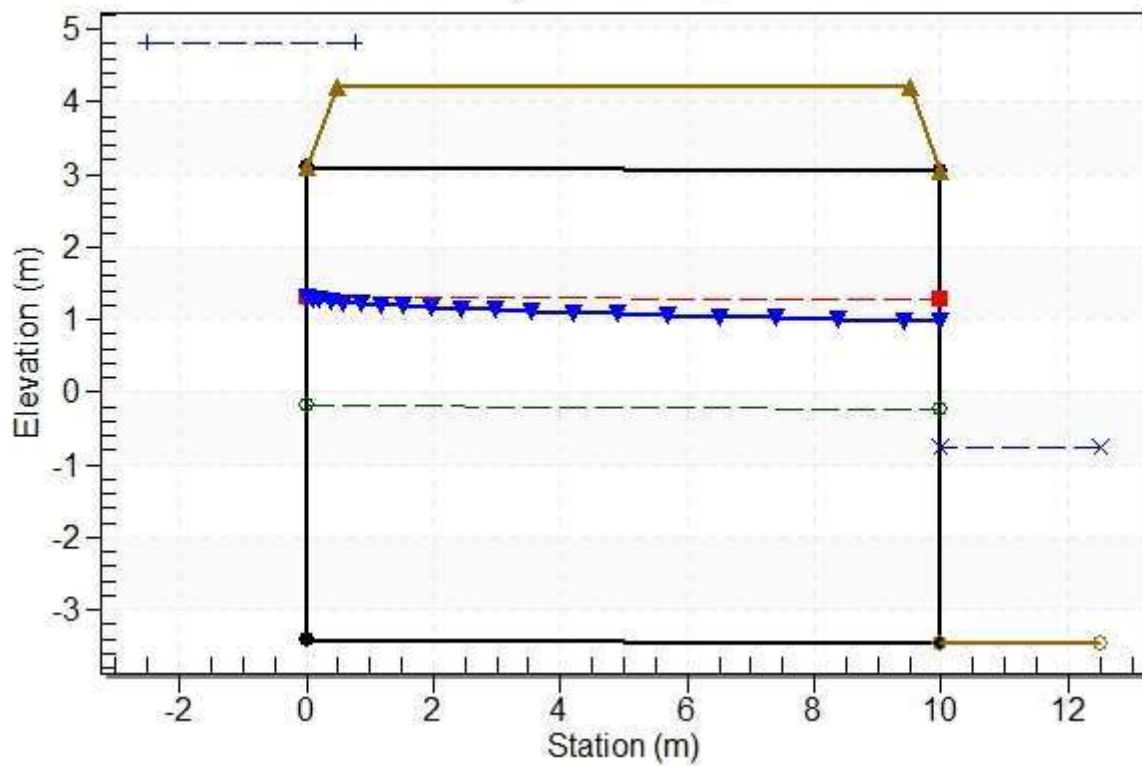
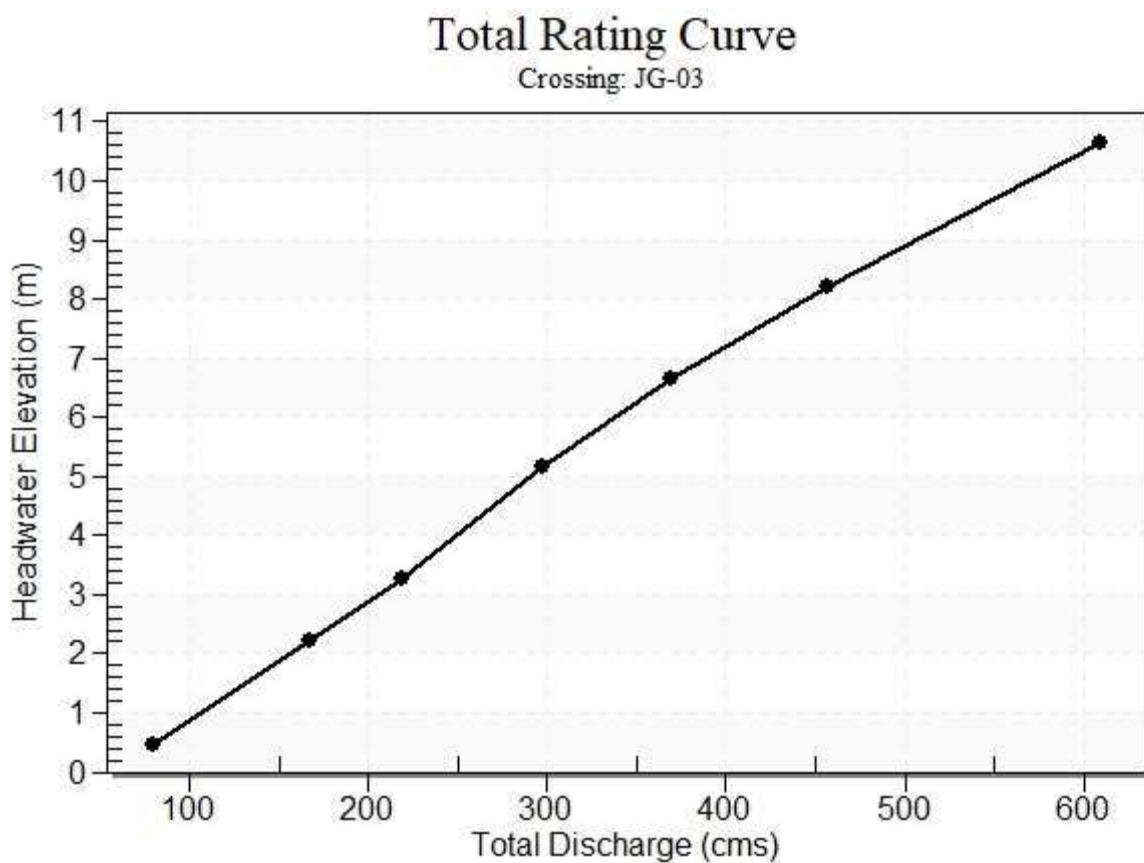


Table 12 - Summary of Culvert Flows at Crossing: JG-03

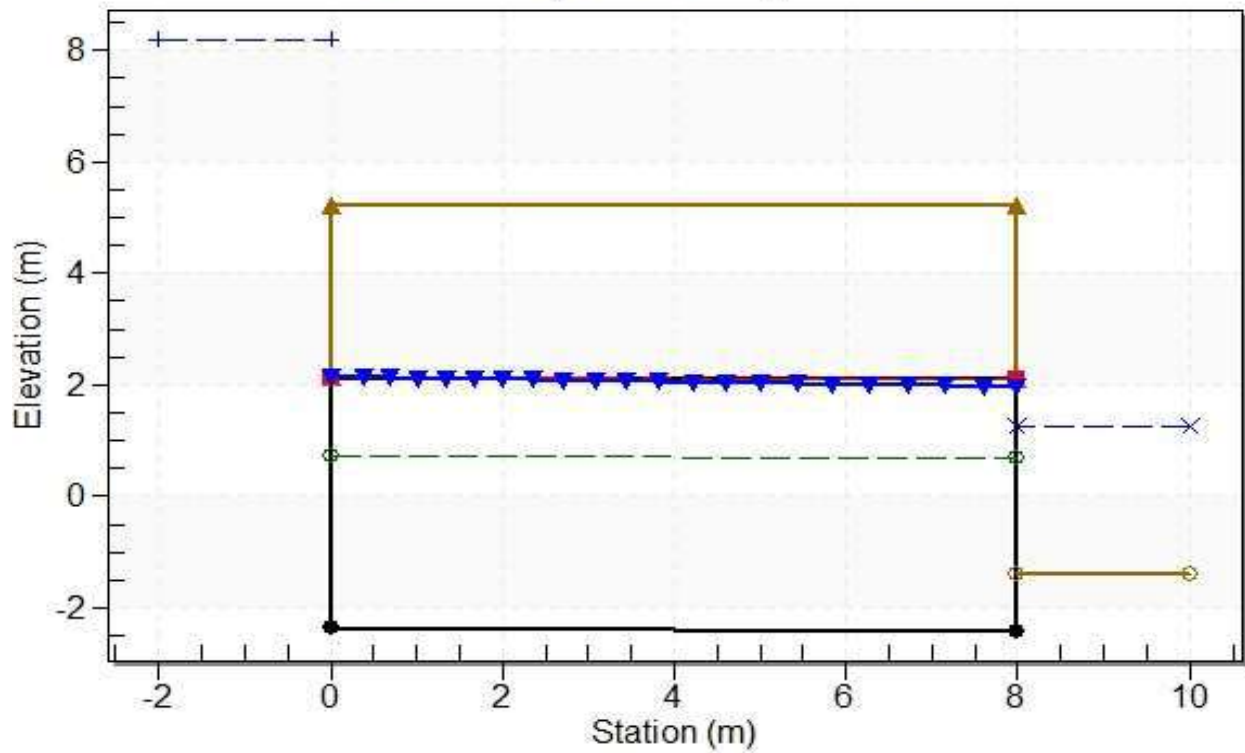
Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	JG-03 Discharge (cms)	Roadway Discharge (cms)	Iterations
0.44	2019	80.00	80.00	0.00	1
2.23	10 RP	167.60	167.60	0.00	1
3.26	10 RP	218.60	218.60	0.00	1
5.14	25 RP	297.50	297.50	0.00	1
6.64	50 RP	369.30	348.71	20.58	6
8.20	100 RP	456.80	394.51	62.28	7
5.20	Overtopping	299.58	299.58	0.00	Overtopping

Rating Curve Plot for Crossing: J



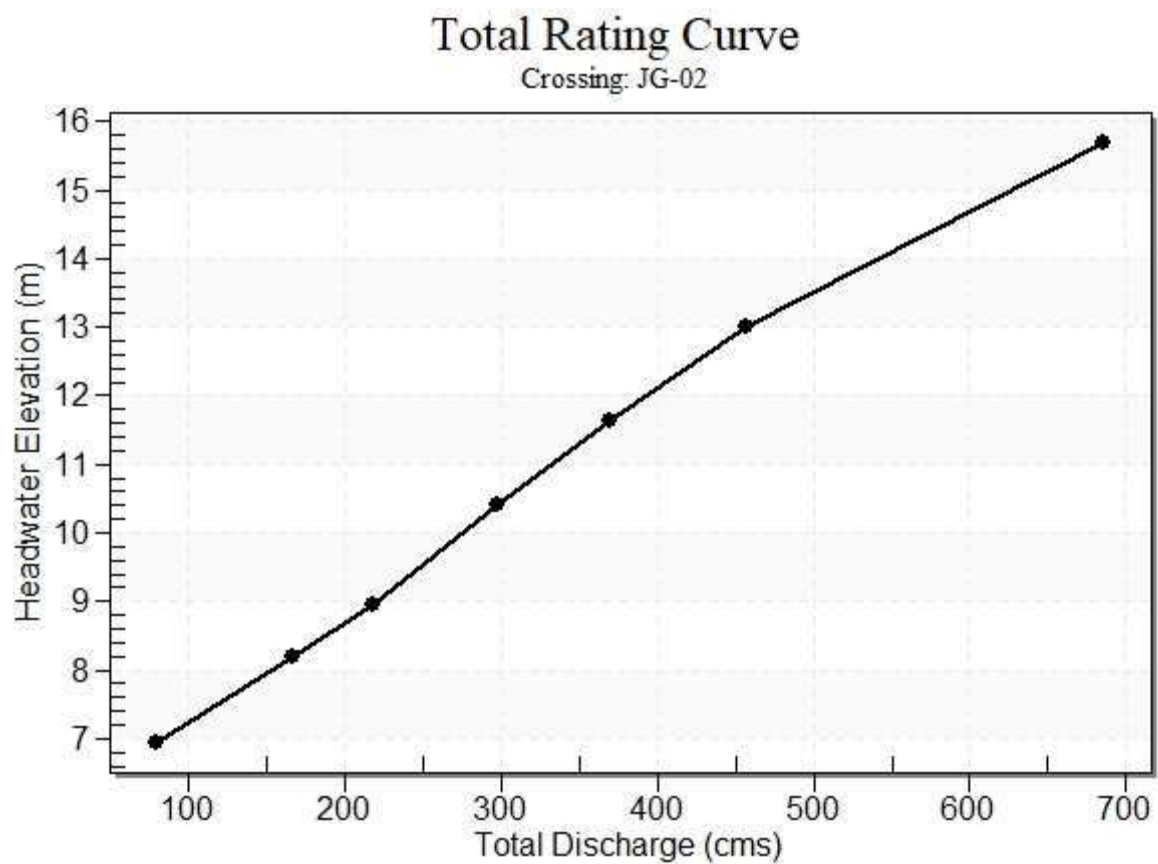
Crossing - JG-03, Design Discharge - 456.80 cms

Culvert - JG-03, Culvert Discharge - 394.51 cms



Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	JG-02 Discharge (cms)	Roadway Discharge (cms)	Iterations
6.95	2019	80.00	80.00	0.00	1
8.20	10 RP	167.60	167.60	0.00	1
8.94	10 RP	218.60	218.60	0.00	1
10.40	25 RP	297.50	297.50	0.00	1
11.63	50 RP	369.30	357.30	11.99	6
12.99	100 RP	456.80	418.00	50.76	17
10.77	Overtopping	315.11	315.11	0.00	Overtopping

