Davistown and Empire Bay Floodplain Risk Management Plan

Draft

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Foreword

The primary objective of the New South Wales (NSW) Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.

Through the NSW Department of Planning, Industry and Environment (DPIE) and the NSW State Emergency Service (SES), the NSW Government provides specialist technical assistance to local government on all flooding, flood risk management, flood emergency management and land-use planning matters.

The Central Coast Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the options of the NSW Government or the NSW Department of Planning, Industry and Environment (DPIE).

The *Floodplain Development Manual* (NSW Government 2005) is provided to assist councils to meet their obligations through the preparation and implementation of floodplain risk management plans, through a staged process. **Figure F1**, taken from this manual, documents the process for plan preparation, implementation and review.

The *Floodplain Development Manual* (NSW Government 2005) is consistent with Australian Emergency Management Handbook 7: *Managing the floodplain: best practice in flood risk management in Australia* (AEM Handbook 7) (AIDR 2017).

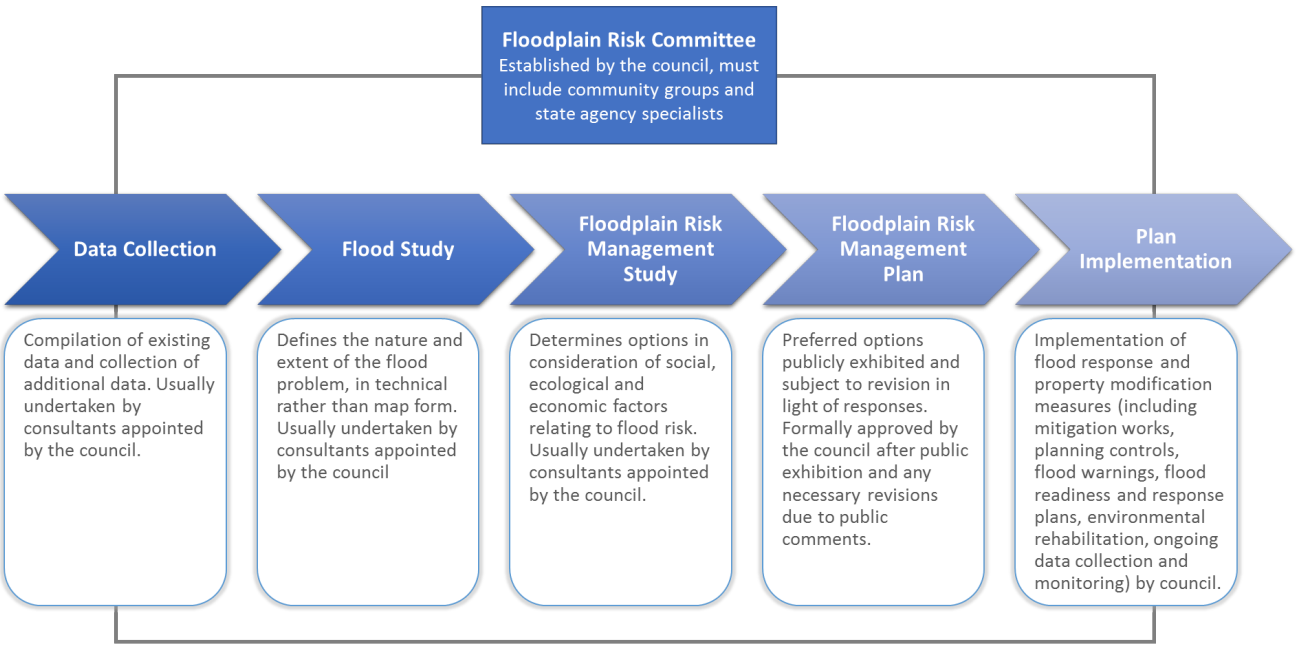

Figure F1 **The Floodplain Risk Management Process (source: NSW Government, 2005)**

Central Coast Council is responsible for local land use planning in its service area, including in Davistown and Empire Bay catchments and their floodplains. Through its Floodplain Risk Management Committee, Council has committed to prepare a comprehensive floodplain risk management plan for the study area in accordance with the NSW Government's *Floodplain Development Manual* (2005). This document relates to the floodplain risk management plan phase of the process.

Executive Summary

Study Overview and Purpose

The Davistown and Empire Bay Floodplain Risk Management Plan (FRMP) has been prepared for Central Coast Council (Council) in accordance with the New South Wales (NSW) Flood Prone Land Policy and the principles of the Floodplain Development Manual (NSW Government, 2005).

This FRMP is to be considered in conjunction with the Floodplain Risk Management Study (FRMS), prepared as a separate document to this FRMP. The FRMS (Rhelm, 2020a), examined options for managing flood risk in the suburbs of Davistown, Empire Bay and portions of Bensville NSW. This FRMP outlines the floodplain management measures recommended as an outcome of the assessment undertaken in the FRMS along with the implementation strategy associated with those measures.

In addition to the FRMS, a separate climate change adaptation study was undertaken by Council (Rhelm, 2020b) to identify feasible strategies to adapt the low lying areas of Davistown and Empire Bay to the impacts of sea level rise. The findings of this study were also considered in the recommendations presented in this FRMP.

The overall objective of this Floodplain Risk Management Plan is to document and convey the decisions on the management of flood risk into the future. Drawing on the investigations undertaken as part of the floodplain risk management study and the Climate Change Adaptation Study for Davistown & Empire Bay (Rhelm, 2020b).

This FRMP outlines a range of measures to manage existing, future and residual risk effectively and efficiently. This document also presents a prioritised implementation strategy, to guide the implementation of the proposed measures.

Study Area

Davistown and Empire Bay catchments are sub-catchments of the Brisbane Water Estuary, which connects to Broken Bay, and are located in the Central Coast Council local government area (LGA).

The Davistown catchment consists primarily of the suburb of Davistown, situated to the south of Saratoga, and the Empire Bay catchment comprises the suburb of Empire Bay and the south-western section of Bensville. The Davistown and Empire Bay catchment areas are approximately 190 ha and 554 ha respectively.

Flood Risk

The study area can be impacted by three mechanisms of flood risk, which can be characterised as follows:

- **Brisbane Water flooding as a result of ocean storms:**
  Ocean storm surge events result in the elevation of the Brisbane Water Estuary levels and can lead to flooding of the low-lying areas of Davistown and Empire Bay. During Brisbane Water flooding events, flood levels typically rise and fall over several hours, with inundation occurring for approximately 5 hours in a 1% AEP event. Flood depths can be up to 0.5 m at the peak of the 1% AEP flood event.
- **Local catchment flooding as a result of local rainfall**:
  Catchment flooding occurs as a result of intense rainfall on the catchment, with the most significant flooding occurring as a result of a 2 hour duration storm event for most design floods. Flooding of roads and private properties is generally associated with shallow depth (<0.3 m) overland flow. Flood depths increase in trapped low points on the low lying, flat portions of Davistown and Empire Bay.

- **Tidal inundation during high tides**:
  The existing flood risks associated with tidal inundation are not significant in Davistown and Empire Bay, in comparison to the other mechanisms of flooding. However, it is expected that in the future, as a result of sea level rise, a large proportion of the study area will be subjected to relatively frequent inundation from high tides. This will compromise the liveability of some portions of the suburbs through flooding of roads, services and private properties.

It should be noted that the effects of climate change will potentially aggravate the impacts of all three types of flooding in Davistown and Empire Bay. As a result of sea level rise, it is expected that the magnitude and frequency of Brisbane Water flooding and tidal inundation will increase considerably. Additionally, the higher ocean level will compromise drainage conditions and exacerbate the consequences of local catchment flooding. These flood risks have been considered in the Climate Change Adaptation Study (Rhelm, 2020b).

Catchment flood behaviour and risk was defined in the Davistown and Empire Bay Catchment Flood Studies (Cardno Lawson Treloar, 2010) and was further assessed as part of the FRMS (Rhelm. 2020a).

The flood risks associated with flooding from Brisbane Water in the study areas have been examined as part of the Brisbane Water Flood Risk Management Study (Cardno, 2015a). This study considered the combined influence of ocean storms and high inflows due to catchment flooding to obtain the Brisbane Water flood levels.

Consultation

Community and stakeholder consultation is an important element of understanding and managing flood risk. The engagement approach undertaken as part of this study was in accordance with the IAP2 framework and the requirements of the NSW Government's Floodplain Development Manual (2005). With the disruption caused by COVID 19 additional resources and adaptations of the originally proposed approach were required during the engagement process (particularly the public exhibition).

The community engagement strategy undertaken as part of this FRMSP includes the following components:

- Community newsletter and questionnaire
- Project website
- Publication of media releases
- Community information (drop-in) sessions
- Agency Consultation
- Stakeholder meetings
- Public Exhibition
- Community virtual sessions.

The community and stakeholders provided valuable insights about the flooding issues experienced in Davistown and Empire Bay and how they could be addressed. The potential flood risk management measures were identified and assessed as part of the FRMS attempted to address the reported issues as far as reasonably possible, considering potential impacts, technical constraints, and the current understanding of the local flood behaviour.

A more detailed description of the community consultation strategy adopted in this FRMSP is provided in **Section 2.4** of this document.

Floodplain Risk Management Study

The Davistown and Empire Bay Flood Risk Management Study (Rhelm, 2020a) provided a comprehensive evaluation of the flood risks in Davistown and Empire Bay and identified potential options to mitigate these risks.

The main outcomes of the FRMS include:

- Evaluation of flood risk to the community based on the outcomes of the Flood Studies (2010). This analysis included Flood hazard and emergency response mapping, and economic damages assessments.
- Review of flood planning policy, including flood-related controls covered by the LEP, relevant DCPs, Council policies and plans. The recommendations proposed as an outcome of this review are presented in this FRMP.
- Identification of a range of flood mitigation measures to address existing and future flood risk and evaluation of these measures with the use of a Multi-Criteria Assessment (MCA) approach. The MCA enabled the comparative assessment of all options based on their economic, social, and environmental aspects, as well as on their effectiveness in mitigating flood risk.

This flood risk management plan will draw from the conclusions of the analysis undertaken in the FRMS and the Climate Change Adaptation Study (Rhelm 2020b) and present the recommended measures for managing flood risk at Davistown and Empire Bay, as well as the strategy to implement these measures.

Climate Change Flood Risk and Planning

The suburbs of Davistown & Empire Bay are representative of a number of suburbs in and around Brisbane Water Estuary that are low lying and susceptible to both the existing flood risk and the effects of climate change. The future preparation of an adaptation masterplan for Davistown and Empire Bay is being considered by Council. This masterplan would identify adaption pathways such as development controls, levees and other mitigation measures which could be implemented over time in consultation with the community.

A climate change adaptation study was recently undertaken by Council (Rhelm, 2020b) to inform the development of a regional adaptation masterplan and these associated processes. The climate change adaptation study (Rhelm, 2020b) focused on the technical analysis of potential landforms and associated measures to provide flood protection against existing and future flood risk associated with both catchment and ocean flooding (both tidal and storm induced).

The proposed landform provided for fill to raise properties and infrastructure above defined flood and tidal levels, as well as being designed to improve runoff during rainfall events (current drainage issues are primarily associated with the flat terrain). Drainage and flood protection measures such as easements and foreshore barriers were also incorporated into the concept designs.

The findings of the climate change adaptation study (Rhelm, 2020b) are presented in **Section 3**

The effects of climate change will potentially aggravate the flood conditions in Davistown and Empire Bay over time and significantly compromise the liveability of some portions of the suburbs through flooding of roads, services, and private properties.

The timely preparation and implementation of a Climate Change Adaptation Masterplan will be crucial to guarantee that the flood mitigation measures are ready for implementation when sea level rise triggers are reached. Therefore, it is recommended that Council proceed with the next stages of the development of a

Climate Change Adaptation Masterplan. This will include assessment of the constructability of the proposed adaptation strategy and the implementation planning. This FRMP will also provide information to assist in the implementation of the Masterplan.

The proposed recommended management measures related to the adaptation to sea level rise impacts on tidal inundation are presented in **Section 4.2.3**.

Additionally, aspects of the infrastructure associated with proposed climate change adaptation (e.g. foreshore barriers and drainage easements) have been considered and assessed in this FRMS and FRMP as options for managing existing flood risk. It was found that not only are these works critical to the future development of climate change adaptation landforms; they also provide immediate management of flood risk through protection against Brisbane Water flooding and improved drainage. These recommended works included:

- A drainage easement between Myrtle Road and Kendall Road (FM EB5)
- A foreshore barrier at Davistown (FM DT1)

Recommended Floodplain Risk Management Measures and Implementation Program

The outcomes of the options analysis undertaken in the FRMS form the basis of this FRMP. A detailed description of the recommended floodplain risk management measures is provided in **Section 4.2**.

Table E-1 summarises the recommended measures, according with the type of flood risk they primarily address (catchment flood, storm surge flood and tidal flood). This table also provides information on the recommended timeframe for the implementation of these options. The two timeline horizons are described below:

- Immediate – this indicates actions that could be implemented in the short term (less than 5 years) if funding and resourcing permits. Feasibility of the action is generally high and additional investigations or further development of the management strategy would be minimal;
- Staged – this indicates actions that could be undertaken in the short to medium term (up to 10 years). However, additional investigations, feasibility studies or further development of the management strategy are likely to be required. Where appropriate, interim policy and planning measures could be employed in the intervening time.

An overview of the recommended measures (where a location is relevant) is presented in **Figure E-1** and **Figure E-2**.

It should be noted that two of the recommended options (FM EB5 and FM DT1) are also elements of the landforms proposed in the Climate Change Adaptation Study (Rhelm, 2020b). These options have been selected due to their effectiveness in managing existing flood risk. However, the recommended works will have the added benefit of assisting in the staged implementation of the future Climate Change Adaptation Masterplan.

Table E-1 Summary of Recommended Floodplain Risk Management Measures

Primary Type of flood Risk Addressed	Option ID	Option Name	Implementation Time Frame / Priority
Catchment Flood Risk	FM EB5	Drainage Easement (Myrtle Road to Kendall Road)	Staged / High Priority

Primary Type of flood Risk Addressed	Option ID	Option Name	Implementation Time Frame / Priority
(Section 4.2.1)	FM EB1 & FM EB6	Pomona Road Easement and Drainage Upgrades	Staged / Low Priority
	PM01	Flood Planning Recommendations	Immediate / High Priority
	EM03	Provide Data to Inform Future Road Drainage Improvements – Empire Bay Drive and Other Flood Affected Roads	Immediate / Medium Priority
	EM05	Flood Warning Signs (at Empire Bay Drive)	Immediate / Medium Priority
Brisbane Water Flood Risk (Section 4.2.2)	FM DT1	Davistown foreshore barrier	Staged / High Priority
	FM EB4	Empire Bay foreshore barrier	Staged / Medium Priority
	EM01	Review of evacuation centres	Immediate / High Priority
	FM EB2	Seawall construction guidelines	Immediate / High Priority
Tidal Flood Risk (Section 4.2.3)	CCA-01	Advance to the next stages of the Davistown and Empire Bay Climate Change Adaptation planning process.	Staged / High Priority
	CCA-02	Provide Information to assist in next stages of the Davistown and Empire Bay Climate Change Adaptation planning process.	Immediate / High Priority
Measures Applicable to All mechanisms of Flooding (Section 4.2.4)	EM06 & PM04	Flood education programs	Immediate / Medium Priority
	EM04	Flood warning systems.	Immediate / Medium Priority

In order to achieve the implementation of relevant management actions, a program of implementation has been developed. The proposed implementation strategy is presented in **Section 4.3**. The proposed program provides information on the estimated costs of each measure, the agency/ organization responsible for the action, as well as the priority and timeline for implementation.

Conclusions and Recommendations

This FRMP provides a practical framework and implementation plan for managing existing, future and continuing flood risk within the study area.

Overall, it is considered that existing risks to Davistown, Empire Bay and Bensville can be managed appropriately through the implementation of development controls, emergency response measures and selected ground works. The effective implementation of development controls will be of key importance in reducing the damages and risk to life associated with flooding into the future through the construction of flood compatible buildings and assets.

More significant flood mitigation and climate change adaptation works will become necessary as sea level rise triggers are reached, further engagement will be required with the community to establish what form these triggers will take. The Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b) outlines a long-term strategy for landform and drainage improvements to achieve ongoing viability of these areas under sea level rise conditions. It is critical that further analysis and design is undertaken as soon as possible to identify sea level rise triggers (i.e. levels at which actions must be taken to allow enough time to adapt), and adaptation measures (e.g. property filling, drainage works and infrastructure design) are confirmed and designed to allow for implementation. Several actions recommended in this FRMP are part of the staged works associated with achieving the landform adaptation.

This FRMP fulfils its objectives accordance with the New South Wales (NSW) Flood Prone Land Policy (NSW Government, 2001) and the principles of the Floodplain Development Manual (NSW Government, 2005).

Figure E-1 Recommended Flood Risk Management Measures - Davistown

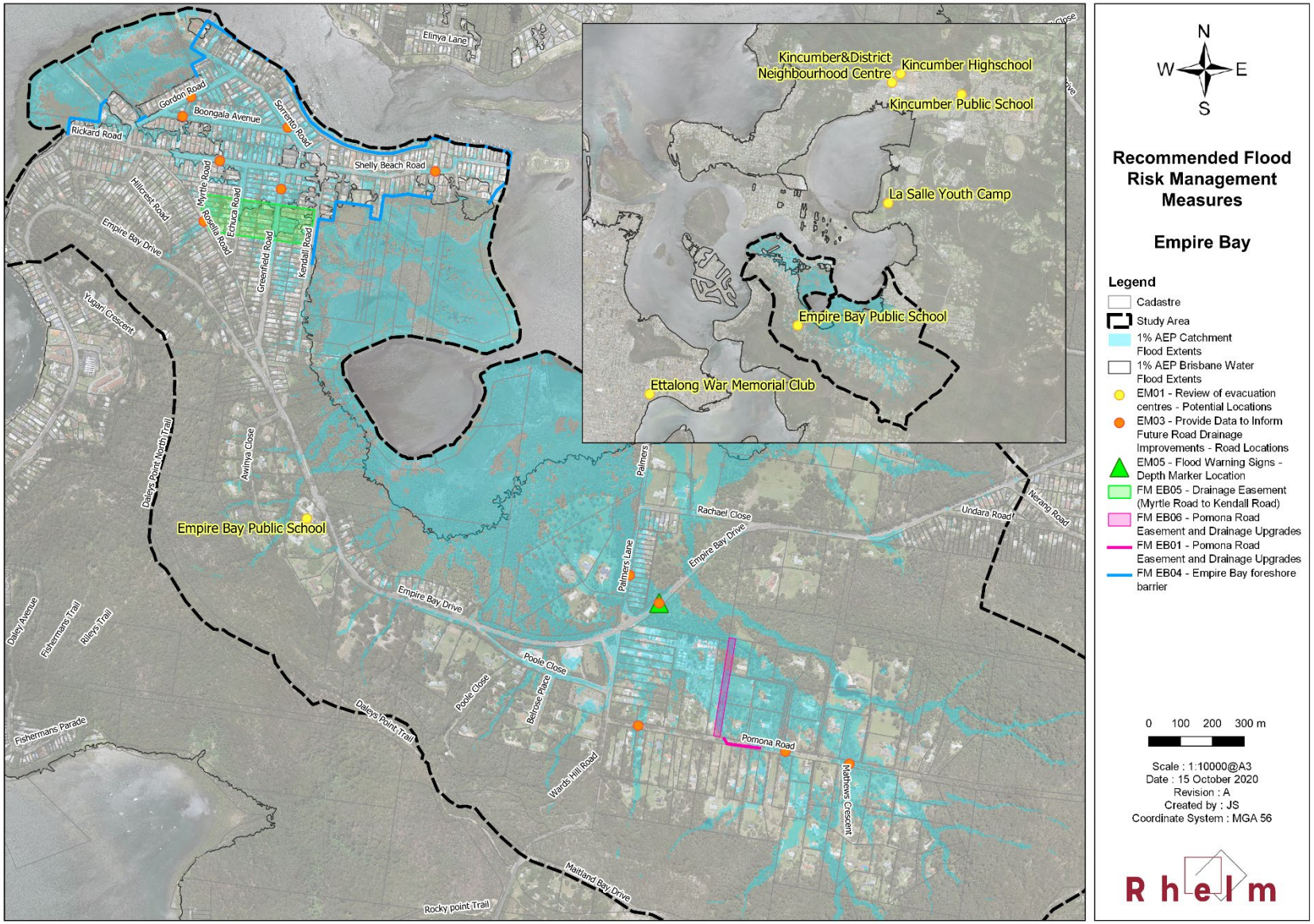

Figure E-2 Recommended Flood Risk Management Measures – Empire Bay

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These are provided as an attachment to this report.

