TECHNICAL REPORT 12

STORMWATER ASSESSMENT

NOVEMBER 2016

NZ TRANSPORT AGENCY
WAKA KOTAHI

East West Link

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Revision schedule

Rev. Nº	Date	Description	Prepared by	Reviewed by	Approved by
0	November 2016	Final for Lodgement	Dale Paice Tony Cain Robin Allison	Stephen Priestley	Patrick Kelly

EXECUTIVE SUMMARY

1. This report forms part of a suite of technical reports prepared for the NZ Transport Agency's East West Link Project (the Project). The purpose of this report is to inform the Assessment of Effects on the Environment (AEE), with respect to operational and construction related stormwater runoff, and to support the resource consent applications, new Notice of Requirement (NoR) and an alteration to existing designation required for the Project.

2. Environmental effects with respect to stormwater runoff and discharges can relate to water quality effects (and subsequent sediment quality) or water quantity effects. In this case, potential quantity effects relate to flooding. This report addresses general runoff from the Project roads, wider stormwater treatment along the foreshore of Māngere Inlet, and construction effects related to earthworks.

Water Quality: Runoff from Project roads

3. The Project has significant water quality benefits.

4. Water quality effects arise as particles from car exhausts, tyres and brakes, silt, oils and litter collect on road surfaces. Many of these small particles adhere to sediments which are washed off impervious surfaces and transported through stormwater runoff to discharge to the receiving environment. Where the water is still, contaminants settle out and accumulate. Other contaminants dissolve as rain passes over them and change the physical-chemical composition of stormwater. The accumulation of sediment, contaminants and changes to the chemical make-up of stormwater affect water and sediment quality and can then have a significant effect on the viability of aquatic resources.

5. To mitigate this effect, runoff from new and modified road surfaces will be captured and passed through stormwater treatment devices that remove the majority of contaminants to typical Auckland Regional standards. These devices are constructed freshwater wetlands or vegetated systems where practicable and otherwise, proprietary in-ground treatment systems. The total Project road surface area is 46 hectares, an impermeable area increase of 21 hectares with respect to the existing situation. All 46 hectares will be treated in new or upgraded treatment devices, totalling 38 devices / treatment areas.

Water Quality: Foreshore Area

6. A feature of the Project is the foreshore stormwater treatment areas which cater for runoff from a further 611 hectares in Onehunga and Penrose; areas that currently drain through pipes directly into the Māngere Inlet without treatment. This has been possible as the location of the Project presents a unique opportunity for treatment measures to be integrated within the landscaped coastal edge and road construction. Onehunga and Penrose are long established urbanised catchments where limited space and the depth of stormwater outfall pipes through landfill areas constrain opportunities for retrofitting stormwater treatment measures further upstream.

7. The opportunity to cater for stormwater runoff from the wider Onehunga - Penrose catchment has resulted from an agreement in principle between the Transport Agency and Auckland Council that the Project should include provision for treatment of the upstream catchment flows as an overall environmental benefit. Based on this the Project has included a stormwater system capable of dealing with the water quality issues from a combined local catchment and Transport Agency road runoff discharge using a target efficiency in line with Council's general requirements set through appropriate guidelines and analysis. The stormwater systems extent and engineering needs are included in the road construction and landscaped coastal edge sought by the Transport Agency, and the landform designs developed to ensure appropriate setting and safety. Flows greater than those being treated for water quality reasons bypass the stormwater treatment system entering directly to the Māngere Inlet.

8. The proposed arrangement is that Auckland Council take over ownership, operation and maintenance of the treatment areas once completed. The details of the treatment areas will be developed in consultation with Auckland Council as future asset owner.

9. The proposed stormwater treatment method in the foreshore area is a combined wetland and biofiltration system, designed to minimise the footprint while maximising treatment. See Figure 1. A system of pipes, underdrains and weirs will convey flow through the systems for treatment before discharge to the Māngere Inlet and one way valves will minimise salt water getting into the freshwater area. The wetland treatment areas and stormwater bund are to be constructed so that they can be adapted for climate change (in particular, sea level rise) over time. This adaptive approach has been adopted as setting the outer bund high enough to accommodate a significant period of sea level rise would exacerbate the flood risk at some low lying properties under existing climate conditions. The adaptations will comprise raising outer bund and overflow levels and amending pipework and valves. This may be required 1 or 2 times over the next 100 years.

10. The Project results in significant reductions to the quantity of suspended solids, metals, hydrocarbons and coliforms discharging via stormwater with respect to current discharges. For the approximately 657 hectares affected, the following changes to long term annual average contaminants discharge are predicted:

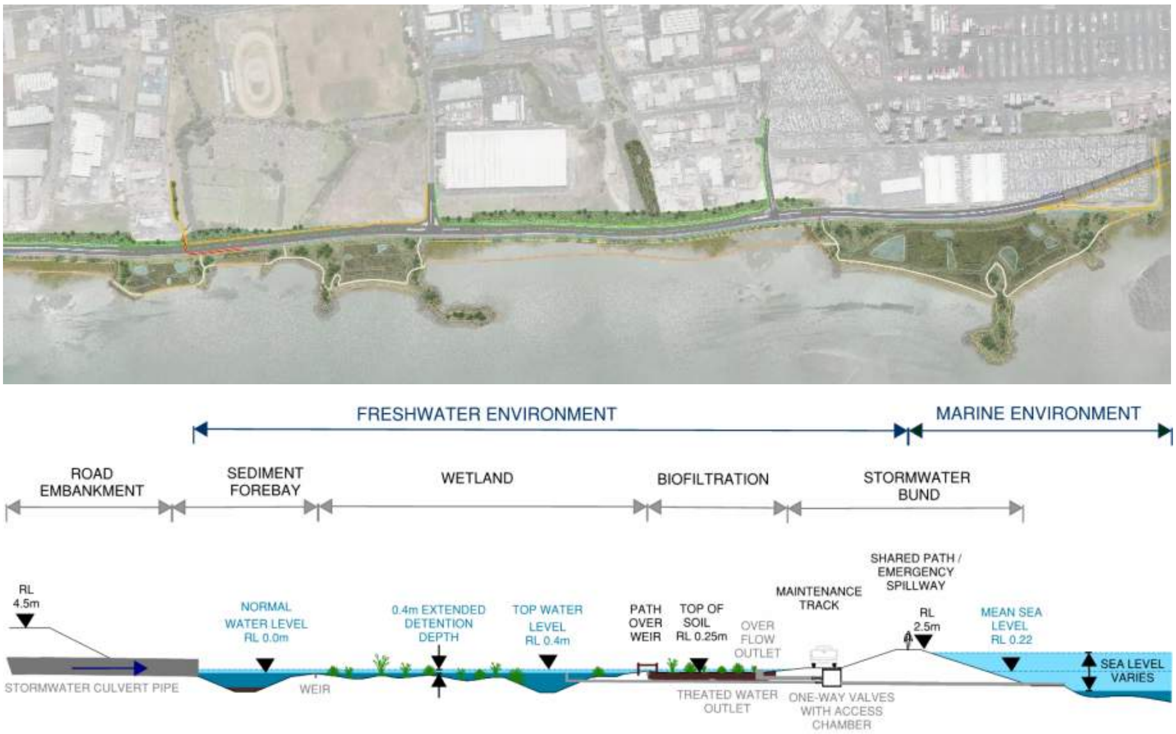
    - A reduction in total suspended solids from 870 to 210 tonnes per year (a 75% reduction);
    - A reduction in total nitrogen from 19 to 10 tonnes per year (a 47% reduction);
    - A reduction in total zinc from 2.67 to 1.17 tonnes per year (a 56% reduction); and
    - A reduction in total copper from 0.24 to 0.08 tonnes per year (a 66% reduction).

11. The Project reduces contaminant discharges to both the east coast (Tamaki Estuary) and west coast (Māngere Inlet and Manukau Harbour). The treatment systems have been designed to treat all stormwater and consequently a 75% reduction in total suspended solids is achieved for both coasts.

12. Other predicted stormwater quality benefits are:

    - Allowing collected leachate from old landfills on the Pikes Point area to be treated in the foreshore wetlands so that it no longer needs to be pumped to trade waste. The new leachate collection system will operate under gravity and discharge leachate to the stormwater treatment wetlands through the embankment. This is proposed because the leachate quality can be sufficiently improved through the proposed stormwater wetlands to ensure no adverse effects on the water quality of the Māngere Inlet.
    - The foreshore treatment systems also contribute to a reduction in contaminants reaching the Māngere Inlet through groundwater. This effect is covered in separately in Technical Report 13 Groundwater Assessment.
    - Protection of the Māngere Inlet from wastewater discharges that enter the stormwater pipe network. These will also be treated in the foreshore treatment areas to remove contaminants prior to coastal discharge;
    - Improved resilience to contaminant spills or contaminant dumping through containment in the stormwater treatment devices; and
    - New freshwater ecological environments created in constructed wetland and biofiltration systems.

Figure 0-1: Foreshore Treatment Areas



Flooding

13. Flood risk protection to the project will meet commonly accepted standards. The proposed new road is set at levels above extreme flood events, high tides and storm surge, allowing for 100 years of predicted climate change effect. In some locations, including along the Māngere Inlet foreshore, this sets the road level higher than some properties upstream. Pipes, inlets and overflows are therefore designed to avoid increasing flood risk at those properties by allowing for overland flow to be directed through the pipes beneath the road. In some locations, stormwater pumps and attenuation tanks will be used to assist with managing floodwaters.

14. Near the foreshore, installing one-way valves on the stormwater pipes will constrict the flow that discharges through pipes in a flood event. One-way valves also do have the potential to become blocked or fail. This will increase the risk of flooding to some existing low lying properties in an extreme rainfall event compared to the existing situation where runoff can discharge freely. However, there is also potential for the foreshore works (road embankment) to provide an improved level of protection to those properties from coastal inundation due to sea level rise over time. These factors will have to be considered carefully throughout the design development including the potential to use supplementary pumps, flow gates, additional valves or additional pipes to mitigate the risk of adverse effects on existing properties.

15. There are residual flood risks associated with reliance on piped systems, one-way valves and pump stations. The risk and consequence of failure of these systems will have to be managed throughout the design development.

Construction effects (erosion and sedimentation)

16. The construction of the Project will be carried out in such a way as to minimise the stormwater effects during construction.

17. During construction, erosion and sediment control measures will be put in place which follow best practice in accordance with Auckland Council's guideline document.[1] Both structural (physical) and non-structural (site management and staging of the works) measures will be employed with an emphasis placed on non-structural practices in the prevention of erosion in the first instance such as appropriate staging and sequencing of works.

18. Sediment retention devices, including sedimentation retention ponds and decanting earth bunds, will be provided and will, where required, be installed with rainfall activated flocculant sheds to increase sediment retention efficiency of the sediment retention devices.

19. The flocculant dosing regime will be informed by bench testing of soil samples from both in-situ material and imported fill to determine the most effective type and dosing rate of flocculant. The flocculant dosing rate may vary across the Project due to the variance in soil conditions. Bench testing will be carried out prior to construction commencing and the dosing rates to be used in any particular location throughout the Project will be detailed within construction stage erosion and sediment control plans.

20. The construction stage erosion and sediment control plans will be prepared as part of the Contractor's wider suite of construction management plans in accordance with any applicable consent conditions and will be developed to allow for flexibility of construction sequencing and activity, whilst ensuring protection of the necessary environmental and amenity values.

21. This management plan approach is standard practice for large earthworks projects and provides an opportunity for input, review and feedback from Auckland Council and the NZ Transport Agency at each stage. A management and monitoring programme will be implemented which will allow for ongoing water quality and continuous improvement of the construction water management methodology.

22. With these measures in place, the potential effects on the receiving environment during construction will be minimised.

[1] Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region, June 2016, Guideline Document 2016/005 (GD05), Auckland Council and Technical Publication 90 – Erosion and Sediment Control – Guidelines for Land Disturbing Activities in the Auckland Region, March 1999, Auckland Regional Council, (TP90)

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Glossary of Technical Terms/Abbreviations

Abbreviation	Term
ACRPS	Auckland Council Regional Policy Statement
AEE	Assessment of Effects on the Environment
AEP	Annual exceedance probability
ALW Plan	Auckland Council Regional Plan: Air, Land and Water
AMA	Auckland Motorway Alliance
AMETI	Auckland-Manukau Eastern Transport Initiative
ARI	Average Recurrence Interval
ARP:C	Auckland Council Regional Plan: Coastal
BCR	Benefit Cost Ratio
BoI	Board of Inquiry
BPO	Best Practicable Option
CLM	Contaminant Load Model
CMA	Coastal Marine Area
CN	Curve Number
CPTED	Crime prevention through environmental design
DEB	Decanting Earth Bund
DMA	Drainage Management Area
DoC	Department of Conservation
DWD	Dirty Water Diversion
DPS	Design Philosophy Statement
EPA	Environmental Protection Authority
ESC	Erosion and Sediment Control
ESCP	Erosion and Sediment Control Plan
EWL	East West Link
EWLA	East West Link Alliance
GD05	Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region – Guideline Document 2016/05
GPSLT	Government Policy Statement on Land Transport
HAIL	Ministry for the Environment's hazardous activities and industries list
LTMA	Land Transport Management Act
MACA Act	Marine and Coastal Area (Takutai Moana) Act 2011
MCA	Multi Criteria Analysis process
NES	National Environmental Standard
NoR	Notice of Requirement
NPS	National Policy Statement
NZCPS	New Zealand Coastal Policy Statement 2010
PAUP	Proposed Auckland Unitary Plan Decisions Version August 2016
PWA	Public Works Act 1981

Abbreviation	Term
RMA	Resource Management Act 1991
RoNS	Road of National Significance
SCS	US Department of Agriculture, Soil Conservation Service
SEA	Significant Ecological Area
SH(x)	State Highway (number)
SRP	Sediment Retention Pond
SWCoP	Auckland Council Stormwater Code of Practice
The NZ Transport Agency	New Zealand Transport Agency
The Plan	The Auckland Plan
TP10	Stormwater management devices: Design guidelines manual 2003 Technical Publication 10
TP90	Erosion and Sediment Control – Guidelines for land Disturbing Activities in the Auckland Region – Technical Publication 90
TP108	Guideline for Stormwater Modelling in the Auckland Region – Technical Publication 108
TR35	Auckland Unitary Plan stormwater management provisions: Technical basis of contaminant and volume management requirements Technical Report 2013/35
TSS	Total Suspended Solids
UDLF	Urban Design Landscape Plans
USLE	Universal Soil Loss Equation
WSUD	Water Sensitive Urban Design

1 Introduction

1.1 Purpose and Scope of this Report

This report forms part of a suite of technical reports prepared for the NZ Transport Agency's East West Link Project (the Project). The purpose of this report is to inform the Assessment of Effects on the Environment (AEE), with respect to operational and construction related stormwater runoff, and to support the resource consent applications, new Notice of Requirement (NoR) and an alteration to existing designation required for the Project.

This report assesses the stormwater effects of the Project as shown on the Project Drawings in Volume 3: Drawing Set.

The purpose of this report is to:

a. Identify and describe the existing stormwater regime, both within the Project and the wider catchments.

b. Describe the potential effects of the Project on stormwater quality and quantity and the implications of these;

c. Describe how the Project design has been developed to avoid or limit potential adverse effects; and recommend measures as appropriate to avoid, remedy or mitigate residual adverse effects;

d. Present an overall conclusion on potential stormwater effects after recommended measures are implemented.

1.2 Project Description

The Project involves the construction, operation and maintenance of a new four lane arterial road from State Highway 20 (SH20) at the Neilson Street Interchange in Onehunga, connecting to State Highway 1 (SH1) at Mt Wellington as well as an upgrade to SH1 between the Mt Wellington Interchange and the Princes Street Interchange at Ōtāhuhu. New local road connections are provided at Galway Street, Captain Springs Road, the port link road and Hugo Johnston Drive. Cycle and pedestrian facilities will also be provided along the alignment.

The primary objective of the Project is to address the current traffic congestion problems in the Onehunga, Penrose and Mt Wellington commercial areas which will improve freight efficiency and travel reliability for all road users. Improvements to public transport, cycling and walking facilities are also proposed. A full description of the Project including its design, construction and operation is provided in Part C: Description of the Project in the Assessment of Environmental Effects Report contained in Volume 1: AEE and shown on the Drawings in Volume 2: Drawing Set.

The Project has been divided into six sectors. These are shown on Figure 1-1 and listed below:

Sector 1. Neilson Street Interchange and Galway Street connections

Sector 2. Foreshore works along the Māngere Inlet foreshore including dredging

Sector 3. Anns Creek from the end of the reclamation in the Māngere Inlet to Great South Road

Sector 4. Great South Road to SH1 at Mt Wellington

Sector 5. SH1 at Mt Wellington to the Princes Street Interchange

Sector 6. Onehunga local road works

Figure 1-1: Project Sector Plan

2 Description of Proposed Stormwater Infrastructure

The proposed stormwater management approach has been developed through a multi-criteria options assessment and selection process. The design process has been carried out in an integrated manner to respond to a range of land-use, visual, environmental, technical, construction, operation and maintenance considerations.

For the purpose of this assessment, the Project is considered as two separate areas being the general stormwater associated with the new road which comprises sectors 1,3,4,5 and 6 of the Project and the foreshore treatment areas which is sector 2. Along the Māngere Inlet foreshore, the location of the proposed road with respect to existing stormwater infrastructure, closed landfills and the coastal edge presents a unique set of constraints and opportunities which has resulted in a stormwater design approach that differs markedly from the general stormwater design approach.

2.1 General Stormwater (Sectors 1, 3, 4, 5 and 6)

It is an objective of the Transport Agency that all stormwater runoff from the new and existing state highway network, within the limits of the Project, receives treatment prior to discharging to the receiving environment.

Wetlands and swales are natural treatment systems which remove contaminants by sedimentation, bio-uptake and trapping of particulates by planted water bodies. These are the preferred method of treatment where sufficient space can be provided. Where space is more constrained, buried proprietary stormwater treatment systems are used. Stormfilters are a proprietary stormwater treatment device approved by Auckland Council for use within the Auckland Region. These are currently in use along sections of the existing SH20 road corridor. Stormfilters are modular, rechargeable, self-cleaning, media-filled cartridges which absorb and retain pollutants contained within stormwater runoff including total suspended solids, hydrocarbons, nutrients, soluble heavy metals, and other pollutants.