Table 13 - Summary of Culvert Flows at Crossing: JG-02

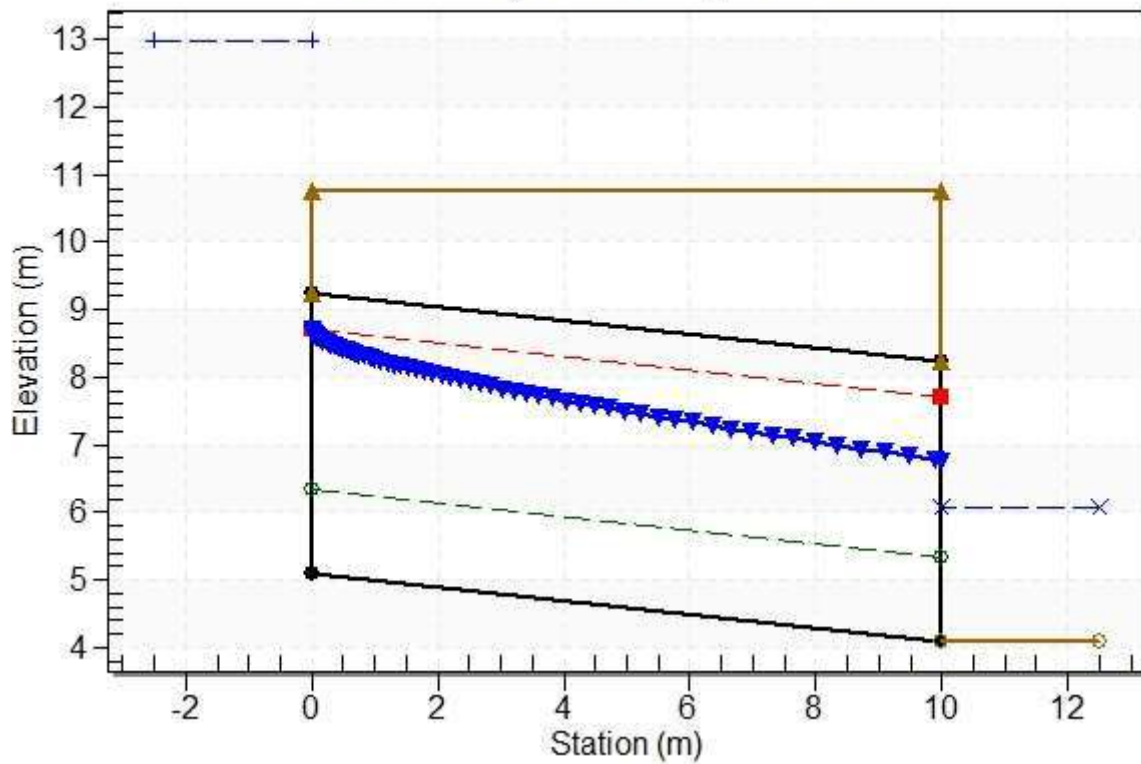


Rating Curve Plot for Crossing: JG-02

Water Surface Profile Plot for Culvert: JG-02

Crossing - JG-02, Design Discharge - 456.80 cms

Culvert - JG-02, Culvert Discharge - 418.00 cms

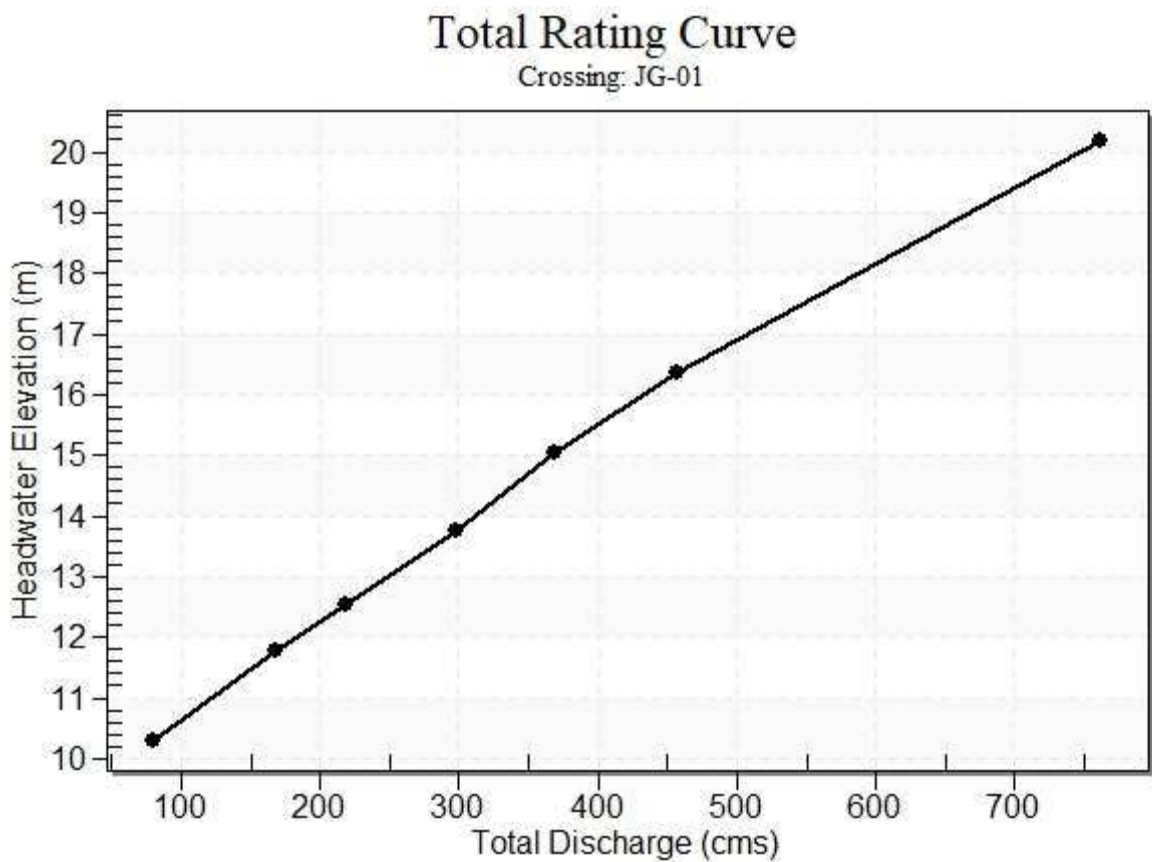


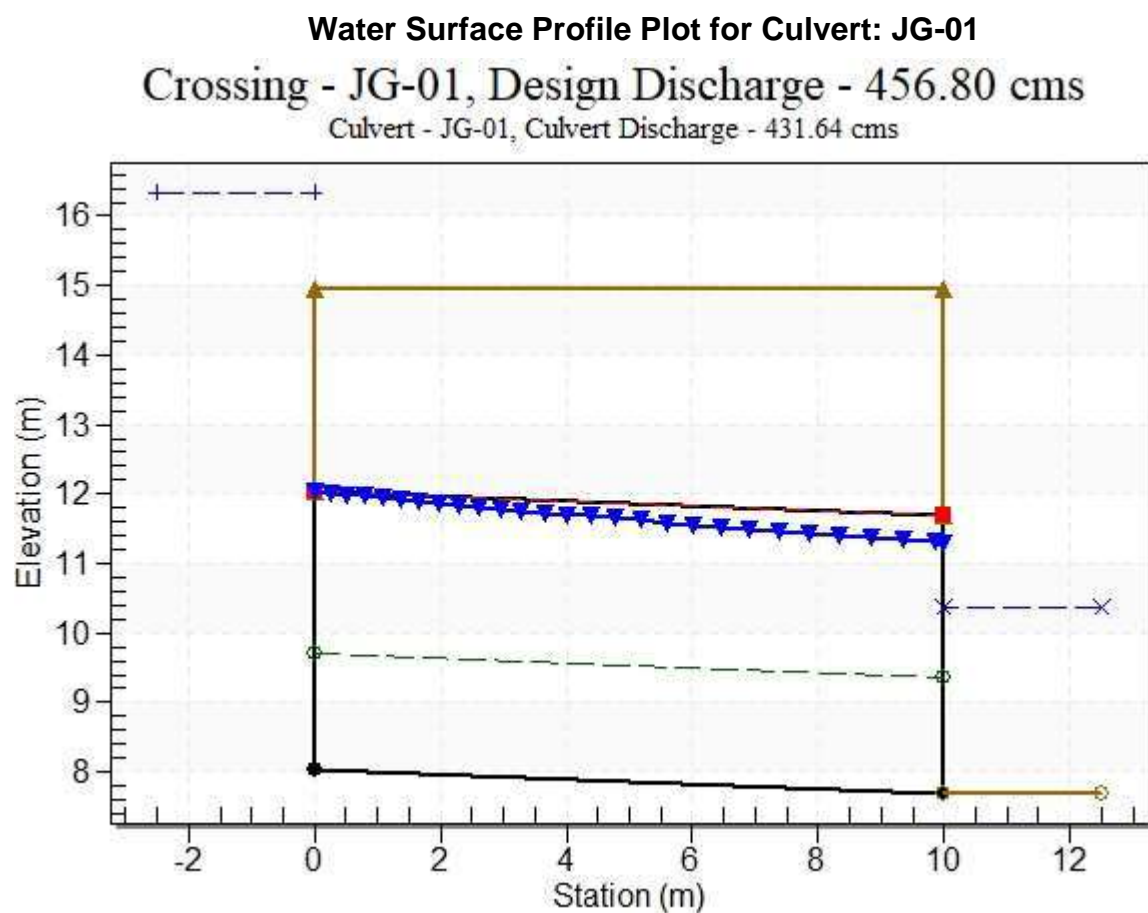
Headwater Elevation (m)	Discharge Names	Total Discharge (cms)	JG-01 Discharge (cms)	Roadway Discharge (cms)	Iterations
10.31	2019	80.00	80.00	0.00	1
11.78	10 RP	167.60	167.60	0.00	1
12.53	10 RP	218.60	218.60	0.00	1
13.75	25 RP	297.50	297.50	0.00	1
15.03	50 RP	369.30	368.92	0.37	7
16.35	100 RP	456.80	431.64	25.16	7
14.94	Overtopping	364.54	364.54	0.00	Overtopping

Table 14
-

Summary of Culvert Flows at Crossing: JG-01

Rating Curve Plot for Crossing: JG-01





9.6 Floodplain Modelling

9.6.1 Objectives and Approach

In order to fully understand the extend of flooding in the investigation area it is necessary to analyze the project area using a holistic approach, taking into account the dynamic nature of storm water surface flow into the existing drainage features. It is therefore necessary to indicate how the various assets are affected by the rainfall incurred during a 10-year, 25-year, 50-year and 100-year future rainfall event. The main objectives of the model are as follows:

- Determine the flood depths at the various regions within the project area
- Determine the effectiveness of the current drain system
- Assess the reduction in flood extents with proposed improvements

9.6.2 Introduction to HEC RAS 5.0.7

HEC-RAS is a software created by the U.S. Army Corps of Engineers to perform one and two-dimensional hydraulic calculations for a full network of natural and constructed channels. The HEC-RAS modelling system is capable of simulating one-dimensional; two-dimensional; and combined one/two-dimensional unsteady flow through a full network of open channels, floodplains, and alluvial fans. The steady flow component can be used to perform subcritical, supercritical, and mixed flow regime calculations in the steady flow computations module while taking into account the hydraulic calculations for bridges, culverts and other hydraulic structures. HEC-RAS also has the capability to perform inundation mapping of water surface profile using geometry and computed water surface profiles. The inundation depths and floodplain boundary datasets are created through the RAS Mapper module within HEC-RAS.

9.6.3 Input

The HEC-RAS steady flow analysis was used to model the capacity of the major drainage structures it enters the storm water Channels, how the water is conveyed downstream to the out-flow points and how the water moves along the flood plain. The input parameters of this model were made up of 2 main components: the geometry and the steady flow data.

9.6.3.1 Geometry

Geometry entails the terrain data derived from a Digital Elevation Map (DEM) of the Kingston area from a previous photogrammetry and LIDAR survey to an accuracy of 0.1m in the vertical direction and 0.5m in the horizontal direction. The culverts and underground drainage features were also delineated and dimensions collected onsite and recreated in the software in order to recreate the flow patterns seen in reality.

In order to simulate the flow though the drainage channel, 1d flow areas were defined by establishing reaches bank lines cross sections and junctions for each of the major drains and channels in additions to all culverts along the drains as seen in the Figure 9.19Figure 9.19 Geometry of HEC-RAS model (1D flow area and terrain).

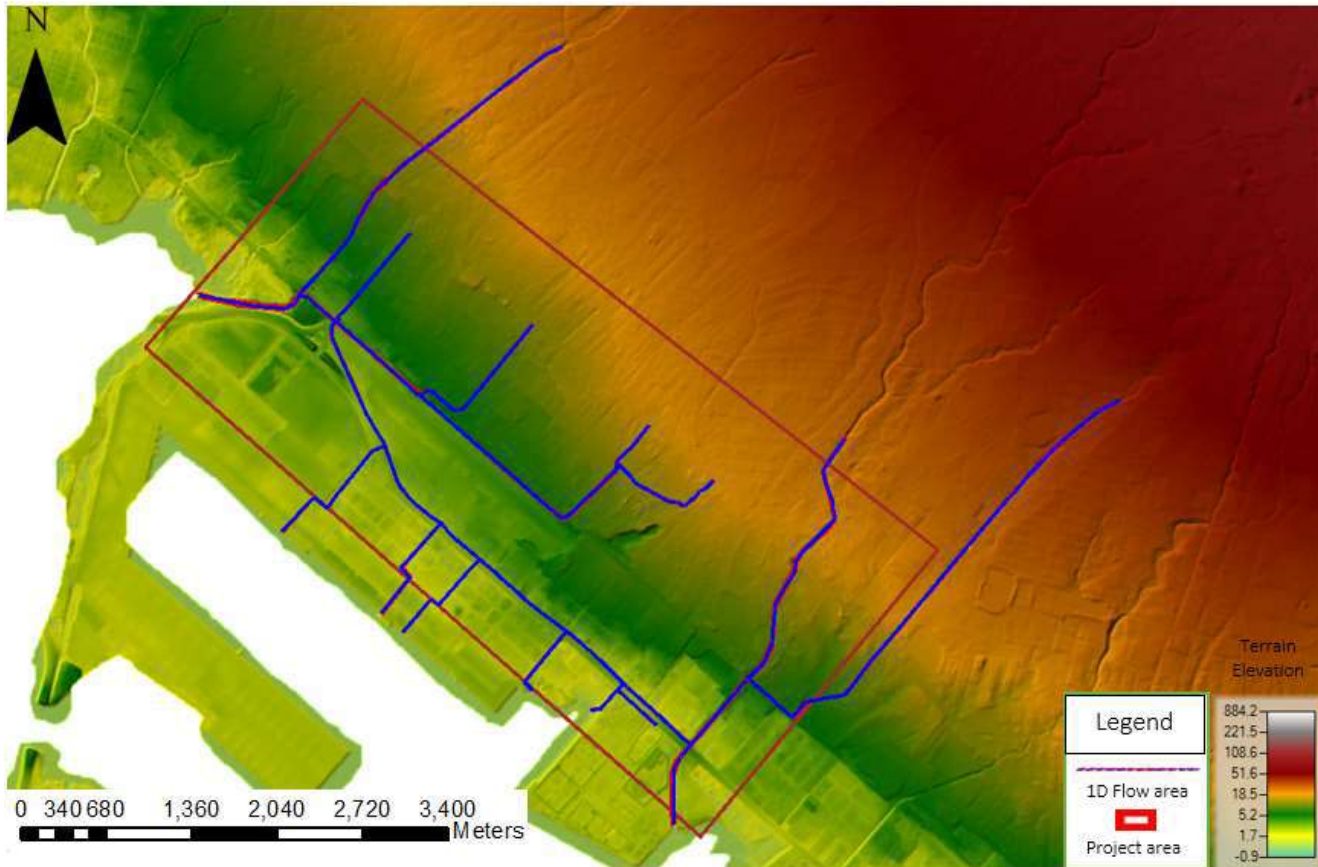


Figure 9.19 Geometry of HEC-RAS model (1D flow area and terrain)

9.6.3.2 Steady peak flow data

The steady flow input parameters are in the inflow to each of the reaches, connectivity of each reach and the outfall boundary condition. The peak flows for each reach were channels were set based on the peak flows in section 5.2 while the outfall conditions were set to a stage hydro graph at sea level for the major drains and normal depth for the underground feature draining into the sea.