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Glossary

Annual exceedance probability (AEP)	The chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (i.e. a 1 in 20 chance) of a peak discharge of 500 m^3/s (or larger) occurring in any one year. (See also average recurrence interval).
Australian Height Datum (AHD)	National survey datum corresponding approximately to mean sea level.
Attenuation	Weakening in force or intensity.
Average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood as big as (or larger than) the selected event. For example, floods with a discharge as great as (or greater than) the 20 year ARI design flood will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. (See also annual exceedance probability).
Catchment	The catchment, at a particular point, is the area of land that drains to that point.
Design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year ARI or 1% AEP flood).
Development	Is defined in Part 4 of the EP&A Act as: - Infill Development: development of vacant blocks of land that are generally surrounded by developed properties. - New Development: development of a completely different nature to that associated with the former land use. - Redevelopment: Rebuilding in an area with similar development.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
Flood	Relatively high river or creek flows, which overtop the natural or artificial banks, and inundate floodplains and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood Awareness	Awareness is an appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response ad evacuation procedures.
Flood Control Lot	A property identified as being impacted by flooding (i.e. within the Flood Planning Area) and where residential development controls may apply. These properties are notated through 10.7 planning certificates.
Flood Education	Education that seeks to provide information to raise awareness of the flood problem to enable individuals to understand how to manage themselves and their property in a flood event.
Flood fringe	Land that may be affected by flooding but is not designated as floodway or flood storage.

Flood hazard	The potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods.
Flood level	The height or elevation of floodwaters relative to a datum (typically the Australian Height Datum). Also referred to as “stage”.
Floodplain	Area of land which is subject to floods up to and including the probable maximum flood.
Floodplain risk management plan	A document outlining a range of actions aimed at improving floodplain management. The plan is the principal means of managing the risks associated with the use of the floodplain. A floodplain risk management plan needs to be developed in accordance with the principles and guidelines contained in the NSW Floodplain Development Manual. The plan usually contains both written and diagrammatic information describing how particular areas of the floodplain are to be used and managed to achieve defined objectives.
Flood planning area (FPA)	The area of land below the flood planning level or other flood level defined in the FRMP that is subject to flood related development controls. Properties within the Flood Planning Area are identified as Flood Control Lots.
Flood planning levels (FPLs)	Flood planning levels selected for planning purposes are derived from a combination of the adopted flood level plus freeboard, as determined in floodplain management studies and incorporated in floodplain risk management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also consider the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plans. The concept of FPLs supersedes the “standard flood event”. As FPLs do not necessarily extend to the limits of flood prone land, floodplain risk management plans may apply to flood prone land beyond that defined by the FPLs.
Flood prone land	Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Risk Management Plans should encompass all flood prone land (i.e. the entire floodplain).
Flood storage	Floodplain area that is important for the temporary storage of floodwaters during a flood.
Floodway	A flow path (sometimes artificial) that carries significant volumes of floodwaters during a flood.
Freeboard	A factor of safety usually expressed as a height above the adopted flood level thus determining the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.
Gauging (tidal and flood)	Measurement of flows and water levels during tides or flood events.
Hazard	A source of potential harm or a situation with a potential to cause loss.

High high water springs (HHWS)	The highest of all high water observations at the time of spring tide over a period of time (generally 19 years).
Historical flood	A flood that has actually occurred.
Hydraulic	The term given to the study of water flow in rivers, estuaries and coastal systems, in particular the evaluation of flow parameters such as water level and velocity.
Hydrograph	A graph showing how a river or creek's discharge changes with time.
Hydrologic	Pertaining to rainfall-runoff processes in catchments.
Hydrology	The term given to the study of the rainfall-runoff process in catchments, in particular, the evaluation of peak flows and flow volumes. .
Isohyet	Equal rainfall contour.
Mean high water springs (MHWS)	"Every day" tidal inundation caused by high tides. The MHWS tide is the average of all high water observations at the time of spring tide over a period of time (generally 19 years).
Peak flood level, flow or velocity	The maximum flood level, flow or velocity that occurs during a flood event.
Pluviometer	A rainfall gauge capable of continuously measuring rainfall intensity.
Probable maximum flood (PMF)	An extreme flood deemed to be the maximum flood that could conceivably occur.
Probability	A statistical measure of the likely frequency or occurrence of flooding.
Riparian	The interface between land and waterway. Literally means "along the river margins".
Runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.
Stage	See flood level.
Stage hydrograph	A graph of water level over time.
Topography	The shape of the surface features of land.
Velocity	The speed at which the floodwaters are moving. A flood velocity predicted by a 2D computer flood model is quoted as the depth averaged velocity, i.e. the average velocity throughout the depth of the water column. A flood velocity predicted by a 1D or quasi-2D computer flood model is quoted as the depth and width averaged velocity, i.e. the average velocity across the whole river or creek section.

Terminology in this Glossary has been adapted from the NSW Government Floodplain Development Manual, 2005, where available.

Abbreviations

1D	One Dimensional
2D	Two Dimensional
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARF	Areal Reduction Factor
ARR	Australian Rainfall and Runoff
ARR87	The 1987 Edition of Australian Rainfall and Runoff
ARR2019	The 2019 Edition of Australian Rainfall and Runoff
BoM	Bureau of Meteorology
CCC	Central Coast Council
DCP	Development Control Plan
DEM	Digital Elevation Model
DPE	Department of Planning and Environment
DPIE	Department of Planning, Industry and Environment
IFD	Intensity Frequency Duration
IWCM	Integrated Water Cycle Management
FPL	Flood Planning Level
FPA	Flood Planning Area
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
FRMSP	Floodplain Risk Management Study & Plan
ha	hectare
HHWS	High high water springs
km	kilometres
km^2	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging
m	metre
m^2	Square metres
m^3	Cubic metres
m AHD	metres to Australian Height Datum
mm	millimetres

m/s	metres per second
MHWS	Mean high water springs
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW)
PMF	Probable Maximum Flood
SES	State Emergency Service (NSW)
WSUD	Water Sensitive Urban Design

1 Introduction

The Davistown and Empire Bay catchments lie adjacent to the Brisbane Water Estuary within the Central Coast Council Local Government Area. The catchments are subject to flood inundation associated with both catchment and estuarine flooding.

The Davistown and Empire Bay Floodplain Risk Management Plan (FRMP) has been prepared for Central Coast Council (Council) and in accordance with the New South Wales (NSW) Flood Prone Land Policy and the principles of the Floodplain Development Manual (NSW Government, 2005). The Davistown and Empire Bay FRMP outlines the floodplain management measures recommended to mitigate flood risk in the suburbs of Davistown, Empire Bay and portions of Bensville, along with the implementation strategy associated with those measures.

This FRMP is to be considered in conjunction with a Floodplain Risk Management Study (FRMS), prepared as a separate document to this FRMP. The FRMS provides a detailed assessment of the flood risks in the study area and examines potential options for managing these risks. The FRMS presents the technical analysis which supports the recommendations proposed in this FRMP.

Typically, a FRMP follows closely behind a flood study however due to the unique characteristics of the study area and exposure to storm surge it was determined that prior to a FRMP being developed for the Davistown and Empire Bay community, completion of the Brisbane Water Foreshore Floodplain Risk Management Plan was critical to understanding how the different flood behaviour would have on mitigation measures to ensure that there was no maladaptation. The Brisbane Water Foreshore FRMP was adopted in 2015.

1.1 Report Context

Davistown and Empire Bay are subject to a complex range of flood risks, including catchment flooding associated with rainfall on the local catchments, flooding from Brisbane Water cause by ocean storm surge and regional rainfall, and inundation of foreshore areas from extreme tides. These areas will become even more susceptible to these risks as a result of sea level rise.

Several significant flooding and climate change investigations have previously been completed to better understand flood behaviour across the Davistown and Empire Bay catchments. These studies include:

- Davistown Catchment Flood Study (Cardno Lawson Treloar, 2010a)
- Empire Bay Catchment Flood Study (Cardno Lawson Treloar, 2010b)
- Brisbane Water Foreshore Flood Study (Cardno Lawson Treloar, 2013)
- Brisbane Water Foreshore Floodplain Risk Management Study (Cardno, 2015a)
- Brisbane Water Foreshore Floodplain Risk Management Plan (Cardno, 2015b)
- Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b)
- Davistown and Empire Bay Flood Risk Management Study (Rhelm, 2020a).

The Davistown and Empire Bay Catchment Flood Studies (Cardno Lawson Treloar, 2010) determined the flood behaviour within their respective catchments due to local storm runoff from a range of flood events. The studies determined the nature and extent of flooding through the estimation of design flood flows, levels and velocities.

Flood impacts due to ocean-driven storm events within the Brisbane Water estuary are detailed in the Brisbane Water Foreshore Flood Study (Cardno Lawson Treloar, 2013) and subsequent Brisbane Water

Foreshore Floodplain Risk Management Study and Plan (Cardno, 2015). Regional scale options for managing the flood risk from ocean storm events were considered in the latter study.

The Davistown and Empire Bay Flood Risk Management Study (Rhelm, 2020a) provided a comprehensive evaluation of the flood risks in Davistown and Empire Bay and investigated potential options to mitigate these risks. The FRMS considered the outcomes of all the previous studies referenced above, as well as additional analysis of the local flood behaviour. Community Consultation was also undertaken as part of the study, which provided key insights on the local flood issues and potential measures to address them.

This FRMP will draw from the conclusions of the analysis undertaken in the FRMS and present the recommended measures for managing flood risk at Davistown and Empire Bay, as well as the strategy to implement these measures.

Sea level rise is predicted to worsen the impacts of flooding on the study area. In addition, sea level rise is predicted to result in increasingly regular flooding of the low lying portions of Davistown and Empire Bay as a result of tidal inundation. The Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b) analysed sea level rise adaptation strategies for the suburbs of Davistown and Empire Bay. The scope of the study included the development of several landform options and evaluating both their performance during tidal and catchment flooding events and their practical feasibility. As a result, an optimal landform was proposed, as well as a phased implementation strategy to stage the proposed works. It should be noted that this technical case study and has not been considered by Council yet for implementation.

1.2 Report Objectives

The overall objective of this FRMP is to document and convey the decisions on the management of flood risk into the future. Drawing on the investigations undertaken as part of the FRMS, this FRMP outlines a range of measures to manage existing, future and residual risk effectively and efficiently. This includes a prioritised implementation strategy, describing what measures are proposed and how they will be implemented.

The primary objectives of this FRMP are to:

- Reduce the danger to safety and flood damage (and associated losses) to property and infrastructure.
- Manage the risk to critical infrastructure during and after flood events, to guarantee they will remain serviceable when needed.
- Ensure future development is controlled in a manner compatible with the flood risk and associated danger to personal safety.
- Protect and where possible enhance the floodplain environment.
- Manage the risk to future infrastructure to reduce potential damages.
- Be fully integrated with the local flood plan, catchment management planning, and council's existing corporate, business and strategic plans and existing and proposed Environmental Planning Instruments. It also needs to meet Council's obligations under the Local Government Act and have the support of the local community.
- Propose measures that are sustainable social, environmental, cultural and economic terms.
- Establish a program for implementation and a mechanism for funding the management plan, including priorities, staging, funding, responsibilities, constraints and monitoring.
- Develop/Update the local flood risk management policy for the study area.
- Consider how to best incorporate plan findings into councils' Environmental Planning Instruments, development control plans and policies.

2 Flood Risk

2.1 Study Location Catchment Description

The **Davistown catchment** consists primarily of the suburb of Davistown, situated to the south of Saratoga. The other boundaries of Davistown are foreshore areas with waterbodies surrounding from the east to the south and to the west, namely The Broadwater, Cockle Bay, Cockle Channel and Lintern Channel. Land-use in the catchment is primarily residential with significant areas of bushland / vegetated areas. A retirement village, RSL club and some commercial buildings are also located in the catchment.

Davistown is relatively flat and stormwater runoff drains discharge to the estuary at multiple locations along the western, southern, and eastern foreshore areas. Pit and piped drainage infrastructure takes the form of many separate branches, each draining to different points on the foreshore. Drainage swales with pipes under driveway crossings are constructed along several streets to convey runoff. The catchment includes two main drainage channels cutting the suburb adjacent to Murna Avenue and behind properties fronting Emora Avenue.

The major drainage channel is located west of Davistown Road draining towards a large open area west of Malinya Crescent, then into Lintern Channel. These areas are tidal. Runoff is also conveyed to depressions that are located within the large vegetated marsh areas.

The **Empire Bay catchment** consists of the suburb of Empire Bay and the south-western section of Bensville. Cockle Channel and Cockle Bay are the waterbodies situated on the northern side of the catchment. Land-use in the catchment is primarily residential with significant areas of bushland / vegetated areas. The density of residential areas varies from low-density detached houses in the main part of Empire Bay and within Bensville, to larger bushland residential lots between these two areas. Several shops are located within the two main residential areas. Large areas of bushland are located on the higher elevations in the southern part of the catchment and along some areas adjoining the estuary, including Cockle Bay Nature Reserve.

The Empire Bay residential area is relatively flat with an elevation down to approximately 1.0 m AHD at the foreshore and the area around Cockle Bay Nature Reserve is also relatively flat. Pit and piped drainage infrastructure convey stormwater runoff through the main residential areas of Empire Bay and Bensville to the foreshore. Several drainage depressions and natural channels convey runoff from the bushland areas to piped systems crossing Empire Bay Drive.

The catchment area is shown in **Figure 2-1**.

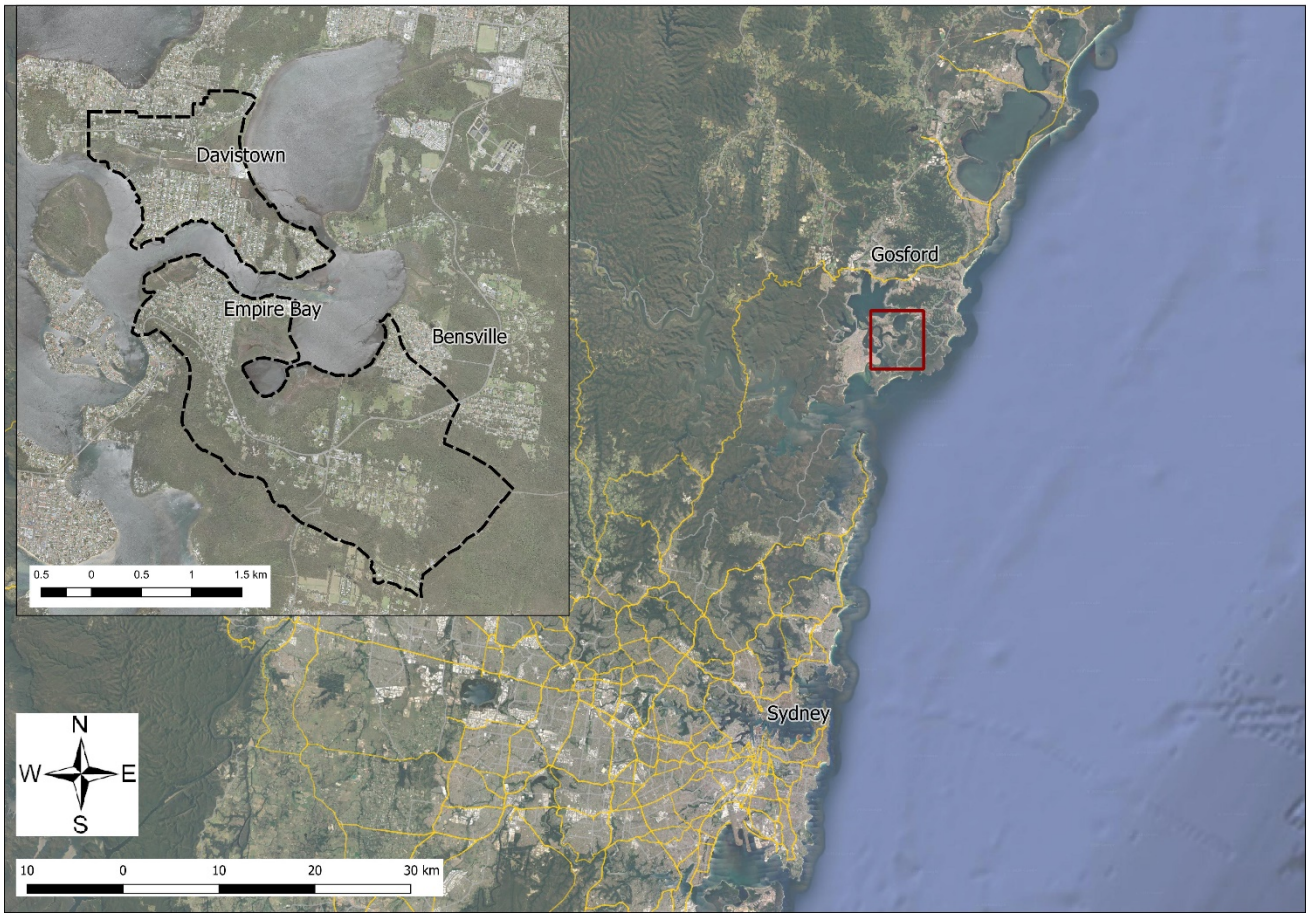


Figure 2-1 Study Area Overview

2.2 Flood Behaviour and Flood Risk

Davistown and Empire Bay can be impacted by three mechanisms of flood risk:

- Brisbane Water flooding as a result of ocean storms,
- local catchment flooding as a result of local rainfall, and
- tidal inundation during high tides.

It is expected that all of these flood risks will be aggravated as an effect of climate change.

Historical flooding in the study area has been primarily driven by ocean storm surges, which lead to the rise of the water levels in the Brisbane Water estuary. Notwithstanding this, inundation of roads, public open spaces and private property at higher elevations have been caused by rainfall runoff along overland flow paths, which can be exacerbated by higher water levels in the estuary.

Major historical coastal flood events for the Brisbane Water Estuary include the severe ocean storm of 1974 (approximating a 1 in 100 year ARI storm event) and the more recent, but less severe, event in 2007. Other significant coastal events included: January 1996, February 1992, February 1990, April 1988, October 1985, November 1984, February 1981, January 1978, March 1977, and April 2015.

A brief explanation of how the study areas are affected by the different sources of flooding and the main flood risks associated with each flooding mechanism is provided in **Sections 2.2.2 to 2.2.4.**

The expected effects of climate change on the flood risk in the study areas are also discussed in **Sections 2.2.2 to 2.2.4**. The assumptions behind the sea water level rise predictions considered in this study are presented in **Section 2.2.1.**

2.2.1 Sea level Rise

An independent report on projected sea level rise in Brisbane Water was prepared by Doug Lord of Coastal Environment Pty Ltd and by Dr David Wainwright from Whitehead and Associates in 2015.

The independent report recommended RCP8.5 as a suitable and defensible basis for sea level rise projection in 2015. The report also identified that research on recent global emissions indicates that we are tracking at the top of the RCP8.5 projection. Within the high emissions scenario (RCP 8.5), there are three possible trajectories (low, medium, high) which encapsulate the range of the modelling. In March 2015 Gosford City Council resolved to adopt sea level rise planning levels based on projections for the Representative Concentration Pathway Scenario RCP8.5, utilising the medium sea level rise projection. This projection has been provided from 2015 mean sea level. The adopted sea level rise predictions are summarised in **Table 2-1**.