The key features of the general Project stormwater infrastructure by individual Sector are as follows:

2.1.1 Sector 1 (Neilson Street Interchange)

- Construction of new stormwater infrastructure and amendment of the existing stormwater collection system within the Neilson Street interchange;
- Conversion of an existing NZ Transport Agency owned stormwater treatment pond to a constructed wetland;
- One new constructed wetland for stormwater treatment adjacent to the existing open channel at the southern end of Hill Street;
- Provision of ten new proprietary stormwater treatment devices;
- Construction of new outfalls to the Coastal Marine Area (CMA) of Manukau Harbour; and
- Provision of a new stormwater pumping station and stormwater storage tank beneath the main East West Link alignment. This storage tank will also incorporate a proprietary stormwater treatment system.

2.1.2 Sector 3 (Anns Creek)

- Provision of a new stormwater collection system incorporated within the bridge structure;
- Provision of one new stormwater constructed wetland at Hugo Johnson Drive; and
- Provision of five new proprietary stormwater treatment devices.

2.1.3 Sector 4 (Great South Road to SH1 at Mt Wellington)

- Provision of new, and the amendment of existing stormwater collections systems;

- Provision of seven new proprietary stormwater treatment devices:
  - Four will discharge to the underground stormwater pipework in Sylvia Park Road which ultimately discharges to the CMA at Anns Creek at the existing outfall location. Anns Creek then flows through a series of open channels and culverts and discharges to the Māngere Inlet;
  - Three will discharge to the underground stormwater pipework in adjacent to SH1 which discharges to Clemow Stream. This in turn flows to the Tamaki River.
- Provision of twin 1,800mm diameter culverts through the Turners and Growers site;
- Construction of a new stormwater pump station and pump main which will pump flows up to the 100yr rainfall event to the existing open channel south west of the Mount Wellington Interchange; and
- Culverting of approximately 20 m of the Clemow Stream at Mount Wellington Interchange.

2.1.4 Sector 5 (SH1 at Mt Wellington to the Princes Street Interchange)

- Conversion of an existing Transport Agency owned stormwater treatment pond at Frank Grey Place to a constructed wetland;
- Provision of eight new proprietary stormwater treatment devices:
  - One will discharge to the stormwater network that flows through Sector 4 and will ultimately discharge to Clemow Stream;
  - Four will discharge to the CMA at Otahahu Creek; and
  - Three will discharge to the existing reticulation system within Frank Grey Place.
- Construction of four new outfalls to the CMA at Otahahu Creek.

2.2 Foreshore Stormwater (Sector 2)

Along the foreshore the proposed road is to be constructed on fill either fully or partially in the intertidal Coastal Marine Area (CMA) of the Māngere Inlet. On the seaward side of the road further fill provides a landscaped coastal edge and public access along the foreshore. Stormwater treatment areas are located between the road and new coastal edge.

The key features of the Project in this sector are:

- A naturalised landscape edge treatment;
- An embankment with a four lane road from the Neilson Street Interchange to Anns Creek via partial reclamation of the northern side of the Māngere Inlet;
- Three lined stormwater treatment areas (landforms 1, 2 and 3) on the seaward side of the embankment comprising freshwater treatment wetlands and biofiltration systems. An outer bund around the stormwater treatment areas provides separation between the freshwater treatment system and marine environment and facilitates public access along the coast;
- Two lined stormwater treatment areas on the landward side of the embankment being:
  - The conversion of Miami Stream to a treatment area comprising a freshwater wetland biofiltration system, and
  - A forebay and biofiltration system in the “triangles” at the intersection of Galway Street;
- Stormwater pipework to convey stormwater from networks servicing Onehunga and Penrose through the foreshore stormwater treatment systems and to one-way valve controlled outlets in the CMA.

The proposed stormwater treatment systems are illustrated in Figure 2-1, Figure 2-3 and Figure 2-4. A typical cross-section of the wetland and biofiltration system is shown in Figure 2-4. The treatment areas are located and shaped to avoid areas of higher existing natural character and ecological value, principally the two volcanic outcrops which remain along the foreshore and Anns Creek.

Other considerations have been the location of existing outlets, avoidance of construction near the Māngere inlet mouth and provision for longer flowpaths through the wetlands.

The stormwater approach for the foreshore area is quite different from the typical approach used for a new road. The treatment areas are designed to treat some additional 611 hectares of catchment serviced by Auckland Council's network rather than simply treating the new road itself. The concept has been developed with the involvement of Auckland Council and with consideration of Iwi aspirations for long term outcomes for the Māngere Inlet.

Other opportunities to provide stormwater treatment for the Onehunga and Penrose catchments are limited. There is a lack of available open space that would be required to construct meaningful stormwater treatment systems. Further, the depth of stormwater outfall pipes through landfill areas constrain opportunities for retrofitting stormwater treatment measures further upstream. As part of new development or redevelopment in the catchment, it is possible that source controls will be installed by property owners, Council or Auckland Transport. However, even with source controls on new developments, implementation is likely to be piecemeal and will not necessarily capture any spills or pollutant dumping that occurs within the catchment.

Figure 2-1: Indicative sketch of stormwater treatment system

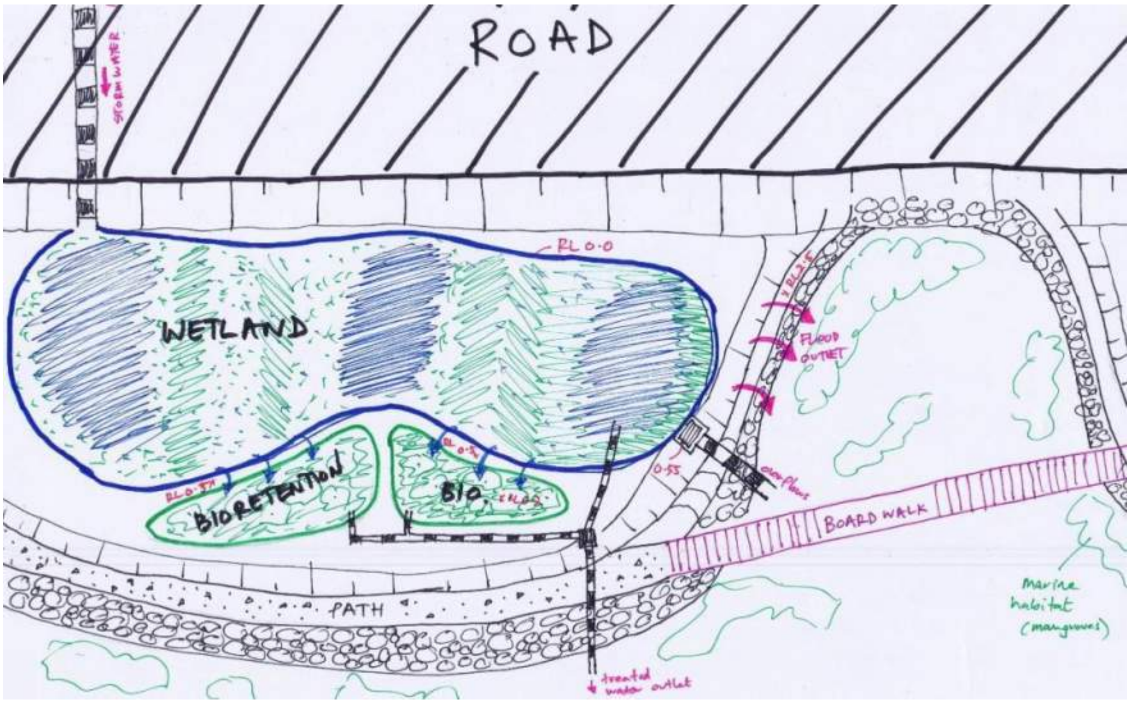
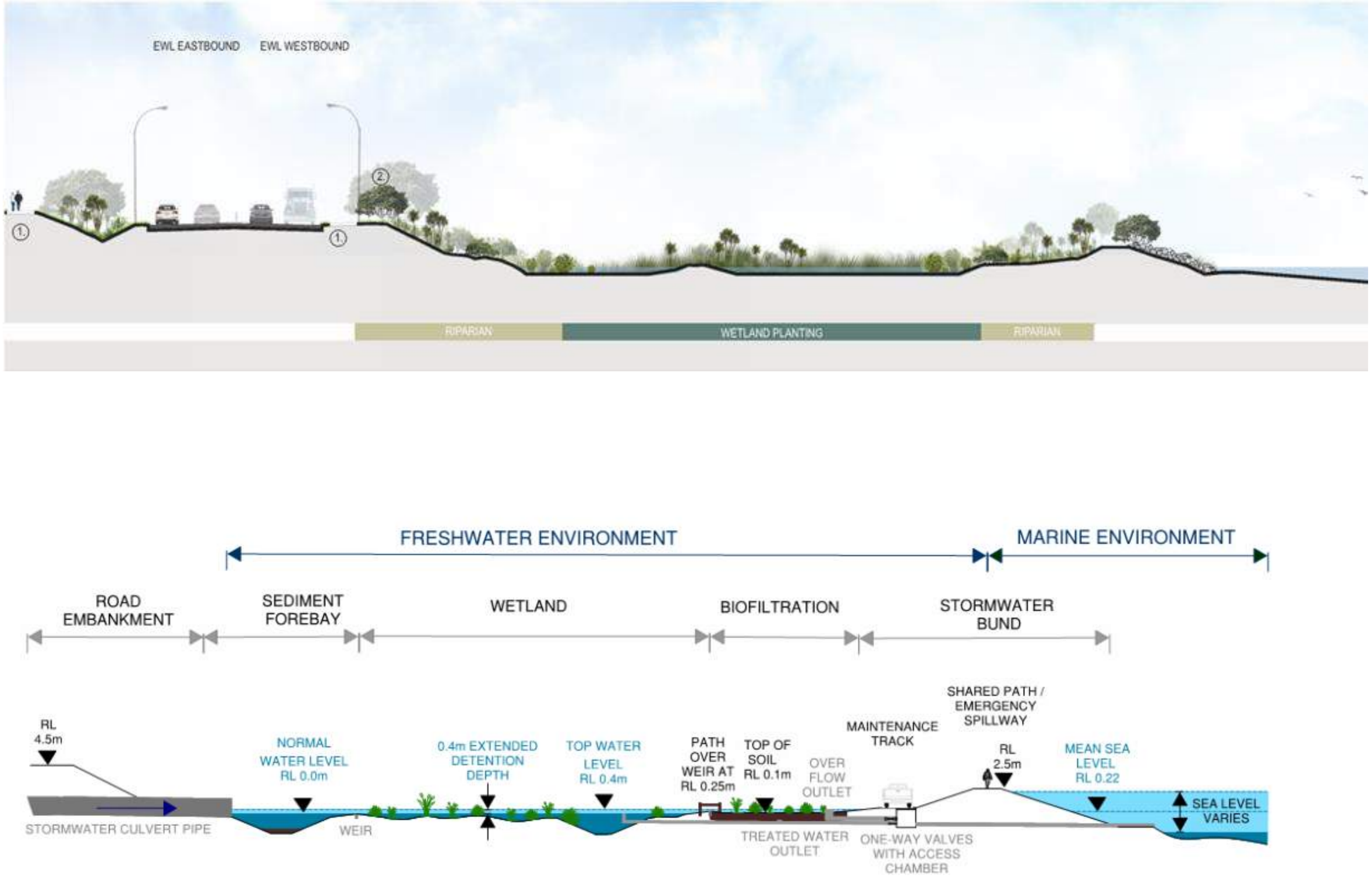


Figure 2-2: Foreshore landscape concept

Figure 2-3: Photo examples of biofiltration and wetland devices

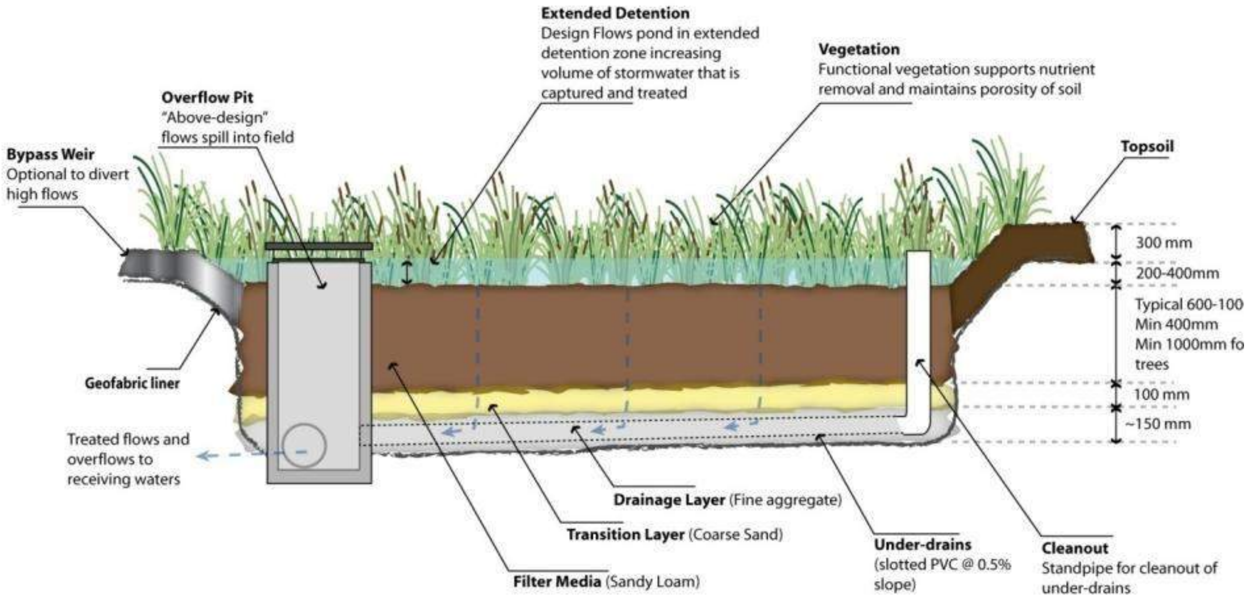
Figure 2-4: Foreshore treatment area cross sections



The operation of the proposed wetland and biofiltration system can be described as follows.

- Stormwater enters the constructed wetland via culverts beneath the road embankment. Coarse sediment will settle out in a forebay and flows will pass to the main wetland. Constructed wetland systems are shallow, extensively vegetated water bodies that use enhanced sedimentation, fine particle filtration and uptake processes to remove contaminants from stormwater. The wetland will treat baseflows, leachate and small storm events with treated flows discharged to the marine environment;
- During minor rainfall events, water levels in the wetlands will rise by 250mm at which point they will overtop weirs into adjacent biofiltration basins. Flow will spread over the biofiltration surface and begin to percolate through the soil media. As flows continues to increase, the water levels will rise over the wetland and biofiltration surface until the water surface is 400mm above normal water level and the biofiltration is inundated by 300mm At this point overflow commences, bypassing treatment. Outlets are configured to slowly release flows after an event, typically over 1-2 days, back to dry weather (normal) water levels;
- Wetlands will typically have a 24-48 hour notional detention time. Typically more than 70-80% of the wetland area is covered with plants and while water can be seen through the vegetation they are not open water bodies;
- The wetland component of the treatment devices will be shaped with internal bunds or walls to provide relatively long flow paths (length to width ratio of 7 or 10 to 1) and be predominately (e.g. 80%) vegetated with mainly shallow water depths (100-300mm) to support plant growth. The bed of the wetlands will gently undulate along its length providing suitable conditions for a range of water plants. The plants will be arranged in bands aligned perpendicular to the main flow paths and use a diversity of species. Plants filter sediments and contaminants from the water and biofilms that grow on the plants can absorb nutrients and other associated contaminants;
- Typical water plants proposed for the wetland include genus such as: Baumea, Bolboschoenus, Cyperus, Eleocharis, Schoenoplectus, Persicaria, Triglochin, Myriophyllum and Vallisneria.
- Biofiltration systems (often called raingardens) are vegetated soil filtration systems that provide efficient sediment and nutrient removal from stormwater. They use ponding above a prescribed soil media surface to maximise the volume of runoff treated through the filtration media. The primary flow direction is downwards through the soil filtration media (e.g. loamy sand) and treated water is then collected within perforated outlet pipes at the base of the media. Contaminants are retained in the system through enhanced sedimentation, fine particle filtration, biological uptake in the vegetation and associated biofilms and biological processes in the soil profile;
- The biofiltration basins will be divided into “cells” of maximum 1,000m^2 to provide management flexibility, promote better flow spreading and allow easier construction and maintenance. Each cell will be positioned to suit the available space and vegetation constraints. The main components of biofiltration are shown in Figure 2-5;
- Proposed vegetation types include shrub species such as Harakeke Flax, Karamu, Oioi, Swamp Astelia and Miniature Toetoe and tree species such as Cabbage Tree, Nikau Palm and Manuka in the biofiltration or riparian environments;
- Treated water from the biofiltration systems and wetlands discharges to the marine environment via pipes controlled by one-way valve systems that prevent saltwater entering the stormwater treatment system in high tides. Most runoff discharges in this way. The one-way valve system could be a flap-gate, duckbill valve or a “WaStop” conical online valve as used by Auckland Council in other assets;
- Overflow pipes collect higher flows once the wetland and biofiltration areas are at full ponding depths and discharges through the outer bund. This will cater to events of up to the 10 year ARI rainfall event; and
- An extreme high rainfall event (10 to 100 year ARI) would discharge via a spillway located in the outer bund. The height of this bund is governed by keeping marine water out from the treatment systems for most tide events yet being low enough to provide relief for the stormwater network in extreme rainfall events (e.g. 10 year flows), around 2.5 m RL.

Figure 2-5: Main components of a biofiltration area / raingarden (www.waterbydesign.com.au)



3 Experience

3.1 Expertise of authors

This report combines assessments of effects of the project on the existing stormwater regime carried out by Dale Paice, Robin Allison and Tony Cain. The report was reviewed by Stephen Priestley.

Dale Paice is a Senior Associate Civil Engineer with Beca Ltd in Auckland. She has a Bachelor of Engineering with First Class Honours in Civil Engineering from the University of Auckland and 14 years post-graduate experience particularly in stormwater management for land development and infrastructure projects. Her projects have included all aspects of stormwater management for land development projects from flood risk, pipe network drainage and stormwater quality treatment.