Flow Change Location				Profile Names and Flow Rates									
	River	Reach	RS	PC 5 RP	PC 10 RP	PC 25 RP	PC 50 RP	PC 100 RP	FC 5 RP	FC 10 RP	FC 25 RP	FC 50 RP	FC 100 R
1	Clifton	Reach 1	209	45.8	61.3	79.5	95.7	112.7	46.7	61.3	83.7	104	128.7
2	Jews	Jews main	4141	164.3	222.4	282.7	339.8	400.2	167.6	218.6	297.5	369.3	456.8
3	Jews	Jews main-Lower	447	349.8	465.1	600.6	720.6	847.3	356.8	465.1	631.8	782.7	965.9
4	Jews	Jews main-Lower	395	349.8	465.1	600.6	720.6	847.3	356.8	465.1	631.8	782.7	965.9
5	Marcus Garvey	Hunts bay drain8	-22	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
6	Marcus Garvey	Hunts bay drain4	2084	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
7	Marcus Garvey	Hunts bay drain3	1622	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
8	Marcus Garvey	Hunts bay drain2	1232	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
9	Marcus Garvey	Hunts bay 1	1001	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
10	Marcus Garvey	Hunts bay 1	854	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
11	Marcus Garvey	Hunts bay drai8	568	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
12	Marcus Garvey1	Reach 2	31	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
13	Marcus Garvey2	Reach 7	2351	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
14	Marcus Garvey2	Reach 2-Lower	2141	9.3	13.5	15.8	19	22.3	9.5	12.3	16.6	20.6	25.5
15	newport west	Reach 5	561	11.7	15	19.8	23.7	31.7	11.7	15	19.8	23.7	31.7
16	newport west1	Reach 1	669	7.1	9.2	12.1	14.5	19.4	7.1	9.2	12.1	14.5	19.4
17	newport west3	Reach 3	481	3.5	4.5	6	7.2	9.6	3.5	4.5	6	7.2	9.6
18	newport west4	Reach 4	669	3.5	4.5	6	7.2	9.6	3.5	4.5	6	7.2	9.6
19	Oaklands	Oaklands	3759	177	235.1	303.1	363.1	426.2	180.6	235.1	318.8	394	485.2
20	Shoe_Marker	Upper_Shoemarke	2024.3	133	177.5	229.8	276.1	324.9	135.7	177.5	241.9	300	370.7
21	Shoe_Marker	Upper_Shoemarke	2024	133	177.5	229.8	276.1	324.9	135.7	177.5	241.9	300	370.7
22	Shoe_Marker	Upper_Shoemarke	2002	133	177.5	229.8	276.1	324.9	135.7	177.5	241.9	300	370.7
23	Shoe_Marker	Lower_SM	726	133	177.5	229.8	276.1	324.9	135.7	177.5	241.9	300	370.7
24	Shoe_Marker	Lower_SM-Lower	383	234.2	313.5	406.5	488.7	575.5	239	313.5	427.9	531.2	656.7
25	Stewarts	Reach 1	496	15.5	21.8	26.6	31.9	37.6	15.8	20.6	28	34.7	42.8
26	Tinson Pen	Reach 6	2164	177	235.1	303.1	363.1	426.2	180.6	235.1	318.8	394	485.2
27	Tinson Pen	Reach 6-Lower	1634	177	235.1	303.1	363.1	426.2	180.6	235.1	318.8	394	485.2
28	Tinson Pen	Reach 6-Lower	1457	177	235.1	303.1	363.1	426.2	180.6	235.1	318.8	394	485.2
29	Tinson Pen	Oaklands-Lower	3023	177	235.1	303.1	363.1	426.2	180.6	235.1	318.8	394	485.2
30	Tinson Pen	Oaklands-Lower	2910	144	192.7	250	300.7	354.3	147	192.7	263.2	326.9	404.6
31	Tinsonpen	Oaklands-Lower	756	144	192.7	250	300.7	354.3	147	192.7	263.2	326.9	404.6
32	Tinsonpen	Oaklands-Lower	754	144	192.7	250	300.7	354.3	147	192.7	263.2	326.9	404.6
33	Trench Town	Trench Town	2204	57.4	76.9	99.7	119.8	141	58.6	76.9	104.9	130.2	160.9

9.7 Flood Maps for 10- and 100-year RP

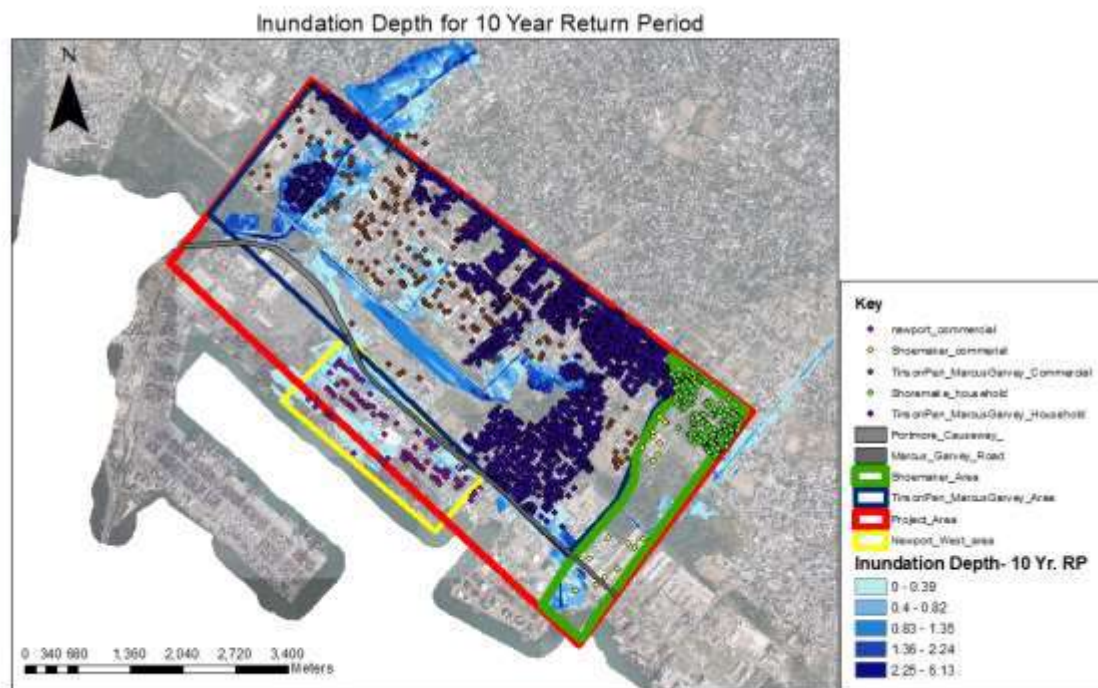


Figure 9.20 Inundation Map for 10 Yr RP

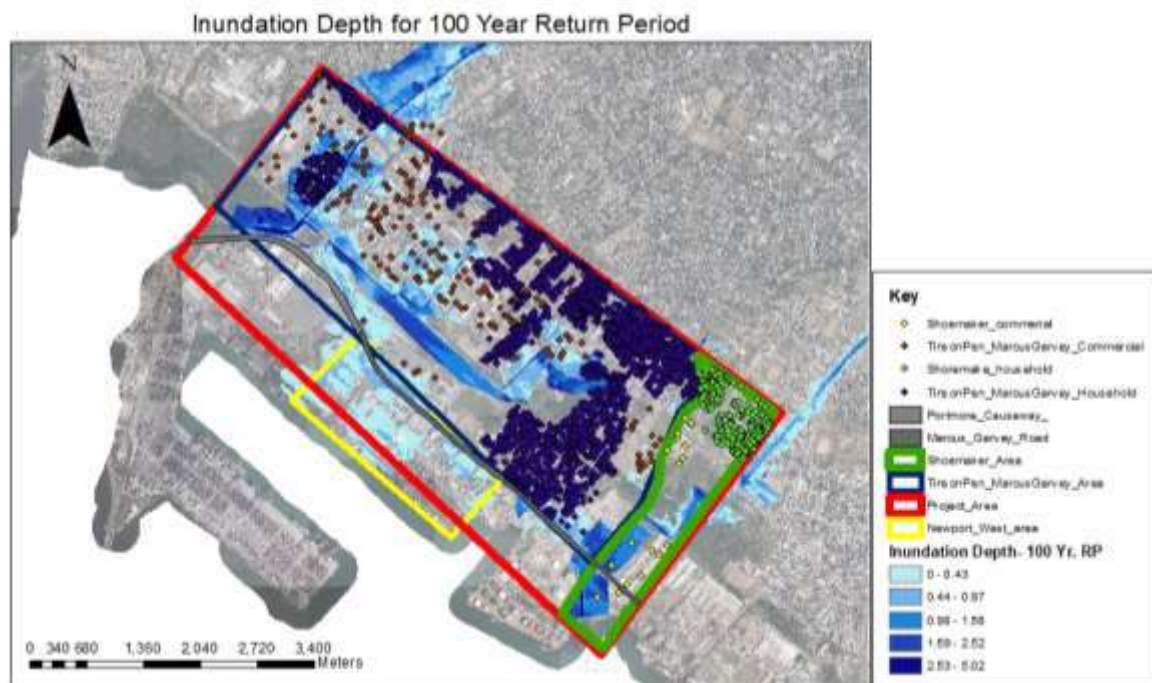


Figure 9.21 Inundation Map for 100-Yr RP

9.8 Cost Estimates

9.8.1 10-year RP

Catchment	Area (ha)	Receiving Stream	Stream Length (m)	Road Length (m)	Current Width (m)	Current Depth (m)	Improved Width (m)	Improved Depth (m)	Improvements Yes=1, No=0	Total (USD)	Sub-total amounts (USD)
PRELIMINARIES (@10%)											\$10,312,311.48
Newport West											
Newport West 1	9.6	NPW Drain 1	200		0.9	0.9	3.4	1.2	1		\$515,869
Newport West 2	13.35	NPW Drain 2	460		0.9	0.9	5.5	1.2	1		\$1,504,185
Newport West 3	11.95	NPW Drain 3	300		0.9	0.9	3.4	1.2	1		\$773,804
Newport West 4	9.58	NPW Drain 4	160		1.2	1.2	1.3	1.2	1		\$302,196
Drainage works				3661							\$3,181,712
Water and sewerage works				3661							\$1,598,300
Road reinstatement works				3661							\$2,257,353
										\$10,133,419	
Marcus Garvey, Tinson Pen and Jews Gullies											
Clifton	117	Clifton Drain	845		5	2	6	3	1		\$4,240,548
Oakland		Oakland Drain	1058		6	4	6	4	1		\$6,240,507
Marcus Garvey Drive	30	Hunts Bay Drain	1562		0.6	1	4	1.5	1		\$4,791,695
Tinson Pen	25	Jew Gully	1462		7.5	2	18	3	1		\$13,738,122
Culvert-estimate w/diversion											\$1,450,544
Jew Gully	109	Jew Gully	790		7.5	2	10	4.5	1		\$6,388,361
Culvert-estimate w/diversion											\$319,418
Hunts Bay canal			1750		75	3	75	4			\$18,585,000
Dentenion basin			120				120	5	1		\$2,281,680
Drainage works				9380							\$8,151,996
Water and sewerage works				9380							\$3,314,000
Road reinstatement				9380							\$5,783,658
										\$75,285,529	
Shoemaker											
Mid Shoemaker	67.8	Mid Shoemaker Gully	480		5	1.5	12	2	1		\$3,037,248
Upper Shoemaker	177	upper Shoemaker Gully	897		5	1.5	6	2.5	1		\$4,214,465
Lower Shoemaker	107.3	Lower Shoemaker Gully	516		10	1.8	20	3	1		\$5,330,555
Drainage works				1956							\$1,699,926
Water and sewerage works				1956							\$1,706,059
Water and sewerage works				1956							\$1,086,800
Culvert-estimate w/diversion											\$629,113
										\$17,704,166	
CONTNGENCIES (@15%)											\$15,468,467
										GRAND TOTAL	\$128,903,893

9.8.2 25-Year RP

Catchment	Area (ha)	Receiving Stream	Stream Length (m)	Road Length (m)	Current Width (m)	Current Depth (m)	Improved Width (m)	Improved Depth (m)	Improvements Yes=1, No=0	Total (USD)	Sub-total amounts (USD)
PRELIMINARIES (@10%)											\$10,672,878.71
Newport West											
Newport West 1	9.6	NPW Drain 1	200		0.9	0.9	3.4	1.2	1		\$515,869
Newport West 2	13.35	NPW Drain 2	460		0.9	0.9	5.5	1.2	1		\$1,504,185
Newport West 3	11.95	NPW Drain 3	300		0.9	0.9	3.4	1.2	1		\$773,804
Newport West 4	9.58	NPW Drain 4	160		1.2	1.2	1.3	1.2	1		\$302,196
Drainage works				3661							\$3,181,712
Water and sewerage works				3661							\$1,598,300
Road reinstatement works				3661							\$2,257,353
										\$10,133,419	
Marcus Garvey, Tinson Pen and Jews Gullies											
Clifton	117	Clifton Drain	845		5	2	6	3	1		\$4,240,548
Oakland		Oakland Drain	1058		6	4	6	4	1		\$6,240,507
Marcus Garvey Drive	30	Hunts Bay Drain	1562		0.6	1	4	1.5	1		\$4,791,695
Tinson Pen	25	Jew Gully	1462		7.5	2	20	3	1		\$14,804,992
Culvert-estimate w/diversion											\$1,442,914
Jew Gully	109	Jew Gully	790		7.5	2	10	5.5	1		\$7,146,761
Culvert-estimate w/diversion											\$1,107,176
Hunts Bay canal			1750		75	3	75	4			\$18,585,000
Dentenion basin			120				120	5	1		\$2,281,680
Drainage works				9380							\$8,151,996
Water and sewerage works				9380							\$3,314,000
Road reinstatement works				9380							\$5,783,658
										\$77,890,928	
Shoemaker											
Mid Shoemaker	67.8	Mid Shoemaker Gully	480		5	1.5	14	3	1		\$3,867,520
Upper Shoemaker	177	upper Shoemaker Gully	897		5	1.5	6	2.5	1		\$4,214,465
Lower Shoemaker	107.3	Lower Shoemaker Gully	516		10	1.8	20	4	1		\$5,929,115
Culvert-estimate w/diversion											\$700,555
Drainage works				1956							\$1,699,926
Water and sewerage works				1956							\$1,086,800
Road reinstatement works				1956							\$1,206,059
										\$18,704,440	
CONTNGENCIES (@15%)											\$16,009,318
										GRAND TOTAL	\$133,410,984

9.8.3 50-Year RP

Catchment	Area (ha)	Receiving Stream	Stream Length (m)	Road Length (m)	Current Width (m)	Current Depth (m)	Improved Width (m)	Improved Depth (m)	Improvements Yes=1, No=0	Total (USD)	Sub-total amounts (USD)
PRELIMINARIES (@10%)											\$11,152,754.99
Newport West											
Newport West 1	9.6	NPW Drain 1	200		0.9	0.9	3.4	1.2	1		\$515,869
Newport West 2	13.35	NPW Drain 2	460		0.9	0.9	5.5	1.2	1		\$1,504,185
Newport West 3	11.95	NPW Drain 3	300		0.9	0.9	3.4	1.2	1		\$773,804
Newport West 4	9.58	NPW Drain 4	160		1.2	1.2	1.3	1.2	1		\$302,196
Drainage works				3661							\$3,181,712
Water and sewerage works				3661							\$1,598,300
Road reinstatement works				3661							\$2,257,353
										\$10,133,419	
Marcus Garvey, Tinson Pen and Jews Gullies											
Clifton	117	Clifton Drain	845		5	2	8	3	1		\$4,857,173
Oakland		Oakland Drain	1058		6	4	8	4	1		\$7,054,885
Marcus Garvey Drive	30	Hunts Bay Drain	1562		0.6	1	4	1.5	1		\$4,791,695
Tinson Pen	25	Jew Gully	1462		7.5	2	24	3	1		\$16,938,732
Culvert-estimate w/diversion											\$1,682,124
Jew Gully	109	Jew Gully	790		7.5	2	12	5.5	1		\$7,799,828
Culvert-estimate w/diversion											\$389,991
Hunts Bay canal			1750		75	3	75	4			\$18,585,000
Dentenion basin			120				120	5	1		\$2,281,680
Drainage works				9380							\$8,151,996
Water and sewerage works				9380							\$3,314,000
Road reinstatement works				9380							\$5,783,658
										\$81,630,763	
Shoemaker											
Mid Shoemaker	67.8	Mid Shoemaker Gully	480		6	2.5	16	3	1		\$4,239,392
Upper Shoemaker	177	upper Shoemaker Gully	897		5	1.5	8	2.5	1		\$4,851,096
Lower Shoemaker	107.3	Lower Shoemaker Gully	516		10	1.8	20	4	1		\$5,929,115
Culvert-estimate w/diversion											\$750,980
Drainage works				1956							\$1,699,926
Water and sewerage works				1956							\$1,086,800
Road reinstatement works				1956							\$1,206,059
										\$19,763,368	
CONTNGENCIES (@15%)											\$16,729,132
										GRAND TOTAL	\$139,409,437