The Brisbane Water Flood Study (2010) considered the flooding that results from coastal processes, such as significant coastal wave events and storm surge associated with low pressure systems off the East Coast of Australia. Analysis undertaken in the Brisbane Water Flood Study (2010) identified that sea level rise would result in an almost equivalent increase in water levels at Davistown and Empire Bay when compared to the open coast. Therefore, the values in **Table 2-1** are applicable at Davistown and Empire Bay.

Table 2-1 Adopted Projected Sea Level Rise RCP8.5

Year	Sea Level Rise (m)
2015	0
2030	0.07
2050	0.20
2070	0.39
2100	0.74

2.2.2 Brisbane Water Flooding

Ocean storm surge events result in the elevation of the Brisbane Water Estuary levels and can lead to flooding of the low-lying areas of Davistown and Empire Bay. High rainfall often, although not always, occurs concurrently with an ocean storm event such as an East Coast Low. This can further exacerbate flood levels in Brisbane Water Estuary, particularly in the upstream reaches. The flood levels in Davistown and Empire Bay during a Brisbane Water Estuary flood events, are primarily driven by ocean levels.

Significant areas within Davistown and Empire Bay are susceptible storm surge, high tides also cause foreshore inundation, especially with joint occurrence with local rainfall. In Davistown, inland penetration by flood waters and number of properties affected by flooding is more significant than Empire Bay due to the very flat terrain in Davistown.

During an ocean storm flood levels typically rise and fall over several hours and accompanied by storm force winds associated with an east coast low pressure system, with inundation occurring for approximately 5 hours in a 1% AEP event. Therefore, it is expected that response times would be relatively long and, provided an effective warning system is in place, that the flood affected residents would be able to safely prepare their

properties to shelter in place or evacuate safely, if needed. However, there could be considerable damage to properties and other infrastructure impacting people's ability to shelter in place or evacuate.

Floor level survey has been collected as part of both the Brisbane Water Foreshore FRMS and the Davistown and Empire Bay FRMS. This information would greatly assist SES in responding to flood events.

The flood risks associated with flooding from the Brisbane Water in the study areas have been examined as part of the Brisbane Water Foreshore Floodplain Risk Management Study (Cardno, 2015a). This study considered the combined influence of ocean storms and high inflows due to catchment flooding to obtain the Brisbane Water Estuary flood levels.

This study also examined the influence of the predicted sea level rise in the Brisbane Water Flood levels at Davistown and Empire Bay, which is shown in **Table 2-2.** The sea level rise values in this tables are equivalent to the ones reported in **Table 2-2**. Mapping of these 1% AEP levels for 2015, 2050 and 2100 are shown in **Figure 2-2**, which shows that there is a significant existing flood risk from Brisbane Water, which becomes exacerbated due to sea level rise. The 2015 condition has been used as the 'base case' or 'existing scenario' against which to assess the impacts of future flooding.

Table 2-2 Brisbane Water Flood Levels (Flood Study Reporting Location 059)

Year	Sea Level Rise (m)	1% AEP (m AHD)	5% AEP (m AHD)	20% AEP (m AHD)
2015	0	1.50	1.40	1.20
2030	0.07	1.57	1.7	1.27
2050	0.20	1.70	1.60	1.40
2070	0.39	1.89	1.79	1.59
2100	0.74	2.24	2.14	1.94

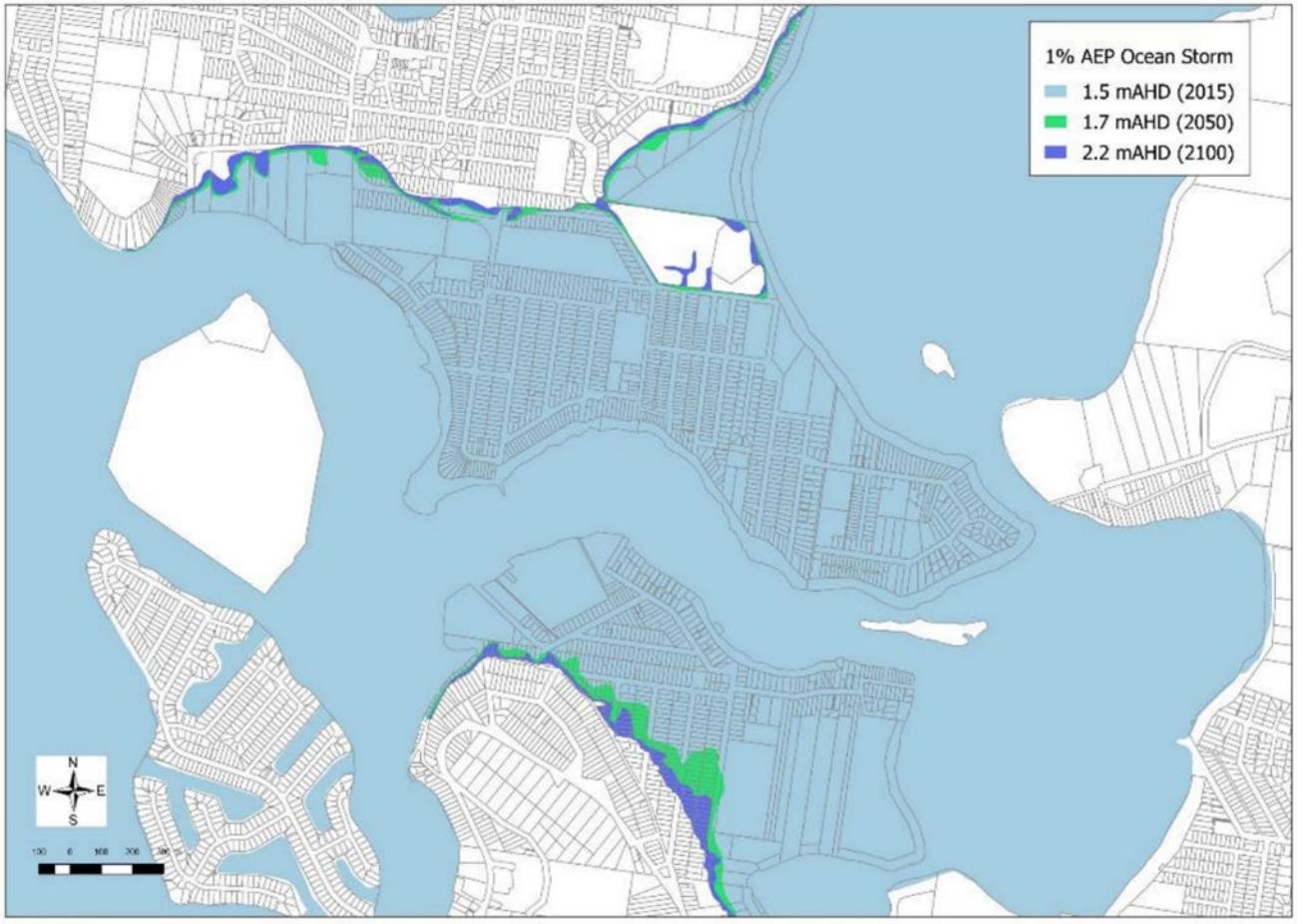


Figure 2-2 Ocean Storm Flooding

2.2.3 Local Catchment Flooding

Catchment flood behaviour was defined in the Flood Studies (2010), and further assessed as part of this FRMSP.

This mechanism of flooding occurs as a result of intense rainfall on the catchment, with the most significant flooding occurring as a result of a 2 hour duration storm event for most design floods. Therefore, it is expected that catchment flood events would allow for little response time (i.e. less than an hour from the start of rainfall to flooding occurring).

Flooding of roads and private properties is generally with shallow depth (less than 0.3 m), overland flow in the 1% AEP flood event. However, more significant flood depths (up to 0.6 m) were identified in trapped low points on the low lying, flat portions of Davistown and Empire Bay.

Maps G301 and G302 illustrate the impacts of catchment flooding in the study area and highlights the roads that are more significantly affected. These roads experience high hazard (greater than H2 Hazard) in a PMF event.

Since the floodwaters only reach relatively shallow depths and recede quickly, the flood hazard associated to catchment flood events primarily impacts pedestrians and vehicles who might be using flood affected roads during the rainfall event.

The number of properties that are subjected to over floor flooding in the analysed catchment flood events is summarised in **Table 2-3**. The economic damages associated with catchment flooding in the study areas are discussed in **Section 2.3**.

Table 2-3 Properties subjected to over floor flooding in catchment flooding events

Flood Event	Properties with Over-Floor Flooding	Avg Over-Floor Depth (m)
PMF	274	0.15
0.5% AEP	45	0.14
1% AEP	36	0.13
2% AEP	24	0.15
5% AEP	20	0.16
10% AEP	11	0.19
20% AEP	9	0.18

The effects of catchment flood events can be further aggravated by high water levels in Brisbane Water Estuary, which can compromise the local drainage (e.g. associated with a high tide or an offshore low pressure system).

The Davistown and Empire Bay Catchment Flood Studies (Cardno Lawson Treloar, 2010a and 2010b) assessed the potential impacts to flood behaviour in the catchments due to climate change for sea level rises. Flood inundation in the low elevation areas of the catchment were particularly affected by increases in sea level which influences the levels in Brisbane Water estuary.

Climate change also has the potential to impact rainfall. The flood studies (2010) identified that a 20% increase of the 1% AEP event rainfall resulted in increases in flood levels up to 0.04m. In general, the increased flow extent rather than increased in depth.

2.2.4 Tidal Inundation

The existing flood risks associated with tidal inundation are not significant in Davistown and Empire Bay, in comparison to the other mechanisms of flooding. However, it is expected that in the future, as a result of sea level rise, a large proportion of the study area will be subjected to frequent inundation from high tides. This will compromise the liveability of some portions of the suburbs through flooding of roads, services and private properties.

Figure 2-3 and **Figure 2-4** provide a comparison between the extreme high tide (HHWS) levels in Brisbane Water and the 1% AEP Brisbane Water flood levels (i.e. as a result of storm surge and rainfall on the regional catchment). The locations of the cross-sections shown in these figures are illustrated in **Figure 2-5**.

A discussion paper was included in the *Brisbane Water Foreshore Floodplain Risk Management Study* (Cardno, 2015) to identify the impacts of projected sea level rise on tidal inundation. A Delft3D hydrodynamic model was used to investigate the tidal response to climate change and entrance morphology. The potential change in tidal attenuation was investigated for the 0. 39m projected sea level rise scenario.

The modelling indicates that a 0. 39m rise in sea levels relates to close to 0.4m rise in estuarine levels at Davistown and Empire Bay.

The sea level rise projections outlined in **Section 2.2.1** were applied to the results of the discussion paper and are summarised in **Table 2-4**. The risk areas associated with the High High Water Spring Solstices (HHWSS) levels is provided in **Figure 2-5**. If we interpolate between the values shown below it can be seen that the majority of the study area will be affected by "king tides" tides by 2100. And it can be inferred that the impacts of "every day (MHWS)" tides will cause significant road and property flooding by approximately 2070.

Table 2-4 Sea Level Rise Impacts on Tidal levels

Year	Sea Level Rise (m)	MHWS (m AHD)[1]	HHWSS (m AHD)[2]
2015	0	0.33	0.56
2030	0.07	0.40	0.63
2050	0.20	0.53	0.76
2070	0.39	0.72	0.95
2100	0.74	1.07	1.30

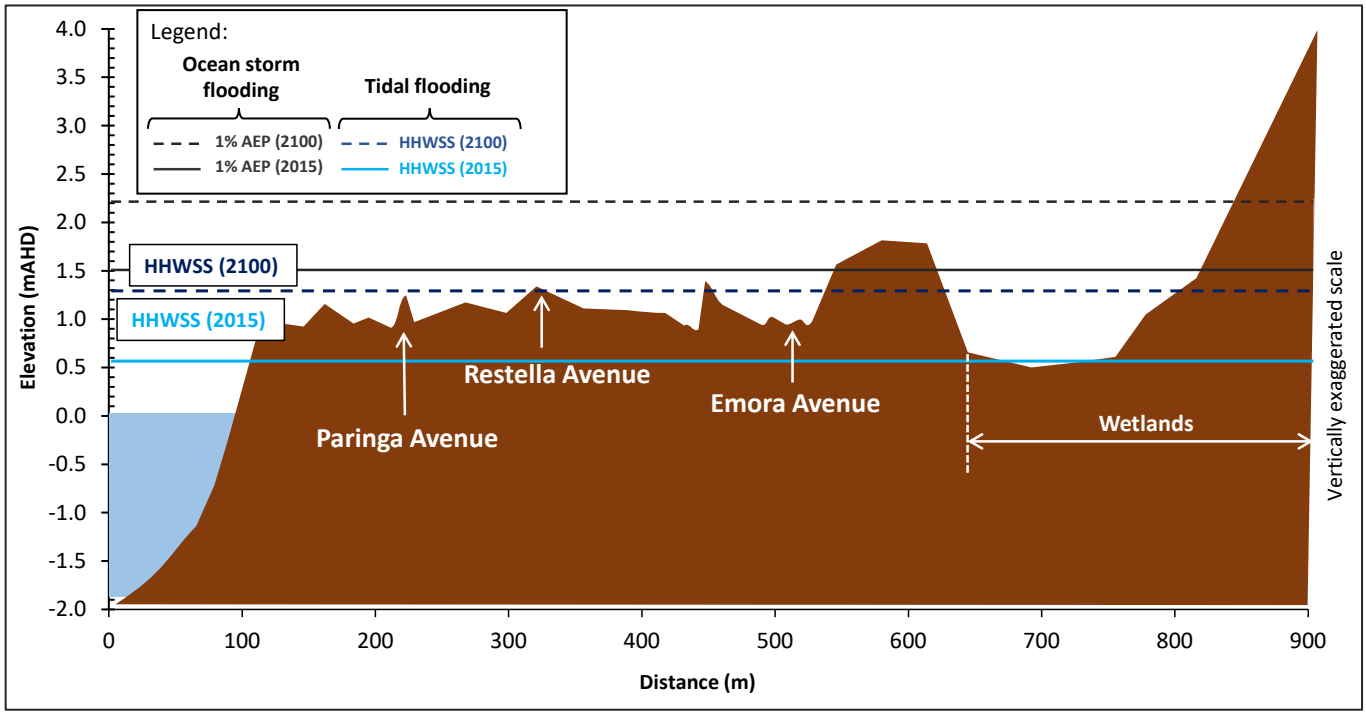


Figure 2-3 Comparison between tidal inundation and Brisbane Water 1% AEP flooding – Davistown (Section A)

[1] Mean High Water Springs (MHWS) – "Every day" tidal inundation caused by high tides. The MHWS tide is the average of all high water observations at the time of spring tide over a period of time (generally 19 years).

[2] High High Water Spring Solstices (HHWSS) – Rare high tides occurring approximately twice a year, during the June and December solstices ("king tides"); and

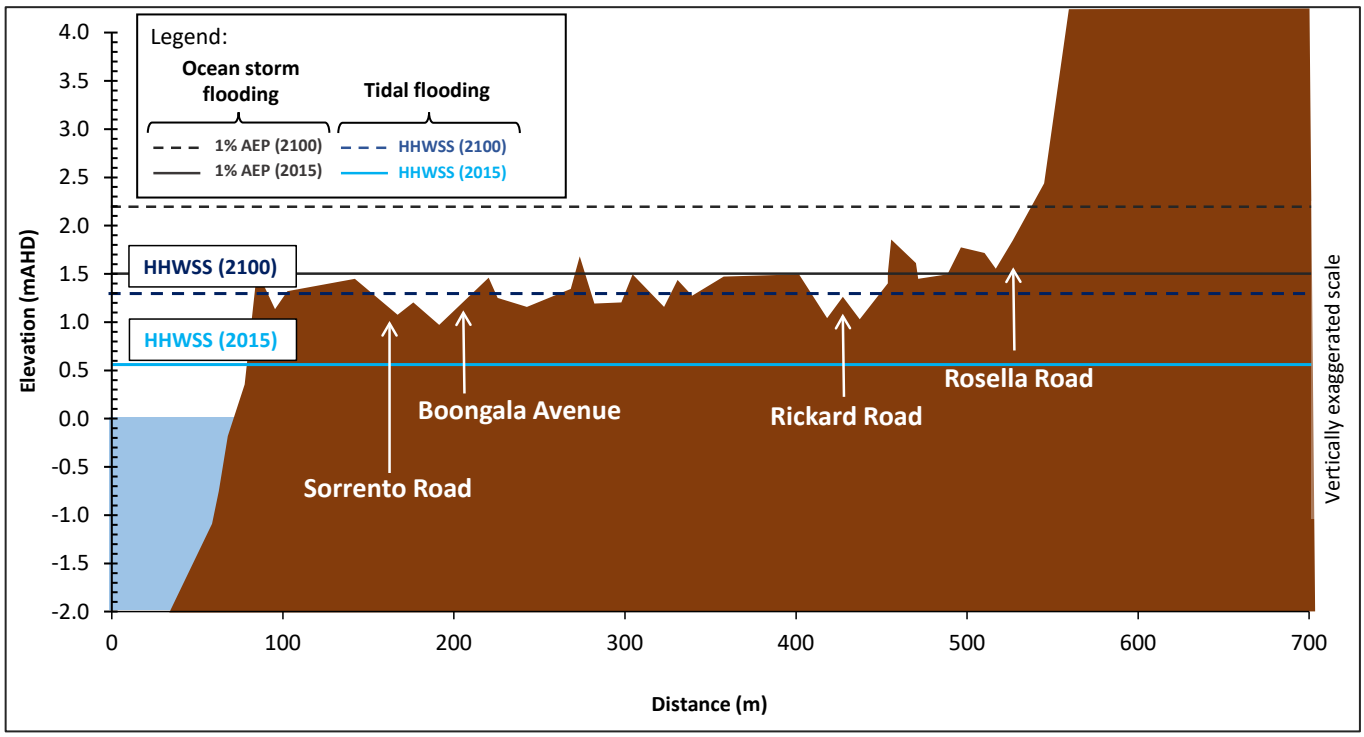


Figure 2-4 Comparison between tidal inundation and Brisbane Water 1% AEP flooding – Empire Bay Section B

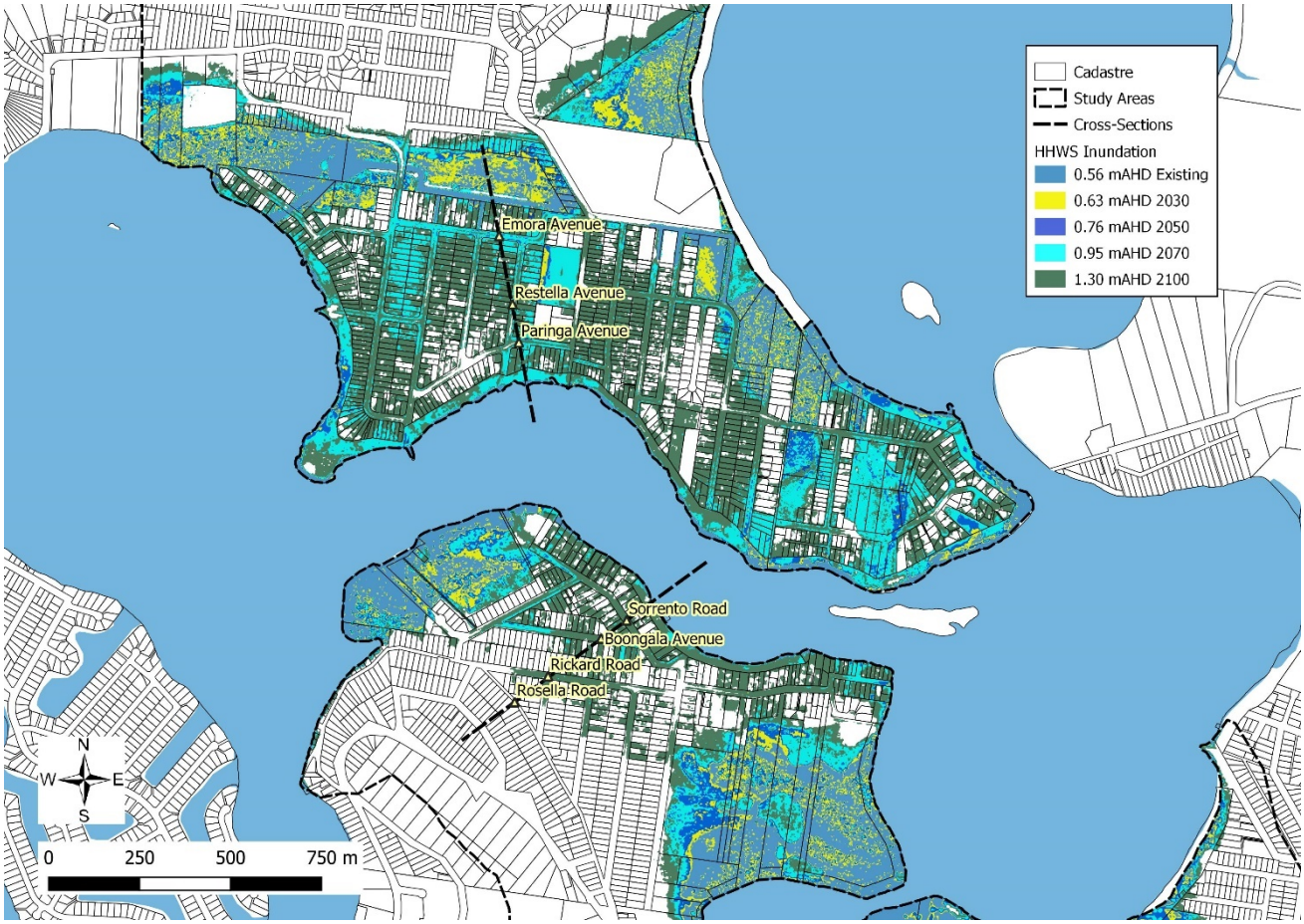


Figure 2-5 HHWS Tidal Inundation

2.3 Economic Flood Damages

In order to quantify the economic impacts of flooding, an economic flood damage assessment has been undertaken. A property may suffer economic impacts from flooding through several ways. These are broadly grouped into three categories, as summarised in **Table 2-5**.