She has carried out drainage design and flood risk assessment for highway projects including Eastlink in Melbourne and Southern Highway Upgrade in Belize and her designs for stormwater quality improvement have included work at the Ports of Auckland and the New Lynn Transit Oriented development.

Robin Allison is an environmental engineer who understands the benefit of water in community spaces. He is a founding Director of Design Flow, a specialist consulting company focussing on water sensitive urban design / low impact design and especially stormwater treatment. He has specialist skills in urban stormwater management, and in particular, integrating and delivering water sensitive urban design in prominent public domain spaces.

He has a PhD in Environmental Engineering (stormwater) and a Bachelor of Engineering (civil). With more than 20 years post graduate experience, Robin has worked on urban development and redevelopment projects, numerous wetland and biofiltration designs, stormwater harvesting, water policy development as well as research and publications on stormwater treatment devices. His expertise covers investigation, planning, design, construction supervision and project management of water infrastructure. In addition he has authored numerous industry guidelines and delivery training on all aspects of water sensitive urban design.

Tony Cain is a Senior Water Engineer at GHD Ltd. He has a Higher National Certificate in Civil Engineering (UK) and has more than 25 years' experience in the civil engineering industry in the UK (1989 to 1999), Ireland (1999 to 2011) and New Zealand (2011 to present) principally as a stormwater and wastewater engineer.

His experience, relevant to the Project, has been in the design of the stormwater collection and treatment systems and, the preparation of erosion and sediment control plans (ESCPs) for infrastructure projects in New Zealand, including small stormwater pipeline replacements and upgrades, land development and large roads projects. Tony's particular experience in New Zealand includes the following projects:

- Albany Highway North Upgrade - Auckland Transport - (Stormwater – Detailed Design);
- Christchurch Southern Motorway Stage 2 - NZ Transport Agency - (Erosion and Sediment Control (ESC) – Consenting Stage);
- Puhoi to Warkworth RoNS Project - NZ Transport Agency - (Erosion and Sediment Control – Consenting Stage); and
- Transmission Gulley Project - NZ Transport Agency - (Construction Stage - Erosion and Sediment Control including Stormwater Management and design during construction).

Tony also provided Evidence in Chief to the Board of Inquiry for the Christchurch Southern Motorway Stage 2 project on behalf of the NZ Transport Agency.

Stephen Priestley has the qualifications of Bachelor of Engineering (1st class honours) and a Master of Engineering Science. He is a Fellow of the NZ Institution of Professional Engineers (IPENZ), a Chartered Professional Engineer, a member of the NZ Coastal Society, and a member of the NZ Hydrological Society.

Stephen has 37 years of experience in civil engineering with a focus on hydrological, hydraulic, coastal and port engineering. He has led and been responsible for projects such as a preparation of the original TP10 for stormwater treatment and TP108 for estimating flood flows in the Auckland Region, stormwater features at Wynyard Quarter, State Highway projects such as Transmission Gully, SH16, and the Hamilton expressway, and stormwater treatment at industrial sites.

The authors of this report have been responsible for the design of the stormwater systems proposed as part of the Project. Dale Paice and Robin Allison were responsible for the foreshore stormwater treatment (Sector 2) and Tony Cain was responsible for the stormwater design for the remainder of the Project (Sectors 1, 3, 4, 5 and 6) and the development of the erosion and sediment control measures throughout.

Stephen Priestley was responsible for the overall stormwater reporting verification.

4 Assessment Methodology

4.1 Preparation

Since January 2016, preparation for design and assessment of effects has included the following activities:

- Site visits;
- Regular design team meetings with the wider project design team;
- Regular technical meetings with Auckland Council;
- Participation in the multi-criteria analysis process for the project alignment and for the foreshore / coastal edge concept selection
- Regular interactions with designers and assessors including ecology, landscape architecture, groundwater, coastal process disciplines;
- Preparation of the Embankment Stormwater Concept Design report
- Preparation of the Roadway Stormwater Design Report; and
- Review of water quality and quantity data as made available.

4.2 Statutory framework and guidelines

The following documents have informed the assessment of stormwater effects.

- The Resource Management Act (1991);
- New Zealand Coastal Policy Statement (2010);
- Auckland Unitary Plan; Decision Version (August 2016);
- National Policy Statement for Freshwater Management (2014);
- NZS 4404: Land Development and Subdivision Infrastructure;
- MFE, 2008: Preparing for Climate Change – a guide for local government in New Zealand;
- MFE, 2009: Preparing for Coastal Change – a guide for local government in New Zealand;
- NIWA, 2013: Coastal Inundation by Storm-Tides and waves in the Auckland Region. Prepared for Auckland Council; and
- GREIG, D, JAMES, 2014: Coastal Effects Assessment Guideline. For NZTA.
- Auckland Council Guideline Document 2015/004 *"Water Sensitive Design for Stormwater"*.

4.3 Methodology for existing environment assessment

The existing environment with respect to stormwater quality and quantity was characterised through the following methods:

a. Review of available catchment information and previous studies including:
   - Draft Auckland Council Integrated Catchment Studies, including flood hazard studies, for six stormwater catchments traversed by the Project: (Auckland City Council / Metrowater, circa 2004)
     - Royal Oak;
     - Onehunga;
     - One Tree Hill;

    - Mount Wellington – Southdown;
    - Mount Wellington South; and
    - Ōtāhuhu East.
  - Hydrological and hydraulic "MOUSE" stormwater models from the above Onehunga and One Tree Hill studies;
  - Auckland Council GIS database for the existing Auckland stormwater network and information on flood storage volumes of topographical depressions; (Accessed January – October 2016)
  - NZ Transport Agency PDF and paper drawings of as-built and design drawings for the stormwater systems for State Highway 20 and State Highway 1 provided by the Auckland Motorway Alliance (AMA);
  - Aerial mapping including historical aerials;
  - 2013 LiDAR existing ground contour data;
  - Auckland Isthmus geological maps;
  - Auckland Unitary Plan zoning maps;
  - Auckland Council and NIWA water quality studies for Auckland; and
  - Rainfall records from the Auckland Airport.

b. Field monitoring of water quality, flow and rainfall (summarised in Appendix C) including:
  - Rainfall monitoring within the catchment;
  - In-pipe flow monitoring;
  - In-pipe automatic sampling during flow events for water quality testing;
  - In-pipe continuous monitoring for turbidity and pH;
  - Grab sampling for water quality testing; and
  - Sediment quality testing.

c. Models built to assess the existing stormwater regime:
  - Rainfall-runoff models to predict stormwater flows and volumes using TP108 methodology and hydraulic grade line assessment of the stormwater networks;
  - Comparison of rain-fall runoff and hydraulic grade line assessments results to previous Council MOUSE modelling;
  - A water quality model using "MUSIC" software to predict contaminant loads in terms of total suspended solids;
  - A water quality model using the using the former Auckland Regional Council's Contaminant Load Model (ARC:CLM) to predict contaminant loads in terms of total copper and zinc; and
  - Sensitivity testing of key assumptions in the modelling such as soil type and impervious cover.

4.4 Methodology for water quality assessment

Water quality effects can occur through contaminants entrained in stormwater or through additional runoff exacerbating soil erosion in the receiving environment. The existing environment assessment found the latter effect unlikely due to the nature of the receiving environment (that is predominantly the CMA or ground soakage) hence the effects assessment focuses on contaminant loading.

Common practice is to express treatment device efficacy in terms of a percentage reduction in contaminant load achieved through the treatment device. In Auckland, the typical standard applied is 75% removal of total suspended solids (TSS) on an annual average basis and hence that measure has been adopted for design of treatment devices throughout the Project. TSS removal also provides a surrogate measure for reduction in other contaminants (e.g. zinc and copper).

It is common practice in Auckland to design treatment devices using the former Auckland Regional Council's 2003 technical publication 10 "Stormwater management devices: design guidelines manual" (TP10) and assess water quality effects using a spreadsheet model (ARC:CLM) produced by the former Auckland Regional Council to suit TP10 treatment devices. However, this approach was not suitable for the Project due to the foreshore treatment systems where two different types of device (wetland and biofiltration) interact differently depending on the size of the rainfall event. For that reason as well as to allow more detailed design refinement for the space constrained foreshore treatment areas, a continuous modelling approach was adopted.

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC – version 6.1) was used for the simulation using 6-minute rainfall data over an eight year period. The MUSIC model is specifically designed to simulate pollutant generation and removal process in urban catchments. Six minute rainfall data were gathered from Auckland Airport (C74082) from 1986 to 1994. The data show an average rainfall depth of 1114mm per year. The results were also compared using a longer data set (15 years) from Albany Wastewater Treatment Plant and were found to have similar results.

The model assumes typical contaminant loads from industry understanding of stormwater quality taking account of the different types of land-use in the catchment. As a means of validating the approach, MUSIC model outputs have been compared to predicted sizes for stand-alone wetlands and biofiltration systems sized using TP10. The required sizes were found to be comparable.

MUSIC also allows contaminant concentrations to be adjusted by the user where data are available. This was done for total nitrogen in baseflows for catchment 6, 6A, 8 and 10 to account for results of the stormwater quality investigations. The higher concentrations were concluded to have come from historical landfill leachate and/or wastewater reaching the stormwater network. Other monitored contaminant levels were within the ranges used by MUSIC.

Table 4-1: MUSIC Stormwater Quality Model Data Inputs

Input	Data used in modelling
Rainfall station	C74082 Auckland airport
Time step	6 minute
Modelling period	1986 – 1994
Mean annual rainfall	1,114mm (for the period used)
Mean annual evapotranspiration	1,059mm

The model simulates the interaction between treatment devices and pollutant generation and removal at each time step to provide a thorough assessment of the pollutant removal process. MUSIC has been developed over more than a decade and is based on thorough research results from the last 18 years on the pollutant removal performance of different treatment systems. MUSIC has become the standard modelling approach for stormwater systems in Australia. Assessing stormwater treatment strategies using MUSIC is a requirement by many local authorities in Australia. MUSIC was also used as the basis for the design of the stormwater treatment systems in Wynyard Quarter (e.g. Jellicoe, Madden and Halsey Streets) and at Wellington's Waitangi Park.

The MUSIC model was used to predict pre and post development total TSS loads and hence assess effects. Figure 4-1 shows a range of expected TSS loads from various sources. The TSS load applied to industrial sites in the Project MUSIC model is shown as an example. The ARC:CLM model was used to predict total copper (Cu) and total zinc (Zn) loads with the reductions achieved in treatment devices predicted proportional to TSS reductions according to the table in Table 4-2.

While modelling can be unreliable at predicting absolute contaminant load due to the variability of contaminant generation in stormwater catchments (as shown on Figure 4-1), effects assessments are relative and hence more reliable.

Figure 4-1: Suspended solids contaminant generation estimates **(chart source: Australian Runoff Quality 2006, Engineers Australia).**

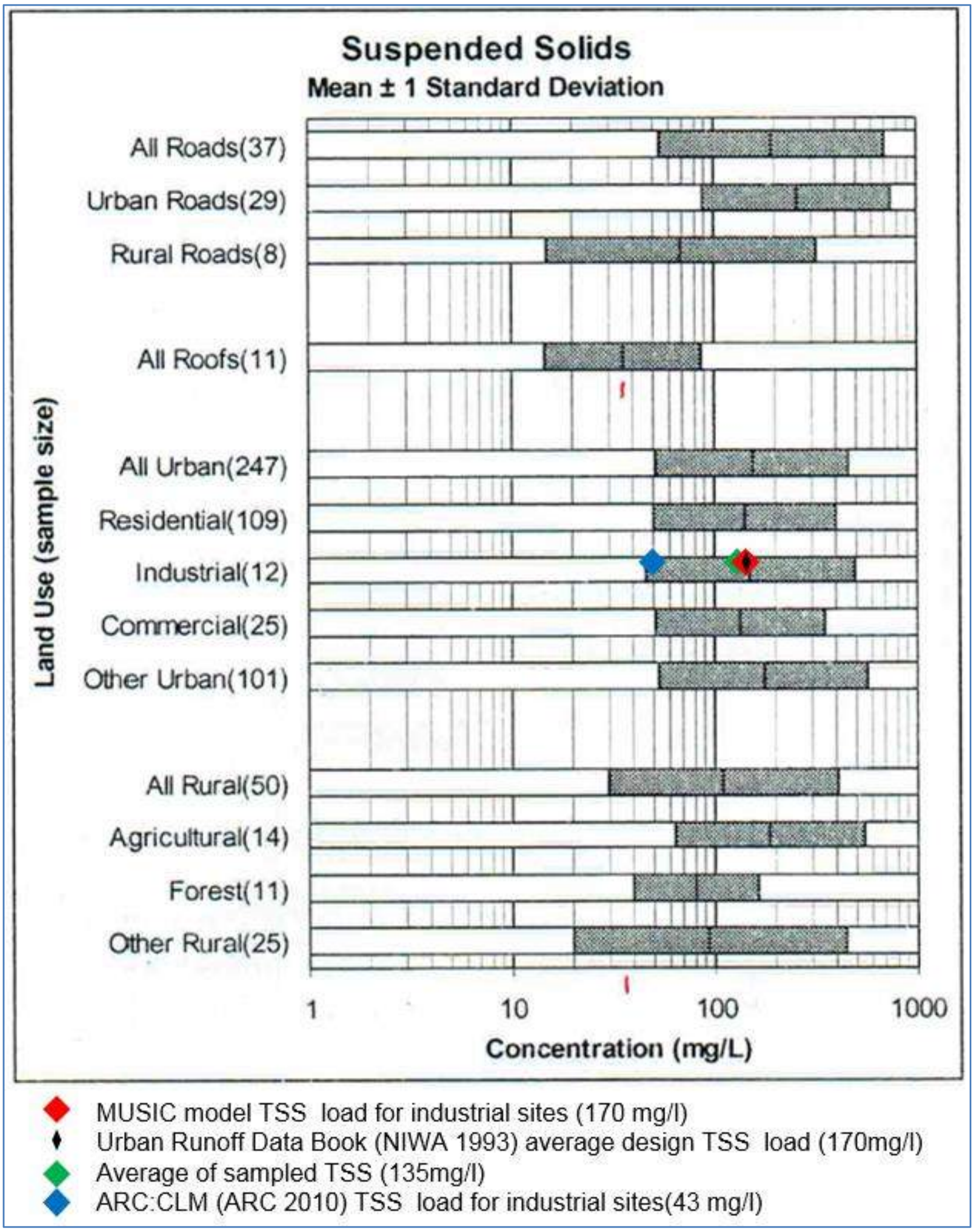


Table 4-2: Load reduction factors for a range of stormwater treatment devices (2)

Roads and other paved surfaces	Load reduction factor			
Treatment Option	TSS	Zn	Cu	TPH
Biomediafiltration	0.75	0.60	0.70	0.70
Catchpit filter	0.40	0.20	0.25	0.30
Catchpits	0.20	0.11	0.15	0.15
Constructed wetland	0.80	0.60	0.70	0.60
Dry pond	0.60	0.20	0.30	0.10
Porous paving	0.50	0.30	0.40	0.50
Rain garden	0.75	0.70	0.75	0.80
Sand-filter	0.75	0.30	0.40	0.70
Storm-filter	0.75	0.40	0.65	0.75
Swale	0.75	0.40	0.50	0.40
Vegetative filter strips	0.30	0.10	0.20	0.30
Wet extended pond	0.80	0.40	0.50	0.20
Wet pond	0.75	0.30	0.40	0.15
Wet pond with flocculation	0.80	0.50	0.60	0.50

MUSIC was also used to estimate the removal of ammoniacal nitrogen from leachate during times of no rainfall (i.e. when not diluted by stormwater). This was done because ammoniacal nitrogen was found to have elevated concentrations in the leachate (up to 80 mg/L) and could impact on marine waters (refer to the existing water quality assessment report included as Appendix B).

Inputs to the MUSIC model were modified to account for monitored levels of ammoniacal nitrogen (30-80 mg/L) and the wetland treatment process algorithm modified to assess ammoniacal nitrogen processing in wetlands (i.e. the K – C* components of the model). Treatment performance values were determined form Constructed Wetlands for Pollution Control (2000, IWA).[3]

This model was developed to specifically investigate ammoniacal nitrogen reduction from leachate. It was assumed (for modelling purposes) that undiluted leachate (30-80mg/L) was the only input at the rates estimated in Technical Report 13 Groundwater Assessment (i.e. 140m^3/day, or 1.6L/s). The leachate is assumed to only be treated in the wetlands as the flows rates from leachate are low and would not cause the wetlands to overflow into the biofiltration systems.

The assessment assumes that leachate will be directed into landform 2 (@ 40m^3/day) and landform 3 (@100m^3/day). To increase conservatism in the modelling, these flow rates were doubled in the model and it was also assumed there was no evaporation from the wetlands. The modelling was performed to provide a degree of certainty that the marine environment would not be affected by ammoniacal nitrogen flowing from the wetlands.

In wet weather, the leachate will be diluted by stormwater and will still be treated as flows pass through the wetlands and biofiltration areas.

[2] Auckland Regional Council Technical Report 2010/003 “Contaminant Load Model User Manual”.

[3] IWA Specialist Group ion Use Of Macrophytes in Water Pollution Control, 2000, *Constructed Wetlands for Pollution Control*, ISBN 1 900222 05 1

4.5 Methodology for flood risk assessment

Flooding assessment was based on:

- Rainfall-runoff models to predict stormwater flows and volumes using TP108 methodology and results from flood studies using MOUSE modelling carried out as part of draft Auckland Council Integrated Catchment Studies carried out circa 2004
- Hydraulic grade line assessment of proposed stormwater infrastructure and comparison to existing case hydraulic grades assessments. The analysis consider pipes, overland flow paths and open channel capacity calculations allowing for losses through outlets, one-way valves, inlets, manholes and pipes.
- Consideration of the existing climate situation and the projected climate allowing for 100 years of climate change.
- Consideration of a range of design events based on the combined probability of extreme rainfall and tidal events.
- Consideration of the risk and consequence of blockage or failure of stormwater infrastructure.

More detailed hydrological and hydraulic modelling is likely to be necessary for detailed design and more detailed modelling would also allow for the refinement of the reticulation system and treatment device sizing. Current modelling of the stormwater flows and contaminants, however, is sufficient to size the outlet pipes and treatment devices and derive the maximum footprint.