9.8.4 100-Year RP

Catchment	Area (ha)	Receiving Stream	Stream Length (m)	Road Length (m)	Current Width (m)	Current Depth (m)	Improved Width (m)	Improved Depth (m)	Improvements Yes=1, No=0	Total (USD)	Sub-total amounts (USD)
PRELIMINARIES (@10%)											\$11,463,231.06
Newport West											
Newport West 1	9.6	NPW Drain 1	200		0.9	0.9	3.4	1.2	1		\$483,869
Newport West 2	13.35	NPW Drain 2	460		0.9	0.9	5.5	1.2	1		\$1,406,435
Newport West 3	11.95	NPW Drain 3	300		0.9	0.9	3.4	1.2	1		\$725,804
Newport West 4	9.58	NPW Drain 4	160		1.2	1.2	1.3	1.2	1		\$284,996
Drainage works				3661							\$3,181,712
Water and sewerage works				3661							\$1,598,300
Road reinstatement works				3661							\$2,257,353
										\$9,938,469	
Marcus Garvey, Tinson Pen and Jews Gullies											
Clifton	117	Clifton Drain	845		5	2	10	3	1		\$5,123,122
Oakland		Oakland Drain	1058		6	4	10	4	1		\$7,377,293
Marcus Garvey Drive	30	Hunts Bay Drain	1562		0.6	1	6	1.5	1		\$5,462,939
Tinson Pen	25	Jew Gully	1462		7.5	2	26	3	1		\$17,066,267
Culvert-estimate w/diversion											\$1,751,481
Jew Gully	109	Jew Gully	790		7.5	2	14	5.5	1		\$7,947,295
Culvert-estimate w/diversion											\$1,192,094
Hunts Bay canal			1750		75	0	75	4			\$18,585,000
Dentenion basin			120				120	5	1		\$2,281,680
Drainage works				9380							\$8,151,996
Water and sewerage works				9380							\$3,314,000
Road reinstatement works				9380							\$5,783,658
										\$84,036,825	
Shoemaker											
Mid Shoemaker	67.8	Mid Shoemaker Gully	480		6	2.5	18	3	1		\$4,294,464
Upper Shoemaker	177	upper Shoemaker Gully	897		5	1.5	12	2.5	1		\$5,729,677
Lower Shoemaker	107.3	Lower Shoemaker Gully	516		10	1.8	20	4.5	1		\$5,846,555
Culvert-estimate w/diversion											\$793,535
Drainage works				1956							\$1,699,926
Water and sewerage works				1956							\$1,086,800
Road reinstatement works				1956							\$1,206,059
										\$20,657,016	
CONTNGENCIES (@15%)											\$17,194,847
										GRAND TOTAL	\$143,290,388

9.8.5 100-Year RP (Revised)

Catchment	Area (ha)	Receiving Stream	Stream Length (m)	Road Length (m)	Current Width (m)	Current Depth (m)	Improved Width (m)	Improved Depth (m)	Improvements Yes=1, No=0	Total (USD)	Sub-total amounts (USD)
PRELIMINARIES (@10%)											\$10,505,331.12
Newport West											
Newport West 1	9.6	NPW Drain 1	200		0.9	0.9	3.4	1.2	1		\$483,869
Newport West 2	13.35	NPW Drain 2	460		0.9	0.9	5.5	1.2	1		\$1,406,435
Newport West 3	11.95	NPW Drain 3	300		0.9	0.9	3.4	1.2	1		\$725,804
Newport West 4	9.58	NPW Drain 4	160		1.2	1.2	1.3	1.2	1		\$284,996
Drainage works				3661							\$3,181,712
Water and sewerage works				3661							\$1,598,300
Road reinstatement works				3661							\$2,257,353
										\$9,938,469	
Marcus Garvey, Tinson Pen and Jews Gullies											
Clifton	117	Clifton Drain	845		5	2	10	3	1		\$5,123,122
Oakland		Oakland Drain	1058		6	4	10	4	1		\$7,377,293
Marcus Garvey Drive	30	Hunts Bay Drain	1562		0.6	1	6	1.5	1		\$5,462,939
Tinson Pen	25	Jew Gully	1462		7.5	2	53	3	1		\$10,876,744
Culvert-estimate w/diversion											\$1,442,005
Jew Gully	109	Jew Gully	790		7.5	2	14	5.5	1		\$7,947,295
Culvert-estimate w/diversion											\$1,192,094
Hunts Bay canal			1750		75	0	75	3			\$15,505,000
Detention basin			120				120	5	1		\$2,281,680
Drainage works				9380							\$8,151,996
Water and sewerage works				9380							\$3,314,000
Road reinstatement works				9380							\$5,783,658
										\$74,457,826	
Shoemaker											
Mid Shoemaker	67.8	Mid Shoemaker Gully	480		6	2.5	18	3	1		\$4,294,464
Upper Shoemaker	177	upper Shoemaker Gully	897		5	1.5	12	2.5	1		\$5,729,677
Lower Shoemaker	107.3	Lower Shoemaker Gully	516		10	1.8	20	4.5	1		\$5,846,555
Culvert-estimate w/diversion											\$793,535
Drainage works				1956							\$1,699,926
Water and sewerage works				1956							\$1,086,800
Road reinstatement works				1956							\$1,206,059
										\$20,657,016	
CONTNGENCIES (@15%)											\$15,757,997
										GRAND TOTAL	\$131,316,639

9.9 Drawings

9.9.1 Existing Flood Control and Drainage

9.9.2 Proposed Flood Control and Drainage

9.9.2.1 25-year RP

9.9.2.2 100-year RP

ANNEX 4 – NEPA GUIDELINES FOR CONDUCTING EIA

National Environment and Planning Agency

***GUIDELINES FOR CONDUCTING
ENVIRONMENTAL IMPACT ASSESSMENTS***

Original: July 1997

Revised: August 2005

Revised: October 2007

By

National Environment and Planning Agency

**Through the support of the CIDA/GOJ Environmental Action (ENACT) Programme
Extension**

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ANNEX I

Terms of Reference for EIA for prescribed Categories pursuant to Natural Resources Conservation (Permits and Licences) Regulations (Amended)2004

- Power Generation Plants: Wind Farms, Hydrothermal& nuclear
- Electrical Transmission Lines & Substations
- Pipelines and Conveyors for Gas Transport, Underground & Underwater Cables
- Port & Harbour, Shipyards & Marinas
- Human Habitation Projects
- Hospitals & Health Services Facilities
- Recreational & Leisure Facilities
- Transportation Centres, Depots & Ports
- Ecotourism & Nature Tourism Projects
- Water Treatment & Storage
- Mining and Mineral Processing – Bauxite, Peat, Sand, Metallic, Non-Metallic Material
- Metal Processing
- Industrial Projects: Food Processing & Processing Plants – Citrus, Coffee, Cocoa, Edible Fats, Coconut, Solar Salt, Fish & Meat, Syrup. Aquaculture facilities, Breweries & Boxing Plants
- Industrial Projects: Petroleum Production, Refinery, Storage & Stockpiling
- Industrial Project: Manufacturing of paints, textiles, pulp & pesticides
- Industrial Project: Offshore drilling
- Road construction
- River Basin
- Water Management
- Drainage projects, dredging, excavation, land reclamation
- Watershed development and soil conservation projects
- Solid Waste storage, Treatment & Disposal facilities.
- Hazardous Waste Storage, Transportation, Treatment or disposal Facilities
- Agro Processing and processing of agriculture waste
- Cemeteries and Crematorium
- Introduction of Species Flora, Fauna, Genetic material & Genetically modified organism
- Abattoirs
- Felling of tress & Land Clearance

ANNEX II

Guidelines for Public Consultations

LIST OF ACRONYMS

CIDA	Canadian International Development Agency
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
MLE	Ministry of Land and Environment
MOH	Ministry of Health
NEPA	National Environment and Planning Agency
NRCA	Natural Resources Conservation Authority
NWA	National Works Agency
JB	Jamaica Bauxite Institute
SEA	Strategic Environmental Assessment
UKDoE	United Kingdom Department of the Environment
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
WRA	Water Resources Authority
GOJ	Government of Jamaica

GLOSSARY OF TERMS

(Source: *Environmental Impact Assessment (EIA) Cutting edge for the twenty-first century* by Alan Gilpin)

Agenda 21: A document adopted by the UN Conference on Environment and Development meeting in Rio de Janeiro in June 1992, representing a programme for the twenty-first century. The conference was held on the twentieth anniversary of the UN Conference on Human Environment, which met in Stockholm in June 1972.

Alternatives: In EIA, an examination of alternative locations, methods, and techniques for a particular project, includes the alternative of not proceeding. It may be demonstrated that a project is not actually needed if demand-management approaches (for example, curbing the demand for water or electricity) are adopted or strengthened. At regional and national levels, a choice of policies, plans and programmes, may be presented, with a range of environmental impacts and mitigation measures.

Applicant: The proponent or developer seeking approval or consent for a proposed activity/development, or seeking the issue of a permit or licence.

Biological diversity: Or biodiversity, an umbrella term to describe collectively the variety and variability of nature. It encompasses three basic levels of organization in living systems: the genetic, species, and ecosystem levels. Plant and animal species are the most commonly recognized units of biological diversity, thus public concern has been mainly devoted to conserving species diversity. This has led to efforts to conserve endangered species and to establish specifically protected areas. However sustainable human economic activity depends upon understanding, protecting, and maintaining the world's many interactive, diverse ecosystems with their complex networks of species and their vast storehouses of genetic information.

Conservation: Defined by the World Conservation Strategy of 1980 as "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations." Conservation is, therefore, something positive embracing preservation, maintenance, sustainable utilization, restoration, and enhancement of the natural environment. This theme was further endorsed by the World Commission on Environment and Development (Brundtland Commission) in its 1987 report to the UN.

Cumulative effects: Progressive environmental degradation over time arising from a range of activities throughout an area or region, each activity considered in isolation being possibly not a significant contributor. Such effects might arise from a growing volume of vehicles, multiple sources of power generation or incineration, or increasing application of chemicals to the land. The solution is better regional planning and control.

Decision-maker: The body or person responsible for deciding whether a project shall proceed or not, or proceed subject to conditions and constraints. The decision-maker is usually an elected body or responsible agency or minister, the decision-making being essentially a function of government.

Developer: The initiator of a project; also called the proponent, or applicant for development consent.

Development: The application of human, financial, and physical resources to satisfy human needs;

inevitably, development involves modification of the biosphere and some aspects of development detract from the quality of life locally, regionally, nationally, or globally. The breadth of development is not always appreciated as the word applies not only to the growth of industry, commerce and infrastructure, but to sanitation, education, medicine, health, housing, national parks, tourist and recreational facilities.

Ecosystem: The plants and animals of an ecological community, and their environment, forming an interacting system of activities and functions regarded as a unit. There are innumerable ecosystems: for example, marine, fresh-water, terrestrial, forest, and grassland. All ecosystems together comprise the biosphere, that part of the Earth's crust and atmosphere inhabited by living things. Ecology is the study of the relationship between an animal or plant and its surrounding.

Endangered species: Fauna and flora likely to become extinct as a result of direct exploitation by humans, intrusion into highly specialized habitats, threats from other species, interruption of the food chain, pollution, or a combination of such factors.

Environment: A concept which includes all aspects of the surroundings of humanity, affecting individuals and social groupings. The EC has defined the environment as "the combination of elements whose complex inter-relationships make up the settings, the surroundings and the conditions of life of the individual and of society, as they are so as they are felt." The environment may be regarded as a parcel of things which render a stream of beneficial services and some disservices to people, though largely unpriced, and which take their place alongside the stream of goods and services rendered by real income, houses, infrastructure, transport, and other people.

Environmental health impact assessment (EHA): The subset of EIA, an assessment of the impacts on the environment and people of aspects of a project recognized as having potentially adverse health effects. In 1982, WHO recommended that EHIA studies should be conducted for all major development projects. Many consider that the adverse effects of the Aswan High Dam in Egypt, such as the spread of bilharzias, were neglected in the EIA.

Environmental impact assessment (EIA): The critical appraisal of the likely effects of a policy, plan, program, project, or activity, on the environment. To assist the decision-making authority, assessments are carried out independently of the proponent, who may have prepared an EIS. The decision-making authority might be a level of government (local, state, or federal) or a government agency (at local, state, or federal level). Assessments take account of any adverse environmental effects on the community; any diminution of the aesthetic, scientific, or other environmental values of a locality; the endangering of any species of fauna or flora; any adverse effect on any place or building having aesthetic, anthropological, archaeological, cultural, historical, scientific, or social significance; any long term or cumulative effects on the environment; any curtailing of the range of beneficial uses; any environmental problems associated with the disposal of wastes; any implications for natural resources; and the implication for the concept of sustainable development. EIA extends to the entire process from the inception of a proposal to environmental auditing and PPA.

Environmental management: A concept of care applied to individual premises, corporate enterprises, localities, regions, catchments, natural resources, areas of high conservation value, lifetime cycles, waste handling and disposal, cleaner processing and recycling systems, with the purpose of protecting the environment in the broadest sense. It involves the identification of objectives, the adoption of appropriate mitigation measures,

the protection of ecosystems, the enhancement of the quality of life for those affected, and the minimization of environmental costs.

Habitat: Or living space; all the things, which collectively make up the place in which organisms, creatures or humans live. Habitat includes non-living influences such as soils, light, temperature, humidity and other abiotic factors; and biotic factors dependent on the activities of individuals and communities. In 1976, a UN conference on human settlements took the title “Habitat.”

Hazard and risk assessment: An essential component of many EISs. Such an assessment embraces the potentially adverse effects of a project involving fire, heat, blast, explosion or food, arising from a manufacturing plant or transportation system. An assessment reveals hazards to life and limb and property, and is expressed in the form of risk probability. Safety depends on the location of a plant, the safety precautions, back-up arrangements adopted, and the degree of training and alertness in the plant. Buffer zones and correct routing of vehicles are also essential.

Health: Defined by WHO as “state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” However, most assessments of health still rely upon morbidity and mortality statistics, such as infant and child mortality rates, and average expectations of life in different countries.

Mitigation measures: Action taken to prevent, avoid, or minimize the actual or potential adverse effects of a policy, plan, programme, or project. Measures might include abandoning or modifying a proposal, or relocating it, substitution of techniques; cleaner methods; recycling; pollution control methods; closure of older plant; land-scaping and rehabilitation; acquisition of properties; and better programming.

Monitoring: A combination of observation and measurement for the performance of a project and its compliance with development consent conditions. Instrumentation might be required in relation to air, water, and land pollutants; noise and blasting; radiation; transportation movements; and land subsidence. Records might be required for materials movements, raw materials, products, wastes, complaints and investigations, instrument and analysis results.

Precautionary principle: A guiding rule in EIA to protect people and the environment against future risks, hazards, and adverse impacts, tending to emphasise safety considerations in the occasional absence of clear evidence.

Project: A proposed installation, factory, works, mine, highway, airport, or scheme, and all activities with possible impacts on the environment.

Proponent: The proposer (or applicant) of an activity, policy, plan, program, or project in the private or public sectors; a proposal usually requires official approval or consent and during the process of obtaining this, the public have increasing opportunities to voice opinions of support and objection.