Table 2-5 Flood Damages Categories

Type of Flood Damages		Description
Tangible	**Direct**	Building contents (internal) Structure (building repair and clean) External items (vehicles, contents of sheds etc.) Infrastructure
	Indirect	Clean-up (immediate removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public services)
Intangible		Social – increased levels of insecurity, depression, stress General inconvenience in post-flood stage

Damage dealt directly to a property or its contents (direct damages) are only component of the total damages accrued during a flood event. Indirect costs, while also tangible, arise as a result of consequences of the flood event, such as clean-up costs, opportunity costs, and other financial impacts. For example, in a recent flood event in Davistown, the sewer system failed resulting in residents needing to use portable toilets. These types of impacts have not been captured in the economic damage analysis.

In addition to tangible damages, there are also a category of damages referred to as intangible damages. Intangible costs relate to social impacts, such as insecurity and depression, that arise as a result of major flood event, or general inconveniences that occur during the post-flood stage. The intangible costs are difficult to calculate in economic terms.

The damage assessment undertaken for this study has examined the tangible damages only. Assessment of the tangible flood damages is based on residential damage curves, which were generated based on the curves prepared by the Department of Natural Resources (now DPIE) in 2007. The magnitude of damage attributed to a property is dependent upon its number of storeys and the depth of inundation experienced for all design flood events assessed.

The damages calculated for each of design event are used to estimate the Annual Average Damages (AAD). The AAD is the typical method that is adopted in economics to annualise damage costs such as those in flooding based on their probabilities. This allows for the conversion of the different flood event damages into a singular annual average that represents (based on the overall probabilities of events) the most likely damage that is likely to be experienced in any given year.

Therefore, the ADD provides a representation of the estimated amount of capital that Council would theoretically need to invest every year to address damages caused by flooding (both frequent and rare).The calculation process is described in detail in the Floodplain Development Manual (2005).

The average annual damage (AAD) for the Davistown and Empire Bay study area under existing conditions is $1,752,358. Over a 50 year assessment period and under a seven per cent discount rate, this AAD is equivalent to a Net Present Value (NPV) of $24.1M. This value is an estimate of the total expenses Council is expected to have due to flooding over 50 years, in today's dollar value.

Table 2-6 summarised the Average Annual Damage associated with both catchment flooding and ocean flooding, as well as the damage values obtained for each of the analysed design events.

Table 2-6 Economic Flood Damages Assessment

Flood Event	Catchment Flooding Damages	Brisbane Water Flooding Damages
PMF	$39,436,465	$45,678,663
0.5% AEP	$11,300,421	$26,870,578
1% AEP	$9,372,400	$20,797,573
2% AEP	$7,883,519	$15,101,762
5% AEP	$6,427,163	$9,737,940

Flood Event	Catchment Flooding Damages	Brisbane Water Flooding Damages
10% AEP	$4,685,971	$5,808,008
20% AEP	$3,805,105	$3,403,768
Average Annual Damages (AAD)	**$1,752,358**	**$2,212,076**

It should be noted that damages associated with ocean flooding have been originally estimated as part of the Brisbane Water FRMS (Cardno, 2015). However, the costs reported in this study were expressed in 2015 dollars. For this reason, the results reported in **Table 2-6** have been based on updated the same data, updated to 2019 currency values for use in this study.

2.4 Consultation Strategy

Public consultation is an important element of understanding and managing flood risk. It can facilitate:

- understanding of flood behaviour by tapping into community knowledge on historic floods
- informing the community of the flood threat they face and how and when to react to this threat
- developing sustainable floodplain management plans that have broad community support.

The approach undertaken to community engagement as part of this study was in accordance with the IAP2 framework and the requirements of the NSW Government's Floodplain Development Manual (2005).

The consultation strategy outlined in **Table 2-7** summarises the main community engagement activities undertaken as part of this FRMSP, as well as the stakeholders involved.

Table 2-7 Engagement Methods

Event/Activity	Purpose	Target Audience	Key outcomes
Community newsletter and questionnaire A one-page community newsletter was distributed in September and October 2019 to over 2,400 dwellings An online version of the questionnaire was also available through Council's Have Your Say webpage and the project website.	• Provide scope and context of project. • Invite community input on what they see as the key flooding issues and how they would like to see them managed.	Residents, property owners, local business owners, and the wider community.	• A total of 162 residents responded to the questionnaire, representing a return of 8% of direct distribution. • The questionnaire responses provided key insights into the community's perception on flooding and emergency response.
Website and Media A project website has been established for the duration of the project and can be accessed at the following link: https://www.davistownempirebayfrmsp.com/ Council provided an additional webpage on their Your Voice Our Coast website (September 2019 – December 2019). Media releases were used throughout the study to inform the community of key project updates and creating opportunities to provide input.	• Provide project information and community updates. • Invite community input, by providing a link to the online survey and an interactive map, through which the community could provide comment on flooding in the area.	Residents, property owners, local business owners, and the wider community.	• There were 296 visits to the webpage (prior to public exhibition) • A large number of the community questionnaires were responded to online through the website (67 from a total of 162 responses).
Community information (drop-in) sessions Two community drop-in information sessions were held in Davistown (16th October 2019) and Empire Bay (17th October 2019).	• Provide scope and context of project. • Invite community input on what they see as the key flooding issues and how they would like to see them managed. • Provide interactive mapping via WaterRide dongles, laptops, Ipads, TVs and connecting cables for ease of representing the study	Residents, property owners, local business owners, and the wider community.	• A total of 70 people attended the community information sessions. • The attendees provided important information on flood issues experienced in the study areas and potential measures to address them.
Agency Consultation Consultation was undertaken with SES at the community drop-in sessions and project meetings.	• Identify the deliverables required from the study to assist SES in effective flood response. • Obtain preliminary inputs for the study from DPIE.	SES and DPIE	• The primary outputs from this study with respects to emergency response were identified in conjunction with the SES. These outputs included information on flood affected access routes and preparation of Flood Emergency Classification (FERC) maps. The discussion with the SES also provided key inputs for

Event/Activity	Purpose	Target Audience	Key outcomes
Additionally, A letter was received from DPIE (Crown Lands) in November 2019 providing some preliminary inputs to the study. DPIE and SES will be engaged with further as part of the public exhibition period.			the identification and assessment of the Emergency Response Modification Measures proposed in the study • A letter sent from DPIE (Crown Lands) identified that the study area contains parcels of Crown Land that could potentially be used for flood mitigation works. The letter also outlined the authorisations required to carry out works in these areas.
Stakeholder meetings Targeted stakeholder meetings were undertaken following the identification of the preliminary flood risk management options, to assist in the selection of options for detailed assessment.	• Provide scope and context of project. • Invite community input on what they see as the key flooding issues and how they would like to see them managed.	Community groups, action groups and other key stakeholders identified	• As part of the stakeholder options workshop meeting, the potential benefits and impacts associated with each of the preliminary options were identified and assessed. The presence of different stakeholders, each with their particular perspective on flood management, resulted in a comprehensive, multidisciplinary assessment. • As an outcome of this assessment, a number of options were selected to be further evaluated in the detailed assessment stage.
Public Exhibition – Your Voice Our Coast page During the public exhibition period, the Draft documents will be made available on Council's "Your Voice Our Coast page" webpage. This will allow the members of the public and all relevant stakeholders to provide feedback on the draft documents.	• Invite feedback on draft documents	Residents, property owners, local business owners, the wider community, agency stakeholders and community groups.	• *To be completed following public exhibition*
Community virtual sessions During the public exhibition period the public will be able to book virtual meetings with the project team to discuss the draft documents.	• Invite feedback on draft documents	All stakeholders	• *To be completed following public exhibition*

2.5 Community Survey and Drop-In Information Sessions

From the distribution and availability of the community survey on the website (in late 2019), 160 responses were received, representing a return of 8% of direct distribution. A return rate of 10% is typical for these types of mail-outs.

An additional 70 people attended drop-in sessions (October 2019) to provide input face to face. This represents a total engagement rate of 12%.

The primary findings of the questionnaire were:

- approximately 56% of the responses were provided by people who have resided/visited the study area for more than 20 years.
- most of the respondents (66%) consider themselves aware of flooding in the region and only 8% report they are "not at all aware" of these risks. The remaining 26% marked the option "Somewhat aware" of flooding.
- when asked if they have any specific concerns about flooding, 43 people answered they have no concerns, 35 people reported they were concerned with flooding on roads and 23 expressed concern of flooding on properties. Additionally, 27 respondents raised issues related to the existing stormwater drainage systems.
- according to the questionnaire answers, the residents consider improvements and better maintenance of the drainage systems are the most important measures for better flood management (98 comments in total).
- half of the respondents reported that they would stay in their houses if a major flood occurs. When asked what their reason for staying at home would be, the most common answer was that they knew their houses could cope with flooding (77 answers). Another common reason, according to the responses, is the concern for the security of the property after an evacuation (54 responses).
- a total of 29% of the respondents stated they would evacuate in a major flood, 14% say they would evacuate early to an official centre and 15% say they would evacuate elsewhere. According to the responses, the most common reason for an evacuation would be the safety of their household (64 responses).
- 82 respondents (51%) reported that, during a flood event, they look for information on road closures and 41 people (31%) stated they look for evacuation notices. Most of the respondents would look for information on the radio (27%), on TV (20%) and on social media (19%).
- the flood management objectives listed in the questionnaire have similar importance for the community, since each option received a similar average score. The objectives that received the higher score (6.31 points) and the lower score (5.27 points) were "Increasing community awareness and understanding of the local flood risk" and "Ensuring management does not disadvantage individual members of the community", respectively.

The community members that attended the drop-in information sessions provided valuable insights about the flooding issues experienced Davistown and Empire Bay and how they can be addressed. The inputs from the community generally included:

- flooding issues reported at specific roads and public locations
- need for maintenance and improvement of existing drainage infrastructure
- Potential evacuation centre locations

- Implementation of additional flood protection/drainage infrastructure
- Potential road access issues during flooding events
- Need for revision of flood planning controls.

The options that were identified and assessed as part of the FRMS attempted to address the reported issues as far as reasonably possible, considering potential impacts, technical constraints, and the current understanding of the local flood behaviour. It should be noted that some of the concerns and suggestions raised in the drop-in sessions were outside of the scope of this study (e.g. erosion and minor drainage issues), these have been reported to council or other relevant organisations.

2.6 Public Exhibition

Following completion of the Draft FRMS and FRMP documents, they are placed on public exhibition to give members of the public and all relevant stakeholders an opportunity to provide feedback. All submissions received from the public during the public exhibition period will be reviewed and will inform the finalisation of the FRMS and FRMP.

3 Climate Change Planning

The suburbs of Davistown & Empire Bay are representative of a number of suburbs that are low lying and susceptible to the effects of climate change and the existing threat from flooding in and around Brisbane Water Estuary. The development of a strategy for climate change adaptation Davistown and Empire Bay is an important step in addressing climate change risk for all low-lying areas of the Central Coast LGA.

By undertaking a climate change adaptation Landform and Drainage Masterplan for Davistown and Empire Bay, adaptation pathways can be developed such as development controls, levees and other mitigation measures which could be implemented over time in consultation with the community. A climate change adaptation case study was recently undertaken by Council (Rhelm, 2020b) for Davistown and Empire Bay to inform the development of a regional adaptation masterplan and these associated processes.

Figure 3-1 demonstrates how the Floodplain Risk Management Process and the Climate Change Adaptation Planning Process for Davistown and Empire Bay are integrated (green studies / plans are completed, blue are yet to be undertaken).

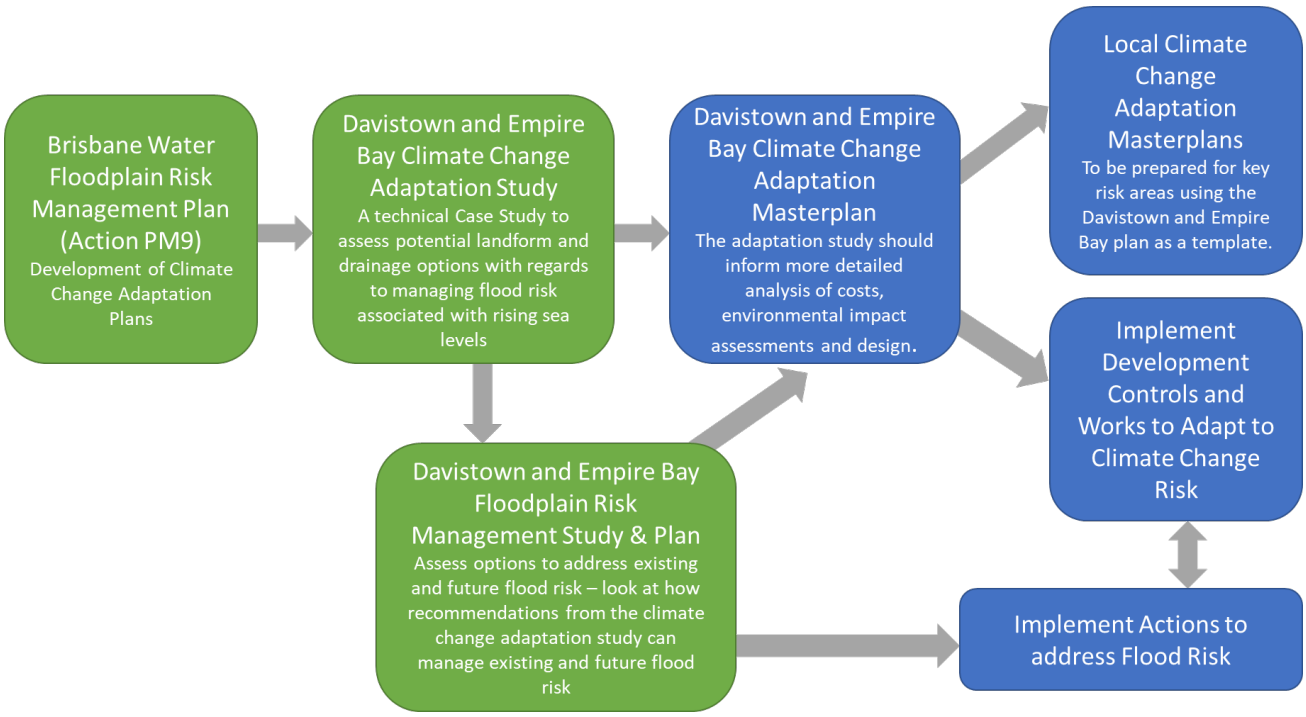


Figure 3-1 Climate Change Adaptation and Floodplain Management for Davistown and Empire Bay

The Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b) focused on the technical analysis of potential landforms and associated measures to provide flood protection against existing and future flood risk associated with both catchment and ocean flooding (both tidal and storm induced).

The adaptation study provided valuable information to assist in the overall climate change adaptation strategy and preparation of a Masterplan. However, this study was of a conceptual nature and further planning is required to allow the adaptation plan to go ahead. This FRMP recommends that Council proceeds with the next stages of the development of a Climate Change Adaptation Landform and Drainage Masterplan for Davistown and Empire Bay. The proposed actions are described in detail in **Section 4.2.3**.

3.1 Approach to Decision Making

Adapting to climate change and rising sea levels is a complex problem, with no single technical solution, and involving multiple interests and stakeholders. The *Decision Support for Coastal Adaptation: The Handbook* (The Handbook) was developed in 2012 to assist the HCCREMS coastal councils more effectively approach and determine adaptation responses and pathways for vulnerable coastal areas. The Handbook discusses ten key stages in the decision-making process. Although the process is presented as a series of numbered stages, it is recognised that in reality decision-making will often jump backwards and forwards between stages. The stages are summarised in **Figure 3-2**.

The stages focused on in the adaptation plan are:

- **Stage 4 Assess hazards and risks:** The existing and future hazards and risks associated with sea level rise have been detailed in previous studies and forms the basis of the adaptation plan.
- **Stage 5 Identify options and pathways:** Various options were explored through review of options outlined in previous studies and plans, and review of climate adaptation in other locations. Through collaboration with stakeholder a preferred approach was identified. Flood behaviour and civil design aspects of the preferred approach were also assessed. Pathways were explored through assessing potential methods of staging of works to manage impacts associated with the works and to identify opportunities for infrastructure works to be undertaken as funding becomes available.
- **Stage 6 Establish Triggers:** A preliminary assessment of triggers was undertaken through the identification of regular inundation of properties and assets. This assessment effectively made assumptions regarding when an area was no longer liveable due to sea level rise. This was assessed over a period of 80 years (2020 to 2100).