4.6 Methodology for construction effects assessment

Stormwater management during the construction phase is a separate and unique stage in the management of stormwater runoff from the Project. It requires the provision of various erosion and sediment control (ESC) measures and practices to be implemented and maintained during construction to minimise the potential for environment effects.

4.6.1 Erosion and Sedimentation Process

Land disturbing activities associated with construction projects increase the potential for erosion of disturbed earth during rainfall events which in turn leads to an increased risk of sediment-laden stormwater runoff from the construction zones being discharged to the receiving environment. Both erosion control and sediment control measures are used to minimise the effects of earthworks activity on the receiving environment.

Erosion is a natural process which occurs when the surface of the land is worn away (eroded) by the action of water, wind, ice or geological processes. Through the erosion process, soil particles are dislodged, generally by rainfall and surface water flow. As rain falls, water droplets concentrate and form small flows. As this flow moves down a slope, the combined energy of the rain droplets and the concentration of flows has the potential to dislodge soil particles from the surface of the land.

Sedimentation occurs when these soil particles are deposited. The amount of sediment generated depends on the erodibility of the soil, the energy created by the intensity of the rain event, the site conditions (for example the slope and the slope length) and the area of bare earth or unstabilised ground open to rainfall.

4.6.1.1 Erosion Control

The control of erosion is based on the practical prevention of sediment generation in the first instance. If erosion control is effective and sediment generation is consequently minimised, then the reliance on the sediment control process is less important. Therefore during construction the emphasis will be placed on the prevention of erosion in the first instance to reduce the amount of sediment being generated.

4.6.1.2 Sediment Control

Sediment control, on the other hand, refers to management of the sediment after it is generated. It is inevitable that some sediment will be generated through earthworks operations, even with erosion control measures in place. Sediment control is designed to capture this sediment and minimise any resultant discharge. It should be noted that whilst sediment control measures will intercept sediment laden discharges, removing the majority of sediment leading to a significant reduction in sediment discharges, they are not capable of intercepting all sediment contained within stormwater runoff from construction sites, and therefore as noted above, a particular emphasis will be placed on the prevention of erosion in the first instance.

4.6.2 Construction Stormwater Effects

We have assessed potential construction related stormwater effects as follows:

- Identified and assessed the construction-related stormwater management issues for the Project;
- Developed construction stormwater management methodologies for key construction activities;
- Described the environmental management issues and possible solutions including Erosion and Sediment Control (ESC) measures for the construction process;
- Assessed environmental risks associated with sediment yield using the Universal Soil Loss Equation (USLE) to determine potential sediment discharges to the environment during construction; and
- Identified monitoring procedures to be carried out during construction.

As noted previously, it is inevitable that some sediment will be generated within each of the construction zones and sediment controls have been developed to capture this sediment to minimise the discharge sediment-laden discharges to the receiving environment.

In addition to ESC structural practices, which include physical measures such as sediment retention ponds (SRP) and decanting earth bunds (DEB), the construction of the Project will also incorporate non-structural practices. These will focus on various site management practices, such as staging and sequencing of construction works, and providing an appropriate level of resourcing for environmental management and monitoring.

4.6.2.1 Erosion and Sediment Control Measures

The indicative ESC measures for the Project are shown on the Project’s Erosion and Sediment Control Plan drawings[4] and have been designed to minimise sediment yield from the project. The measures detailed in the ESCP have been designed to Auckland Council’s GD05 (Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region) and are proposed throughout the Project and especially where there is a probable risk of sediment discharges reaching the receiving environment. ESC measures will be implemented with a hierarchy and priority order as follows:

- Avoidance of effects will be the first priority;
- Erosion control will be a priority in all circumstances by preventing sediment generation through a range of structural (physical measures) and non-structural means (methodologies and construction sequencing);
- Sediment retention devices such as Sediment Retention Ponds (SRPs) and Decanting Earth Bunds (DEBs), which may also include chemical treatment, will be the primary sediment control method to be utilised;
- Discharge locations will be carefully selected; and

[4] Plan set 10: Erosion and Sediment Control (Volume 2: Drawings)

- Stream works will only be undertaken where they are a necessary component of the Project and stream crossings will be based on bridge structures, where at all possible, to avoid direct stream disturbance activities.

The Transport Agency has a proven track record with respect to ESC on large infrastructure projects with many of these such as the ALPURT, Waterview Connection and the Northern Busway projects demonstrating the effectiveness of the approach taken which is based on the ongoing approval of CESCPs, or the equivalent of, throughout the Project. The ESC approach taken is consistent with the approach taken by other consenting authorities for large scale projects throughout New Zealand.

5 Existing Environment

5.1 Rainfall

Rainfall for storm events has been determined from TP108. Average annual rainfall depths in Auckland are in the order of 1100 to 1200mm. For water quality monitoring 6 minute rainfall data from a gauge at the Auckland Airport for an 8 year period of record was used.

Table 5-1: Summary of rainfall event depths

Event	Rainfall depth (mm)	Rainfall depth (mm) with 100 years of climate change
100 Year ARI	185mm	16.8% increase on rainfall depth (=216mm)
10 Year ARI	125mm	13.2% increase on rainfall depth (=142mm)
2 Year ARI	75mm	9.0% increase on rainfall depth (=82mm)
First Flush / Water Quality Volume	1/3 2 Year ARI = 25mm	No long term increase expected (=25mm)

5.2 Tide

The tidal characteristics for Māngere Inlet, as recorded at Onehunga Wharf, are summarised in Table 5-2. The effect of climate change over the next 100 years is predicted to raise tide levels by as much as 1 m. (Proposed Auckland Unitary Plan).

Table 5-2: Tidal Characteristics for Māngere Inlet recorded at Onehunga Wharf

Tidal Levels	Chart Datum (m) for 2016	Auckland Vertical Datum (1946 – m RL) (i.e. Project Datum)
Highest Recorded Tide (1965)	5.24	3.04
Highest Astronomical Tide (HAT)	4.54	2.34
Mean High Water Springs (MHWS)	4.25	2.05
Mean High Water Neaps (MHWN)	3.44	1.24
Mean Sea Level (MSL)	2.42	0.22
Mean Low Water Neaps (MLWN)	1.33	-0.87
Mean Low Water Springs (MLWS)	0.45	-1.75
Lowest Astronomical Tide (LAT)	0.10	-2.10
Lowest Recorded Tide	-0.48	-2.68

5.3 Combined rainfall and tide events

Astronomical tidal levels for Onehunga Wharf were analysed in terms of the amount of time exceeded above mean seal level (RL 0.22 m). If it assumed that tidal and storm (rainfall) events are independent, then it is feasible to assess the combined probability of these events. For widespread storm events, storm surge can also be present due to low atmospheric pressures and strong winds. An allowance of 0.5 m storm surge was included in the analysis.

Table 5-3: Storm and Tidal Events for 1% AEP (100 year ARI) Probability

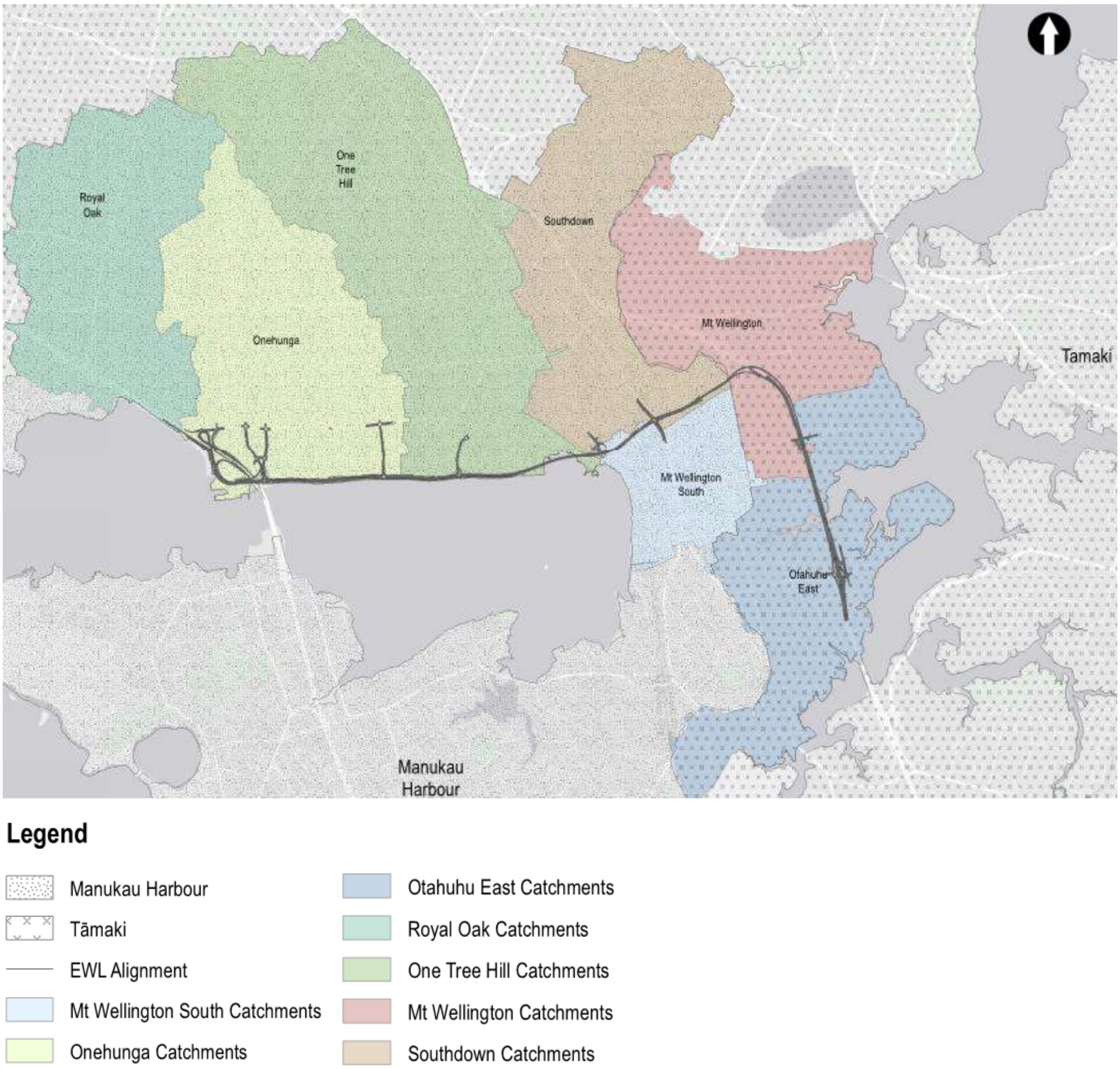
Storm Event AEP/ARI	Tidal Event: Exceedance above MSL	Tidal Level (m RL)	Storm Surge (m)	Still Water Level (m RL)	Combined Rainfall/Tide AEP
1% (100 years)	100%	0.22	0.5	0.72	1%
2% (50 years)	50%	1.15	0.5	1.65	1%
2.2% (45 years)	45%	1.24	0.5	1.74	1%
10% (10 years)	10%	1.8	0.5	2.3	1%
20% (5 years)	5%	2.05	0.5	2.55	1%
Nominal	<1%	2.3	0.7	3.0	1%

5.4 Existing catchments

In general, there are two major catchments through which the project traverses, the Manukau Harbour (including the Māngere Inlet) and the Tamaki River. Within these catchments there are six sub-catchments studied separately in Auckland Council catchment management studies, as shown in Figure 5-1.

- Royal Oak - Discharges to the Manukau Harbour;
- Onehunga - Discharges to the Māngere Inlet;
- One Tree Hill - Discharges to the Māngere Inlet;
- Mount Wellington Southdown - Discharges to the Māngere Inlet and the Tamaki River;
- Mount Wellington South – Discharges to the Māngere Inlet; and
- Ōtāhuhu East– Discharges to the Tamaki River

Figure 5-1: Auckland Council Catchment Management Studies Sub-Catchment Plan (extract from drawing GIS-AEE-SW-038 in Appendix A)



5.5 Existing soils and land use

The soils in the Project area catchments vary from clay, volcanic soils underlain by basalt, roadway and fill areas. Landuse is generally fully developed urban catchment with residential, commercial and industrial uses. TP108 uses a US Department of Agriculture, Soil Conservation Service (SCS, 1986) approach which assigns a curve number to describe the runoff characteristics of the land based on soil type and land use. The curve numbers assigned for the Project catchments are shown in Table 5-4. Areas modified by earthworks, such as fill embankments, cut slopes and spoil sites, are likely to generate higher runoff, and to reflect this, higher curve numbers are assigned.

Appendix A includes drawing GIS-AEE-SWE-010 which outlines these soil groups over the foreshore area stormwater sub-catchments.

Table 5-4: SCS Curve Numbers Assigned to the Project Catchments

Hydrological Soil Category	Soil Category Description	Curve Number *
A	Granular volcanic loam	39
B	Alluvial Sediments	61
C	Clay	74
CN = 17	Granular volcanic loam underlain by free-draining basalt	17
Fill	Fill	Assumed = 74
Impermeable Areas	Roadways and Roofs	98

* Curve Number reflects the percentage runoff during an extreme rainfall event of 250mm.

5.6 Existing streams

Many of the catchments traversed by the Project drain to soakage rather than through freshwater streams. Receiving environments for Project stormwater are typically via existing stormwater networks to discharge to ground soakage or the coastal marine area.

Estuarine watercourses in the Project area include Miami Stream and Anns Creek. Miami Stream is located in the Māngere Inlet foreshore area and is also referred to as Green Stream following a contamination incident (URS, 2010). Review of historical aerial photographs have shown that Miami was not originally a stream but has been formed as an open channel left between landfills placed in the intertidal zone during the last century. There is one freshwater watercourse, referred to as Clemow Stream which drains catchments from the Mt Wellington Area to the coastal marine area at Tamaki River.

Auckland Council, through the Proposed Auckland Unitary Plan, identifies areas through an overlay (“Stormwater Management Area : Flow”) where new stormwater discharges to freshwater streams are controlled and required to provide detention for slow release to avoid increasing bank erosion and improve ecological health in the receiving streams. These controls are not applied to any of the Project catchments.

5.7 Existing stormwater management

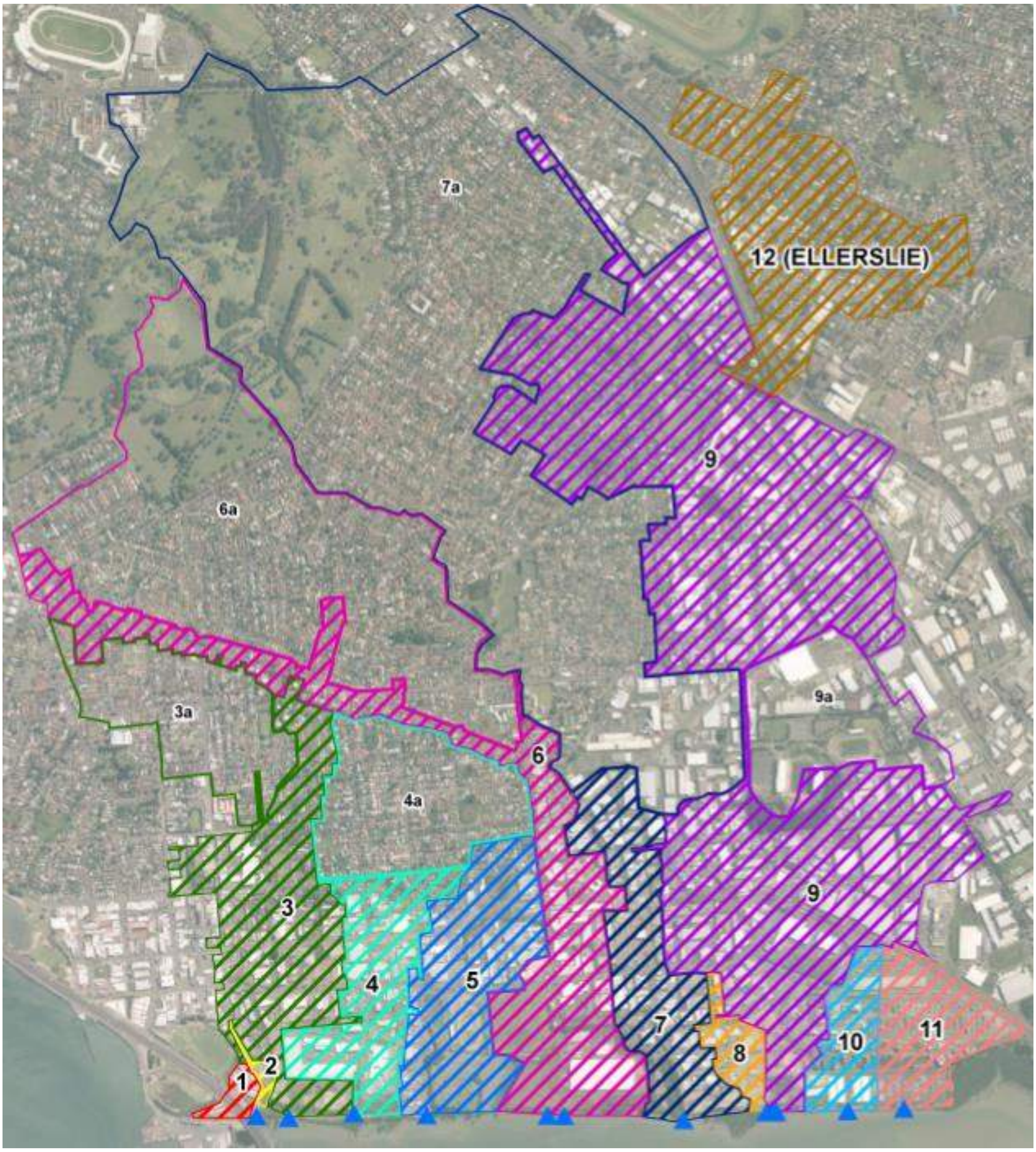
The following sections describe the existing stormwater management regime by sector, addressing stormwater infrastructure, water quality and flood risk.

5.7.1 Sector 2 (foreshore area)

5.7.1.1 Existing stormwater infrastructure

The catchment affected by the Project in Sector 2 is some 10 times greater than the catchments affected by the remainder of the Project.