Public inquiry or hearing: An opportunity for members of the public, voluntary bodies, and government agencies, to express opinion before an independent and impartial commissioner of inquiry, to enable issues about a controversial proposed development to be fully discussed. The usual outcome is the submission of a report by the commissioner with recommendations to a decision-making body or minister, the report becoming immediately a public document. The success of the public inquiry hinges upon the

choice, integrity and independence of the commissioner; and upon a political and social context, which encourages full participation by all citizens, without fear of reprisal or discrimination. The public inquiry often stands at the apex of EIA processes.

Quality of life: In current usage, a concept embracing a miscellany of desirable things not always recognized, or adequately recognized, in the marketplace. It embraces such highly relevant matters as real income, housing and working conditions, health, and education services and recreational opportunities, which might be regarded as the general standard of living. Other highly relevant matters include community relationships, race relationships, civil liberties, compassion, justice, freedom, and fair play, safety and security, law and order, and environmental conditions.

Sanitation: An important health-related branch of development embracing drainage and sewage, sewage and sullage treatment and effluent disposal, safe and adequate domestic water supplies, avoidance of public nuisances and controlled tipping, and drainage facilities for floodwater and surface run-off. Few countries renowned for high-tech achievements have been able to resolve the basic requirements of sanitation, relying on primitive methods (or none).

Scoping: A procedure, carried out as early as possible, to help ensure that an EA focuses on key environmental issues associated with a proposed activity or development; scoping involves meeting between the proponent and planning or environmental agencies, members of the public, and other interests likely to be affected. The result should determine the scope and depth of the significant issues to be examined in the forthcoming EIS.

Strategic EIA (also SEA): The application of EIA not only to individual projects, but to policies, plans, programmes, activities, and regional land-use objectives. There is a growing conviction that matters cannot be completely resolved at project level when many matters have been decided already at a higher level. Matters difficult or impossible to settle at the project level relate to the cumulative effects of other projects within the same or related programs; to transportation decisions governing the modal split between road and rail movement; to energy policies relating to power generation; to greenhouse strategies; and to natural resource conservation and management.

FOREWORD

As a result of human interactions with natural systems, natural processes often experience disruptions and/or changes that affect their normal progression. These changes can in turn affect environmental quality and in turn human settlements and livelihoods. The need to manage this interaction is termed environmental management. Scientific studies on the physical, biological/ecological and social characteristics of planet earth have contributed to the understanding of environmental systems, and the results of these multifaceted and sometimes interdisciplinary studies help to guide assessments of the interaction between human endeavour and natural systems.

Within the limited land space and often fragile ecosystems of Small Island Developing States (SIDS) and the Caribbean in particular, the need to reduce poverty and all its ramifications has increased the imperative for development, and therefore the challenge to harmonise development with sound environmental management principles is often monumental. Various policies, procedures, processes and tools have evolved to assist this environmental management, and one such tool is the Environmental Impact Assessment (EIA). The EIA process has itself undergone evolutionary changes as more data have become available on natural systems, and on human development and the built environment.

This Guideline document attempts to present procedures for conducting an EIA in accordance with the legal and regulatory framework of Jamaica, ecological realities and development imperatives of the island nation, and international agreements and standards for sustainable development.

GUIDELINES FOR CONDUCTING ENVIRONMENTAL IMPACT ASSESSMENTS

SECTION 1: GENERAL

1.1 Purpose

Guidelines for conducting Environmental Impact Assessments were first produced by the Natural Resources Conservation Authority (NRCA) in July 1997, as a means of assisting developers and environmental consultants to understand the NRCA requirements for EIAs. This followed on from the introduction of the Permit and Licence System on January 1, 1997, and which spoke to the new requirements for the conduct of EIAs for certain types of developments.

Now, some eight years later, much has been learned through the permit and licence application process as well as through the EIAs that have been conducted and submitted to the NRCA and now NEPA, over these years.

NEPA has undertaken a review of the existing EIA Guidelines in an effort to update the document, to incorporate emerging global issues, and natural hazard impacts as well as to create a more user friendly and practical set of guidelines for developers and consultants.

This document presents the revised guidelines. The purpose of the document is to provide clear guidelines for conducting and reporting on EIA study in a useful form that can guide decisions on development in Jamaica.

1.2 The National Environment and Planning Agency (NEPA)

In 1991, Jamaica promulgated the Natural Resources Conservation Authority Act by which an Authority (the NRCA) was established to provide for the management, conservation and protection of the natural resources of Jamaica. The NRCA, was also

charged with administering the Beach Control Authority Act (1956) the Watershed Protection Act (1963) and the Wildlife Protection Act (1945).

In 2001, the NRCA merged with the Town Planning Department (TPD) and the Land Development and Utilisation Commission (LDUC) to form the National Environment and Planning Agency (NEPA). As a regulatory agency NEPA therefore now has responsibility for the legislation listed above as well as the other pieces of legislation which underpinned the TPD and the LDUC, that is, the Town and Country Planning Act , and the Land Development and Utilization Act.

This new agency (NEPA) represents an amalgamation of the Natural Resources Conservation Authority (NRCA) which has a statutory mandate for the conservation, protection and proper management of the natural resources of Jamaica; the Town and Country Planning Authority (TCPA) which has the statutory mandate to ensure the orderly planning of Jamaica, and the Land Development and Utilization Commission (LDUC) with a statutory mandate to ensure that prime agricultural lands are kept in agricultural production in the interests of *inter alia* food security and self sustainability. (**Davis-Mattis**, 2002).

1.3 Contextual Framework

1.3.1 Environment and Development

The island of Jamaica covers a land area of 11, 500 square kilometres. Adjacent territorial seas (12 mile radius) and an Exclusive Economic Zone (EEZ) were declared in 1996 and 1991 respectively. The island accommodates a population of 2.6 million (Census 2001) with increasing numbers occupying urban spaces (52%, 2001). Settlement and livelihood patterns have influenced the state of the environment across the country, and interacting with development imperatives and the natural resource base, these patterns are increasingly aggravating environmental degradation.

Integrating environmental considerations with development planning and programme development is essential to the sustainable development of Jamaica. A small island nation with pressing problems of poverty, and social needs, Jamaica must also seek to reduce its vulnerability to external shocks from natural hazards which seem to be

increasing in frequency and ferocity. Flood damage has derailed budgetary considerations annually over the past five years in particular, and attendant slope failures have necessitated road repairs and infrastructure replacement, as well as dislocated livelihoods and loss of earnings. Sound environmental management will also reduce disasters. In that regard, NEPA has sought to enhance the environmental assessment process to meet the national mandate of balancing economic development programmes and projects with environment, economic development, and social justice.

1.3.2 The Project Cycle

It has been demonstrated that environmental assets can be enhanced and liabilities reduced if environmental assessments are appropriately integrated throughout the project cycle. Project identification should be accompanied by screening for environmental issues (including natural hazard risk), and pre-feasibility analysis should include scoping of the issues identified through the Screening process. The feasibility study that follows should then include the Environmental Impact Assessment if the screening and scoping processes identify that need. The site and project-specific assessment will undertake more detailed investigation and will identify positive and negative impacts. Mitigation measures may be suggested where deemed appropriate and these should then be integrated into project design and implementation procedures. During the operational phase of the project a monitoring and evaluation program should also include the identified and recommended environmental parameters.

1.4 What is the EIA?

The environmental impact assessment' (EIA) involves the process of identifying, predicting and evaluating potential environmental impacts of development proposals. The term describes a technique and a process by which information about the interaction between a proposed development project and the environment is collected, analysed, and interpreted to produce a report on potential impacts and to provide the basis for sound decision-making. The results of the study are taken into account by the Regulatory Authority in the determination of whether the proposed development should be allowed, and under what conditions.

The term 'environment' in this regard, includes all relevant aspects of the natural and

human or built resources on the project development site, as well as within the sphere of influence (setting/situation) of the proposed development. The EIA investigates the characteristics of the environment into which the development will be placed, and evaluates the expected interaction with the physical, biological and built environment. The EIA is therefore based on predictions, and must use informed and experienced professional judgment based on scientific method to attempt to predict the potential changes in environmental quality which could result from the proposed project/action, or the proposed challenges that the environment may present to the development.

The study therefore requires a multi- and inter-disciplinary approach to be undertaken by experienced professionals. It should be carried out as integral to the project evaluation process, adding the environmental dimension to the financial and economic feasibility analysis.

The EIA also compares various alternatives by which the project could be realized and seeks to identify the one, which represents the best combination of economic and environmental costs and benefits. Alternatives include location as well as approach to design, process, and construction technology. The EIA is one of the most commonly used environmental management tools to integrate environmental concerns effectively into project design and the development process. EIA means an examination, analysis and assessment of planned activities with a view to ensuring environmentally sound and sustainable development.

The EIA as a procedure is used to examine both beneficial and adverse environmental consequences of a proposed development project, and should be viewed as an integral part of the project planning process. Findings of the study should be taken into account in project design and recommendations implemented should the project be approved.

Three definitions of an Environment Impact Assessment are given below:

The EIA is the need to “identify and predict the impact of the environment and on man’s health and well-being of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about impacts”

(Munn, 1979)

“The term ‘environmental assessment’ describes a technique and a process by which information about the environmental effects of a project is collected, both by the developer and from other sources, and taken into account by the planning authority in forming their judgments on whether the development should go ahead”.

(UK DoE, 1989)

EIA is “an assessment of the impact of a planned activity on the environment”.

(UN Economic Commission for Europe, 1991)

1.5 UNEP Goals and Principles of EIA

The NRCA, since its inception has adopted the goals and principles of the EIA as articulated by the United Nations Environment Programme (1987). As UNEP has indicated these goals and principles are necessarily general in nature and may be further refined when fulfilling EIA tasks at the national, regional and international levels.

GOALS

1. To establish that before decisions are taken by the competent authority or authorities to undertake or to authorize activities that are likely to significantly affect the environment, the environmental effects of those activities should be taken into account.
2. To promote the implementation of appropriate procedures in all countries consistent with national laws and decision-making processes, through which the foregoing goal may be realized.
3. To encourage the development of reciprocal procedures for information exchange, notification and consultation between States when proposed activities are likely to have significant trans-boundary effects on the environment of those States.

PRINCIPLES

Principle 1: States (including their competent authorities) should not undertake or authorize activities without prior consideration, at an early stage, of their environmental effects. Where the extent, nature or location of a proposed

activity is such that it is likely to significantly affect the environment, a comprehensive environmental impact assessment should be undertaken in accordance with the following principles.

Principle 2: The criteria and procedures for determining whether an activity is likely to significantly affect the environment and is therefore subject to an EIA, should be defined clearly by legislation, regulation, or other means, so that subject activities can be quickly and surely identified, and EIA can be applied as the activity is being planned.

Principle 3: In the EIA process the relevant significant environmental issues should be identified and studied. Where appropriate, all efforts should be made to identify these issues at an early stage in the process.

Principle 4: An EIA should include, at a minimum:

- (a) A description of the proposed activity;
- (b) A description of the potentially affected environment, including specific information necessary for identifying and assessing the environmental effects of the proposed activity;
- (c) A description of practical alternatives, as appropriate;
- (d) An assessment of the likely or potential environmental impacts of the proposed activity and alternatives; including the direct, indirect, cumulative, short-term and long-term effects;
- (e) An identification and description of measures available to mitigate adverse environmental impacts of the proposed activity and alternatives, and an assessment of those measures;
- (f) An indication of gaps in knowledge and uncertainties which may be encountered in compiling the required information;
- (g) An indication of whether the environment of any other State or areas beyond national jurisdiction is likely to be affected by the proposed activity or alternatives.
- (h) A brief, non-technical summary of the information provided under the above headings.

Principle 5: The environmental effects in an EIA should be assessed with a

degree of detail commensurate with their likely environmental significance.

Principle 6: The information provided as part of EIA should be examined impartially prior to the decision.

Principle 7: Before a decision is made on an activity, government agencies, members of the public, experts in relevant disciplines and interested groups should be allowed appropriate opportunity to comment on the EIA.

Principle 8: A decision as to whether a proposed activity should be authorized or undertaken should not be taken until an appropriate period has elapsed to consider comments pursuant to principles 7 and 12

Principle 9: The decision on any proposed activity subject to an EIA should be in writing, state the reasons therefore, and include the provisions, if any, to prevent, reduce or mitigate damage to the environment. This decision should be made available to interested persons or groups.

Principle 10: Where it is justified, following a decision on an activity which has been subject to an EIA, the activity and its effects on the environment or the provisions (pursuant to Principle 9) of the decision on this activity should be subject to appropriate supervision.

Principle 11: States should endeavour to conclude bilateral, regional or multilateral arrangements, as appropriate, so as to provide, on the basis of reciprocity, notification, exchange of information, and agreed-upon consultation on the potential environmental effects of activities under their control or jurisdiction which are likely to significantly affect other States or areas beyond national jurisdiction.

Principle 12: When information provided as part of an EIA indicates that the environment within another States is likely to be significantly affected by a proposed activity, the State in which the activity is being planned should, to the extent possible:

- a. notify the potentially affected State of the proposed activity;
- b. transmit to the potentially affected State any relevant information from the EIA, the transmission of which is not prohibited by national laws or regulations; and
- c. When it is agreed between the States concerned, enter into timely consultations.

Principle 13: Appropriate measures should be established to ensure implementation of EIA procedures.

SECTION 2: JAMAICA - STATUTORY REQUIREMENTS

The NRCA Act and subsequent legislation and regulations stipulate that persons undertaking new developments, which fall within a prescribed category will require a permit. Licenses will be required for the discharge of trade or sewage effluent and for the construction or modification of facilities. As part of the permit application an EIA may be required.

Sections 9 & 10 of the NRCA Act gives the Authority the power to request that an environmental impact assessment be conducted as part of a permit application. The Authority also has the power to request that the applicant furnish documents or information as the Authority thinks fit. Criteria for requesting this information may include the urgency, the level of technology employed in the operation of the project, and the likely adverse impacts to be expected from the project.

Under the Act the NRCA is also authorized to issue, suspend and revoke permits and licenses if facilities are not in compliance with the environmental standards and conditions of approval stipulated.

2.1 Prescribed Categories

The following is a list of prescribed categories under the NRCA Act.