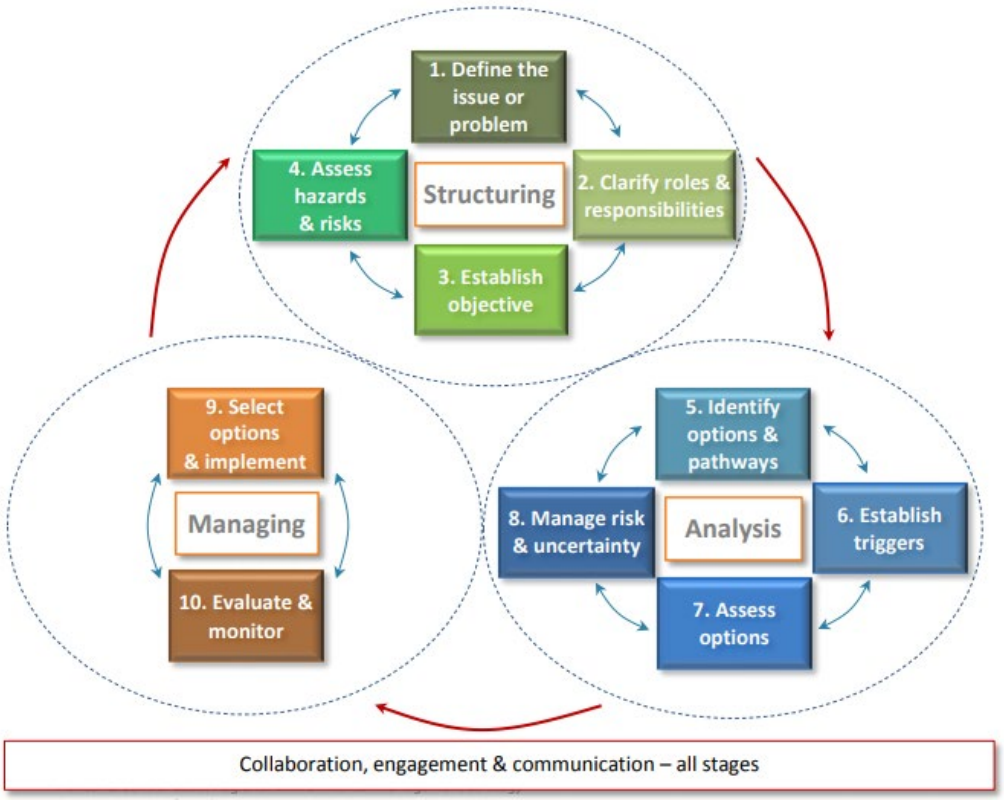


Figure 3-2 Stages in the adaptation decision making process (HCCREMS, 2012)

3.2 Climate Change Adaptation - Concept Designs

3.2.1 Concept Landform and Drainage Plan

The Gosford DCP 2013 requires all floor levels of residential buildings to be above the Flood Planning Level (FPL). To assist in achieving this level, filling of individual properties is permitted by the FRMP (2015) where it does not impact on active flow areas in the stream networks feeding Brisbane Water. Filling operations must include adequate provision for drainage of surface water erosion and siltation control and be so placed and graded as to prevent the shedding of surface water directly to adjoining properties.

The flood planning level for Davistown and Empire Bay as a result of Brisbane Water Estuary flooding varies slightly depending on location but is approximately 2.2 m AHD (comprised of 1% AEP level + 0.5m freeboard + a Sea Level Rise component commensurate to the asset life). There is currently very little direction in Council's DCP with regards to filling properties in the floodplain, the fill level, and how filling of properties can be undertaken to minimise the long-term impacts on local drainage.

The *Brisbane Water Foreshore Floodplain Risk Management Study* (2015) assessed options to address flood risk that included broadscale filling of Davistown and Empire Bay (Option FM9). However, it was found that master planning, consultation and effective staging, were required to establish whether filling would be feasible on a regional scale. Further the *Brisbane Water Foreshore Floodplain Risk Management Study (2015)* suggested that planning controls could consider longer term management strategies such as incremental filling. The *Brisbane Water Foreshore Floodplain Risk Management Study (2015)* noted that the potential change in flood hazard (i.e. from low to high hazard) as a result of climate change would need to be considered in any filling strategy (i.e. partial filling of the areas could result in flood island surrounded by high hazard flooding in the future).

The initial step in investigating fill options was to identify an appropriate level of protection. Based on existing flood studies and predicted rates of sea level rise, it was determined that a minimum level of 1.5m AHD provides reasonable protection for existing and future risks, namely because:

- The existing 1% AEP flood level is approximately 1.5m AHD, and
- This provides protection from king tides (HHWS) and 1% PoE past 2100.

It should be noted that floor levels would generally be set higher than the ground level affording a greater level of protection than the fill levels proposed, e.g. the Flood Planning Level of flood affected properties under current conditions would be around 2.2 m AHD (1% AEP level + 0.5m freeboard + Sea Level Rise).

The landforms for both Davistown and Empire Bay adopted a minimum grade along roads of 0.3%, which is less than the preferred 0.5%, but within acceptable range for drainage and an increase in the grade of the existing landform in most locations.

Landform features such as drainage easements were incorporated into the concept design to minimise the depth of fill as much as possible, and the manage impacts on flood behaviour on private property.

3.2.1.1 Davistown

A landform concept design was developed for Davistown that provided a minimum level of protection of 1.5mAHD. The minimum levels were primarily location along the foreshore, wetland perimeters, and within Davistown Reserve. The concept design provides an undulating landform providing improved drainage across the suburb.

Davistown Memorial Park's incorporates a 0.3% grade towards the proposed swale. This will assist in reducing minor ponding as a result of rainfall events and the park remaining usable for longer as sea levels rise.

A conceptual pit and pipe system was included to provide drainage in low points along the roadways to achieve the desired drainage outcomes. The proposed pits are located within the roadside swales and are assumed to be grated inlet pits with a 1.2 x 1.2 m opening. During detailed design, the inlet sizes may vary depending on approaching flows in the swales, or potentially be changed to a letterbox style inlet pit as is currently used in Empire Bay.

Design of typical roadside swale sections for longitudinal drainage was provided as part of the concept design. This includes various sizes of swales and some piped drainage to eliminate significant flooding of the roadways during minor local catchment rainfall events.

The proposed landform is shown on **Map G303**.

To achieve the ultimate landform design presented by any of the filling options above, the majority of roads cannot be filled until all adjoining properties have also been filled to allow for access and avoid drainage issues (i.e. if the street is higher than the property, the property will not be able to drain to the street. Depending on Council's approach to policy and planning around property filling, it is likely that in the short term, at least, properties will be filled as Development Applications are lodged for property redevelopment and therefore the staging will be subject to progressive urban renewal.

Although there will likely be trigger points with regards to sea level rise that may expediate property owners need or desire to fill, the reality is that impacts associated with king tides and ocean storm events are likely to increase to a level that causes access issues and property damage before the final landform is achieved.

In Empire Bay, this is likely to be less of an issue due to the smaller number of properties and the fact that 'key locations' could be targeted by Council for voluntary or compulsory acquisition to allow for landform completion.

In Davistown an interim measure may be required if property filling does not progress sufficiently in time to provide adequate protection from sea level rise. A foreshore barrier has been identified as a potential option for this purpose.

The preliminary concept design of the foreshore barrier includes:

- Achieving a barrier for the majority of Davistown at 1.5m AHD
- Retrofitting existing drainage pipes which discharge from behind the barrier to Brisbane Water with non-return valves or flap gates
- Integrating a foreshore cycle / pathway along the existing foreshore reserve
- Integrating with ground levels already at or above 1.5m AHD to reduce the length of constructed barrier
- Incorporating 'walls' in locations that do not allow for a battered slope
- Utilising the barrier to protect wetlands from the impacts of sea level rise (i.e. restricting flows through the barrier to replicate existing tidal flows into the future).

Once the final landform is complete, the foreshore barrier would no longer be higher than the adjoining ground levels.

The use of foreshore barriers to manage existing flood risks from Brisbane Water flooding was assessed in the FRMS. The configuration of the preferred foreshore barrier at Davistown (**Section 4.2.2**) is compatible with the climate change adaptation approach identified for Davistown.

3.2.1.2 Empire Bay

A landform concept design was developed for Empire Bay that provided a minimum level of protection of 1.5mAHD. The minimum levels were primarily location along the foreshore, wetland perimeters, and within a proposed drainage reserve (further details on this are below). The concept design provides an undulating landform providing improved drainage across the suburb.

The concept landform design proposes the introduction of a drainage reserve between, and aligned perpendicular to, Myrtle Road and Kendall Road to allow for drainage improvements both immediately and into the future.

It is proposed to raise Rickard Road to create a ridge in the landform where runoff is split between flowing south to the proposed channel and north to the existing drainage points to Brisbane Water.

A conceptual pit and pipe system was included to provide drainage in low points along the roadways to achieve the desired drainage outcomes. The proposed pits are located within the roadside swales and are assumed to be grated inlet pits with a 1.2 x 1.2 m opening. During detailed design, the inlet sizes may vary depending on approaching flows in the swales, or potentially be changed to a letterbox style inlet pit as is currently used in this area.

Design of typical roadside swale sections for longitudinal drainage was provided as part of the concept design. This includes various sizes of swales and some piped drainage to eliminate significant flooding of the roadways during minor local catchment rainfall events.

The proposed landform is shown on **Map G304**.

The most significant change to the landform of Empire Bay is the introduction of a drainage reserve crossing all of Echuca Road, Greenfield Road and Kendall Road. The total length is approximately 360 m and a set of three 3.7m wide x 0.6m high reinforced concrete box culverts are proposed beneath the aforementioned roadways. The proposed channel is essentially a rectangular section with an invert at 0.9 m AHD for the purposes of modelling; however, the final form is flexible and may range from a swale set in public open space, a buried culvert, or a full width channel. This is largely dependent on Council's and the community's preference and what can hydraulically convey the flows east to Brisbane Water. Whichever form the channel eventually takes, a degree of property acquisition will be necessary to create the drainage easement.

It is noted that hard drainage structures such as box culverts will not provide opportunity for water quality measures or activity corridors. The inclusion of open space in the corridor will allow for scope for maintenance access, water quality improvement, and recreation. Should this measure be considered to proceed to a feasibility study and potential funding from DPIE alternate options (Cost Effectiveness Analysis) will be considered with the community and other strategies.

This feature was introduced to 'cut off' the high energy flows approaching from the steep slopes to the south. In previous landform design iterations, these high flows resulted in runoff not being able to be contained to the roadways in the 1% AEP without the introduction of large lengths of cost prohibitive culverts which may also be susceptible to blockage.

In addition to the ability to convey runoff to the receiving waters, the channel is also able to lower the surrounding road and property fill depths because it relies on hydraulic head and not gradient to discharge water to the east.

It should be noted from a staging point of view; it would be essential to construct the proposed channel / drainage easement prior to raising of the adjacent properties and roadways.

3.2.2 Drainage

For Davistown and Empire Bay, the proposed landform addresses many of the existing drainage issues within the study areas. Refer to the attached set of drawings for a contoured plan of the Davistown and Empire Bay landforms and sections showing typical street drainage.

In Davistown, trapped low points are removed and roads are raised to provide positive drainage gradients along roadways. The regrading of lots above the roadways will also eliminate the potential for isolated ponding areas within private properties.

The drainage outcomes for both study areas achieve:

- Flood free private properties in all events equal to or less than the 1% AEP,
- A minor drainage system to convey runoff in roadside swales and drains in all event equal to or less than the 20% AEP, and
- Swales have been designed to keep the velocity-depth product below 0.3m/s.

Potential flooding issues were identified from the increasing of flood depths on properties adjacent to those which have raised ground levels. A preliminary analysis of the impacts of property filling was undertaken as part of the FRMS. The outcomes were used to inform recommendations regarding planning controls (**Section 4.2.3**). This will need to be investigated further as part of detailed design, and as part of individual DA submissions for larger developments, or developments located in key locations (i.e. locations where filling is more likely to impact flood levels on adjoining properties).

Further investigation into the outlet arrangement for existing drainage which crosses the flood barrier has been undertaken as part of the options analysis for this FRMS.

3.3 Economic Analysis

An economic assessment was undertaken on the proposed landform and drainage plan for Empire Bay and Davistown to understand the overall economic viability of implementing it. This was undertaken adopting a similar approach to the economic damages assessment undertaken for floodplain risk management options as part of the Draft Davistown and Empire Bay FRMS.

An economic assessment is undertaken by comparing one alternative against another. It is important that these scenarios or alternatives are clearly defined to ensure a robust analysis. Three scenarios have been adopted for this assessment:

1. **Base Case** – this represents the 'Do-Minimum' scenario and represents the base case against which the masterplan options are considered.
2. **Masterplan Scenario** – this scenario incorporates the masterplan (landform and drainage plan), without the proposed levee around Davistown.
3. **Masterplan with the Levee Scenario** – this scenario incorporates the masterplan plus the levee. It is noted that the levee only benefits Davistown, and therefore there is no change to Empire Bay in this scenario, when compared to Scenario 2.

The economic assessment was undertaken by comparing the masterplan scenarios against the base case, for both Davistown and Empire Bay using a discount rate of 7 percent. These results are summarised in **Table 3-1**.

For Davistown, the masterplan with no levee has a BCR of 1.5, with the present value of benefits exceeding the costs. This suggests that the masterplan is economically viable.

The incorporation of the levee provides a significant improvement for Davistown, with the BCR increasing from 1.5 to 1.7. This is a result of the significant reduction in flood damages both now and moving forward throughout the assessment period, which compensates for the increase cost of the levee relative to the masterplan scenario with no levee. It is also noted that the scenario with the levee provides additional benefits, such as flexibility in timing of filling and development of the masterplan levels, which is not incorporated in this analysis.

Empire Bay has a BCR of 0.9, which is still within the NSW Government Guide to Cost Benefit Analysis benchmark of 1.0 being an initiative is potentially worthwhile if the NPV is positive or the BCR is greater than 1.00, suggesting that it is marginally unviable based on the assumptions in this report. However, the incorporation of some of the unquantified benefits may change this outcome.

It is also important to note, the ground levels of the properties as a whole in Empire Bay are higher than those in Davistown. However, there are still a number of low-lying areas. The economic outcome may improve if the masterplan were focused to more of the low-lying properties. However, further testing would be required to confirm this.

Table 3-1 Summary of Economic Results[3]

Davistown				Empire Bay	
Masterplan - no levee		Masterplan - with levee		Masterplan	
NPV	BCR	NPV	BCR	NPV	BCR
$4.95M	1.5	$13.27M	1.7	$-0.41M	0.9

The results suggest that the masterplan is economically viable for Davistown, with a BCR of 1.5 without the levee, and 1.7 with the levee. Empire Bay has a lower BCR of 0.9, which suggests that it is marginal unviable. However, there are a number of unquantified benefits that may change this outcome.

3.4 Implementation Approach

The implementation of the proposed landform and drainage plan needs to consider:

- How to fill private land.
- When roads and public land can be filled, i.e. filling of these areas may not be possible until adjoining private land has been filled to avoid drainage issues on remaining low-lying private land.
- Staging of implementation.
- Establishing triggers and thresholds for action with the community at the earliest time frame possible so as to create a monitoring regime to address the rate of change over time. Triggers and thresholds enable the understanding of how much time is available to implement adaptation. Knowing this in advance of the trigger being reached is critical; the point that the business as usual approach has not

[3] BCR – Benefit Cost Ratio, NPV – Net Present Value

been successful, and the hazard is unacceptable to the community as it will be impractical or uneconomically to maintain essential infrastructure.

It was proposed that the landform and drainage plan be implemented through the following approach:

- Preparation of a detailed Masterplan that develops a detailed design of the proposed landform and also provides property filling design guidelines and other specifications.
- Update of *Gosford Council DCP 2013* (or the Draft Central Coast DCP) to require filling of properties in accordance with this climate change adaptation plan. This would be enforced as part of any significant development application within the study area. This would incrementally raise private property to the final landform levels, allowing Council to then raise roads and other infrastructure.
- Council to look for opportunities to raise roads. This would likely be done as part of road maintenance programs. However, there may also be opportunities to raise key access roads through the state government floodplain risk management process to improve existing emergency response access during Brisbane Water flood events. **Section 4.2.1.4** provides details on locations where existing flooding is an issue at the locations identified for road raising in the interim scenario for the climate change adaptation landform.
- Council to implement the foreshore barrier / access path as soon as practical. This would likely be as funds become available. Funds could be secured through the NSW Government Floodplain Management Grants as a result of the findings of this FRMP (see **Section 4.2.2** for further details).
- Implementation of selected aspects of the landform and drainage plan that address existing flood risk. This FRMP recommends the implementation of:
    - A drainage easement between Myrtle Road and Kendall Road (FM EB5)
    - A foreshore barrier at Davistown (FM DT1)
- Raising of infrastructure, including roads as completion of adjoining property filling allows.

4 Floodplain Risk Management

4.1 Floodplain Risk Management Options

Flood risk is a combination of the likelihood of occurrence of a flood event and the consequences of that event when it occurs. It is the human interaction with a flood that results in a flood risk to the community. This risk will vary with the frequency of exposure to this hazard, the severity of the hazard, and the vulnerability of the community and its supporting infrastructure to the hazard. Understanding this interaction can inform decisions on which treatments to use in managing flood risk.

As defined in the *Australian Disaster Resilience Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR, 2017), there are three types of flood risk:

- Existing flood risk – the risk associated with current development in the floodplain. Knowing the likelihood and consequences of various scales of floods can assist with decisions on whether to treat this risk and, if so, how
- Future flood risk – the risk associated with any new development of the floodplain. Knowing the likelihood and consequences of flooding can inform decisions on where not to develop and where and how to develop the floodplain to ensure risks to new development and its occupants are acceptable. This information can feed into strategic land-use planning
- Residual flood risk – the risk remaining in both existing and future development areas after management measures, such as works and land-use planning and development controls, are implemented. This is the risk from rarer floods like the PMF, which may exceed the management measures. Residual risk can vary significantly within and between floodplains. Emergency management and recovery planning, supported by systems and infrastructure, can assist to reduce residual risk

The alternate approaches to managing risk are outlined in **Table 4-1**.

Table 4-1 Flood Risk Management Alternatives

Alternative	Examples
Preventing/avoiding risk	Appropriate development within the flood extent (i.e. development commensurate to the flood risk)
Reducing the likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention
Reducing the consequences of risk	Development controls to ensure structures are built to withstand flooding
Transferring risk	Via insurance – may be applicable in some areas depending on insurer
Financing risk	Natural disaster funding
Accepting risk	Accepting the risk of flooding because of having the structure where it is located

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. There are three broad categories of management:

- Flood modification measures – options aimed at preventing/avoiding or reducing the likelihood of flood risks through modification of flood behaviour in the catchment
- Property modification measures – options focused on preventing/avoiding or reducing the consequences of flood risks. Rather than necessarily modify flood behaviour, these options aim to

modify existing properties (e.g. by house raising) and/or impose controls on property and infrastructure development to modify future properties. Property modification measures, such as effective land use planning and development controls for future properties, are essential for ensuring that future flood damages are appropriately contained, while at the same time allowing ongoing development and use of the floodplain

- Emergency response modification measures – options focused on reducing the consequences of flood risks, by generally aiming to modify the behaviour of people during a flood event.

A comprehensive range of possible flood risk management measures for Davistown and Empire Bay were examined, as part of the Floodplain Risk Management Study (2020a). The identified measures were a product of an extensive investigation of the flood risks in the study area, which considered:

- Outcomes of all previous flood studies undertaken in the study area (referenced in **Section 0**);
- Flood hazard and emergency response mapping, and economic damages assessments undertaken as part of the FRMS; and
- Inputs obtained through workshops with stakeholders and community engagement activities.

The identified measures were than evaluated with the use of a Multi-Criteria Assessment (MCA) approach, which enabled the comparative assessment of all options based on their economic, social, and environmental aspects, as well as on their effectiveness in mitigating flood risk. Flood modelling and flood damages analysis were also undertaken as part of the evaluation process and provided key inputs for the Multi-criteria assessment.

As an outcome of this assessment, the options that were identified as being the most advantageous have been recommended as part of this FRMP and are further discussed in **Section 4.2**.

A summary of all the flood risk management options that were assessed for Davistown and Empire Bay is provided in **Appendix A.** This appendix presents a brief description of each option, the flooding issues they aim to address and how the options were identified.

4.2 Recommended Flood Risk Management Measures

Taking into consideration the assessment described in **Section 4.1**, a range of flood risk management measures are recommended as part of this FRMP. These measures are shown on **Maps G305 and G306** (where a location is relevant).