Figure 5-2 Sub-catchments draining to Māngere Inlet via the foreshore area



The overall catchment potentially discharging to the foreshore area is approximately 1350 Ha. Of this, approximately half drains to soakage. The remaining half (or 675 hectares) is serviced by the stormwater pipe network which drains to 11 outfalls along the foreshore as shown on Figure 5-2. There is also a pipe connection that allows runoff from part of Ellerslie (shown as catchment 12 on Figure 5-2) to discharge into the catchment 9 pipe network, however that pipe is an overflow that only operates in high flow events when soakage capacity and attenuation pond capacity in Ellerslie is exceeded. Overall, in low flow or treatment events, the catchment estimated to discharge to the foreshore area is approximately 611 Ha.

The overall catchment is approximately 45% industrial, 10% park space and 45% residential space, with a handful of special purpose zones throughout. The zones are shown on drawing GIS-AEE-SWE-011 in Appendix A. Industrial areas are predominantly to the south and south-east of the catchment, immediately adjacent to the Māngere Inlet, whereas residential areas are mostly located towards the north and north-west, along Mt Smart Road and on the slopes of One Tree Hill. Overall the catchment has approximately 70% impervious area.

5.7.1.2 Existing stormwater quality

There are few stormwater treatment devices in the catchment with most of the stormwater runoff currently untreated. Council records do indicate the following devices in the catchment or vicinity, however, there are likely to be some other private devices not recorded:

- Southdown Reserve Wetland – 127-129 Hugo Johnston Dr;
- Bassant Reserve Pond – 45 Walls Rd;
- Anns Creek Reserve Wetland – 811-813 Great South Rd;
- A stormwater treatment wetland off Captain Springs Road; and
- Six proprietary devices on sites on Great South, Sylvia Park Road and Cawley Street.

Information available from the East West Link water quality monitoring programme and review of previous studies indicates that stormwater quality is likely to be at least typical of an untreated developed catchment in Auckland and potentially worse in terms of the stormwater contaminant type and load such as TSS and metals. Elevated faecal coliforms and ammoniacal nitrogen levels indicates wastewater cross connections and overflows within the stormwater network and potentially leachate ingress. A summary of water quality data is included in Appendix B.

The area has been identified by Council as likely contributing significant quantities of contaminants to Māngere Inlet (Integrated Catchment Study Area 4: Onehunga – Medium Level Options Analysis Report, 2004, Auckland City and Metrowater). In addition, the nature of the catchment land uses (i.e. industrial and use and heavy traffic movement) significantly increase a risk of spills which have a high likelihood of reaching the Māngere inlet as there are few treatment devices to trap them.

Modelling predicts approximately 870 tonnes of suspended sediment is generated from the affected 657 hectares of catchment each year. In addition to suspended solids, there are expected to be many other pollutants typically carried in stormwater from urban areas such as metals, hydrocarbons, nutrients and coliforms. Total zinc and total copper loads were estimated to be 2.7 and 0.2 tonnes per year respectively.

5.7.1.3 Existing spill and dumping risk

Auckland Council provided details of recorded spills in the Māngere and Onehunga area. No major spill events were identified and most were considered relatively minor. It should be noted that the Council's record on spill events is not considered complete as it typically requires a member of the public or the spill originator to notify the Council's Pollution Response team. Recorded spills included paint and oil spills and wastewater entering stormwater drains. Auckland Council operations staff have reported anecdotally that spills, including hydrocarbons, are observed relatively frequently during routine inspections in existing stormwater treatment wetlands in local catchments.

During Project field investigations, a member of the public (who wished to remain anonymous) provided photographs of release of a red chemical that they had observed entering the Māngere Inlet from a stormwater outlet located east of the Miami Stream outfall. Also during the field investigations for this project, Project field staff observed visual indicators of apparent petroleum hydrocarbon contamination in the stormwater outfalls into the Māngere inlet. Photographs are provided on drawing SW-E-007 in Appendix A of observations during stormwater sampling, potentially representing hydrocarbon, sewage and leachate contamination entering Māngere Inlet.

5.7.1.4 Existing interaction with landfills and leachate

The Māngere Inlet catchment contains some of the most heavily industrialised parts of Auckland's central isthmus. There is a widespread legacy of contamination, including several coastal reclamation sites that were historically used for landfills and uncontrolled filling. There is a possibility that some of the legacy landfills along the foreshore are leaking leachate into the stormwater network (as well as into groundwater system) and to the Inlet as described in Technical Report 13 Groundwater Assessment and in the existing water quality assessment included as Appendix B.

Initial leachate quality results from samples collected from boreholes in Pikes Point and Galway Street landfill areas show average concentrations for a range of parameters. Landfill leachate is reasonably comparable to other closed landfills within Auckland city. The exception to this is chloride, which historically has been significantly higher than other closed Auckland landfills due to seawater ingress.

Ammoniacal nitrogen was also detected at elevated levels in leachate and stormwater base flows in catchment 6, 6A, 8 & 10 (refer to the existing water quality assessment in Appendix B). These elevated values have been adopted in the assessment model (Section 4.4).

5.7.1.5 Existing sediment quality

Existing sediment quality is covered in Technical Report 16 "Coastal Processes Assessment".

Initial results of the sediment quality testing carried out for the Project found that concentrations of organic contaminants (such as organochlorine pesticides, polycyclic aromatic hydrocarbons, petroleum hydrocarbons, and semi-volatile organic compounds) were generally not detected above laboratory trace analytical detection limits.

Concentrations of up to 39 mg/kg ammoniacal nitrogen were measured in some sediment samples, indicative contamination from leachate and/or waste water.

The mean total arsenic concentration observed during investigations for the Project was elevated above the average concentration for both the Waitemata and Manukau harbours. The upper concentration range for arsenic in sediment ranged from 30 mg/kg - 69 mg/kg. Parent soil materials (both volcanic and non-volcanic soils) in the Auckland region have naturally occurring concentrations of between 0.4 - 12 mg/kg. This indicates that a portion of the arsenic measured in sediments is likely due to contamination from anthropogenic sources.

In the Māngere inlet, the mean total copper and lead concentrations in sediment were generally consistent with concentrations for the wider Manukau harbour, and consistent with naturally occurring concentrations in parent soil materials (both volcanic and non-volcanic). The mean total zinc concentration measured in sediment was below the mean for the Waitemata and Manukau Harbours.

A series of samples were taken at and adjacent to the existing saltmarsh area near the Neilson Street interchange as shown in Figure 4-2. These results show the saltmarsh / mangrove areas retaining contaminants in sediment. A similar pattern has been identified in the vegetated areas of Miami Stream. These results could indicate that these areas are acting as a natural vegetated saltwater treatment systems. It could also indicate that the intertidal sediment related contaminants are diluted by other sediments from the wider harbour.

Figure 5-3: Sediment sampling at and adjacent to existing saltmarsh

Sample Type: Sediment

	Sample Name:	1.a. 08-Jul-2016 7:00 am	1.b. 08-Jul-2016 7:00 am	2.a. 08-Jul-2016 7:10 am	2.b. 08-Jul-2016 7:10 am	3.a. 08-Jul-2016 7:20 am
	Lab Number:	1613227.1	1613227.2	1613227.3	1613227.4	1613227.5
Total Recoverable Copper	mg/kg dry wt	66	42	16.8	17.5	15.3
Total Recoverable Lead	mg/kg dry wt	139	65	22	23	22
Total Recoverable Zinc	mg/kg dry wt	210	220	111	119	110

	Sample Name:	3.b. 08-Jul-2016 7:20 am				
	Lab Number:	1613227.6				
Total Recoverable Copper	mg/kg dry wt	13.8	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	20	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	105	-	-	-	-

5.7.1.6 Existing flood risk

The Auckland Council commissioned flood hazard studies carried out circa 2004 summarise existing flood issues in the Onehunga and One Tree Hill catchments.

Only a few historical incidences of residential habitable floor flooding were identified with three in the One Tree Hill Report and one in the Onehunga report. All four locations are upstream in the residential catchments near the One Tree Hill reserve, and outside the zone of influence of the Project. It is understood that inadequate soakhole capacity causing overland flows contributed to the flooding of those properties.

The studies also predicted that approximately 82 houses of a total number of 9,400 houses (that is 0.9%) are at significant risk of flooding for the “Maximum Probable Development” land use scenario in a 100 year ARI rainfall event coupled with a Mean High Water Spring tide. In that same event, it was predicted that 71 hectares of land out of the total 1378 hectares modelled (or 5.2%) would be inundated floodplain (excluding overland flow paths).

A number of industrial and commercial buildings were also identified as being subject to inundation in extreme flood events. These are typically further down the catchment and closer to the Project works. Limitations in pipe discharge capacity and lack of overland flow paths into the Māngere Inlet contribute to flooding of low lying commercial areas at the southern part of the catchment, as does the influence of tide. The Auckland Council flood hazard studies did not include predicted climate changes effects on rainfall or sea level.

The lowest ground level at a property (industrial) in the local area is estimated to be at 2.8m RL (Auckland Chart Vertical Datum), on Miami Parade. Mean High Water Springs level is 2.05m RL and the Highest Recorded Tide is 3.04m RL so some properties are susceptible to flooding from tidal inundation in extreme events. Current Auckland Council guidance is to consider a 1 metre increase in sea level over a 100 year period to account for climate change.

Table 5-5 sets out the numbers of properties potentially affected at a range of tide levels. Note that this assessment has been based on ground levels and does not necessarily indicate that buildings within a property will be inundated.

Table 5-5: Number of estimated sites below corresponding extreme tidal level

Tide Level (m RL Auckland Vertical Datum)	Estimated # of Potentially Affected Sites	Estimated # of Potentially Affected Sites with existing buildings
2.5	0	0
3.0 (Current climate 1% AEP event)	21	16
3.5	70	51
4.0 (1%AEP event with 1.0m sea level rise)	107	82
4.5 (min level of road embankment)	211	148

5.7.2 Sector 1 (Neilson Street)

At the Neilson Street Interchange, the Project interfaces with a 105 ha catchment in Onehunga, and from a review of the data provided by Auckland Council it appears that stormwater flows from this catchment discharge to the open channel at the end of Hill Street, prior to discharging to the CMA via a 900mm and 1,500mm diameter culvert constructed beneath SH20.

The Council flood hazard study did identify individual and commercial sites subject to ponding in flood events in Wharangi Street, Hill Street and the western end of Neilson Street, specifically:

- SH20 between the Onehunga Harbour Motorway off ramp and SH20;
- Inside the Hōpua Tuff Ring; and
- Nielson Street, Hill Street and Wharangi Street

Limitations in pipe discharge capacity and the lack of secondary overland flow paths into the Manukau Harbour contribute to flooding of these low lying commercial areas at the southern end of the catchment, as does the influence of tide. These properties do have the potential to be affected by the Project.

5.7.3 Sector 3 (Anns Creek)

There are 2 existing outfalls within Sector 3. The first is at Southdown Wetland Reserve on Hugo Johnson drive and the second is Anns Creek at Great South Road.

- Southdown Wetland Reserve - The Southdown Reserve is an existing stormwater treatment wetland which is managed by Auckland Council. However, due to historic contamination with asbestos it is currently closed to the public. The Southdown reserve performs a stormwater treatment function for the existing catchment of approximately 128 ha and is part of the Mount Wellington-Southdown drainage management area (DMA). The Southdown Reserve discharges to the CMA, in the north eastern corner of the Māngere Inlet, via three 1,350mm diameter culverts which are constructed beneath the Kiwi Rail corridor; and
- Anns Creek receives stormwater flows from an overall catchment of approximately 259 ha which is part of Mount Wellington South. At the Great South Road intersection the upstream catchment area is approximately 131 ha and receives flows via two 1,800mm diameter culverts from Sylvia Park Road (Sector 4) to the east and Great South Road to the North.

Residential habitable floor flooding incidences were reported in the Mount Wellington Southdown Council flood hazard study. However, all of these properties are outside the zone of influence of the Project. It is understood that inadequate soak hole and pipework capacity causes overland flows and contributes to the flooding of those properties.

The flood hazard study did identify individual and commercial sites along Hugo Johnson Drive to be at risk of flooding. It is thought that limitations in pipe discharge capacity and the lack of secondary overland flow paths into the Māngere Inlet via the Southdown Wetland Reserve along with the influence of the tide contribute to flooding of these low lying commercial areas at the southern end of the catchment. These properties do have a limited potential to be affected by the Project.

5.7.4 Sector 4 (Great South Road to SH1 at Mt Wellington)

There are two existing outfall locations in Sector 4. The first forms part of the Sylvia Park Road catchment which discharges stormwater flows to Anns Creek in Sector 3 beneath Great South Road and ultimately discharges to the CMA in the Māngere Inlet. The second outfall location is at Clemow Stream beneath the existing Mount Wellington interchange, which flows in an easterly direction in an open channel and discharges to a tributary of the Tamaki River.

- Anns Creek – The catchment area affected by the Project is the 27ha catchment along Sylvia Park Road between Great South Road and Mount Wellington Highway. Stormwater treatment is currently provided by a Gross Pollutant Trap (Hynds Cleansall) located at 19-21 Sylvia Park Rd, which traps gross pollutants and litter from this predominantly industrial and commercial catchment prior to discharge to Anns Creek;
- Clemow Stream – Clemow stream is a small open channel which runs from Mount Wellington Highway and flows eastwards between Clemow Drive and the existing Kiwirail Corridor. At the Mount Wellington interchange, the upstream catchment area is approximately 59 ha and includes SH1 between the Mount Wellington Interchange and Panama Road to the south as described below;
  - From Panama Road to CH6750, stormwater runoff from SH1 discharges to an open drain on the western side of SH1, which in turn discharges to an underground twin 900mm diameter culvert which runs along the eastern boundary between the Turners and Growers site and SH1 and ultimately discharges to an open drain approximately 100m south east of Clemow Drive. This open drain is culverted beneath Clemow Drive immediately to the west of the Mount Wellington interchange and discharges directly to the Clemow Stream;
  - Stormwater runoff from the southbound super elevated section of SH1 between the Mount Wellington Interchange and CH6900 discharges via an underground pipe and into one of the 900mm diameter culverts. Stormwater runoff from the northbound lanes along this section of SH1 discharges to an existing stormwater pump station which lifts stormwater into one of the 900mm diameter culverts; and

There are no known stormwater treatment systems in the catchment upstream of the Clemow Stream outfall (including SH1).

Residential habitable floor flooding incidences were reported in the Mount Wellington Southdown and Mount Wellington South Council flood hazard studies. However, all of these properties are outside the zone of influence of the Project. It is understood that inadequate soak hole and pipework capacity causes overland flows and contributes to the flooding of those properties.

The flood hazard study did identify individual and commercial sites along Great South Road, Sylvia Park Road, Pacific Rise to be at risk of flooding. It is thought that limitations in pipe discharge capacity and the lack of secondary overland flow paths into the Māngere Inlet via Anns Creek along with the influence of the tide contribute to flooding of these low lying commercial areas. These properties do have a potential to be affected by the Project.

Flood risk areas are identified on the existing SH1 at the Mount Wellington off ramp and beneath the Panama Road Bridge. The Project will directly affect these localised areas.

The flood hazard study did identify individual and commercial sites subject to ponding in flood events in as follows:

- # 19-21 and #20L-N Sylvia Park Road;
- Pacific Rise;
- Railway Corridor Between Mount Wellington Highway and Mount Wellington Interchange;
- SH1 and the Mount Wellington northbound off ramp; and
- Turners and Growers Site.

5.7.5 Sector 5 (SH1 at Mt Wellington to the Princes Street Interchange)

The northern 300 metres of SH1 in Sector 5 flows northwards and flows into the stormwater network which ultimately discharges to Clemow Stream which is discussed in the Sector 4 section above. There are five stormwater outfalls on SH1 in Sector 5, four of which are at Ōtāhuhu Creek and the remaining one is via an existing Transport Agency operated stormwater treatment pond located within the existing Princes Street Interchange.

North of Ōtāhuhu Creek, stormwater runoff from SH1 between CH7450 Panama Road and Ōtāhuhu Creek discharges untreated stormwater on both the eastern and western sides of SH1. South of Ōtāhuhu Creek, stormwater runoff between Ōtāhuhu Creek and the Princes Street interchange is discharged to Ōtāhuhu Creek on the eastern and western sides of SH1. Treated stormwater discharges on the south western side of Ōtāhuhu Creek via a sand filter which serves the northbound lanes of SH1 between Ōtāhuhu Creek and the Princes Street Interchange. There are no other known stormwater treatment devices within the catchment upstream of Ōtāhuhu Creek.

Stormwater runoff from the existing Princes Street interchange is currently discharged through a Transport Agency treatment pond. This treatment pond also receives flow from the Princes Street interchange to the southern limits of the Project. Approximately 0.9 ha of the existing SH1 does not discharge into the pond but connects directly to the existing stormwater pipework which bypasses the treatment pond and connects to a 900mm diameter pipe in Frank Grey Place and discharges to an open drain adjacent to #3A Frank Grey Place and ultimately to Ōtāhuhu Creek.

Residential habitable floor flooding incidences were reported in the Ōtāhuhu East study. However, the majority of these properties are outside the zone of influence of the Project. It is understood that inadequate soak hole and pipework capacity causes overland flows and contributes to the flooding of those properties. There are a number of properties identified to be at risk of flooding adjacent to the existing SH1 as follows:

- #85 and 85A Luke Street; and
- #4 and # 6 Frank Grey Place

These properties are located within localised depressions and the overland flow paths from these properties is indicated to flow onto the existing SH1.

Flood risk areas are identified on the existing SH1 at the Panama Road Bridge and the Northbound lane opposite the southbound Princes Street Off Ramp are also identified as being at risk of flooding, and the design of the Project will directly affect these localised areas.

6 Assessment of stormwater effects

6.1 Potential effects

Potential stormwater effects relate to changes in stormwater quality, flood risk or receiving environment erosion and sedimentation. Effects can occur in operation and construction.