- Development projects
 - Subdivisions of 10 to 50 lots
 - Subdivisions of 51 lots or more
 - Housing projects of 10 to 50 projects
 - Hotel resort complex of 12 to 50 rooms
 - Hotel resort complex of 51 rooms or more
- Citrus, coffee, cocoa, coconut, sugar cane processing factories
- Solar salt production
- Watershed development and soil conservation projects including river training such as river channel diversion works and works for the transfer of water

resources between river basins, check dams, and retaining walls

- Agro processing and processing of agricultural wastes
- Office complexes of 5000 square meters or greater
- Eco-tourism and nature tourism projects
- Water treatment facilities, including water supply and desalination plants
- Fish and meat processing
- Food processing plants
- Detergent manufacturing including manufacturing of soap
- Manufacturing of containers and package materials including cans, bottles, boxes and cartons
- Distillery brewery and fermenting facilities
- Manufacturing of edible fats, oil and associated processes
- Tanners
- Boxing plants
- Manufacturing of textiles
- River basin development and improvement
- Irrigation and water management and improvement projects
- Slaughter house and abattoirs
- Theme parks
- Hospitals
- Airports and air fields, including runway expansion greater than 20% of the original length
- Sewage and industrial waste water treatment facilities
- Metal processing
 - Ferrous metals
 - Non ferrous metals
 - Metal Plating
 - Foundry operations
- Industrial projects
 - Chemical plants
- Pulp, paper and wood processing
- Petroleum production, refinery, storage, and stockpiling
- Cement and lime production
- Paint manufacture

- Manufacturing of pesticides or other hazardous or toxic substances
- Construction of new highways, construction of arterial roads, construction of new roads on slopes greater than 20 degrees, major road improvement projects including construction of a road of 4 or more lanes or realignment or widening or an existing road into four lanes where such road realignment or widening would be ten (10) kilometers or more in continuous length
- Land reclamation and drainage projects
- Modification, clearance or reclamation of wetlands
- Dredging, excavation, clearing and reclamation of riverine, swamp, beach wetlands or marsh areas
- Solid waste treatment and disposal facilities including waste disposal installation for incineration and chemical landfills or systems for the destruction reprocessing or recycling of such waste
- Cemeteries and crematoria
- Introduction of flora, fauna and genetic material
- Introduction of genetically modified organisms
- Hazardous waste storage, transportation, treatment or disposal facilities
- Clear cutting of forested areas and clearing of trees on land of 3 hectares and over on slopes greater than 25 degrees
- Golf Courses
- Transportation centres for more than 10 vehicles
- Construction or demolition of reservoirs, dams, dykes and aqueducts
- Railways, tramways, and cable car operations
- Causeway and multiple span bridges
- Shopping centres
- Aquaculture facilities and ponds and intensive fish farming
- Storage of scrap metal including derelict vehicles
- Off shore drilling for extraction of oil, natural gas or minerals
- Dry cleaning operations
- Mining, quarrying and mineral processing, bauxite, peat, sand, minerals, including aggregate, construction and industrial materials
 - Metallic
 - Non metallic
- Ship yards

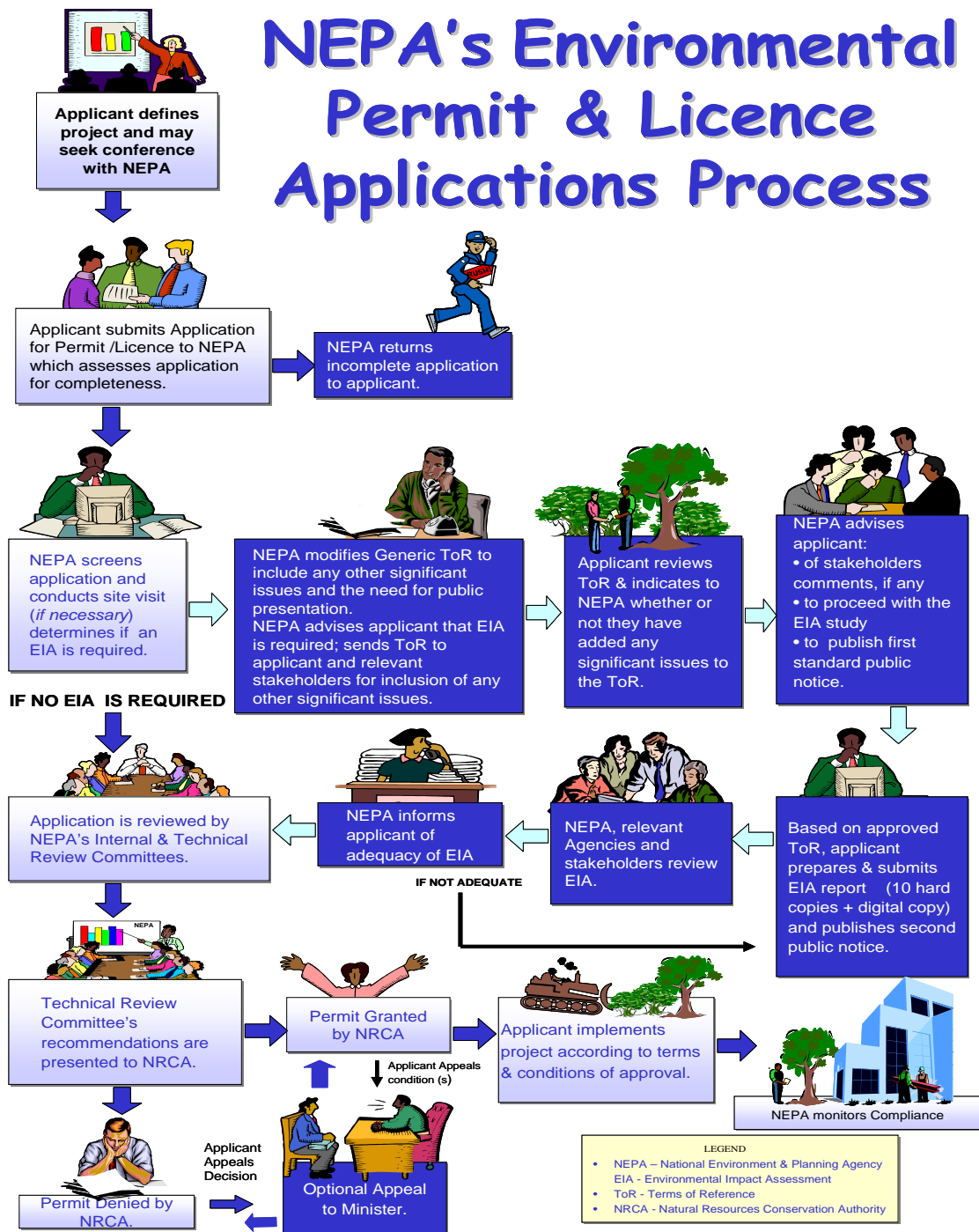
- Marinas and boat yards
- Power generation plants including hydroelectric plants and installations for the harvesting of wind power for energy production and nuclear reaction above one megawatt
- Electrical transmission lines and substations greater than 69 kv
- Pipelines and conveyors including underground cables, gas lines, and other such infrastructure with a diameter of more than 10 centimeters for the transport of gas, oil, or chemicals
- Port and harbour development

2.2 The Application Process

An applicant is required to complete an application form (for permit and or licence) and a Project Information Form (PIF) for submission to the NEPA. The Permit Application and Project Information forms require description of the project as well as selected aspects of the existing biophysical and built environment into which the project will be placed. These forms can be obtained at NEPA and at the regional offices of the Jamaica Information Services. Guidelines for Project Proponents are issued along with application forms.

The Application Process as managed by NEPA is governed by the Permit and License System, which came into effect on January 1, 1997, and is shown in Figure 2.2. The Permit & License System (P&L) is a mechanism to ensure that all Jamaican facilities (developments), within the prescribed categories, meet required standards in order to minimize negative environmental effects.

Figure 2.2: The Application Process



The System seeks to:

- Ensure compliance with Sections 9 & 10 of the NRCA Act of 1991, which gives the NRCA the right to issue permits to persons undertaking new developments and request EIA studies where necessary.
- Ensure that environmental considerations are taken into account early in the planning of new projects.
- Monitor the discharge of certain waste into the environment.
- Ensure compliance with established NRCA environmental standards and conditions of approval.
- Ensure that goods and services are produced in an environmentally sound manner.
- Bring existing facilities into compliance with environmental standards.

Persons undertaking new developments that fall within a prescribed category are required to obtain a permit. Licences will be required for the discharge of trade or sewage effluent and for the construction or modification of facilities.

2.3 The NEPA Screening and Scoping Process

The application forms when received by NEPA are examined by the relevant technical officers within NEPA and in association with the respective technical support GOJ agencies. This screening seeks to identify aspects of the development, and their predicted interaction with the existing environment, and the findings help to determine the level of investigation required to inform the permitting process. Where potentially significant environmental issues are identified further study through an environmental impact assessment may be required. Where potential environmental impacts are deemed minimal, no EIA may be required. Should an EIA be deemed necessary the project proponent and their representatives will be provided with the Terms of Reference generic to the category of development with issues highlighted for particular attention.

NEPA has developed ***Generic Terms of Reference (ToRs)*** for different categories of development, (Annex I). The respective ToRs need to be modified as appropriate to the

respective development project to include any significant issues. The final TORs for the EIA study will be agreed between the project proponent and NEPA, and the EIA study will then proceed in accordance with these TORs.

A public presentation is a requirement as part of the EIA process. However, the Authority from time to time may waive this requirement, if deemed appropriate. The public presentation gives the proponent an opportunity to present to the public the finding of the EIA. It also provides additional avenue for the public to raise questions about the proposed project and for the proponent to respond to these issues and make any necessary changes to the project and the EIA report.

If an EIA is required, the applicant will be notified within ten (10) working days of NEPA's receipt of the application.

The applicant will then be required to post two notices to the public. The first public notice (Sample 1) will indicate that

- an EIA has been requested by NEPA
- how and where the public can access the ToRs for review.

This will allow the public to do their own research/gather information on the project/site and to comment on the draft ToRs, if they wish to do so.,

The second public notice (Sample 2) will indicate that

- the EIA Report has been submitted to NEPA;
- where the public can access the EIA Report for perusal

This second public notice may include information about when and where the public presentation will be convened.

The public presentation should be conducted no less than 3 weeks after the EIA has been made available to the public and no less than 3 weeks after the first notice announcing public presentation has been published.

Sample Public Notice (#1)

Notice of Intention for Environmental Impact Assessment Study Public Comment Invited

- Insert Name of Development, Parish -

In accordance with the Natural Resources Conservation (Permits and Licences) Regulations of the Natural Resources Conservation Authority (NRCA) Act 1991, the NRCA has exercised its right to require an environmental impact assessment (EIA) of the above-captioned development proposal before a decision to issue a Permit or Licence is made.

This development is proposed by – *insert name of developer* – on – *insert details of parcel of land* – located – *insert details of the project location* –, as shown in the map below. The proposal entails – *insert details of development*. *Insert name of developer* – has retained – *insert name of consultant* – to assist them with the conducting of the EIA study.

These draft ToRs are available for public inspection at the following locations.

- *Insert names, address and opening hours of public library closest to the project site;*
- *Insert the name of the consultant or developer, their address and opening hours; and*
- NEPA Documentation Centre, 11 Caledonia Ave., Kingston 5, open 9-4.
- NEPA Web Site

If you wish to comment on the draft ToRs for this project, please do so within **7 days** of the date of the publication of this notice. Comments should be addressed to:

Manager
Applications Secretariat Branch
Insert name of project
National Environment and Planning Agency
10 Caledonia Ave.
Kingston 5
Tele: (816) 754-7547 0
e-mail: applications@nepa.gov.jm

If you do not wish to comment on the draft terms of reference, but wish to stay apprised of project developments, please contact – *insert name of developer* – at the above-noted address.

(Add map of proposed development site here)

Date of Notice: _____

Sample Public Notice (#2)

Notice of Completion of Environmental Impact Assessment Study Public Comment Invited

- - *Insert Name of Development Parish* -

In accordance with the Natural Resources Conservation (Permits and Licences) Regulations of the Natural Resources Conservation Authority (NRCA) Act 1991, the NRCA has exercised its right to require an environmental impact assessment (EIA) of the above-captioned development proposal before a decision to issue a Permit or Licence is made.

This development is proposed by – *insert name of developer* – on *insert details of parcel of land* – located – *insert details of the project location* –, as shown in the map below. The proposal entails – *insert details of development*.

- *Insert name of developer* – has retained – *insert name of consultant* – to assist them with the conducting of the EIA study. A final EIA report of this proposed development has now been completed. A review of this study will be the basis upon which a decision is made by the NRCA to grant a permit and/or licence for the development or not. Accordingly, the EIA report needs to be reviewed by the relevant government review agencies and interested members of the public. The report is available for public inspections at the following locations:
- *Insert name, address and opening hours of the public library closest to the project site;*
- *Insert the name of the consultant or developer, their address and opening hours; and*
- NEPA Documentation Centre, 11 Caledonia Ave., Kingston 5, open 9–4

If you wish to comment on the EIA report please do so within 3 weeks of the publication of this notice and address them to:

- *Insert information about when and where of the public presentation will be convened if available. (Refer to Guidelines for Conducting Public Presentation)*

Manager
Applications Secretariat Branch
Insert name of project
National Environment and Planning Agency
10 Caledonia Ave.
Kingston 5
Tele: (816) 754-7547 – 40
e-mail: applications@nepa.gov.jm

(Insert map of proposed development site here)

Date of Notice: _____

SECTION 3: THE EIA STUDY

3.1 The EIA Methodology

The EIA methodology includes a number of steps as outlined below.

3.1.1 Steps in Data Collection and Analysis

The EIA study is based on a systematic process which includes the following steps:

- a. Description of the proposed project
- b. Description of the proposed site location
- c. Liaison with NEPA to determine legal requirements
- d. Determination of the Terms of Reference and Scope of Work (NEPA Generic Terms of Reference for different types of development are presented in Annex II)
- e. Collection and Analysis of Baseline Data Conditions
- f. Identification and Description of Applicable Legal and Regulatory Framework
- g. Identification of Critical Issues
- h. Determination of Potential Impacts
- i. Determination of Relevant Mitigation Measures
- j. Consideration of Project Alternatives
- k. Determination of Environmental Quality Objectives (Recommendations for Sound Environmental Management/Best Practices)
- l. Identification of Post Permit Requirements

The presentation of data for the EIA must include information from existing studies and reports as well as current data from field research. All information should be properly sourced to indicate accuracy on the level of information and the date of the information being presented.

3.1.2 Data Sources

Information should be obtained from recognized and specialized sources such as the following:

- a. Libraries at universities and other academic institutions (University of the West Indies, University of Technology, etc.)
- b. Government agencies (Water Resources Authority, National Works Agency, Public Health Department, National Environment and Planning Agency, Mines and Geology Division, Office of Disaster Preparedness and Emergency Management, Meteorological Office, Forestry Department, etc.)
- c. Non-governmental Organisations (Jamaica Environment Trust, Jamaica Conservation and Development Trust, Friends of the Sea, Northern Jamaica Conservation Association, Caribbean Coastal Area Management, etc.)
- d. Internationally funded projects (Coastal Water Quality Improvement Project, Trees for Tomorrow, etc)
- e. Legal Instruments, Policies and Regulations from NEPA and other relevant agencies should also be consulted and referred to.
- f. International documents relevant to the proposed development

Additionally, a list of recommended texts, which details aspects of EIA Methodology, are given below:

Y. J. Ahmad and G. K. Sammy: ***Guidelines to Environmental Impact Assessment in Developing Countries*** UNEP Regional Seas Reports and Studies No. 85, UNEP, 1987.

World Bank Technical Paper Number 139: ***Environmental Assessment Sourcebook, Vols. I - III***, Environment Department, World Bank, Washington D.C., December 1991.

Jones Williams, Margaret. *Environmental Impact Assessment EM614. Course Material* M.Sc. Natural Resources Management, UWI Mona 2004.

Glasson: John, Riki Therivel and Andrew Chadwick ***Introduction to Environmental Impact Assessment: The Natural and Built Environment*** Series 1, (1994)

Caribbean Development Bank ***NHIA-EIA Sourcebook*** (in progress)

3.2. Description of the Existing Environment – Baseline Studies

An EIA must be a site specific and project specific study. An EIA for a particular development in a particular setting cannot be transferred either to another development or even the same development in another setting.

The EIA is a multi-disciplinary study that must span the relevant aspects of the natural and built environments. Critical areas to be studied will be dependent on the project site and the project details. A checklist gives some of these critical factors, which should be considered as may be relevant in describing the environment. This description of the environmental setting is a record of conditions prior to implementation of the proposed project. It is primarily a benchmark against which to measure environmental changes and to assess potential impacts.