The recommended measures are presented in **Sections 4.2.1 to 4.2.4**, according with the type of flood risk they primarily address (catchment flood, storm surge flood and tidal flood). For each floodplain risk management measure, the following general information has been provided:

- Description
- Associated costs (implementation and maintenance)
- Agency responsible for implementation

Table 4-2 summarises all recommended measures:

Table 4-2 Recommended Floodplain Risk Management Measures

Primary Type of flood Risk Addressed	Option ID	Option Name	Reference Section
Catchment Flood Risk (Section 4.2.1)	FM EB5	Drainage Easement (Myrtle Road to Kendall Road)	**Section 4.2.1.1**
	FM EB1 & FM EB6	Pomona Road Easement and Drainage Upgrades	**Section 4.2.1.2**
	PM01	Flood Planning Recommendations	**Section 4.2.1.3**
	EM03	Provide Data to Inform Future Road Drainage Improvements – Empire Bay Drive and Other Flood Affected Roads	**Section 4.2.1.4**
Brisbane Water Flood Risk (Section 4.2.2)	FM DT1	Davistown foreshore barrier	**Section 4.2.2.1**
	FM EB4	Empire Bay foreshore barrier	**Section 4.2.2.2**
	EM01	Review of evacuation centres	**Section 4.2.2.3**
	FM EB2	Seawall construction guidelines	**Section 4.2.2.44.2.3.1**
Tidal Flood Risk (Section 4.2.3)	CCA-01	Advance the development of a Davistown and Empire Bay Climate Change Adaptation Strategy and Masterplan	**Section 4.2.3.1**
	-CCA-02	Provide Information to assist in the implementation of the Davistown and Empire Bay Climate Change Adaptation Strategy and Masterplan	**Section 4.2.3.2**
Measures Applicable to All mechanisms of Flooding (Section 4.2.4)	EM06 & PM04	Flood education programs	**Section 4.2.4.1**
	EM04	Flood warning systems.	**Section 4.2.4.2**

4.2.1 Catchment Flood Risk Management

Catchment flooding occurs as a result of intense rainfall on the catchment. The flood behaviour is generally characterised by short duration shallow flooding. However, numerous roads can be impacted, and private property flooding can result in significant garden damage and in some cases over floor flooding. Further details are provided in **Section 2.2.3**.

The FRMS identified that there are only limited opportunities to undertake works in the floodplain to manage flooding. Drainage improvements are limited due to the flat terrain and “backing up” water from Brisbane Water. Additionally, the cost and other impacts of implementing works is not often commensurate with the small reduction in flood risk associated with the work.

Table 4-3 summarises the management measures that were found in the FRMS to be beneficial in a program of flood risk management.

Table 4-3 Recommended Measures – Catchment Flood Risk

Option ID	Option Name	Reference Section
FM EB5	Drainage Easement (Myrtle Road to Kendall Road)	**Section 4.2.1.1**
FM EB1 & FM EB6	Pomona Road Easement and Drainage Upgrades	**Section 4.2.1.2**
PM01	Flood Planning Recommendations	**Section 4.2.1.3**
EM03	Provide Data to Inform Future Road Drainage Improvements – Empire Bay Drive and Other Flood Affected Roads	**Section 4.2.1.4**

It is also recognised that the proposed climate change adaptation landform and drainage upgrades would result in a more efficient drainage system once completed. The further development of the climate change adaptation strategy is a key recommendation of this FRMP (see **Section 4.2.3.1**), initial works such as the drainage easement between Myrtle Road and Kendall Road (**FM EB5**) are critical to the proposed adaptation landform, and also provide for immediate flood benefits through improved drainage.

Details of each of these recommendations are provided in the management summaries presented in **Section 4.2.1.1** to **4.2.1.4**.

4.2.1.1 FM EB5 - Drainage Easement (Myrtle Road to Kendall Road)

<table>
<tr><th colspan="3">Drainage Easement (Myrtle Road to Kendall Road)</th></tr>
<tr><td colspan="2">Flood Management Type: Flood Modification (ID: FM EB5)</td><td>Responsibility: Council</td></tr>
<tr><td colspan="2">Type of flood Risk: Catchment flood</td><td rowspan="2">Associated Costs:</td><td>Initial Cost: $6,481,400</td></tr>
<tr><td colspan="2">MCA Ranking: #3</td><td>Recurrent Cost: $4,000 p/year</td></tr>
<tr><td colspan="4">Overview:
The proposed works involve a drainage easement from Myrtle Road to Kendall Road including a grassed swale or natural channel to direct the flows coming from the south of the swale to the wetlands on the eastern side of Empire Bay.
The proposed easement provides flood management under existing conditions (by diverting stormwater through this constructed low point) and is also a key feature of the proposed landform adaptation plan to adapt to impacts of sea level rise in the future.</td></tr>
<tr><td colspan="2">Flooding issue addressed by the recommendation:
During rainfall events excessive ponding can occur in Myrtle, Echuca and Greenfield Roads and adjacent properties. This issue is primarily caused by the significant amount of water that flows from the upper catchment areas (Empire Bay Drive and Rosella Road) and then suddenly slows down when it arrives at the flat grade around the affected area.
These flows also contribute to flooding across properties and roads to the north of and including Rickard Road.</td><td colspan="2">Location:
The easement would be situated between Myrtle Road and the wetlands to the east, crossing Echuca Road, Greenfield Road and Kendall Road.
The easement would cover the area that is currently occupied by residential lots.
The location of the proposed works is illustrated by Map G307.</td></tr>
<tr><td colspan="2">Expected Mitigation Outcomes:
The results from the flood modelling show that the implementation of the drainage channel would lead to a small reduction in flood depths (on average 0.05m). However, the benefits were widespread; reaching as far north of the easement as Sorrento Road and Gordon Road.</td><td colspan="2">Considerations:
• These works will likely require property acquisitions, this would need to be done through consultation with relevant property owners.
• The alignment and width of the easement can be altered to accommodate property acquisitions, and design objectives (e.g. a wider easement would allow for multi-use open space and pathways but would require more property acquisition).
• Ultimate design would need to consider long term maintenance, access, water quality buffer zones, and foundation stability of adjacent proprieties.
• Cost Effectiveness Analysis against alternative options would be considered during the feasibility phase.</td></tr>
</table>

4.2.1.2 FM EB1 & FM EB6 - Pomona Road Easement and Drainage Upgrades

<table>
<tr><th colspan="3">Pomona Road Easement and Drainage Upgrades</th></tr>
<tr><td colspan="2">Flood Management Type: Flood Modification (ID: FM EB1 & FM EB6)</td><td>Responsibility: Council</td></tr>
<tr><td colspan="2">Type of flood Risk: Catchment flood</td><td rowspan="2">Associated Costs:</td><td>Initial Cost: $371,400</td></tr>
<tr><td colspan="2">MCA Ranking: #13</td><td>Recurrent Cost: $5,000 p/year</td></tr>
<tr><td colspan="4">Overview:
This recommendation proposes an open grassed channel (or similar landscaped easement) connected to the existing natural watercourse to the north of Pomona Road. This drainage design would be located within the existing 20m wide Council easement.
The drainage works within the easement would be designed to direct the runoff coming from the South-East of Pomona Road to the watercourse and, subsequently to the culvert under Empire Bay Drive. This requires some excavation to allow for appropriate grade along the easement to achieve these flow diversions.
The proposed works also comprises:
• Upgrades in the capacity of the culverts under Pomona Road, to maximize the volume of runoff that is directed to the swale.
• Implementation of retaining walls (approximately 0.5 m high), positioned in two sections of the channel, where the existing terrain elevations are particularly low. These retaining walls would restrict flows from overtopping the left channel bank. It is proposed that the retaining walls be executed as grassed embankments or ‘natural looking’ rock walls, which would not negatively impact the existing landscape.</td></tr>
<tr><td colspan="2">Flooding issue addressed:
The flows from the higher terrain on the south-east portion of the Empire Bay catchment impacts a large area extending from the properties on the eastern end of Pomona Road to the wetlands to the north-east of Palmers Lane. The flooding affects key infrastructure such as Empire Bay Drive, which is an important evacuation route, and vulnerable areas such as the caravan park on Pomona Road.
The proposed works seek to divert a considerable volume of these flow to the existing creek, through the use of an existing drainage easement on the north side of Pomona Road.</td><td colspan="2">Location:
The easement proposed would be situated on Pomona Road, to the east of the Caravan Park. The easement would extend from Pomona Road to the natural watercourse in the north.
The location of the proposed works is illustrated by Map 308.</td></tr>
<tr><td colspan="2">Expected Mitigation Outcomes:
The results from the FRMS flood modelling show that, in all the evaluated scenarios, the flood depths and extents to the west of the proposed drainage easement would be significantly reduced (up to 0.3m). A decrease in flood depths was also observed in the properties along Palmers Lane and a section of Empire Bay Drive.</td><td colspan="2">Considerations:
• Based on the results of the detailed assessment, redirecting the flows coming from the south-east to the culvert under Empire Bay Drive may lead to a minor increase in flood depths in the properties located downstream of this structure. Flooding was also seen to increase in the properties in the corner of Allawa Close and</td></tr>
</table>

Pomona Road Easement and Drainage Upgrades	
In the 1% AEP a considerable portion of the lots to the west of Pomona Road and to the North of Wards Hill Road would no longer be flooded. Additionally, in this flood event, the hazard classification in the Pomona Road Caravan Park would be significantly reduced. With the implementation of the easement, the majority of the areas that are currently classified as H2 and H3 in this location, would be categorized as H1.	Palmers Lane and the rural properties and wetlands north of Allawa Close. • Removal of some existing trees may be necessary to maximise channel capacity. • The feasibility of the proposed works may be limited by the fact that Council would need to negotiate the use of private land at the northern end of the easement. The costs associated with this land use have not been considered in the costing of this option.

4.2.1.3 PM01 - Flood Planning Recommendations

Flood Planning Recommendations			
Flood Management Type: Property Modification (ID: PM01)		**Responsibility: Council**	
Type of flood Risk: Catchment Flooding		**Associated Costs:**	**Initial Cost:** -
MCA Ranking: #4			**Recurrent Cost:** -
Overview: Council's existing land use planning controls were reviewed in the FRMS. As an outcome of this review a series of recommendations have been made to assist Council in achieving best practice flood planning in the Davistown and Empire Bay catchments and across the LGA. The recommendations made below relate to local catchment flooding.			
Flood Planning Recommendations			
Issue		**Recommendation**	
1	The FRMS investigated the appropriate definition of the Flood Planning Area and the Flood Planning Level.	It is recommended that the Flood Planning Area (FPA) within the Davistown and Empire Bay Catchments is defined as **1% AEP extent including 30% increase in rainfall**. The FPA is shown on **Maps G312 and G313.** It is recommended that the Flood Planning Level (FPL) within the Davistown and Empire Bay Catchments is defined a **1% AEP level + 500mm freeboard**. This would be applied only where this level is higher than the Brisbane Water FPL.	
2	Existing flood planning does not consider Flood Planning Constraint Categories (*Australian Disaster Resilience Guideline 7-5 Flood Information to Support Land-use Planning, AIDR 2017*).	The Flood Planning Constrain Categories (FPCC) have been mapped using the outputs of the Flood Studies (2010) and FRMS (2020a) in **Maps G314 and G315**. These categories can assist Council in making planning decisions in the floodplain. Council may want to consider referencing FPCC in future updates to the DCP.	
3	Clause 7.2 in the GLEP 2014 defines the Flood Planning Area as the area below the Flood Planning Level. No further definition of the Flood Planning Level is provided in this clause. This provides some scope for the Flood Planning Level to be defined for each floodplain within the relevant Floodplain Risk Management Plan. However, Clause 7.3 in the GLEP 2014 indirectly defines the Flood Planning Level to be 1% AEP plus 500mm. This planning level may not be appropriate for	It is recommended that the Council provide scope within their LEP to allow for the Flood Planning Level (FPL) and the Flood Planning Area (FPA) to be defined for each floodplain within the relevant Floodplain Risk Management Plan. Further, it is recommended that the wording in the LEP allows for the FPA to be defined as other than the land below the FPL. As this is not consistent with the recommendations in this FRMP.	

Flood Planning Recommendations		
	all floodplains, especially where flooding is dominated by shallow overland flow, such as Davistown and Empire Bay. Discussion on selection of an appropriate Flood Planning Area and Flood Planning Level are provided in the FRMS).	
4	The Department of Planning, Industry and Environment (DPIE) has been working to update the Flood Prone Land Package which provides advice to councils on considering flooding in land use planning.	Council's future revision of the LEP, DCP and Planning Certificates should consider the outcomes of the Flood Prone Land Package once it is finalised.
5	The DCP makes reference to the Flood Planning Area being land below the 1% AEP + 500mm (clause 6.7.7.6.4) rather than being defined for each floodplain within the relevant Floodplain Risk Management Plan.	It is recommended that the Council provide scope within their DCP to allow for the Flood Planning Level (FPL) and the Flood Planning Area (FPA) to be defined for each floodplain within the relevant Floodplain Risk Management Plan. Further, it is recommended that the wording in the DCP allows for the FPA to be defined as other than the land below the FPL. As this is not consistent with the recommendations in this FRMP.
6	Floor levels for *Group homes, seniors housing, and emergency facilities* are set at the PMF. However, there may be situations where the PMF is lower than the FPL.	Sensitive, vulnerable, or critical use developments that require floor levels to be set at the PMF should be updated to include all sensitive, vulnerable, or critical uses defined in the Flood Prone Land Package.
		Floor levels for sensitive, vulnerable, or critical uses should be set at the higher of the PMF and FPL. The FPL is higher than the PMF in almost all locations within the study area (for catchment flooding).
7	The flood related planning controls applicable in Davistown and Empire Bay, can be confusing due to the range flood risks present. Compiling all relevant controls into a simple format, would assist developer and property owners comply with the required controls.	A draft Floodplain Risk Planning Matrix template has been provided in **Appendix B**. This would need to be completed and adopted following completion of the FRMP.

4.2.1.4 EM03 - Provide Data to Inform Future Road Drainage Improvements Empire Bay Drive and Other Flood Affected Roads

<table>
<tr><th colspan="3">Provide Data to Inform Future Road Drainage Improvements –
Empire Bay Drive and Other Flood Affected Roads</th></tr>
<tr><td colspan="2">Flood Management Type: Emergency Response Modification (ID: EM03).</td><td>Responsibility: Council</td></tr>
<tr><td colspan="2">Type of flood Risk: Catchment flood</td><td rowspan="2">Associated Costs:</td><td>Initial Cost: -</td></tr>
<tr><td colspan="2">MCA Ranking: #14</td><td>Recurrent Cost: -</td></tr>
<tr><td colspan="4">Overview:
As part of the analysis undertaken in FRMSP, valuable information has been produced on the flooding impacting Empire Bay Drive and other key access routes in the study areas.
Whilst the analyses undertaken in the FRMS did not recommend specific flood mitigation works for road improvements, the information on flood affected roads should be used to inform Council decisions on asset upgrades and road maintenance.
Key access routes that are subjected to high hazard (larger than H2) in the PMF flood event are identified in Maps G301 and G203. These locations should be considered high priority for road upgrades which could provide road raising or improved drainage.
It should be noted that road raising may not be appropriate in some of the identified locations. Due to the flat terrain, raising the roads might direct the runoff into private properties, worsening the flood conditions at these locations. Where road raising is not a viable option, regrading of crossroad grades or improving road drainage might be better suited.
The Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b) recommended road raising for specific road sections, as part of the landform interim scenario. Based on the assessment undertaken on the adaptation study, these locations should be able to be raised without making flooding worse for adjoining properties.
Among the high hazard road locations identified in this option (shown on Maps G301 and G203), the following roads were recommended for road raising in the interim landform scenario proposed by the adaptation study:
• Kincumber Crescent, Davistown
• Shelly Beach Road, Empire Bay
As stated above, this FRMP does not recommend any specific modification works for the identified high hazard locations. The purpose of this option is to provide information to assist council in assessing and prioritizing future infrastructure upgrade/maintenance projects.
It is also recommended that additional drainage assessments should be undertaken at locations along Empire Bay Drive where overtopping of the road has been identified (see Maps G301 and G203). The flood model is of a regional nature and may not be suitably representing the drainage and road design at these locations, as such the overtopping may not be likely, or may be worse than indicated. Empire Bay Drive is a critical access road for the area and any flooding of the road up to the PMF should be managed.</td></tr>
<tr><td colspan="2">Flooding issue addressed:
High hazard flooding (higher than H2) on access routes in Davistown and Empire Bay, which could compromise safe access during and after major flood events.</td><td colspan="2">Location:
Key access routes that are subjected to high hazard (larger than H2) in the PMF flood</td></tr>
</table>

<table>
<tr><th colspan="2">Provide Data to Inform Future Road Drainage Improvements –
Empire Bay Drive and Other Flood Affected Roads</th></tr>
<tr><td>Any flooding in Empire Bay Drive is of concern, as this the main access route in and out of Empire Bay.</td><td>event are identified in Maps G301 and G203.

All locations where flooding of Empire Bay Drive is greater than 0.3m in the PMF have also been shown on these maps.</td></tr>
<tr><td>Expected Mitigation Outcomes:

It is expected that Council will consider the outcomes of this FRMSP when assessing future infrastructure upgrade/maintenance projects and that works in flood affected access routes will be prioritised.

Additionally, Council will be able to incorporate flood immunity improvements as design requirements for future works in these roads.</td><td>Considerations:

• No specific modification works are proposed in Empire Bay Drive or other flood affected roads in the study area. The aim of this measure is to guarantee the information produced in this FRMSP is considered in any future road management works/upgrades carried out by Council.
• The Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b) recommends raising specific road sections as part of the interim landform scenario for Davistown and Empire Bay. Kincumber Crescent and Shelly Bach Road are among the roads identified as being suitable for road raising. For the other road sections identified in this option, alternatives to road raising might need to be considered, as road raising could adversely affect flooding on private property.
• Most of flood affected sections of Empire Bay Drive correspond with a culvert crossing or are located immediately next to a crossing. Therefore, drainage investigations should be undertaken to confirm the capacity of these culverts and upgrades should be considered utilising the design flows from the Flood Study (2010).
• The section of Empire Bay Drive immediately east of Palmers Lane (EB 09) is the section that is most critically affected. Detailed drainage investigations should be undertaken at this location to identify if culverts could be provided to carry flow under the road, rather than overtopping.</td></tr>
</table>

4.2.2 Brisbane Water Flood Risk Management

Ocean storm surge events result in the elevation of the Brisbane Water Estuary levels and can lead to flooding of the low-lying areas of Davistown and Empire Bay. The flood levels impact low lying areas first and will tend to rise over a period of 6 hours (with the incoming tide). In a 1% AEP event the majority of Davistown is inundated, and a large portion of Empire Bay. In this flood event, a total of 203 properties would be impacted by over floor flooding in Davistown and a total of 47 in Empire Bay. Further details are provided in **Section 2.2.2**.

Flood mitigation options to address Brisbane Water flooding were assessed as part of the Brisbane Water Floodplain Risk Management Study (Cardno, 2015). However, recommendations for Davistown and Empire Bay were limited, and several options required consideration of local catchment flooding before recommendations could be made.

The options assessment undertaken in the Davistown and Empire Bay FRMS (2020a) reviewed options previously identified in the Brisbane Water FRMS (2015). The outcome was the recommendation of the following flood management measures summarised in **Table 4-4**.