6.1.1 Water quality

Particles from car exhausts, tyres and brakes, silt, oils and litter collect on road surfaces. Many of these small particles adhere onto sediment which is transported through stormwater runoff to discharge to the harbour. Where the water is still, contaminants settle out and accumulate. Other contaminants dissolve as rain passes over them and change the physical-chemical composition of stormwater. The accumulation of sediment, contaminants and changes to the chemical make-up of stormwater affect water and sediment quality and can then have a significant effect on the viability of aquatic resources. The measures of water quality effects used for this assessment are:

- Adequate treatment is considered to be achieved if 75% Total Suspended Solids (TSS) removal on an annual average basis for any new or modified impervious area;
- A benefit is considered to be achieved if the overall load of stormwater contaminants reaching receiving environments is reduced compared to the existing situation. For the purposes of this assessment, the contaminants considered are TSS, total nitrogen, total zinc and total copper; and

6.1.2 Erosion effects

Water quality can also be affected by erosion at discharge points in freshwater streams or through increased stormwater runoff increasing velocities in freshwater streams.

6.1.3 Flood risk

Flooding can affect road users including vehicles, cyclists and pedestrians. It can also affect nearby properties where changes to existing overland flow paths and through constructed piped networks can increase flood levels upstream or divert more flow to properties downstream. For flood risk, the measures used to assess potential effects are:

- Whether properties outside the Project would be subject to increased flood risk with respect to the existing situation; and
- Whether the components of the Project (e.g. the road, walkways) can be designed to achieve commonly accepted flood protection standards.

6.1.4 Construction erosion and sedimentation

Potential stormwater effects in construction relate to increased erosion and sedimentation in receiving environments. There is also the potential for effects on the receiving environment from stormwater discharges during construction as land disturbance activities, such as construction, exposes bare earth surfaces, which when exposed to the elements increases the potential for the generation and discharge of elevated levels of sediment, and consequently have an adverse effect on the quality of water bodies and coastal water.

For erosion and sedimentation the measure used to assess effects is whether industry accepted practice methods for erosion and sediment control will be applied.

6.2 Predicted operational project effects

6.2.1 Stormwater quality

Overall, the Project will provide a benefit with respect to stormwater quality. .

The total Project road surface area is 46 hectares, an impermeable area increase of 21 hectares with respect to the existing situation. All 46 hectares will be treated in new or upgraded treatment devices. In addition, the foreshore treatment areas will cater for a further 611 hectares comprising roads, roofs and sites upstream of the road in Onehunga and Penrose that currently drain through pipes directly into the Māngere inlet without treatment. Stormwater quality modelling shows that the proposed stormwater treatment devices will remove 75% removal of total suspended solids on an annual average basis from the contributing catchments.

As stormwater treatment is provided for a much greater area than the Project itself, the overall result would be a reduction to the quantity of suspended solids, nutrients, metals, hydrocarbons and coliforms currently discharging to the receiving environment via stormwater runoff.

The following changes with respect to the existing situation to long term annual average contaminants discharge are predicted from the approximately 657 hectares of affected catchment:

- A reduction in total suspended solids from 870 to 210 tonnes per year (a 75% reduction));
- A reduction in total nitrogen from 19 to 10 tonnes per year (a 47% reduction);
- A reduction in total zinc from 2.67 to 1.17 tonnes per year (a 56% reduction); and
- A reduction in total copper from 0.24 to 0.08 tonnes per year (a 66% reduction).

The new stormwater treatment systems will also provide a barrier to any accidental spills or dumped substances in the catchments from reaching the marine environment. In wetland areas this may operate in two ways – for smaller spills (of not particularly toxic material) the dilution through the wetland system will enable the pollutants spilled to be broken down through natural processes. For large spills or when the spills contain very toxic material the outlet from the wetland can be shut off and the spill extracted from within the wetland (but this does require notification of the spill and action taken). Both methods will reduce coastal discharge of spilled pollutants.

For Stormfilters, an isolation valve can be provided as part of the structure allowing containment of the spilled contaminants within the treatment chamber, forebay and upstream pipework until they can be removed by mechanical means.

The treatment measures put in place mean that new discharges to either the Inlet or Ōtāhuhu Creek to the inlet or both catchments are unlikely to give rise to the production of any conspicuous oil or grease films, scums or foams or floatable or suspended materials, any conspicuous change in the colour or visual clarity or any emission of objectionable odour.

Where the road embankment is constructed at the coastal edge there is an opportunity to reduce contaminants reaching the Māngere inlet from leachate generated from the existing closed landfills. This effect is covered in separately in Technical Report 13 Groundwater Assessment.

An additional benefit is the opportunity to collect leachate from old landfills on the Pikes Point and treat it in the foreshore wetlands so that it no longer needs to be pumped to trade waste. The new leachate collection system will operate under gravity and discharge leachate to the stormwater treatment wetlands through the embankment. This is proposed because the leachate quality can be sufficiently improved through the proposed stormwater wetlands to ensure no adverse effects on the water quality of the Māngere Inlet. In order to predict the treatment efficiency for leachate, we considered ammoniacal nitrogen because it was found to occur at relatively high concentrations in the leachate and it has potential toxicity in the marine environment. Treatment of ammoniacal nitrogen through the wetlands was modelled under both dry and wet weather conditions using conservative assumptions. Under both conditions, the predicted leachate quality discharging to the Inlet will be acceptable. To provide contingency, provision for removal of leachate by pumping to trade waste will also be made if monitoring indicates it is needed

Ammoniacal nitrogen has been detected in sampled leachate (up to 80 mg/L) Ammonia levels at similar or higher concentrations are common for waters entering vegetated treatment wetlands (particularly in wastewater wetlands).

Removal of nitrogen (including ammoniacal nitrogen) in wetlands is a complex process. The primary process is nitrification, where ammonium is oxidised to nitrate (and nitrite) via a process mediated by aerobic bacteria. The nitrate/nitrite is then converted to gaseous nitrogen via denitrification, a process mediated by anaerobic bacteria.

The gaseous nitrogen is then released to the atmosphere via the water column. Nitrification and denitrification processes occur within both the water column (via the biofilms present on the plant stems) or within the upper sediments. The ability of a wetland to remove ammonia is dependent of the wetland configuration and particularly the availability of dissolved oxygen. Temperature and other factors (such as the loading rate) also play a role in the reaction process (with higher temperatures resulting in faster reaction times). Other ammonium and nitrate removal mechanisms include adsorption and plant uptake (either directly via the water column or from the sediment pore water in the plant root zone).

Fully vegetated wetlands are proposed for the foreshore treatment areas that will receive leachate flows. Water plants will play an important role to maintain dissolved oxygen levels within both the water column and the sediments, providing suitable conditions for nitrification and denitrification to occur. Plants will also directly consume ammonium but the overall load removed via this pathway is expected to be substantially less than the ammonia load removed via nitrification and denitrification. A study of American wetlands[5] (predominately wastewater wetlands) reports removal rates of up to 70% for influent concentrations as high as 200mg/L (from liquid swine manure).

The Project wetlands are designed for flow rates associated with stormwater. Much lower flow rates associated with the leachate will result in longer contact times and therefore enhance the reduction of ammonia nitrogen. It is also expected that leachate flow rates will reduce over time as the bund prevents any seawater ingress into groundwater.

Ammonical nitrogen reduction form the leachate was assessed by using the MUSIC stormwater treatment model (Section4.4) and modifying pollutant generation characteristics to match the ammonical nitrogen monitored in the leachate. The assessment was performed for times when there was no rainfall, i.e. when runoff would not dilute the leachate.

Treatment afforded by the wetlands was also modified to match reported rates of ammonia reduction in constructed wetlands.[6]

Using these assumptions, the MUSIC model predicts reductions in ammonical nitrogen of more than 90% with the wetlands proposed.

To provide additional contingency, the system will be designed to enable leachate to be captured and diverted to the reticulated wastewater system as trade waste if the leachate has negative effects on the wetland or removal rates are deemed too low. There is however, confidence that the integrity of the wetlands will be maintained with leachate entering the wetlands and a reduction in ammoniacal nitrogen will be afforded to the leachate prior to marine discharge. \

[5] California State University, Sacramento, 2009, *Ammonia removal in wetlands: a literature review*, report for Sacramento Regional County Sanitation District

[6] IWA Specialist Group on Use of Macrophytes in Water Pollution Control, 2000, *Construction Wetlands for Pollution Control*, Scientific and Technical Report No. 8, Published by IWA Publishing UK, ISBN 1 900222 05 1

Table 1-9-1 in Appendix D including reference to the Project drawings which show more detail.

6.2.2 Stream erosion effects

Erosion is not likely to be increased as a result of the Project.

The existing environment assessment identified Anns Creek, Southdown Creek and Clemow Stream as the only freshwater streams receiving runoff from the Project works. The stream catchments are already fully developed and not identified by Auckland Council as requiring detention of new discharges under the “Stormwater Management Area Flow” overlay in the PAUP. Hence the potential for additional runoff to affect stream bank erosion is considered low and no stormwater runoff detention is provided in the Project stormwater devices. The potential for local erosion at discharge locations can be managed through appropriate outfall design.

6.2.3 Flood risk effects

Flood risk protection to the Project will meet commonly accepted standards. The proposed new road is set at levels above extreme flood events, high tides and storm surge, allowing for 100 years of predicted climate change effect. In some locations, including along the Māngere Inlet foreshore, this sets the road level higher than some properties upstream. Pipes, inlets and overflows are therefore designed to avoid increasing flood risk at those properties by allowing for overland flow to be directed through the pipes beneath the road.

In two locations, stormwater pumps and attenuation tanks will be used to assist with managing floodwaters, one an existing pump and the other a the proposed new pump station within the new trench through the existing Onehunga Wharf area. Should a mechanical or electrical failure occur during a rainfall event stormwater could flood the East West Link roadway beneath the proposed structure. This potential effect has been addressed in the design through the inclusion of a stormwater storage tank with a volume of approximately 1,700 m^3, which would provide approximately 8 hours storage in a 100yr ARI rainfall event. There are residual flood risks associated with reliance on pump stations. The risk and consequence of failure will have to be further considered throughout the design development.

Near the foreshore, installing one-way valves on the stormwater pipes will constrict the flow that discharges through pipes in a flood event. One-way valves also do have the potential to become blocked or fail. This will increase the risk of flooding to some existing low lying properties in an extreme rainfall event compared to the existing situation where runoff can discharge freely. However, there is also potential for the foreshore works (road embankment) to provide an improved level of protection to those properties from coastal inundation due to sea level rise over time. These factors will have to be considered carefully throughout the design development including the potential to use supplementary pumps, flow gates, additional valves or additional pipes to mitigate the risk of adverse effects on existing properties.

The wetland treatment areas and stormwater bund are to be constructed so that they can be adapted for climate change (in particular, sea level rise) over time This adaptive approach has been adopted as setting the outer bund high enough to accommodate a significant period of sea level rise would exacerbate the flood risk at some low lying properties under existing climate conditions. The adaptations will comprise raising outer bund and overflow levels and amending pipework and valves. This may be required 1 or 2 times over the next 100 years.

Other changes over time could be in increase in runoff from additional development in the catchment or an increase in peak flows from stormwater network upgrades in the catchment. While the design has taken into account the maximum probable development in the catchment, further future proofing can be provided by placing additional pipes through the road embankment during construction. These would be left capped and only need to put into service if Auckland Council upgrades the stormwater network in the future.

A summary of existing and new stormwater discharges for the Project are given in Table 1-9-2 Appendix D.

6.2.4 Other associated effects

In addition to water quality effects, the proposed stormwater treatment systems can contribute to other benefits and effects as summarised below.

6.2.4.1 Naturalised Edge

The wetlands and biofiltration systems will enhance the creation of the naturalised edge to the coast. It will provide a diverse range of plant species, attract wildlife and allow for more natural ecosystem processes to occur.

6.2.4.2 Ecology

Wetlands provide a range of physical, chemical and biological ecosystem services that reflect the wetland water regime, soils, microbial processes and aquatic vegetation species present. Wetlands play an important role in land stabilisation, stormwater attenuation, sediment filtration and capture, nutrient cycling, and pollution capture and treatment. These ecosystem services have a benefit for the wider receiving environment.

6.2.4.3 Wildlife habitat

Constructed wetlands may provide habitat for a range of flora and fauna if designed for that purpose. These species include a variety of macroinvertebrates, fish and bird species specifically adapted to wetland environments. The types of species that occupy wetlands is dependent upon the water regime, size, level of disturbance, proximity to a source population, water quality and aquatic vegetation communities present. Wetlands that have a range of conditions, such as shallow and deep areas may be used by wading birds for foraging, nesting, sunning and loafing.

6.2.4.4 Enhancing plant communities

The plant species chosen for a biofiltration system can be selected to mimic local vegetation communities that provide habitat and food for invertebrates, fish and birds. A mixed native plant community that reflects the local flora and, if possible, includes rare and threatened species will also be adapted to local environmental conditions and may require less ongoing management and weed control. The biofiltration areas provide the opportunity to encourage different tiers of vegetation including grasses and trees which can add habitat complexity and structure.

6.2.4.5 Amenity and public access

In addition to playing an important role in stormwater treatment, wetlands can also have community benefits. They provide habitat for wildlife and a focus for recreation, such as walking paths and resting area and opportunities for nature play. They can also improve the aesthetics of a development and be a central feature in a landscape. By creating the wetland systems (in particular) offer opportunities to create an interesting network of path, boardwalks and viewing area (particularly for birds). They will add diversity to the landscape and allow different experiences along the linear shared path.

6.2.4.6 Loss of coastal marine area

The proposed works result in an overall reduction in the coastal marine area. The effect of that loss is assessed in Technical Report 15 “Coastal Processes Assessment” and TR and Ecology.

6.3 Construction Stormwater Runoff Effects (Erosion and Sediment Control)

There are potential effects on the receiving environment from sediment discharges during construction as land disturbance activities, such as construction, exposes bare earth surfaces. When exposed to the elements these disturbed surfaces can increase the potential for the generation and discharge of elevated levels of sediment, and consequently have an adverse effect on the quality of waterbodies and coastal water.

The preliminary erosion and sediment control measures that have been developed for the Project are shown on Plan Set 10: Erosion and Sediment Control Volume 2: Drawings.

The proposed erosion and sediment control approach is described in the following sections and demonstrates that accepted ESC measures and practices can be applied and acceptable sediment reductions achieved during construction.

The following key points are noted with respect to erosion and sediment control for the Project

- The statutory framework and policy documents and guidance applicable in the Auckland Region and the Transport Agency, require contractors to be aware of and ensure that all necessary erosion and sediment controls are in place, managed and maintained during construction
- All ESC measures will be designed in accordance with best practice guidelines and standards
- The successful management of erosion and sediment control relies on the contractor appointed to undertake the works to prepare Construction stage Erosion and Sediment Control Plans (CESCPs), which will be prepared in advance with applicable consent conditions and submitted for approval by Auckland Council prior to any construction works taking place. The preparation of the CESCPs shall also take cognisance of any requirements of the Project's Contaminated Land Management Plan with regards to the presence of contaminants in any earthworks areas.
- Sediment retention devices, including sediment retention ponds and decanting earth bunds, will be provided and will, where required, be installed with rainfall activated flocculant sheds to increase sediment retention efficiency of the sediment retention devices. The flocculant dosing regime will be informed by bench testing of soil samples from both in-situ material and imported fill to determine the most effective type of flocculant that can be used and the optimal dosing rate, which may differ across the Project, due to the variance in soil conditions. Bench testing will be carried out prior to construction commencing and the dosing rates to be used in any particular location throughout the project will be detailed within the CESCPs.

Table 6-1 summarises the calculated construction related sediment yields at each outfall location considered. The supporting calculations are contained in Appendix E.

Table 6-1: Estimated Construction Based Annual Sediment Yields

Outfall Location	Estimated Construction Based Annual Sediment Yields (Tonnes)		
	Construction Zone Area	No ESC Measures	With ESC Measures
Manukau Harbour Catchment			
Neilson Street Interchange	6.18	20.9	7.7
Foreshore Embankment	8.66	75.8	12.9
Southdown Reserve	2.51	25.3	5.6
Anns Creek	0.82	74.5	25.0
Total	**18.17**	**196.6**	**51.2**
Tamaki Estuary Catchment			
Clemow Stream	1.63	6.6	1.8
Ōtāhuhu Creek	1.54	8.4	2.3
Frank Grey Place	2.13	0.9	0.3
Total	**5.31**	**16.0**	**4.4**

6.3.1 Description of proposed erosion and sediment control measures

This section describes the methods and practices that may be implemented to minimise the effects of sediment generation on the aquatic receiving environments during construction. It provides details of the erosion and sediment control (ESC) measures that are applicable to the Project and has been included to support the assessment of environmental effects.

During construction, ESC measures will be put in place to minimise potential adverse effects by utilising measures which meet industry best practice guidelines such as reflected by Auckland Council's Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region Guideline Document 2016/005 (GD05).

The details of the ESC measures discussed in this report have been prepared prior to a contractor being appointed. As expected with a project of this nature, construction stage Erosion and Sediment Control Plans (CESCPs) will be developed prior to construction and will follow the general principles of ESC discussed below. The CESCPs will be developed as part of an overall Construction Environmental Management Plan for the Project in accordance with the applicable consent conditions and shall also take cognisance of any requirements of the Project's Contaminated Land Management Plan with regards to the presence of contaminants in any earthworks areas.

The production of CESCPs will enable the contractor, Transport Agency and Auckland Council to have further input into the proposed construction methodologies, whilst minimising the potential effect on the receiving environment.

The receiving environment throughout the Project is a mixture of freshwater and marine environments with varying degrees of ecological and amenity values. It is imperative that ESC options and measures to be implemented during construction take cognisance of these values and mange stormwater / sediment discharges from construction zones accordingly.

6.3.2 Methodology for assessment of risk

Estimating sediment yields for the Project has generally followed the process outlined in GD05, specifically the procedures for calculating the sediment yield within the USLE. The primary purpose of the USLE is to provide a gauge of potential sediment generation and yields, and to assist in identifying controls required for managing this risk to the environment from sediment discharges from earthworks sites.

The USLE is a tool that has been used in New Zealand to estimate the potential annual soil loss for a site and is based site slopes, rainfall patterns, soil types, topography, vegetation cover and site management practices. The USLE can help identify the scale of potential effects on receiving environments, and the risk associated with those sedimentation effects. However the USLE does not choose the most appropriate ESC practice, but is used to identify those areas of a site with a higher sediment generating potential.

The selection of the most appropriate form of ESC measure is then determined based on the sediment removal efficiency of the selected ESC measure.