Data Collection and Interpretation should involve a combination of: desktop research including satellite imagery, project related documents, review of relevant literature, topographical maps and site plans; field reconnaissance and investigation; and structured interviews. Each of the realms of environmental data should be investigated, viz. physical, biological and human, and the relevant aspects included in the study.

BASIC CHECKLIST OF CRITICAL ASPECTS TO BE CONSIDERED IN EIA

Box I.

PHYSICAL ENVIRONMENT

a. Climatic variables

Rainfall patterns – mean, mode, seasonality
Temperature patterns
Extreme events
Climate change projections
Prevailing Wind - direction, speed, anomalies

b. Geology

Underlying rock type
Surficial material
Geologic structures (faults etc.)
Geologic resources (minerals, etc.)

c. Topography

Slope form
Landform and terrain analysis
Specific landform types

d. Coastal dynamics and morphology

Wave patterns
Currents
Shoreline morphology – nearshore, foreshore
Sediment – characteristics and transport

e. Soil

Type and characteristics
Porosity and permeability
Sub-soil permeability
Run-off rate
Effective depth (inches/centimetres)
Inherent fertility
Suitability for method of sewage disposal

f. Drainage

Surface hydrology
Drainage network
Rainfall runoff relationships
Hydrogeology
Groundwater characteristics – springs, etc.

g. Water Quality

Terrestrial - rivers, lakes, ponds, gullies
Coastal

h. Air Quality

Ambient
Respirable
Airshed Importance
Odour levels

i. Noise

j. Natural Hazard Risk - See Box II

BOX II

NATURAL HAZARD RISK

- a. Seismicity**
Earthquake hazard; liquefaction potential, tsunami
- b. Slope stability**
Landslide potential
- c. Soil erodibility**
- d. Flood hazard**
Extreme events
Drainage network and storm water runoff potential
- e. Hurricanes**
Wind
Extreme rainfall
Storm waves and surge potential
- f. Elements of Environmental Protection**
Reefs, Wetlands, Watershed conditions, Forest/vegetation cover

a. Flora

General type and dominant species
Densities and distributions
Habitat value
Historically important specimen
Watershed value
Introduced species
Rare and Endangered species (location, distribution and conditions)
Fire potential
Timber value
Specimen of scientific or aesthetic interest

b. Fauna

General types/dominant species
Densities and distribution
Habitat (general)
Migratory species
Exotic (introduced) species
Rare and endangered species
Commercially valued species

c. Terrestrial ecology

d. Marine/coastal Ecology

e. Riverine ecology

f. Nuisance species

g. Aesthetic appeal

h. Landscape vistas

Box IV**Human Environment**

- a. Sphere of Influence
- b. Land Use – Site and Situation
- c. Zoning and Density Regulations
- d. Livelihoods
- e. Demographics
- f. Community Structure
- g. Proposed Developments
- h. Transportation and Traffic Patterns
- i. Settlement patterns and Social structure
- j. Water supply
- k. Energy supply
- l. Telecommunications
- m. Services – health, educational facilities, recreational facilities
- n. Archaeological heritage
- o. Cultural values
- p. Natural Hazard Vulnerability and History

3.2.1 Physical Environment

As indicated in the checklist (**Box I**), several aspects of the physical environment must be considered. The presentation of the information may follow the basic sequence below:

- Climate, including the relevant hydrometeorological considerations for the project and climate change scenarios (within the scope of data available)
- Topography and soils
- Geology/ geomorphology
- Drainage
- Natural hazard risk
- Ground water - hydrogeology
- Coastal morphology
- Air quality
- Noise
- Landscape
- Aesthetic appeal

3.2.2 Biological Environment

The biological environment includes several inter-related components, which are based on the physical supporting structure. The components of the biological environment may be presented in the following sequence:

- Habitats
- Flora
- Fauna
- Endangered species
- Commercial species
- Endemic species
- Nuisance species
- Parks and Protected Areas

3.2.3 Human Environment

The human environment may also be described as the socio-economic or the built

environment. Aspects of the human environment will be determined by the physical and biological environments, and the information may be presented according to the following sequence:

- Population and Demographics
- Land and Livelihood /Employment
- Settlement patterns and Social structure
- Services – health, educational facilities, recreational facilities
- Natural Hazard Vulnerability and History
- Recreational activity
- Archaeological heritage
- Cultural values

3.2.4 Description of the Proposed Project

This is a detailed statement of all the critical components, attributes or phases of the proposed development. This should also include pre-construction, and construction phase activities, through commissioning, to the operational phases of the development

3.2.5 Legislative and Regulatory Framework

This section of the report should present information on the regulatory framework within which the potential development will have to operate. This should include:

- Policy framework for conducting EIAs
- The EIA process
- Relevant statutory designations (nature reserves, parks and protected areas, heritage sites, listed buildings, monuments, protected species)
- Relevant national and regional legislation, regulations, and policy initiatives
- Relevant international legislation

3.2.6 Potential Impacts

3.2.6.1 Prediction of Impacts

The objective of prediction is to identify the magnitude, significance, and other dimensions of potential change in and interaction with the environment given the project intervention. This should be an objective exercise utilizing scientific knowledge with a combination of informed professional judgment according to accepted procedure.

The following aspects should be covered in impact prediction:

Direction	Positive Or Negative
Duration	Long-, Medium- Or Short - Term, Episodic
Location	Direct or Indirect Project On Environment Environment On Project
Magnitude	Large Or Small – Major, Minor
Extent	Sphere Of Influence - Local, National, Regional

Impact identification is a critical step in an EIA. An Impact Matrix should be used to document the impacts according to the criteria above.

The impacts are selected, based on magnitude, significance, extent and special sensitivity, for further study.

- Magnitude is measured on a selected scale and the impact ranked accordingly. Magnitude refers to the amount of change to be created by the project-environment interaction
- Significance refers to the level of change especially as it relates to environmental quality objectives
- Extent refers to the area to be affected.
- Quantification of impacts is a difficult technical aspect of an EIA. For some impacts, the theoretical basis for computing the magnitude does not exist. Such

impacts may have to be addressed in a qualitative way.

Natural Hazard Impact is an essential consideration. The natural hazards within the project environment should have been identified in the physical baseline descriptions, and the impact assessment ought to consider vulnerability of the project site and situation to natural hazard impact. An assessment of the extent to which the project may exacerbate hazard vulnerability must also be assessed.

3.2.6.2 Cumulative Impacts

In addition to the potential and site specific impacts, Cumulative Impacts should also be identified when appropriate. Cumulative Impacts are those impacts which will show an increase over time as a result of successive additions to the environmental changes. Cumulative Impacts are particularly important for projects which are large in size, scale and geographic range. Cumulative Impacts will also be important for areas which have limited development and in which the proposed project may make a significant change in character or resource base. Conversely, Cumulative Impacts will also be important for areas which are already extensively developed, or which have several other developments proposed, and in which the proposed project may add to or exacerbate existing environmental conditions.

3.2.6.3 Positive Impacts

Positive impacts to be derived from the implementation of the project should also be described. These may include the following:

- a. Improved land use options
- b. Improved character of a community
- c. Provision of jobs in the short term and/or long term
- d. Creation of opportunities for improved environmental awareness
- e. Creation of opportunities for implementation of conservation methods
- f. Opportunities for international investment
- g. Improved standard of living

3.2.7 Public / Community Involvement and Review

Civil society, which includes citizens, community-based and non-governmental organizations (NGO's) within the sphere of influence of the project (project setting) should be given the opportunity to share information for the EIA study. This will facilitate obtaining views and perceptions of the proposed development, as well as the inclusion of local knowledge and expertise. Local anecdotal knowledge can sometimes help to facilitate differentiation between those impacts which are of major importance in the local context and those which are not.

Civil society should include but not necessarily be limited to:

- Environment and Development NGO's
- Chambers of Commerce
- Service Clubs
- Citizens Associations

Information obtained from NGO's and community groups can be of invaluable assistance in providing approaches to problem solving and resolving conflicts. This information obtained as part of the public consultations should be documented in the EIA report.

Annex II shows various public consultation methods that may be employed depending on the nature of the project, the method of data collection, knowledge/expertise required, and the problem solving value.

Apart from being directly involved in the actual EIA study the public may be involved in the review of the EIA. Depending on the nature of the project, the EIA may be the subject of a public hearing or presentation, and/or posted on the website. The public is generally given thirty (30) days to send in written comments to NEPA, following public access to the document.

3.2.8 Mitigation Measures

It is recognised that it is seldom possible to eliminate an adverse environmental impact altogether, but it is often feasible to reduce its intensity. This reduction is referred to as

mitigation. For each potential adverse impact the plan for its mitigation at each stage of the project should be documented and its cost assessed. This is an important consideration in the selection of the preferred alternative. In the case of beneficial impacts it should be demonstrated how these can be optimized.

3.2.9 Consideration of Alternatives

All the alternatives taken into account in developing the project should be documented. Documentation of the project alternatives illustrates that the developer may have considered other approaches to the project. These may include the consideration of other project sites; technology; densities, and / or means of minimizing environmental damage.

For example, if the project were to be sited elsewhere, the impacts associated should be reviewed and the associated mitigation action defined. Each alternative should be evaluated in respect of its potential environmental impact and capital and operating costs. The environmental losses and gains must be combined with the economic costs and benefits to give the full picture for each alternative.

Identification and Analysis of Alternatives or the Consideration of Alternatives often occurs early in the project planning stage, and should include the following as may be appropriate:

- No action alternative
- Alternative locations
- Alternative scales of the project
- Alternative processes or equipment
- Alternative site layouts
- Alternative operating conditions
- Alternative ways of dealing with potential impacts

3.2.10 Environmental Management of the Project

An outline for environmental management of the project should be stipulated and this will be finalized to include permit conditions following approval of the project by NEPA. The management plan should include the Environmental Quality Objectives related to the project and its environmental setting, the mitigation measures recommended in the EIA, the awareness and training for project staff, including construction and operations personnel, and an outline monitoring plan which will be used during the construction phase of the project.

3.2.10.1 Environmental Quality Objectives (EQO)

Environmental Quality Objectives are determined by the physical, biological and social characteristics of the project site and setting as identified in the Baseline studies, by the nature of the project and potential impacts, and by the mitigation measures recommended. Quality Objectives should be applied to both the construction and operational phases of the development and they generally relate, though not exclusively, to:

- ✓ Protection and Enhancement of environmental assets (habitat, coastal resources, vegetation cover, *inter alia*.)
- ✓ Slope Stability, Coastal Protection, Drainage optimization
- ✓ Environmental Health – Water Quality, Air Quality , Sanitation /Hygiene
- ✓ Disaster Risk Reduction
- ✓ Human settlements
- ✓ Conservation of resources (water, energy)

3.2.10.2 Training

Sensitisation training for staff is essential to meeting the environmental quality objectives. This process need not be exhaustive, but should be sufficient to ensure that all managers and line staff understand the obligations of the development under conditions of the environmental permit and the EQOs.

3.2.10.3 Outline Monitoring Plan

The need for a Monitoring Plan should be stated in the EIA Report if it is the considered opinion of the Consultants that it is required for a particular project. The requirement for the Monitoring Plan will be listed as a condition of the environmental permit issued by NEPA, if NEPA so requires.

A draft of the proposed Monitoring Plan will include the mitigation measures recommended and will present procedures and reporting relationships. The programme should clearly state:

- Institutional arrangements for carrying out the work parameters to be monitored
- Methods to be employed
- Standards or guidelines to be used
- Evaluation of the results
- Schedule and duration of monitoring
 - Initiation of action necessary to limit adverse impacts evident from monitoring
- Format and frequency of reporting.

Parameters to be included in the Monitoring Plan will be dependent on the parameters analysed in the baseline data collection and the site specific conditions. Examples of parameters to be monitored include the following:

- a. Riverine water quality (suspended solids, oil and grease, total and faecal coliforms, etc.)
- b. Coastal water quality (suspended solids, oil and grease, total and faecal coliforms, etc.)
- c. Vegetation (side-tipping of spoil, protected species, identified trees, etc.)
- d. Wildlife (turtle nesting beaches, sensitization of workers, etc.)
- e. Air quality (respirable particulates, dust, opacity, noxious fumes, etc.)
- f. Noise (perimeter noise, etc.)
- g. Stack emissions (nitrous oxides, sulphur oxides, particulates, etc.)
- h. Solid Waste Management (number, type and placement of receptacles, etc.)

- i. Public Health (sanitary facilities, portable toilets, food waste, etc.)
- j. Worker Health and Safety (safety gear, dust masks, hard hats, work boots, ear plugs, etc.)

The plan may need to be adjusted and finalized to take account of conditions stipulated in the environmental permit. The final Monitoring Plan must be approved by NEPA.

3.3 The EIA Team

The team assembled to conduct the EIA should consist of qualified and experienced professionals from the range of disciplines required for the EIA, based on the critical aspects identified for the project.

The following is a list of professionals that may be required depending on the environmental setting and the nature of the project:

- a. Project Manager/Team Leader
- b. Geographer
- c. Geologist
- d. Hydrologist/Hydrogeologist
- e. Hazard Management Specialist
- f. Chemist
- g. Marine Biologist
- h. Botanist/Floristic Surveyor
- i. Ornithologist
- j. Herpetologist
- k. Lepidopterist
- l. Parks and Protected Areas Specialist
- m. Urban/Regional Planner
- n. Socio-economist
- o. Demographer
- p. Impact Assessment Specialist

3.4 The EIA Report

The EIA should be documented by a written report, supported by references, photographs, maps, plans and data tables as appropriate.

The report should contain an introduction explaining the need for, and context of the project. This document should have the following basic aspects included in the Table of Contents, unless specified otherwise in the Terms of Reference.

Executive Summary

- Policy, Legal and Administrative Framework
- Description of the Existing Environment
- Description of the Proposed Project in detail
- Identification and Assessment of Potential Environmental Impacts
 - Physical
 - Natural Hazard Risk
 - Biological
 - Human/Social
- Cumulative Impacts
- Positive Impacts
- Public Involvement
- Recommended Mitigation Measures
- Identification and Analysis of Alternatives
- Environmental Management of the Project
 - Environmental Quality Objectives
 - Training
 - Draft Outline Monitoring Programme
- List of References
- Appendices including:
 - Reference documents
 - Photographs/ maps
 - Data Tables
 - Terms of Reference
 - Composition of the consulting team
 - Notes of Public Consultation sessions

SECTION 4: EIA REVIEW

4.0 EIA Review

The Final EIA report is submitted to NEPA for review. The process of review of EIA reports is primarily the responsibility of the National Environment and Planning Agency (NEPA). However stakeholder participation is essential in the sustainable development process, and relevant agencies of government and other institutions with the requisite knowledge, expertise and responsibility form part of the EIA and Permit Review process through the Technical Review Committee.

An Internal Review Committee (IRC) comprising the relevant technical staff from within NEPA reviews the report and solicits responses from the applicant where there may be queries. The IRC then prepares the project for presentation to the Technical Review Committee, which comprises stakeholder agencies external to NEPA.

Some of the stakeholders frequently involved in the process include:

- ✓ Water Resources Authority (WRA)
- ✓ Environmental Health Unit (EHU)
- ✓ Ministry of Health
- ✓ Mines and Geology Division
- ✓ Jamaica Bauxite Institute (JBI)
- ✓ National Solid Waste Management Authority (NSWMA)
- ✓ Institute of Jamaica
- ✓ Office of Disaster Preparedness and Emergency Management (ODPEM)
- ✓ Jamaica Natural Heritage Trust (JNHT)
- ✓ National Water Commission (NWC)
- ✓ National Irrigation Commission (NIC)
- ✓ Fisheries Division
- ✓ National Works Agency (NWA)
- ✓ National Land Agency (NLA)
- ✓ University of the West Indies (UWI)
- ✓ Parish Councils
- ✓ Select Non- Governmental Organizations

NEPA is obliged to undertake a thorough review of EIA reports and the stakeholder agencies will focus at a minimum on the areas for which they have legal responsibility or specific expertise. Agencies selected to review specific EIAs will be dependent on the nature of the project. During the Review process all reviewers are required to direct queries to the Applications Secretariat Branch, NEPA.