Table 4-4 Recommended Measures – Brisbane Water Flood Risk

Option ID	Option Name	Reference Section
FM DT1	Davistown foreshore barrier	**Section 4.2.2.1**
FM EB4	Empire Bay foreshore barrier	**Section 4.2.2.2**
EM01	Review of evacuation centres	**Section 4.2.2.3**
FM EB2	Seawall construction guidelines	**Section 4.2.2.4**

Details of each of these recommendations are provided in the management summaries presented in **Section 4.2.2.1** to **4.2.2.4**

4.2.2.1 FM DT1 - Davistown Foreshore Barrier

<table>
<tr><th colspan="3">Davistown Foreshore Barrier</th></tr>
<tr><td colspan="2">Flood Management Type: Flood Modification (ID: FM DT1)</td><td>Responsibility: Council</td></tr>
<tr><td colspan="2">Type of flood Risk: Ocean Flooding (Storm induced)</td><td rowspan="2">Associated Costs:</td><td>Initial Cost: $12,343,000</td></tr>
<tr><td colspan="2">MCA Ranking: #1</td><td>Recurrent Cost: $15,000 p/year</td></tr>
<tr><td colspan="4">Overview:
This recommendation includes the construction of a foreshore barrier around Davistown, which would offer protection against ocean flooding from the Brisbane Water. The barrier crest would be set at 1.5m AHD, which corresponds to the existing 1% AEP Brisbane Water flood level and the 1% PoE in 2100.
Most properties of Davistown would be protected by the barrier, with the exception of properties on the peninsula east of Magnolia Ave and the southern side of Morton Crescent.
The foreshore barrier would be comprised of various components, utilising the existing topography and infrastructure, where possible:
• Shared pathway along foreshore reserve areas
• Existing ground levels, where these already exceed 1.5mAHD
• Roadways
• Retaining walls along private property boundaries.
The foreshore barrier design has been developed to balance the cost of the structure against flood protection, while also minimising disturbance on natural ecosystems. For this reason, the foreshore barrier has not been proposed to extend around the most eastern portion of Davistown. There are relatively fewer properties per metre length of the foreshore barrier, and the large areas of tidal wetlands, as such extending the foreshore barrier to protect these additional properties, would result in several cost and feasibility challenges.
Levees were investigated for Davistown as part of the Brisbane Water FRMS (2015), the FRMS (2015) identified that a levee could impact on catchment flooding. However, the regional nature of the study did not allow for detailed analysis of this issue. This particular issue has been explored further in this current study through the hydraulic modelling outlined in the FRMS (2020a) and the preliminary consideration of design features such as one way valves on stormwater outlets.
The foreshore barrier has been further designed and evaluated to the one proposed in the Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b), outlined in Section 3. In the Climate Change Adaptation Study, the foreshore barrier would be included as part of an interim scenario, providing additional flood protection while the landform adaptation plan is implemented.
Two other foreshore barrier options were analysed as part of the FRMS. One option covered all properties in Davistown (FM DT2) and the other covered the same extents as FM DT1, but offered protection only up to the 5% AEP flood event (FM DT3). These options are summarised in Appendix A. However, as an outcome of the Multi-Criteria Assessment, option FM DT1 was identified as the most advantageous in managing flood risk, primarily because it resulted in a better cost-benefit ratio; minimal works in private properties and less associated environmental/social impacts.</td></tr>
<tr><td colspan="2">Flooding issue addressed:
Flooding as a result of storm surge events contribute the most significant types of flooding for the majority of Davistown. This type of flooding is expected to increase in severity and frequency as a result of climate change. The</td><td colspan="2">Location:
The location of the proposed works is illustrated by Map G309.</td></tr>
</table>

proposed foreshore barrier would protect the majority of Davistown from elevated water levels in Brisbane Water up to 1.5mAHD.	
Expected Mitigation Outcomes: The barrier would offer protection against flooding up to the 1% AEP Brisbane Water flood level. The foreshore barrier would also provide protection from tidal inundation for predicted sea level rise.	**Considerations:** • Minor retaining wall works might need to be carried out on private land. • There is potential for altering flood regime within wetlands upstream of the barrier. Flood gate sizing should be designed to mitigate this. • Preliminary analysis of drainage requirements through the levee have been undertaken to show the feasibility of the design. Further drainage design of outlets (i.e. one way valves) would be undertaken as part of the detailed design of the foreshore barrier. • This flood risk management option has been recommended in this FRMP due to its effectiveness in managing existing flood risk. However, the recommended works will have the added benefit of assisting in the staged implementation of the future Climate Change Adaptation Masterplan.

4.2.2.2 FM EB4 - Empire Bay Foreshore Barrier

<table>
<tr><th colspan="3">Empire Bay Foreshore Barrier</th></tr>
<tr><td colspan="2">Flood Management Type: Flood Modification (ID: FM EB4)</td><td>Responsibility: Council</td></tr>
<tr><td colspan="2">Type of flood Risk: Ocean Flooding (Storm induced)</td><td rowspan="2">Associated Costs:</td><td>Initial Cost: $ $4,554,000</td></tr>
<tr><td colspan="2">MCA Ranking: #5</td><td>Recurrent Cost: $15,000 p/year</td></tr>
<tr><td colspan="4">Overview:
The proposed works consist of a foreshore barrier around Empire Bay similar to the one proposed for Davistown. The barrier crest would be set at 1.5m AHD, which corresponds to the existing 1% AEP Brisbane Water flood level and the 1% PoE in 2100.
The foreshore barrier would be comprised of various components, utilising the existing topography and infrastructure, where possible:
• Shared pathway along foreshore reserve areas
• Existing ground levels, where these already exceed 1.5mAHD
• Roadways
• Retaining walls along private property boundaries.
Levees were investigated for Davistown as part of the Brisbane Water FRMS (2015), the FRMS (2015) identified that a levee could impact on catchment flooding. However, the regional nature of the study did not allow for detailed analysis of this issue. This particular issue has been explored further in this current study through the hydraulic modelling outlined in the FRMS (2020) and the preliminary consideration of design features such as one-way valves on stormwater outlets.
The primary difference between this foreshore barrier, and the other Davistown foreshore barrier options is that the Climate Change Adaptation Study (Section 3) did not include a foreshore barrier for Empire Bay.</td></tr>
<tr><td colspan="2">Flooding issue addressed:
Flooding as a result of storm surge events contribute the most significant types of flooding for the low lying areas of Empire Bay. This type of flooding is expected to increase in severity and frequency as a result of climate change.
The proposed foreshore barrier would protect Empire Bay from elevated water levels in Brisbane Water up to 1.5mAHD.</td><td colspan="2">The location of the proposed foreshore barrier is illustrated by Map G310.</td></tr>
<tr><td colspan="2">Expected Mitigation Outcomes:
The barrier would offer protection against flooding up to the 1% AEP Brisbane Water flood level.
The foreshore barrier would also provide protection from tidal inundation for predicted sea level rise.</td><td colspan="2">Considerations:
• The implementation of the foreshore barrier would lead to increased ponding of runoff in a number of private properties upstream of the barrier. The affected properties include houses along Sorrento Road, Shelly Beach Road, Rickard Road and Kendall Road. However, the volume of ponding and flows at these locations would suggest that more detailed design of the drainage infrastructure associated with the foreshore barrier would be able to address these issues.</td></tr>
</table>

Empire Bay Foreshore Barrier	
	• Significant amount of works would need to be carried out on private land, including: retaining walls at back of properties, raising of private seawalls. • The implementation of the foreshore barrier would lead to increased ponding of runoff in a number of private properties upstream of the barrier. In order to mitigate the flooding in these areas it would be necessary to install drainage infrastructure in private land. • This flood risk management option has been recommended in this FRMP due to its effectiveness in managing existing flood risk. However, the recommended works will have the added benefit of assisting in the staged implementation of the future Climate Change Adaptation Masterplan.

4.2.2.3 EM01 - Review of evacuation centres

Review of evacuation centres		
Flood Management Type: Emergency Response Modification (ID: EM01)	**Responsibility: Council and SES**	
Type of flood Risk: Ocean Flooding (Storm induced).	**Associated Costs:**	**Initial Cost:** -
MCA Ranking: #8		**Recurrent Cost:** -

Overview:

Flood-free locations that could function as evacuation centres for Davistown and Empire Bay have been identified below. The list below includes venues identified in the Brisbane Water FRMS (Cardno, 2015) and in the Gosford Local Flood Plan, as well as additional locations identified as part of this FRMSP:

Davistown

- Kincumber and District Neighbourhood centre
- Green Point Community Centre
- Brisbania Public School
- Saratoga Community Hall
- Davistown RSL Club

Davistown/Empire Bay

- Kincumber High School
- Kincumber Public School
- La Salle Youth Camp

Empire Bay

- Ettalong War Memorial Club
- Empire Bay Public School

The identification of the potential evacuation centre locations took into consideration the impact of Brisbane Water flooding and local catchment flooding in Davistown and Empire Bay. Therefore, the effects of local catchment flooding in locations outside the study area was not considered in the analysis and might need to be evaluated prior to the definition of the evacuation entre venues.

The location of the identified venues is shown in **Map G311.** These venues have been identified exclusively from a flood access perspective. Council and the SES should review the venues including the facilities, indoor area available and flood free access to the sites and liaise with the owners and / or managers of the venues to identify appropriate evacuation centres.

Flooding issue addressed:

Evacuation Centres would play a fundamental role in the Emergency Response to a major ocean flooding event in the study areas. In this type of flooding event, dislocating towards an evacuation centre could be the appropriate response option for many residents in Davistown and Empire Bay. The relatively slow rate of rise and fall of the floodwaters would give people enough time to evacuate safely, however it would also result in properties remaining flooded for a longer period, until floodwaters recede.

In catchment flooding events, the flood depths in properties and roads rise rapidly after the start of the rainfall event, allowing for little response time. Therefore, evacuation in this scenario would be a less viable option and would not be recommended for some locations. However, immediately after the event, the evacuation centres could be required for residents who had their properties significantly damaged.

Review of evacuation centres	
Expected Mitigation Outcomes: As an outcome of these recommendations, designated evacuation centres will be defined for Davistown and Empire Bay. Therefore, flood affected residents will have the option to seek shelter in these locations, during and immediately after a major flood event. This would likely be associated with Brisbane Water flooding but could also provide refuge for residents if their properties sustain damage from catchment flooding or other storm impacts such as wind.	**Considerations:** • In Davistown and Empire Bay, evacuation might not be the recommended response during a flood event, depending on the mechanism of flooding. During catchment flooding events, there is typically little response time available and, for some locations, staying at home might be the safest course of action. It is fundamental that residents are aware of the how to respond to the different mechanisms of flooding their local area is subjected to. The Flood Education Measure proposed in this FRMP (**Section 4.2.4**) should address this issue.

4.2.2.4 FM EB2 - Seawall construction and maintenance guidelines

<table>
<tr><th colspan="3">Seawall construction and maintenance guidelines</th></tr>
<tr><td colspan="2">Flood Management Type: Flood Modification (ID: FM EB2)</td><td>Responsibility: Council</td></tr>
<tr><td colspan="2">Type of flood Risk: Ocean Flooding (Storm induced)</td><td rowspan="2">Associated Costs:</td><td>Initial Cost: $10,000</td></tr>
<tr><td colspan="2">MCA Ranking: #12</td><td>Recurrent Cost: -</td></tr>
<tr><td colspan="4">Overview:
Seawalls along private properties can provide protection against flooding from storm surge and extreme tides. However, no clear guidance exists for the local area to assist landowners in maintaining or upgrading seawalls to contribute to this flood protection.
It is recommended that survey be undertaken to identify:
• The existing height and condition of seawalls on private properties and public land.
• The ground level adjoining the seawalls.
This information should be compared against the existing and future (considering sea level rise) Brisbane Water levels. This would identify an appropriate minimum design crest level to be applied in Davistown and Empire Bay. Ideally the crest level would be equal to the proposed foreshore barrier level of 1.5mAHD. However, achieving this height may need to be staged over time. An appropriate crest height (as close to 1.5 mAHD as possible) should be selected that does not provide undue impact on foreshore access, or visual amenity. This would largely be driven by the existing ground levels and access arrangements (e.g. boat ramps).
This crest level should be incorporated into seawall construction and maintenance guidelines along with other specifications relevant to flood protection, such as:
• ‘flood gate’ options for openings in the seawalls e.g. boat ramps
• design considerations to allow for raising of seawall height over time (i.e. to achieve the 1.5 mAHD foreshore barrier height)
• wave run up mitigation design considerations.
The seawall constructions guidelines should also consider the objectives and specifications of the Guidelines for Environmentally Friendly Seawalls (DECCW, 2009a)</td></tr>
<tr><td colspan="4">Flooding issue addressed:
At a minimum improved seawall construction would protect properties from more frequent Brisbane Water flood events, and over the long term as seawall continuity is achieved and crest levels are raised, protection may also be provided against events up to the 1% AEP and extreme tides.</td></tr>
<tr><td colspan="2">Expected Mitigation Outcomes:
It is expected that this measure will result in increased protection against smaller ocean flooding events and wave run-up.
Improvements on the existing seawalls will also result in greater resistance to coastal erosion.</td><td colspan="2">Considerations:
• Flood protection using seawalls is contingent on all seawalls being consistent. Some property owners may not be able to afford to upgrade or maintain their seawalls. Council may look at a merits based grants program to provide assistance for these works.</td></tr>
</table>

4.2.3 Tidal Flood Risk Management (Sea Level Rise)

An adaptation strategy to mitigate the future flood risks associated with tidal inundation was proposed as part of the Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020a), which is summarised in **Section 3**.

The Climate Change Adaptation Study outlines a long-term strategy for landform and drainage improvements to achieve ongoing viability of these areas under sea level rise conditions. It is critical that further analysis and design is undertaken as soon as possible to identify sea level rise triggers (i.e. levels at which actions must be taken to allow enough time to adapt), and adaptation measures (e.g. property filling, drainage works and infrastructure design) are confirmed and design to allow implementation.

Sections 4.2.3.1 and **4.2.3.2** outline the measures recommended as part of this FRMP to assist with the next planning stages of the climate change adaptation process.

Additionally, some of the measures proposed in the climate change adaptation study are also effective in mitigating existing flood risk and, therefore, are recommended as part of this FRMP. These measures include:

- Davistown Foreshore Barrier - FM DT1 (**Section 4.2.2**); and
- Drainage Easement Myrtle to Kendall - FM EB5 (**Section 4.2.1**),

In addition to being effective in mitigating existing flood risk these measures are also elements of the landforms proposed in the climate change adaptation study and will assist in the management of future flood risks associated with sea level rise.

4.2.3.1 CCA-01 - Advance to the next stages of the Davistown and Empire Bay climate change adaptation planning process

The Climate Change Adaptation Study (Rhelm, 2020b) provided valuable information to assist adaptation planning for Davistown and Empire Bay. However, this study was of a conceptual nature and further planning is required to allow the recommended landform and drainage works to proceed.

This FRMP recommends that Council progresses with next planning stage, which is the development of a Climate Change Adaptation Landform and Drainage Master Plan.

Table 4-5 outlines the actions proposed in the FRMP to progress climate change adaptation for Davistown and Empire Bay. Further details can be found in the Climate Change Adaptation Study (Rhelm, 2020b).

Table 4-5 Proposed actions to advance climate change adaptation

Proposed Action	Description
Refining the design of the landforms and associated infrastructure proposed in the Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b).	The conceptual landforms proposed in the Climate Change Adaptation Study (Rhelm, 2019) need to be further refined for implementation. This will include: • Detailed feasibility analysis • Development of detailed design drawing and plans • Detailed design of drainage components associated with the landforms • Detailed staging plans to manage the impacts of filling and raising infrastructure on adjoining properties.

Proposed Action	Description
Identifying the pathways along which a Climate Change Adaptation Plan needs to proceed.	In accordance with the *Decision Support for Coastal Adaptation: The Handbook* (HCCREMS, 2012), to progress the climate change adaptation planning for Davistown and Empire Bay, decision making pathways, thresholds and trigger must be clearly established. This involves: • **Mapping out adaptation pathways**; this is a process that will not only provide an understanding of how different options fit together over time but also how the timing of options will be treated in the assessment process. • **Selecting thresholds and triggers** to fit given circumstances and options. Thresholds and triggers support adaptation strategies that maintain the acceptable level of risks and only implement adaptation actions, if actual changes in risk start to eventuate.
Updating existing policies and planning controls to allow a Climate Change Adaptation Plan to proceed.	Some of the existing planning controls for Davistown and Empire Bay will need to be updated to enable the implementation of the Climate Change Adaptation Plan. An example of sections that should be updated is provided in Table 4-6. However, there are likely to be other instances where updates are required (i.e. planning controls not related flood risk management – which are outside of the scope of this FRMP).

4.2.3.2 CCA-02 - Provide Information to assist in next stages of the Davistown and Empire Bay Climate Change Adaptation planning process

This FRMP will also provide information to assist in the implementation of a Climate Change Adaptation Masterplan.

These recommendations are summarised in **Table 4-6**.

Table 4-6 Conclusions from this FRMSP, which will inform the implementation of a Climate Change Adaptation Masterplan

Conclusion from this FRMSP	Recommendation for the implementation of a Climate Change Adaptation Plan
As an outcome of the review of the existing land use planning controls applicable to Davistown and Empire Bay, it was identified that Section 6.7.7.6 of the DCP requires all new development in the floodplain to not adversely impact flood behaviour with respect to private and public lands. This primarily stipulates (although further considerations apply) that works in the floodplain, inclusive of their cumulative effects, should not increase exiting peak flood depths by more than 10mm. Assessment of filling in the floodplain, undertaken in this FRMSP, indicate that filling of the floodplain in Davistown	In the low lying areas of the FRMS, where filling is required for adaptation to rising sea levels, restrictions should be softened with respect to 'adverse impacts' being greater than 10mm. Based on hydraulic impact modelling, the maximum cumulative impact on peak flood depths on private properties could be: • + 150mm in the 1% AEP, and • + 200mm in the PMF. Given that it is the cumulative impact causing these peak flood depth impacts, and not a single lot being raised, Council could consider an approach where developers are required to contribute (based on per square metre area

Conclusion from this FRMSP	Recommendation for the implementation of a Climate Change Adaptation Plan
and Empire Bay as part of the proposed future landform for climate change adaptation will cause some impact to flood risk on properties not yet raised	of their lot) to a drainage fund. The capital accumulated in this fund shall be used for lot-scale drainage works to mitigate that interim impacts of cumulative filling in the floodplain. The mechanism for releasing these funds should be further considered by Council based on the progress and pattern of filling realised in the future.
House raising options were assessed in this FRMSP with regards to catchment flooding and in the Brisbane Water FRMS with regards to Brisbane Water flooding As an outcome of this analysis, several properties were identified as satisfying DPIE's guidelines / requirements for house raising funding.	House raising is not compatible with the landform proposed in the climate change adaptation strategy. Considering the context of the climate change adaptation study, it is preferable that properties fill and redevelop, rather than raise existing structures and maintain existing ground levels. Therefore, Council may want to consider directing funding that would have been applied to house raising to incentivising flood compatible redevelopment and raising of the ground levels to be consistent with the proposed adaptation landform. Council should also guarantee that the same approach is applied to the properties in Davistown and Empire Bay that have been identified for House Raising as part of the Brisbane Water Foreshore FRMP. It is also recommended that Council creates a consolidated list including properties eligible for Voluntary House Raising across the entire LGA. It would be advantageous to implement the House Raising Program for all properties simultaneously, as opposed to doing it multiple times for small groups of properties.
A number of residents from Restella Avenue, Davistown raised issues about the easement located in Davistown Memorial Park, which drains to Paringa Avenue. Residents living along the easement were concerned that the filling associated with recent construction of units could worsen flooding conditions on their properties. The following preliminary measure was identified as part of the FRMS to Improve drainage through the drainage easement: • **FM DT5 - Drainage easement (Davistown Memorial Park to Paringa Ave)** The assessment of this option did not progress further because it addresses an inter-allotment drainage issue, which should be the responsibility of private property owners. However, the drainage issues in this easement are a known public concern. Additionally, this easement could be utilised to ensure adequate drainage exists during filling associated with the landforms proposed by the Climate Change Adaptation Study (Rhelm, 2020b).	The easement located in Davistown Memorial is an important drainage element of the landforms proposed as part of the Climate Change Adaptation Study (Rhelm, 2020b). Therefore, it is recommended that Council ensures that the easement is managed effectively. Actions that should be undertaken by council include: • Undertake frequent maintenance inspections in the easement. • Undertake the required maintenance work to guarantee satisfactory drainage capacity, • Guarantee that no existing or future development adversely affects the drainage capacity of the easement.

4.2.4 Measures applicable to all mechanisms of flooding

Flood management within Davistown and Empire Bay has considered all flooding mechanisms, where possible in the previous sections the recommendations of this FRMP have identified which flooding mechanisms they aim to manage. However, it was important to combine all aspects of flood management the recommendations summarised in **Table 4-7**.

Table 4-7 Recommended Measures – All Mechanisms of Flooding

Option ID	Option Name	Reference Section
EM06 & PM04	Flood education programs	**Section 4.2.4.1**
EM04	Flood warning systems.	**Section 4.2.4.2**

4.2.4.1 EM06 & PM04 - Flood education programs

Flood education programs		
Flood Management Type: Emergency Response Modification (ID: EM06); Property Modification (ID: PM04).	**Responsibility: Council and SES**	
Type of flood Risk: All mechanisms of flooding	**Associated Costs:**	**Initial Cost:** $120,000
MCA Ranking: #6		**Recurrent Cost:** $120,000 p/year

Overview:

During a major catchment driven flood event it is unlikely that emergency response services, such as the SES will have time and resources to assist all flood-affected resident. Therefore, the community's readiness and preparedness will have a substantial impact in preventing loss of life and damages to properties.