The sediment removal efficiencies for the various sediment retention devices have been extracted from the Transport Agency's "Erosion and sediment control guidelines for state highway infrastructure" and have been used in the analysis of the ESC measures, these efficiencies have been are summarised in Table 6-2.

Table 6-2: Sediment Control Efficiencies

ESC Measure	Sediment Control Efficiency (Without Flocculation)	Sediment Control Efficiency (With Flocculation)
Sediment Retention Pond	75%	90%
Decanting Earth Bund	60%	80%
Silt Fence	50%	N/A
Supersilt Fence	50%	N/A

6.3.3 Manukau Harbour and Māngere Inlet

The key element of risk for the Project in Sectors 1 and 2 is the close proximity of the CMA and that any uncontrolled sediment-laden runoff from the construction areas will be immediately discharged to the marine environment.

The particular aspects of each area within these 2 sectors are discussed below.

Neilson Street Interchange

From an ESC perspective the works within the Neilson Street Interchange will rely on the placement of DEBs, establishment of Dirty Water Diversion (DWD) drains and ensuring the existing stormwater system is kept operating for as long as possible during construction, to ensure stormwater runoff from the wider catchment and SH20 will bypass the construction works.

DWDs will be required within the Hōpua tuff ring adjacent to the SH1 northbound off ramp, which will discharge stormwater runoff to DEB's established prior to commencing construction works.

These measures along with the rapid and progressive stabilisation of exposed areas will be a key element of the ensuring that the discharge of sediment laden runoff is minimised.

The close proximity of the CMA to the works will require close attention to be paid to the establishment of ESC measures and their ongoing inspection and maintenance to ensure their continued effective operation during construction.

Pumping of groundwater will be required to dewater excavations within the Neilson Street interchange and pumping operations will discharge to the DEBs within the area. During pumping operations sediment can be entrained within the groundwater pumped out of the excavation. Therefore during pumping operations, the decant systems within the DEBs will be manually raised and the DEB manually batch dosed with flocculant to increase the sediment retention capability of the DEB.

The decant will only be lowered once sufficient clarity (100mm) has been observed in the water within the DEB.

With respect to the EWL Trench, earth will be removed during construction. The construction methodology for the EWL Trench involves the installation of piled walls, which will also assist in preventing ground water ingress into the trench during operation.

Excavated material will be loaded onto trucks for disposal off-site and no stockpiling of this material within the works is anticipated. Groundwater will be pumped to an SRP where it will be treated prior to discharge to the receiving environment. During pumping operations the decants within the SRP will be manually raised as noted above. The decant will only be lowered once sufficient clarity (100mm) has been observed in the water within the DEB.

Foreshore Area

The works in this area are largely associated with construction within the CMA to establish the new road embankment and foreshore landscaping treatment.

The objective is to establish the outer bund to encapsulate the area required to construct the foreshore landscaping areas and proposed foreshore stormwater treatment areas and this will ensure that sediment laden discharges to the Māngere Inlet are prevented.

Once the outer bund has been established stormwater flows from the existing upstream catchment will be diverted around the working area to prevent inundation of the area behind the outer bund and this can be achieved through the use of diversion pipework or stabilised channels.

Once the outer bund has been established and stormwater flows have been diverted works can commence on the establishment of the mudcrete lining to the stormwater treatment areas which will be fully contained within the outer bund. The works required to establish the mudcrete liner will be the excavation of marine muds which will be mixed to form mudcrete and placed where required. Any excess excavated material will be disposed of off-site to an appropriately managed disposal facility.

Rain falling within the working area will be pumped to one or more of the sediment retention devices for treatment to ensure a dry working environment.

The ESC assessment of the works within the CMA to establish the outer bund is discussed in Technical Report 15 “Coastal Processes Assessment” and stormwater pipework has been provided. The area landside of the bund is effectively isolated from tidal influences.

Southdown Reserve

There is an earth embankment proposed to be constructed at the end of Hugo Johnston Drive. The area to the south of the existing Southdown Reserve is proposed to be used for a stormwater treatment pond and also a construction yard. This area is known to contain asbestos contamination, as is the Southdown reserve.

An SRP is proposed to be located within the area, which will provide treatment of construction related stormwater discharges from this site and will be sized to cater for a contributing area of 2 ha.

Two DEBs are also proposed within this construction zone to intercept stormwater runoff from the site and are sized to cater for an area of approximately 3,000 m^2 each.

SRP #S3_1 will discharge to the Southdown wetland reserve which in turn discharges to the Māngere Inlet approximately 90m away via a triple barrel 1,350mm diameter culvert. DEBs S3_1 and DEB S3_2 will both discharge to the existing stormwater reticulation system which discharges to the estuarine environment of Anns Creek to the south of Hugo Johnson Drive.

Based on the USLE calculations carried out during this assessment it is estimated that uncontrolled discharges of sediment laden runoff would be approximately 25 tonnes based on a construction period in this zone of approximately 6 months. With the proposed SRP and DEBs in place this would reduce to 6 tonnes over the same period, based on treatment efficiencies of 75% for SRPs and 60% for DEBs.

It is also noted that the treatment efficiencies of the SRP and DEBs will be improved to approximately 90% and 80% respectively with the use of flocculants and would reduce estimated sediment yield to 2.6 tonnes over the same 6 month period. The type and dose rate of flocculants will be determined through bench testing of soils which will be carried out prior to construction commencing

As with other areas the rapid and progressive stabilisation of exposed areas will be a vital component of the works to reduce the potential for erosion and subsequent sedimentation.

Anns Creek

The construction activity within Anns Creek entails the establishment of a construction yard, and the construction of bridge piers.

Construction Yard Establishment

Anns Creek at the location of the construction yard currently receives stormwater flows from an upstream catchment of approximately 27.4 ha, which includes Great South Road to the North (approx. 10.4 ha) and Sylvia Park Road to the east (approx. 27 ha). The establishment of the proposed construction yard will require these existing flows to be passed through the site area prior to the placement of fill.

Part of the Anns Creek area at this location has also been identified as having significant ecological areas.

The works required to establish the construction yard are as follows:

1) Establishment of a new access from the TR group site to the North;

2) The construction of a twin 2,500mm diameter culvert to allow stormwater runoff from the upstream Great South Road and Sylvia Park Road catchment to pass beneath the site, which will first require the establishment of a temporary stream diversion; and

3) The placement of approximately 30,000 m^3 of fill material over an area of approximately 8,200 m^2 (approx. 2.5 to 3.5m above existing ground level) to provide a stable, construction platform for the storage of plant and materials during the construction period.

One SRP (SRP #S3_2) is proposed to be constructed to service the construction yard during the filling operation. As the tidal influence will affect the operation of the outlet from this SRP and will need to be constructed above Mean High Water Springs (MHWS) level (RL 2.05m), the pond will not become operational until approximately 3m to 4m of fill has been placed in the area and the SRP can be established within the placed fill.

Until the SRP becomes operational the ESC measures to be established using super silt fences and bunding around the perimeter of the site, along with rapid and progressive stabilisation of exposed surfaces would be the only practical control until the SRP can become established and made operational.

Based on the methodology required to establish the construction yard in this location the resultant sediment yields calculated using the USLE would be as follows:

1) No ESC measures during filling operation over a 2 month period 8.5 tonnes;

2) Super silt fences in place during filling operation 4.3 tonnes;

3) SRP established and full stabilisation of the site approx. 2.2 tonnes (using a sediment reduction efficiency of 75% for a SRP);

4) SRP established and full stabilisation of the site, using flocculation of the SRP - 0.9 tonnes over the same 2 month period; and

5) With the construction yard in place and operational, whilst maintaining the ESC measures the annual sediment yield expected would be approximately 6 tonnes/year.

As can be seen from the results above the reduction in estimated sediment yields for the site would reduce by approximately 50% once the SRP become operational. It is therefore imperative that the filling operation is completed in the minimum amount of time practicable to allow the SRP to be constructed and the site progressively stabilised as filling operations progress.

This in conjunction with effective site management practices, such as dry weather working and stabilisation of the any disturbed areas within the site in response to forecast rainfall events would see a further reduction in the estimated sediment yields for the site.

In all of the above, as with the other areas of the Project, emphasis will be placed upon the rapid and progressive stabilisation of disturbed areas, monitoring and maintenance of all controls, and particular attention will be paid to these areas prior to, during and after rain events.

Bridge Pier Construction

To enable the construction of the bridge structure between Hugo Johnson Drive and Great South Road, which passes above the northern side of Anns Creek, a temporary raised staging platform will be established above existing ground level, from which piling plant can operate to construct the permanent piles for the structure.

The temporary staging platform is provided by driving steel H piles into the ground from above, then joining these piles with a precast concrete platform capable of supporting the weight and working loads required for the construction of the permanent works.

Soil disturbance will be minimised as all works are carried out from above ground level. The only soil disturbed will be from where the H pile enters the ground and minimal ESC measures will be required. Vegetation clearance will be carried out by hand and any cleared areas will be mulched.

Once the staging platform is complete, works can commence on the construction of the insitu concrete piles. Permanent piles will be constructed by boring into the ground from above, within a steel casing.

As the works proceed the soils and subsoils removed from the ground by the auger from the boring plant will be lifted back up to the temporary staging platform where it will be loaded onto a sealed truck for disposal off site.

As the bore proceeds below ground level the steel casing is pushed down to provide ground support for the open area, which reduces the potential for soil loss during construction, as soils are contained within the casing, it also reduces the potential for ground water ingress within the bore.

Once the required depth has been reached, a steel reinforcement cage is lowered in to the casing, which is then filled with concrete.

If the steel casings were unable to prevent the ingress of groundwater, the pile concrete will be poured using the Tremie Concrete method. Concrete is placed below water level through a pipe, the lower end of which is kept immersed in fresh concrete and as concrete rises from the bottom of the pile it displaces any water above it without washing out the cement.

However, this method will still result in cement contaminated water within the bore, which will require treatment before discharge. This will either be conducted on site using treatment tanks and the pH of the water tested before discharge to the receiving environment, or the water removed from site and treated elsewhere through the use of sucker trucks.

Concrete placement will be carefully controlled to ensure no loss to the environment. Designated concrete truck wash out areas will be required at the construction yards and these will contain the water from washing the trucks drums and chutes which can be treated and disposed of offsite.

6.3.4 Tamaki Estuary

Clemow Stream

The proposed works between the Mount Wellington Interchange and CH7450 of SH1 will ultimately discharge to Clemow Stream.

The disturbed area of earthworks will be approximately 1.6ha, including the construction of mechanically stabilised earth walls for the new Sylvia Park Road Ramps. Seven DEBs are proposed to manage stormwater runoff during from the construction none of which exceed the 0.3ha limit required by GD05.

Based on an the USLE calculations carried out as party of this assessment it is estimated that uncontrolled discharges of sediment laden runoff would be approximately 6.6 tonnes, based on a 6 month construction programme and with the proposed DEBs in place this would reduce to 2 tonnes over the same timeframe. With the use of flocculation for each of the DEBs this would further reduce to 0.9 tonnes.

As with other areas the rapid and progressive stabilisation of exposed areas will be a vital component in the management of erosion and sedimentation of this area.

It is considered that DEBs along this area would be the best practicable option as it will provide effective treatment of stormwater runoff from the construction zone.

In addition, due to the linear restrictions of the site, the construction methodology requires the use of progressive stabilisation to be carried out in the form of granular subbase material for road formation and fill to be wrapped in geotextile during the construction of the MSE walls, which would also assist in the reduction of sediment laden discharges reaching the receiving environment at Clemow Stream.

The sediment yields discussed above are based on the whole of the construction zones being worked concurrently. It is expected that the sediment yields would be reduced through appropriate phasing of the works and the progressive and rapid stabilisation of exposed areas.

Ōtāhuhu Creek

The works on SH1 between CH 7450 and the northern extent of the Princes Street include the following:

- Widening of SH1 between CH 7450 and Ōtāhuhu Creek;
- Construction of a new bridge structure and removal of the existing concrete box culvert beneath SH1; and
- Widening of SH1 between Ōtāhuhu Creek and the Northern extent of the Princes Street interchange.

Similarly as with the section of SH1 draining to Clemow stream, this section of the works is predominantly widening of the existing SH1 and will follow the same construction methodology.

This section of the works discharges to Ōtāhuhu Creek and construction related stormwater runoff will be treated using DEBs located on either side of SH1 at Ōtāhuhu Creek.

Based on an the USLE calculations carried out as part of this assessment it is estimated that without effective ESC measures in place uncontrolled discharges of sediment laden runoff would be approximately 4.9 tonnes/year, and with the proposed DEBs in place this would reduce to 2.0 tonnes / year.

Widening of SH1 between CH 7450 and Princes Street Interchange

This section of SH1 falls towards Ōtāhuhu Creek and DEBs are proposed to be constructed on either side of SH1 near to the location of the existing outfalls, the majority of the works involve lane widening works, which will be stabilised as works progress.

Most of the alignment along this section of SH1 is in cut below the level of the properties either side of the motorway and therefore there is little risk that sediment laden discharges will flow outside of the road corridor.

The extent of the widening works will be approximately 0.29 ha for the northbound lanes and 0.51 ha for the southbound lanes, in addition to the progressive stabilisation of exposed areas the ESC measures proposed are DEBs, which are designed to cater for a maximum open area of 0.3 ha each.

The 0.3 ha design limit for DEBs will have the effect of restricting the open area of earthworks for the southbound lane widening to 0.3ha at any one point in time.

It was considered during the development of the ESC measures that an SRP could be used, but given the restrictions of the site (little available land and the close proximity of overhead power cables) it was determined that the construction, operation and maintenance of a SRP at this location would be unsafe and therefore a DEB was selected as being the best practicable option from a ESC perspective.

Based on an the USLE calculations carried out as part of this assessment it is estimated that without effective ESC measures in place uncontrolled discharges of sediment laden runoff would be approximately 8.4 tonnes, and with the proposed DEBs in place this would reduce to 2.3 tonnes and could be further reduce with the use of flocculants to 1 tonne. These sediment yields are based on a 6 month construction period.

Frank Grey Place

In addition to the road widening works through this location, it is also proposed to construct a new bridge and associated support structures. The construction zone, including the 2 proposed construction yards discharging to the outfall at Frank Grey Place is approximately 2.13 ha.

Based on an the USLE calculations carried out as part of this assessment it is estimated that without effective ESC measures in place uncontrolled discharges of sediment laden runoff would be approximately 1.0 tonne and with the proposed DEBs in place this would reduce to 0.3 tonnes with flocculation this would further reduce to 0.13 tonnes.

7 Alternative discharge methods

7.1 General stormwater

Alternative discharge methods have been considered for stormwater discharges arising from the new and modified road surfaces. In considering the alternatives, the nature of the discharge and the nature of the receiving environment have been considered.

The nature of the discharge is runoff from additional impervious road surfaces with will result in an overall increase in total runoff volume and peak flows. The first flush of runoff will contain contaminants arising from car exhausts, tyres and brakes, silt, oils and litter and from time to time, spills that could occur on the road network.

The receiving environments are:

- Discharge through piped networks to the CMA or estuarine streams.
- Discharge through piped networks to ground soakage.
- Discharge to Clemow Stream and ultimately the CMA.

Where the receiving environment is the CMA or ground, it is not sensitive to adverse erosion effects from increased peak flows. While erosion can occur at outlets, this is a localised effect that can be managed through outfall design. Freshwater streams are more sensitive to erosion effects, however Clemow Stream already has a fully developed urban catchment and has been subject to modification over time and hence is not very sensitive to the anticipated increases in peak flows. The receiving environments are more sensitive to effects arising from contaminants entrained in stormwater including potential spills.

The following alternative methods of discharge have been considered:

- Discharge to existing networks without treatment. This would have resulted in adverse water quality effects and been inconsistent with relevant policy and regulatory requirements.
- Discharge to existing networks with treatment for additional impervious area only. This may have resulted in some adverse effect and would have been inconsistent with relevant policy and regulatory requirements. Further, it would have limited potential for stormwater treatment improvements in the future.
- Discharge to alternative locations. Stormwater discharge locations were generally dictated by gravity and the constraints imposed by existing stormwater networks.
- Discharge using alternative treatment methods including:
  - Constructed wetlands. These have good treatment efficiencies and other ecology and amenity benefits and have been included where space allows. Being a mature developed catchment, there were many locations where it was determined that wetlands were impracticable because of land requirements.
  - Proprietary filtration devices. Because these are buried devices with small footprints they have been used where space is particularly constrained.
  - Swales. These have good treatment efficiencies and have been included where local topography suits.
  - Raingardens / biofiltration devices. It was found that these did not suit the proposed road due to hydraulic constraints, catchment size and maintenance and operation preferences.
  - Combined wetland and biofiltration areas (similar to the foreshore). The general road stormwater issues are typical of projects of this type and hence the decision was taken to follow the current standard Auckland treatment devices guidance. A more bespoke solution as developed for Sector 2 was not required.
  - Ponds. These have similar footprints to the wetlands but slightly lower treatment efficiencies and the potential to generate temperature effects.

  – Filter strip. There were no locations where these suited the topography and space constraints.
  – Permeable pavements. The anticipated traffic loadings mean that permeable pavement for the new and modified road surfaces were considered impractical.
  – Infiltration. There were limited opportunities to increase the amount of runoff discharging to ground as the affected catchments are generally fully developed.

7.2 Foreshore stormwater

For the foreshore stormwater, the receiving environment is the Māngere Inlet CMA, an environment that is likely to be sensitive to the effect of contaminants and potential spills. For this part of the project, the stormwater discharge of concern is an existing discharge from the approximately 611 hectare catchment in Onehunga and Penrose. The nature of the stormwater discharge does differ from the general stormwater as it comes from a much broader range of activities that just road surface including residential, commercial areas. In that sense, the nature of contaminants is expected to vary more significantly and a greater potential for spills may be anticipated. Key drivers for selection of the discharge method for this part of the project are the ability to integrate the measures into a naturalised landscaped foreshore environment with minimal footprint. The following alternative methods of discharge have been considered.