In an effort to adhere to the ninety-day (90) timeline for processing applications NEPA requests that the reviewing agencies submit their responses within thirty-days (30) of receiving the EIA report.

The Findings of the Technical Committee and the Internal Review Committee are then compiled and the project presented to the NRCA Board for consideration and approval.

SECTION 5: POST PERMIT REQUIREMENTS

5.0 Post Permit Requirements

Depending on the nature and scope of the project, NEPA may request particular actions on the part of the developer, after the permit is issued. These actions are usually stipulated in the permit and if not followed through, the developer could be found in breach of the permit conditions. Examples of types of actions that may be required are the preparation of any of the following:

5.1 Environmental Management and Training

This section should document how the environment will be managed during the implementation of the project both construction and operational phases. The training programme for employees of the facility should be outlined. This section should identify any institutional needs for implementing the recommendations of the EIA.

5.2 Monitoring Programme

A detailed environmental monitoring programme/plan should be described. The reasons for and the costs associated with the monitoring activities should be covered. It should be noted that some details presented may change depending on the final designs after the EIA preparation and review. These changes must be submitted to and approved by the NRCA.

The monitoring programme should clearly state the:

- institutional arrangements for carrying out the work

- parameters to be monitored
- methods to be employed
- standards or guidelines to be used
- evaluation of the results
- schedule and duration of monitoring
- initiation of action necessary to limit adverse impacts
- disclosed by monitoring
- format and frequency of reporting

5.3 Emergency Response Plan

An Emergency Response Plan is a procedures manual to deal with both internal and external emergencies such as:

- ✓ fires
- ✓ accidents
- ✓ earthquakes
- ✓ hurricanes
- ✓ floods
- ✓ civil unrest
- ✓ handling of hazardous materials
- ✓ spills contingency
- ✓ malfunctioning equipment

Other types of post permit requirements could include:

- ✓ Wildlife Management Plan
- ✓ Nursery Manual and Protocol

SECTION 6: A WORD ABOUT STRATEGIC ENVIRONMENTAL ASSESSMENTS

A Strategic Environmental Assessment (SEA) is defined as “the formalized, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or programme and its alternatives, including the preparation of a written report on the findings of that evaluation, and using the findings in publicly accountable decision-making” (Therivel *et al*, 1992).

A policy may be defined as an inspiration and guidance for action, a plan as set of coordinated and timed objectives for the implementation of a policy, and a programme as a set of projects in a particular area (Wood, 1991).

An SEA may be described as an EIA of policies, plans and programmes, where impacts are predicted at a strategic level. Cumulative Impacts which are applicable to EIAs are certainly of increased importance in the SEA. In fact individual project EIAs will not adequately consider the cumulative impacts caused by several projects being proposed by developers, independent or otherwise.

An SEA should be carried out early in the decision-making process and should encompass all of the projects of a certain type or within a certain area. The SEA may ensure that alternatives are adequately assessed, that cumulative impacts are considered, that the public is fully consulted and that decisions concerning individual projects are made in a proactive way rather than in a reactive way (Glasson *et al*, 1994).

On the technical side, the many future developments planned over a large area can result in analytical complexity. This is because the information about proposed developments and projected future environmental conditions, may be limited and difficult to assess.

Three SEAs have been conducted in Jamaica in recent years, and serve to show the

following:

- a. the emerging importance of the SEA
- b. the contribution of the SEA to informed decision-making
- c. the benefits of the SEA to the developer
- d. the early dissemination of information to the public on proposed developments

These three SEAs have been for three distinctly different types of projects, in three different geographical areas, and each with a unique set of issues. These SEAs are:

- a. Port Royal Heritage Tourism Project (The proposed development of a town in a renowned heritage area, with themed sections, and associated development for the cruise ship and tourism market).
- b. Highway 2000 (The proposed development of a cross nation, toll road covering over 240 km and traversing different types of terrain)
- c. Rose Hall Developments Ltd. (The proposed development, based on government mandate, of prime north coast real estate, for the tourism market, and to include hotels, golf courses, condominiums and conference center.)

Recognizing the emerging importance and application of the SEA, The Cabinet Office (supported by the ENACT Programme and NEPA) has produced a Draft Manual on conducting Strategic Environmental Assessments. An SEA policy was also accepted by Cabinet in 2005.

LIST OF REFERENCES

1. Y. J. Ahmad and G. K. Sammy: ***Guidelines to Environmental Impact Assessment in Developing Countries*** UNEP Regional Seas Reports and Studies No. 85, UNEP, 1987.
2. Conrad Douglas and Associates: Natural Resources Conservation Authority ***Guidelines for the Preparation of an Environmental Impact Assessment*** - Draft, September 29, 1993.
3. Davis-Mattis, Laleta. Natural Environmental and Planning Agency ***Jamaica's Commitment to the Conservation and Management of Natural Resources ...Ten Years in Retrospect*** March 2002
4. World Bank Technical Paper Number 139: ***Environmental Assessment Sourcebook, Vols. I - III***, Environment Department, World Bank, Washington D.C., December 1991.
5. Municipal Engineers Association of Ontario: ***Class Environmental Assessment for Municipal Road Projects***, Chapter 5 - Public Consultation June 1993.
6. ***Goals and Principles of Environmental Impact Assessments*** [Adopted by decision 14/25, of the Governing Council of UNEP, of 17 June, 1987] Chapter IV.
7. Jones Williams, Margaret. *Environmental Impact Assessment EM614*. M.Sc. Natural Resources Management, UWI Mona 2004.
8. Glasson: John, Riki Therivel and Andrew Chadwick ***Introduction to Environmental Impact Assessment: The Natural and Built Environment***- Series 1, (1994)
9. Caribbean Development Bank ***NHIA-EIA Sourcebook*** (in progress)

LIST OF ANNEXES

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| Annex I | NEPA Generic Terms of Reference for Prescribed Categories of Developments |
| Annex II | Guidelines for Conducting Public Presentations |

Annex I

NEPA Generic Terms of Reference for Prescribed Categories of Developments

Annex II

Guidelines for Conducting Public Presentations

NATIONAL ENVIRONMENT AND PLANNING AGENCY

**NATURAL RESOURCES CONSERVATION
AUTHORITY**

**GUIDELINES FOR CONDUCTING
PUBLIC PRESENTATIONS**

2007-10-25

SECTION 1: GENERAL GUIDELINES

1.1 Introduction

There are usually two forms of public involvement in the Environmental Impact Assessment (EIA) process. The first is direct involvement of the affected public or community in public consultations during the EIA study. These consultations allow the developer to provide information to the public about the project and to determine what issues the public wishes to see addressed. The extent and results of these consultations are included in the documented EIA report.

The second level of involvement takes place after the EIA report and addendum, if any, have been prepared after the applicant has provided the information needed for adequate review by NEPA and the public.

Public involvement in the review process is in keeping with Principle 7 of the United Nations Environment Programme (UNEP) decision published as Goals and Principles of Environmental Impact Assessment [Decision 14/25 of the Governing Council of UNEP, of 17, June, 1987]

1.2 Purpose

These guidelines are prepared for the use of the developer/project proponent; the consultants involve in conducting the EIA study and prepared the EIA report and the public.

SECTION 2: SPECIFIC GUIDELINES FOR PUBLIC PRESENTATIONS

2.1 Requirements

Arrangements for the public presentation must be made in consultation with NEPA in respect of date, time, venue, chairperson and participants.

A permanent record of the meeting is required hence, the project proponent/consultant will submit to NEPA a copy of the verbatim report of the public presentation within seven (7) days of the date of the meeting.

2.2 Public Notification

The public must be notified at least three weeks before the date of the public presentation. The developer/consultants must seek to ensure that in addition to specific invitation letters, at least three (3) notices are placed in the most widely circulated newspapers advertising the event. The notice shall also be forwarded to NEPA for posting on the website. To ensure that the notice is distributed as widely as possible, other methods of notification such as community notice board, flyers, town criers etc. shall be utilized as appropriate. In addition, specific notice to relevant local NGOs and community groups should be made by the developer/consultants.

The notice should indicate that:-

- the EIA has been submitted to NEPA;
- the purpose of the meeting;
- how to access the EIA report for review
- the date, time and venue of the public presentation.

The public presentation should be conducted no less than 3 weeks after the EIA has been made available to the public and no less than 3 weeks after the first notice announcing public presentation has been published by the applicant.

(A typical notice is in Appendix 1).

2.3 Responsibility of Developer/Consultant Team

The developer/consultant is responsible for distribution of copies of the EIA Report to make them available to the public at least three weeks before the public presentation.

Copies should be placed in the Local Parish Library and the Parish Council Office as well as at the nearest NEPA Regional Office and other community locations as agreed upon.

A summary of the project components and the findings of the EIA in non-technical language should also be prepared for distribution at the public presentation.

2.4 Conduct of the Meeting

With respect to the conduct of the meeting, the chairperson should be independently selected so as to ensure his/her neutrality. NEPA should be consulted regarding the selection of a chairperson. The role and responsibilities of the chairperson are outlined **Appendix 3**.

The technical presentation by the project proponent/consultant should be simple, concise and comprehensive. The main findings of the EIA including adverse and beneficial impacts identified and analyzed should be presented.

Mitigation measures and costs associated with these measures should be presented. The presentation should inform the public on how they will get access to monitoring results during the construction and operational phases of the project, bearing in mind that the public and non-governmental groups are expected to be involved in post-approval monitoring. Graphic and pictorial documentation should support the technical presentation.

Presenters are advised to keep the technical presentation simple and within a time limit of 20-30 minutes depending on the complexity of the project and to allow a minimum of 30 minutes for questions.

The project proponent/consultant will submit to NEPA a copy of the verbatim report of the public presentation within seven (7) days of the date of the meeting.

Please note that the public will be given a period of thirty (30) days after the Public Presentation to send in written comments to NEPA.

(A typical agenda for a meeting is given in Appendix 2)

APPENDIX 1

NOTIFICATION OF PUBLIC MEETING

THERE WILL BE A PUBLIC PRESENTATION ON THE ENVIRONMENT
IMPACT ASSESSMENT REPORT

OF:

VENUE:

DATE:

TIME:

THE PUBLIC IS INVITED TO PARTICIPATE IN THE PRESENTATION BY WAY
OF ASKING QUESTIONS RELATING TO THE PROPOSED PROJECT.

A COPY OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT MAY
BE CONSULTED AT THE

_____ PARISH LIBRARY
_____ PARISH COUNCIL OFFICE

For further information contact:

APPENDIX 2

AGENDA

1. WELCOME AND INTRODUCTION
2. PRESENTATION OF EIA FINDINGS AND MEASURES TO MINIMIZE IMPACTS
3. QUESTION AND ANSWER SESSION
4. CLOSING REMARKS

APPENDIX 3

ROLE AND RESPONSIBILITIES OF THE CHAIRPERSON

The chairperson has the main role of guiding the conduct of the meeting and seeing to it that the concerns of the public are adequately aired and addressed by the proponent/consultants.

The responsibilities of the chairperson include explaining the NEPA approval process, that is, the steps involved and the role of the NEPA at these public presentations. In other words, the chairperson should explain the context within which the meeting is taking place.

The chairperson should ensure that adequate time is allowed for questions and answers, and must understand clearly and communicate the purpose of the meeting to the audience. The chairperson is responsible for introducing the presenters.

The chairperson should contribute to but not monopolize the meeting.

ANNEX 5 – STANDARD FORMAT FOR THE ESIA SCOPING REPORT

Structure of the report

1. Executive summary
2. Description of the project under consideration and its alternatives
3. Applicable environmental, social, legislative and institutional framework
4. Key stakeholders and their concerns and social dynamics (including vulnerable groups)
5. Key environmental and social aspects and project-environment / community interactions to be addressed in the ESIA
6. Scope of the environmental and social baseline and areas of project influence
7. Recommendations on specific impact identification and evaluation methodologies
8. Proposed methodology for identifying and assessing environmental, social and climate-related risks, constraints and opportunities
9. Timeframe and resources needed to carry out the ESIA
10. Technical appendices
 - a. Stakeholder engagement methodology
 - b. List of stakeholders consulted (including contact details)
 - c. Records of stakeholder engagement
 - d. List of documents consulted

ANNEX 6 – STANDARD FORMAT FOR THE PRELIMINARY & FINAL ESIA REPORT

Structure of the report

1. Executive summary
2. Background
 - a. Project justification and purpose
 - b. Project location
 - c. Project description and associated activities
 - d. Alternatives
 - e. Environmental & social policy, legislative and institutional framework
3. Approach and methodology

(This chapter must set out the approach and methodology used in the ESIA and how the data and information collected has been incorporated in the findings and recommendations).

- a. General approach
 - b. Geographical or mapping units
 - c. Environmental and social quality indicators
 - d. Assumptions, uncertainties and constraints
4. Environmental and social baseline study
5. Impact identification and evaluation

(Cumulative effects and interaction between effects could form additional subject headings to ensure that these aspects are not overlooked. Table and diagrams should be used to summarise and clarify findings in this chapter).

6. Mitigation/optimisation measures and residual impacts
7. Conclusions and recommendations on impact mitigation and optimisation
 - a. Statement of impact

(This section must include one of the three ‘statements of impact’ set out below:

- *The alternative(s) (name or number of the concerned alternatives) will not have a significant environmental and social impact, providing that measures recommended in the ESIA are followed through;*
- *The less damaging alternative(s) identified (name, or number) will have some significant environmental and social impacts, which cannot be feasibly mitigated. Therefore, it is recommended to identify and assess additional alternatives or to check that the expected social and economic benefits are sufficiently high in order to justify the project despite its environmental and social impact;*
- *Each alternative identified will have a significant and unacceptable environmental and social impact irrespective of proposed mitigation and monitoring measures. Therefore, it is recommended that the project proposal is comprehensively re-worked and alternatives re-assessed).*

- b. Conclusions and recommendations

(This section must present a clear statement of the conclusions and recommendations on actions to be taken to ensure that environmental and social issues are adequately addressed in subsequent project preparation, implementation, monitoring and evaluation phases. These conclusions and recommendations must be complete, yet concisely and clearly formulated, so that this section can be incorporated into the project documentation).

- 8.** Identification and evaluation of environmental, social and climate-related risks, constraints and opportunities
- 9.** Proposed adaptation and risk management measures
- 10.** Conclusions and recommendations on environmental, social and climate-related risks, constraints and opportunities
- 11.** Technical appendices
 - a. Input into the logical framework planning matrix of the proposed project design (intervention logic, indicators, assumptions and preconditions);
 - b. Maps of the project area and other illustrative information not incorporated into the main report;
 - c. Other technical information and data, as required;
 - d. Records of stakeholder engagement;
 - e. Draft Preliminary Environmental and Social Management Plan.
- 12.** Other appendices
 - a. Study methodology / work plan (2–4 pages);
 - b. Contractor' itinerary (1–2 pages);
 - c. List of stakeholders consulted or engaged (1–2 pages);
 - d. List of documentation consulted (1–2 pages);
 - e. Curriculum vitae of the consultants (1 page per person);
 - f. Terms of Reference.