Additionally, the availability of reliable flood warnings for areas impacted by catchment flooding is limited. For this reason, in order to get the most benefit out of the warnings that are available, residents in the floodplain need to have an adequate understanding of the potential effect flooding would have on their property the access routes in their local area. People will also need to know how to react to a flood situation and be able to assess when it is safe and necessary to evacuate and what would be the best way to do it.

Council's Flood Education Strategy is outlined in a working document, which summarises flood education objectives, measures, and resources. However, it is understood that this document has not been updated recently and does not reflect Council's existing practices.

Taking into consideration what has been discussed in this section, it is recommended that the existing Flood Education Strategy is reviewed and updated. The updated strategy should contemplate the following awareness campaigns for the floodplain. These should be prepared together with the SES, as they have joint responsibility for community awareness under the DISPLAN.

- Preparation of a FloodSafe brochure relevant to the study area by the SES, for both residential and business premises. Such a brochure with a fridge magnet may prove to be a more effective means of ensuring people retain information. Once prepared, the FloodSafe brochure can then be uploaded to the Council and SES websites in a suitable format, where it would be made available under the flood information sections of the website. The brochures could also be made available at Council offices and community halls. The brochure should address both catchment flooding and foreshore inundation, or separate brochures be prepared.
- Targeted awareness programs for specific groups of residents, such as older people in retirement villages (e.g. Alloura Waters), or residents that may be cut off from transport routes and isolated. Examples of the areas that could be potentially isolated include the properties between Sorrento Road

<table>
<tr><th colspan="2">Flood education programs</th></tr>
<tr><td colspan="2">and Rickard Road and north of Pomona road (Empire Bay). Other potentially isolated areas are identified in the Flood Emergency Response Category maps in the FRMS.
• Development of a Schools Package from existing material developed by the SES and distribution to schools accordingly. Flood education in schools is not only useful in educating the students but can also be useful in dissemination of information to the wider community.
• A regular (annual) meeting of local community groups to arrange flood awareness programs on a regular basis. Engaging with long term residents who have memories of past flood events can be useful to share this knowledge with other residents at these events.
• Flood awareness information, including the FloodSafe brochure and relevant warnings should be regularly distributed at community events and gatherings.
• Information dissemination is recommended to be included in Council rates notices for all affected properties on a regular basis.
• Prepare educational materials of the flood planning controls that apply to them and their properties, as well as the consequences of non- compliance.

Additionally, it is proposed that a Property Flood Risk Education Program is undertaken to advise the local community and prospective property purchasers about the risk and effects of flooding.

the Property Flood Risk Education Program could include measures such as:
• Ensure that spatial risk information is readily available to members of the public
• Provide flood risk brochures at real-estate agencies
• Include brochures titled “What does my Planning Certificate mean?” with all property planning certificates when received by property purchasers.

An effective flood awareness program requires ongoing commitment. Therefore, it is recommended that Council’s team includes a dedicated person (or group of people) responsible for guaranteeing the effective and consistent implementation of the Flood Education Strategy. The dedicated officer would coordinate the flood education program across the entire LGA, overseeing the implementation of awareness campaigns and the development of educational material, as well as collecting constant feedback from the community.</td></tr>
<tr><td colspan="2">Flooding issue addressed:

Davistown and Empire Bay can be affected by both catchment flooding and foreshore inundation due to ocean storm events. The response time available associated with both mechanisms of flooding is substantially different, which impacts the recommended actions that should be taken by the community during ocean flood and catchment flood events. Therefore, it is important that public education progress address the two different types of flooding and what would be the adequate response for each. It should be noted that ocean flooding events can occur concurrently or separately from catchment flooding.</td></tr>
<tr><td>Expected Mitigation Outcomes:

If the members of the community understand their role in the overall floodplain management strategy for the study area, they are able to respond quickly and effectively to an emergency.

A flood ready community are more likely to take actions to protect life and property such as:
• Moving possessions within their home or business to higher levels
• Moving parked cars to safe locations</td><td>Considerations:

• The involvement of the SES in the flood education program in Davistown and Empire Bay is critical. The outcomes of the engagement process suggest the SES participation would positively impact the community’s perception of the program and consequently lead to more effective results.
• Another aspect that needs to be considered is that the terminology used in the flood awareness program is</td></tr>
</table>

Flood education programs	
• Ensuring flow paths are not blocked by debris, or other moveable items • Evacuating, if appropriate • Checking on neighbours.	accessible and that it effectively communicates the level of flood risk.

4.2.4.2 EM04 - Flood Warning Systems

Flood Warning Systems		
Flood Management Type: Emergency Response Modification (ID: EM04)	**Responsibility: Council**	
Type of flood Risk: All Mechanisms	**Associated Costs:**	**Initial Cost:** $50,000
MCA Ranking: #8		**Recurrent Cost:** $5,000 p/ year

Overview:

The NSW Bureau of Meteorology (BOM) is the instance responsible for issuing warnings when potential flood emergencies are imminent. In New South Wales, these warnings are carried out by the New South Wales and Australian Capital Territory Flood Warning Centre, which is a specialised organization within the BOM. In Davistown and Empire Bay, the Council and the SES play an important role in distributing these warning to the local community.

Currently there is no consolidated system in place for delivering these warnings and for informing the community of the recommended course of action.

Ocean Flooding

The Brisbane Water Floodplain Management Study (Cardno, 2015) provides a series of recommendations for the review of flood warning systems in the Brisbane Water foreshore (EM4). The measures listed below would be applicable to Davistown and Empire Bay and are also proposed in this FRMSP.

- Ensure that warnings for storm-surge flooding are appropriately distributed (in addition to warnings for catchment flooding) by acknowledging the similarities and differences between the two flooding types.
- Liaise with the TfNSW so that light-emitting diode (LED) variable messaging signage (VMS) (both permanent and demountable) can be utilised to provide flood warnings.
- Integrate the results of the Brisbane Water FRMS into NSW SES flood planning (e.g. sharing of GIS data for use by NSW SES).
- Develop/review alternative routes and detours and distribute plans as appropriate.
- Undertake periodic liaison (between BoM, NSW SES and Council) to ensure consistency.

In order to increase the effectiveness of distributing any extreme weather of flood watch warnings to the community, they should be made available in as many means of communication as possible. Potential suggestions include (and may already be utilised):

- Council's website and social media pages
- SES website and social media pages
- local radio and TV channels
- community centres and public schools, through printed posters or fliers.

Catchment Flooding

In catchment flood events, the flood depths rise rapidly after the start of the rainfall event, allowing for a relatively short response time. For this type of flooding event, an early severe weather alert system would likely be a better option.

Council could also develop an early warning alert database of members, to provide severe weather alerts to registered residents and business owners. Council could deliver alerts to the residents based on weather warning provided by BoM and other sources. These alerts could also include a consideration of the ocean level conditions and how they could interact with the catchment flooding.

The alerts could cover events, such as:

- hail and severe thunderstorms
- destructive winds and cyclones

<table>
<tr><th colspan="2">Flood Warning Systems</th></tr>
<tr><td colspan="2">

- floods from a number of different sources including king tide, storm surge and tsunamis.

Alerts could be sent by:

- e-mail
- SMS
- recorded message to a landline.

Additionally, these alerts could be also broadcasted in local radio channels and provide to local community groups to distribute to their members.

</td></tr>
<tr><td colspan="2">

Flooding issue addressed:

Flood warnings and alerts have the potential to reduce the flood risks associated with both catchment and ocean driven flooding. Although the ability to better predict elevated ocean levels, and the longer warning time means that flood warnings associated Brisbane Water flooding are likely to have more benefits.

</td></tr>
<tr><td>

Expected Mitigation Outcomes:

Increasing the communities readiness for a flood event will reduce flood risk to property and life by allowing them time to take actions such as:

- Moving possessions within their home or business to higher levels
- Moving parked cars to safe locations
- Ensuring flow paths are not blocked by debris, or other moveable items
- Evacuating, if appropriate
- Checking on neighbours.

</td><td>

Considerations:

- The effectiveness of flood warnings and alerts will be increased through a concurrent flood education program.
- The wording of the issued flood warnings would be critical to increase responsiveness, without creating unnecessary alarm.
- Based on the responses from the community survey (**Section 2.5**) Most of the respondents would look for updates or information on radio (27%), on TV (20%) and on social media (19%). Therefore, it is recommended that these avenues be targeted when releasing information related to weather and flood warnings.
- Warning could also be sent using SMS messages and e-mails. However, this approach needs to be considered with caution, as a few false alarms could deteriorate the community's trust in the system and negatively affect future emergency responses. The ability to forecast and predict catchment flooding is limited, and as such this method of flood warning would likely have limitations.
- The flood warning system recommendations in this FRMS are aligned to short term propositions outlined in the Southern Central Coast Storm and Flood Forecasting Study (MHL, 2017).
- The flood forecasting study also outlines long-term recommendations applicable to Davistown and Empire Bay. The proposed measures include the implementation of an Early Warning Network Alert and Flood

</td></tr>
</table>

Flood Warning Systems	
	Forecasting System (EWNAFFS), the development of a web based EWNAFFS portal and the development of a "Floods Near Me" application specific to the Central Coast. This FRMS recommends that these measures are included in Council's long-term strategy. The flood forecasting study did not include medium-term recommendations relevant to Davistown and Empire Bay.

4.2.4.3 EM05 - Flood Warning Signs

<table>
<tr><th colspan="3">Flood Warning Signs</th></tr>
<tr><td>Flood Management Type: Emergency Response Modification (ID: EM05)</td><td colspan="2">Responsibility: Council</td></tr>
<tr><td>Type of flood Risk: Catchment Flooding</td><td rowspan="2">Associated Costs:</td><td>Initial Cost: $5,000</td></tr>
<tr><td>MCA Ranking: #15</td><td>Recurrent Cost: -</td></tr>
<tr><td colspan="3">Overview
A depth marker is recommended for installation on Empire Bay Drive (to the east of Palmers Lane), since this road in an important access road to and from Empire Bay. In the PMF event, the section where the recommended marker would be installed is overtopped for approximately 5 hours, with a maximum flood depth of 0.6 m. This section is also upstream of a culvert, which could potentially become blocked and further increase the flood depth on the road surface.</td></tr>
<tr><td colspan="3">Flooding issue addressed:
Driving through floodwater can be extremely dangerous. Often people drive through floodwaters because it is unclear how deep the flooding is. Depth markers or warning signs can assist in deterring drivers from entering flood waters. Ideally, roads are closed when flooding occurs, but this is not always feasible as flooding can occur quickly and across numerous locations at once.</td></tr>
<tr><td>Expected Mitigation Outcomes:
Reducing drivers entering floodwaters and therefore reducing accidents, damage to property and risk to life.</td><td colspan="2">Considerations:
• This location is a wide flat area, which is primarily affected by shallow flooding. The location of the depth markers or flood warning signs should consider this.</td></tr>
</table>

4.3 Implementation Program

The actions listed in **Table 4-8** are recommended for implementation as an outcome of the NSW Government Floodplain Risk Management Process. In order to achieve the implementation of relevant management actions, a program of implementation has been development.

Table 4-8 provides the following information relevant to the implantation of the management actions:

- An estimate of capital and recurrent costs for each action (this may, in some cases, include existing staff and funding);
- The agency or organisation likely to be responsible for the action;
- The timeline for implementation (immediate or staged) and priority for implementation (high, medium or low).

The following provides further detail on the implementation timelines:

- Immediate – this indicates actions that could be implemented in the short term (less than 5 years) if funding and resourcing permits. Feasibility of the action is generally high and additional investigations or further development of the management strategy would be minimal;
- Staged – this indicates actions that could be undertaken in the short to medium term (up to 10 years). However, additional investigations, feasibility studies or further development of the management strategy are likely to be required. Where appropriate, interim policy and planning measures could be employed in the intervening time.

The following provides further detail on the priorities:

- **High priority:**
    - Require relatively low implementation effort and cost.
    - Achieved a high score in the MCA (rank higher than 5) and are fundamental elements of the landforms proposed in the Davistown and Empire Bay Climate Change Study.
- **Medium Priority:**
    - Achieved a high score in the MCA (rank higher than 5) but are not elements of the landforms proposed in the in the Climate Change Plan.
    - Achieved a medium score in the MCA (rank higher than 10).
- **Low:**
    - Achieved a relatively low score in the MCA (rank lower than 10).

Table 4-8 Implementation Action List

Option ID	Recommended Action	Indicative Costs[4]		Potential Funding Sources/ Responsibilities	Implementation Time Frame	Priority	Performance Measures
		Capital Cost	Recurrent Cost				
FM DT1	Davistown Foreshore Barrier	$ 12,343,000	$ 15,000	**Council**	Staged	High	Stage completion: Feasibility study (and design) undertaken. Construction of the barrier and associated infrastructure is completed.
FM EB1 & FM EB6	Pomona Road Easement and Drainage Upgrades	$371,400	$ 5,000	**Council**	Staged	Low	Stage completion: Feasibility study (and design) undertaken. Easement and drainage works complete
FM EB2	Seawall construction guidelines	$ 60,000[5]*	-	**Council**	Immediate	High	Guidelines are prepared and published.
FM EB4	Empire Bay foreshore barrier	$ 4,554,000	$ 15,000	**Council**	Staged	Medium	Stage completion: Feasibility study (and design) undertaken. Construction of the barrier and associated infrastructure is completed.
FM EB5	Drainage easement (Myrtle to Kendall Rd)	$ 6,481,000	$ 4,000	**Council**	Staged	High	Stage completion: Feasibility study (and design) undertaken. Implementation of the easement and associated infrastructure is completed.
PM1	Land Use Planning Recommendations	-	-	**Council**	Immediate	High	Land Use Planning documents are updated. Flood Planning Matrix completed and adopted.
PM4 & EM6	Flood Education Programs	$ 120,000	$ 120,000	**Council and SES**	Immediate	Medium	Flood education program is prepared. Program is implemented (each component may have specific performance metrics)

[4] Some of the costs vary from the values reported on the FRMS, as they were reassessed following the completion of the study.
[5] The cost associated with this option has been estimated based on the assumption that the work will be carried out by Council. The cost will vary if the external consultants need to be hired.

Option ID	Recommended Action	Indicative Costs[4]		Potential Funding Sources/ Responsibilities	Implementation Time Frame	Priority	Performance Measures
		Capital Cost	Recurrent Cost				
EM1	Review of evacuation centre locations	-	-	**Council and SES**	Immediate	High	List of evacuation centres suitable for flood emergency evacuation is prepared and added to SES protocols. Identification of evacuation centres in need of upgrades.
EM3	Provide Data to Inform Future Road Drainage Improvements – Empire Bay Drive and Other Flood Affected Roads	-	-	**Council**	Staged	Medium	Incorporate these locations in Council capital works expenditure program (COPEX)
EM4	Flood warning systems	$ 50,000	$ 5,000	**Council and SES**	Immediate	Medium	Documented review of flood warning systems is completed. Actions outlined in EM4 and Southern Central Coast Storm and Flood Forecasting Study (MHL, 2017) completed.
EM5	Flood warning signs (at Empire Bay Drive only)	$5,000	-	**TfNSW / Council**	Immediate	Medium	Installation of roadside signage at Empire Bay Drive
CCA-01	Advance to the next stages of the Davistown and Empire Bay Climate Change Adaptation planning process	$150,000	$20,000	**Council**	Staged	High	Undertaken further feasibility studies, including detailed design and staging plan for works (filling, levees, drainage and infrastructure raising) Identify Sea Level Rise triggers and associated actions Update Council's Policy and Planning Controls to enable to implementation of adaptation drainage and landform works
CCA-02	Provide Information to assist in next stages of the Davistown and Empire Bay Climate Change Adaptation planning process	-[6]	-	**Council**	Immediate	High	Update Council's DCP and other mechanisms to allow filling in the landform areas and also manage significant impacts on flooding. Consolidate all properties identified for House Raising and Voluntary Purchase across the LGA. Then look at an approach to incentivise filling for those properties within the landform area. Undertake regular maintenance of the drainage easement between Memorial Park and Paringa Ave.

[6] No costs associated with easement maintenance have been included as this work would not be funded under the DPIE Floodplain Risk Management Program

5 Conclusions

This FRMP provides a practical framework and implementation plan for managing existing, future and continuing flood risk within the study area.

Overall, it is considered that existing catchment flooding risks to Davistown, Empire Bay and Bensville can be managed appropriately through the implementation of development controls, emergency response measures and selected on ground works. The effective implementation of development controls will be of key importance in reducing the damages and risk to life associated with flooding through the construction of flood compatible buildings and assets.

More significant flood mitigation works will be necessary for mitigating risks from Brisbane Water Estuary flooding and for addressing future issues associated with sea level rise. The Myrtle Road drainage easement and the Davistown and Empire Bay foreshore barriers recommended in this FRMP will require substantial implementation effort and financial investment. However, this flood mitigation measures are key elements of the landforms proposed in the Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b) and, therefore, have the added benefit of assisting with the staged implementation of the landform adaptation.

The Davistown and Empire Bay Climate Change Adaptation Study (Rhelm, 2020b) outlines a long-term strategy for landform and drainage improvements to achieve ongoing viability of these areas under sea level rise conditions. It is critical that further analysis and design is undertaken as soon as possible to identify sea level rise triggers (i.e. levels at which actions must be taken to allow enough time to adapt), and adaptation measures (e.g. property filling, drainage works and infrastructure design) are confirmed and design to allow implementation. Several actions recommended in this FRMP are part of the staged works associated with achieving the landform adaptation.

In order to achieve the implementation of relevant management actions, a program of implementation has been developed. The actions listed in **Section 4** are recommended for implementation.

The steps in progressing the floodplain risk management process from this point onwards are:

- Council will consider adopting the final Plan and submit applications for funding assistance to relevant State and Commonwealth agencies, as appropriate and within Council's available resources;
- The flood management actions will be prioritised for funding through the Integrated Planning and Reporting Process; and
- As funds become available from DPIE, the Commonwealth, other state government agencies and/or from Council's own resources, recommended management actions will be implemented in accordance with the established priorities.

This FRMP fulfils its objectives accordance with the New South Wales (NSW) Flood Prone Land Policy (NSW Government, 2001) and the principles of the Floodplain Development Manual (NSW Government, 2005).

6 References

Cardno (2015a) *Brisbane Water Floodplain Risk Management Study*, Prepared for Gosford City Council

Cardno (2015b) *Brisbane Water Floodplain Risk Management Plan*, Prepared for Gosford City Council

Cardno Lawson Treloar (2010a) *Davistown Catchment Flood Study*, Prepared for Gosford City Council

Cardno Lawson Treloar (2010b) *Empire Bay Catchment Flood Study*, Prepared for Gosford City Council

Cardno Lawson Treloar (2013) *Brisbane Water Foreshore Flood Study*, Prepared for Gosford City Council

Central Coast Council (2015) Flood Education Strategy - Working Document (2011-2015)

Central Coast Council (2018) Civil Work Specification - Design Guidelines

DECC (2007) Practical Consideration of Climate Change

Gosford City Council (2014a) Gosford Local Environmental Plan 2014

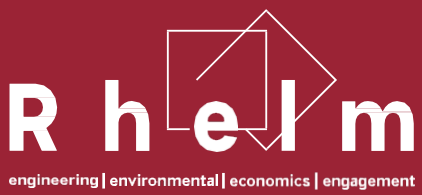
Gosford City Council (2014b) Gosford City Council Development Control Plan

NSW Government (2005) Floodplain Development Manual

Manly Hydraulics Laboratory - MHL (2017) Southern Central Coast Storm and Flood Forecasting Study

Rhelm (2020a) *Davistown and Empire Bay Floodplain Risk Management Study* for Central Coast Council

Rhelm (2020b) *Davistown and Empire Bay Climate Change Adaptation Study,* Prepared for Central Coast Council



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