- Discharge without treatment. This would have meant the Project had no effect on stormwater quality with respect to the existing situation. This could be an acceptable alternative in that it is the current situation. However, one of the philosophies of the Project was to explore the opportunities presented by working in this location to address existing stormwater issues.
- Discharge using a pumped system. Discharge from the proposed stormwater treatment areas relies on one-way valve systems because of the influence of tide in this area. An alternative could have been pumped discharge. It is considered that a one-way valve system is likely to be more reliable and simpler to operate and maintain that a pumped system with power supply requirements.
- Discharge to alternative locations. Stormwater discharge locations required consideration of a number of competing constraints but were generally dictated by gravity, the constraints imposed by existing stormwater networks, landscape outcomes and potential effects on coastal process arising from occupation in the Inlet.
- Separation of Project road runoff from the wider catchment stormwater for separate treatment and discharge. While the primary purpose of the foreshore treatment areas is to cater for runoff from existing catchments from Onehunga and Penrose, they do also cater for runoff from the proposed new and modified roads. That runoff makes up less than 1% of the contributing catchment. Consideration was given to separating the new road runoff and treating it according the general stormwater approach. While this is achievable, it would lead to an overall greater number of treatment assets to operate and maintain.
- Discharge using alternative treatment methods including:
  – Constructed wetlands. These would have a footprint approximately twice as large as that achieved with the proposed combined wetland and biofiltration system or a reduced treatment efficiency.
  – Raingardens / biofiltration devices. On their own, these would be likely to perform poorly or require significantly more frequent maintenance as being subject to continuous baseflow would lead to filter media clogging frequently at the surface. In addition, without the wetland areas where head can build up, there unlikely to be sufficient driving head for biofiltration devices to work effectively in this location.
  – Proprietary filtration devices. These are suited for at-source treatment of small catchments. An installation that could cater for a catchment this size would be impractically large and was not considered to align as well with the Project objectives for a more naturalised foreshore.
  – Swales, ponds, filter strips, permeable pavements and infiltration. These were all considered and discounted for similar reasons to the general stormwater assessment at paragraph 7.1 above.

8 Recommendations

The overall benefit predicted for stormwater quality relies on infrastructure being well designed, constructed, maintained and operated. To that end, following are recommendations for addressing potential effects throughout the further stages of the Project:

- Assessment of the likelihood and consequence of blockages, valve, pump and electrical failures and other extreme events be carried out in future design stages;
- Preparation of operation and maintenance plans for the stormwater treatment devices, stormwater network and pump stations. The details of the required planned maintenance programme to ensure continued levels of service. Plans should address clean-up procedures for spills, routine inspections, post event inspections, procedures for regular maintenance, disposal of contaminated material, equipment and parts lists (e.g. replacement one-way valves, submersible pumps, oil containment booms).
- Preparation of emergency response and action plans for the stormwater treatment devices, stormwater network and pump stations that include the details the required actions and procedures to be carried out in the event of failure of any part of the stormwater infrastructure to ensure the safety of road users and the local community;
- Health and safety in design reviews of the stormwater treatment system which take into account the life cycle of the project including design, operation and maintenance and decommissioning requirements; and
- Erosion protection for stormwater outfalls to streams and watercourses to minimise bed scour and bank erosion in receiving environment. Design of stormwater outfalls shall assess various rainfall and tidal levels to ensure the critical storm is considered.

With respect to construction effects, the following erosion and sediment controls are recommended to minimise adverse effects for the Project.

- Where practicable erosion and sediment control measures should be located at the same location as the permanent stormwater treatment devices.
- Erosion and Sediment control measures shall at all times throughout the construction period achieve as a minimum the requirements of Auckland Council's guidelines (currently GD05 and TP90);
- Construction stage Erosion and Sediment Control Plans (CESCPs) to be prepared by the contractor appointed to undertake the construction for each work zone or activity prior to construction commencing.
- ESCs should be based on both structural and non-structural measures with equal emphasis placed on the non-structural management techniques such as appropriate staging of the works to reduce the erosion potential of disturbed areas;
- A management and monitoring programme should be implemented which will allow for ongoing water quality assessment of the construction programme. Continuous improvement of the construction water management methodology will form an integral part of this monitoring programme; and
- Chemical treatment of DEBs and SRPs should be implemented on the Project and documented in a Flocculant Management Plan. Bench testing should be carried out to determine the most effective flocculant dosing regime and type(s) of flocculant to be used.

9 Conclusion

Overall, the proposed works present a significant benefit with respect to stormwater quality.

9.1 Stormwater Quality

The total Project road surface area is 46 hectares, an impermeable area increase of 21 hectares with respect to the existing situation. All 46 hectares will be treated in new or upgraded treatment devices. A feature of this part of the works is that the stormwater treatment areas treat more than the new road itself. They cater for the runoff from 611 hectares of roads, roofs and sites upstream of the road in Onehunga and Penrose that currently drain through pipes directly into the Māngere inlet without treatment. This has been done as the location of the proposed works has created a unique opportunity to do so in a way that is integrated with the landscaped coastal edge and road construction.

Stormwater quality modelling shows that the proposed stormwater treatment devices remove 75% of total suspended solids on an annual average basis from the contributing catchments. Because treatment is provided for a much greater area than the Project itself, the overall result is a significant reduction to the quantity of suspended solids, nutrients, metals, hydrocarbons and coliforms discharging via stormwater. The following changes to long term annual average contaminants discharge are predicted from the approximately 657 hectares of affected catchment:

- A reduction in total suspended solids from 870 to 210 tonnes per year (a 75% reduction);
- A reduction in total nitrogen from 19 to 10 tonnes per year (a 47% reduction);
- A reduction in total zinc from 2.67 to 1.17 tonnes per year (a 56% reduction); and
- A reduction in total copper from 0.24 to 0.08 tonnes per year (a 66% reduction).

Other predicted water quality benefits are:

- Allowing collected leachate from old landfills on the Pikes Point area to be treated in the foreshore wetlands so that it no longer needs to be pumped to trade waste. The new leachate collection system will operate under gravity and discharge leachate to the stormwater treatment wetlands through the embankment. This is proposed because the leachate quality can be sufficiently improved through the proposed stormwater wetlands to ensure no adverse effects on the water quality of the Māngere Inlet.
- The foreshore treatment systems also contribute to a reduction in contaminants reaching the Māngere Inlet through groundwater. This effect is covered in separately in Technical Report 13 Groundwater Assessment.
- Improved resilience to contaminant spills or contaminant dumping through containment in the stormwater treatment devices; and
- New freshwater ecological environments created in constructed wetland and biofiltration systems.

9.2 Stormwater Quantity

- Flood risk protection to the Project will meet commonly accepted standards. The proposed new road is set at levels above extreme flood events, high tides and storm surge, allowing for 100 years of predicted climate change effect. In some locations, including along the Māngere Inlet foreshore, this sets the road level higher than some properties upstream. Pipes, inlets and overflows are therefore designed to avoid increasing flood risk at those properties by allowing for overland flow to be directed through the pipes beneath the road. In two locations, stormwater pumps and attenuation tanks will be used to assist with managing floodwaters.

- Near the foreshore, installing one-way valves on the stormwater pipes will constrict the flow that discharges through pipes in a flood event. One-way valves also do have the potential to become blocked or fail. This will increase the risk of flooding to some existing low lying properties in an extreme rainfall event compared to the existing situation where runoff can discharge freely. However, there is also potential for the foreshore works (road embankment) to provide an improved level of protection to those properties from coastal inundation due to sea level rise over time. These factors will have to be considered carefully throughout the design development including the potential to use supplementary pumps, flow gates, additional valves or additional pipes to mitigate the risk of adverse effects on existing properties.

The wetland treatment and bund are to be constructed so that they can be adapted to climate change sea level rise over time. This adaptive approach has been adopted as setting the outer bund high enough to resist 1 metre of sea level rise would create a constraint on discharging stormwater runoff that would exacerbate the flood risk at some low lying properties under existing climate conditions. The adaptations would comprise raising the outer bund level and amending pipework, overflow structures and valves 1 or 2 times over the next 100 years.

9.1 Construction Effects from Sediment Discharges

During construction, a range of erosion and sediment control measures are proposed to firstly minimise erosion and secondly reduce the sediment generating potential of the various construction areas in line with industry guidelines

The proposed erosion and sediment control measures include the rapid and progressive stabilisation of exposed earth surface with vegetation, mulch, geotextile and hardfill where appropriate and ensuring that clean stormwater runoff from the upper catchment is diverted around the active work zone, thereby reducing the contributing area discharging to the sediment control devices and consequently reduces runoff volumes that need to be treated within the sediment control devices.

The following key points are noted with respect to erosion and sediment control for the Project:

- The statutory framework and policy documents and guidance applicable in the Auckland Region and the Transport Agency, require contractors to be aware of and ensure that all necessary erosion and sediment controls are in place, managed and maintained during construction.
- Chemical treatment in the form of flocculation is expected to be implemented on site, which will increase the efficiency of the physical sediment retention measures incorporated as part of the works. Chemical treatment will be provided in the form of rainfall activated, pumping and / or batch dosing depending on the location of the works and construction activity taking place.

The nature of erosion and sediment control practice is that it is not possible or practical to retain 100% of the sediment load discharging to the various physical control measures. However, the erosion and sediment control measures proposed for the Project are in line with industry guidelines.

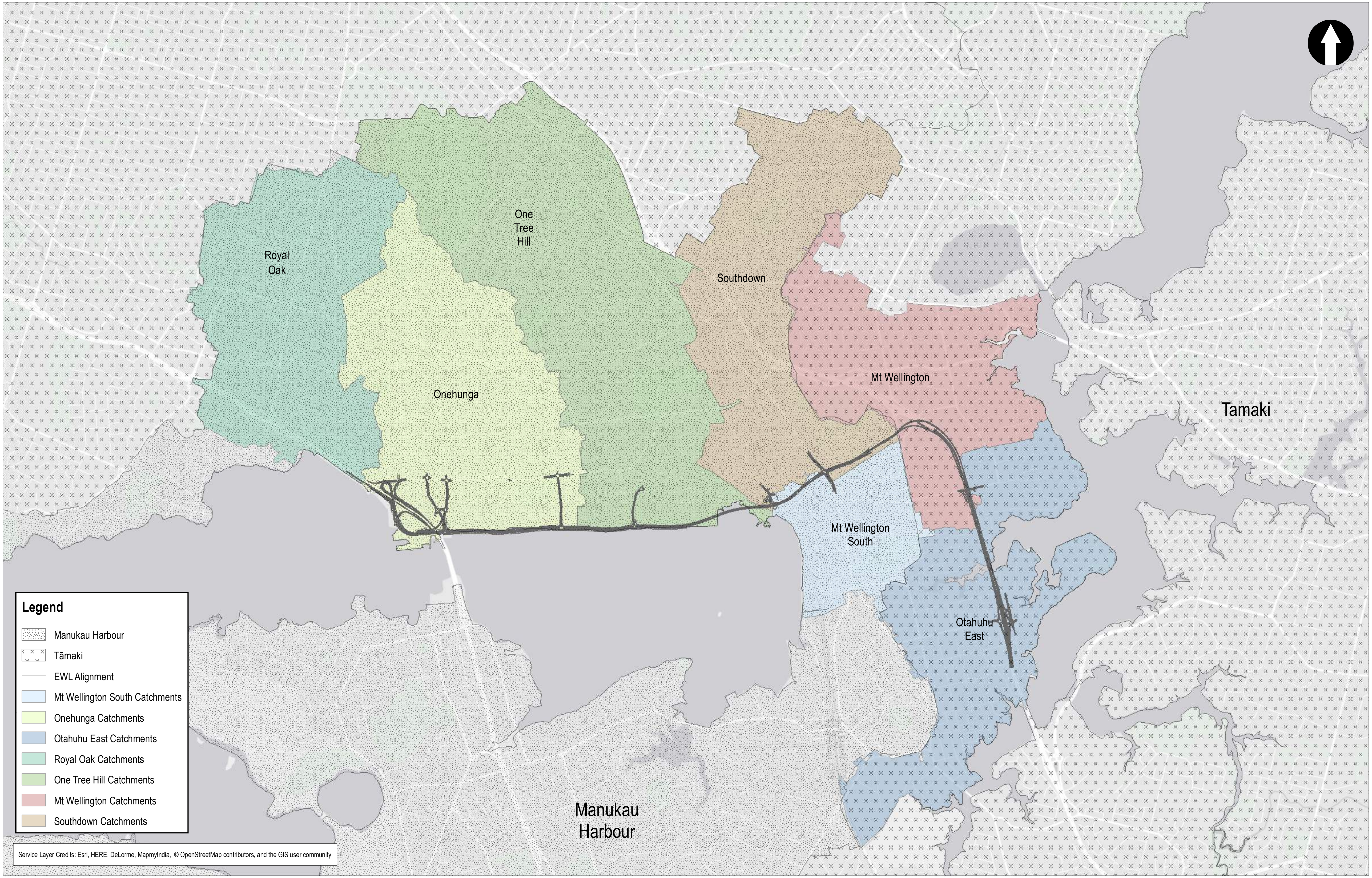
The successful management of erosion and sediment control during construction will rely on the contractor appointed to undertake the works preparing construction stage erosion and sediment control plans in accordance with requirements of applicable consent conditions. These plans will consider the constraints of the site, the construction activity required, and the various erosion and sediment control measures to be incorporated within the construction zone whilst taking cognisance of the ecological values of the downstream receiving environment.

The production and submission of construction stage erosion and sediment control plans will also allow for the input from, and approval by, Auckland Council and the Transport Agency prior to any construction works taking place.

With these measures in place, the potential effects on the receiving environment during construction will be minimised.

Appendix A

Figures



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A	ISSUED FOR INFORMATION ONLY	Bap	LB	LB	25/10/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

Drawn	Drafting Check	Reviewed Design Manager	Approved Alliance Manager
Designed	Design Check		
Scale: 1:35,000	Original Size: A3	Contract No PA4041	

Drawing Title

STORMWATER

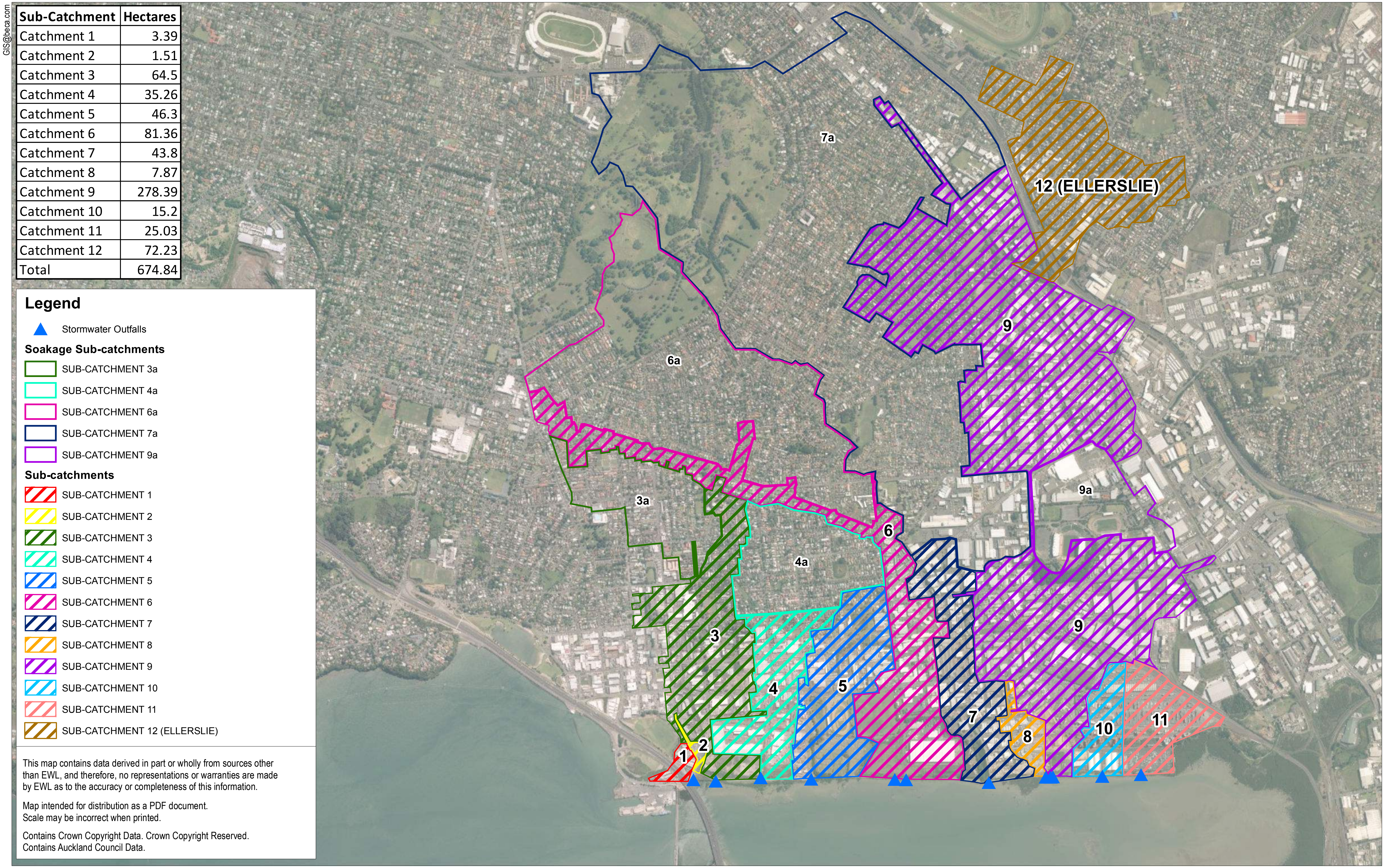
Stormwater catchments affected by the Project

Drawing Number GIS-AEE-SW-038

Rev No. A

Plot Date: 25/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Stormwater (SW-E)\DRAFTS\GIS-SW-E-038_Catchments_Stacked.mxd

Sub-Catchment	Hectares
Catchment 1	3.39
Catchment 2	1.51
Catchment 3	64.5
Catchment 4	35.26
Catchment 5	46.3
Catchment 6	81.36
Catchment 7	43.8
Catchment 8	7.87
Catchment 9	278.39
Catchment 10	15.2
Catchment 11	25.03
Catchment 12	72.23
Total	674.84



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A	Original Issue	Bap	SO	SO	08/08/16
No	Revision — Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Verified	Approved	Date

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NZ TRANSPORT AGENCY
WAKA KOTAHI

East West Link

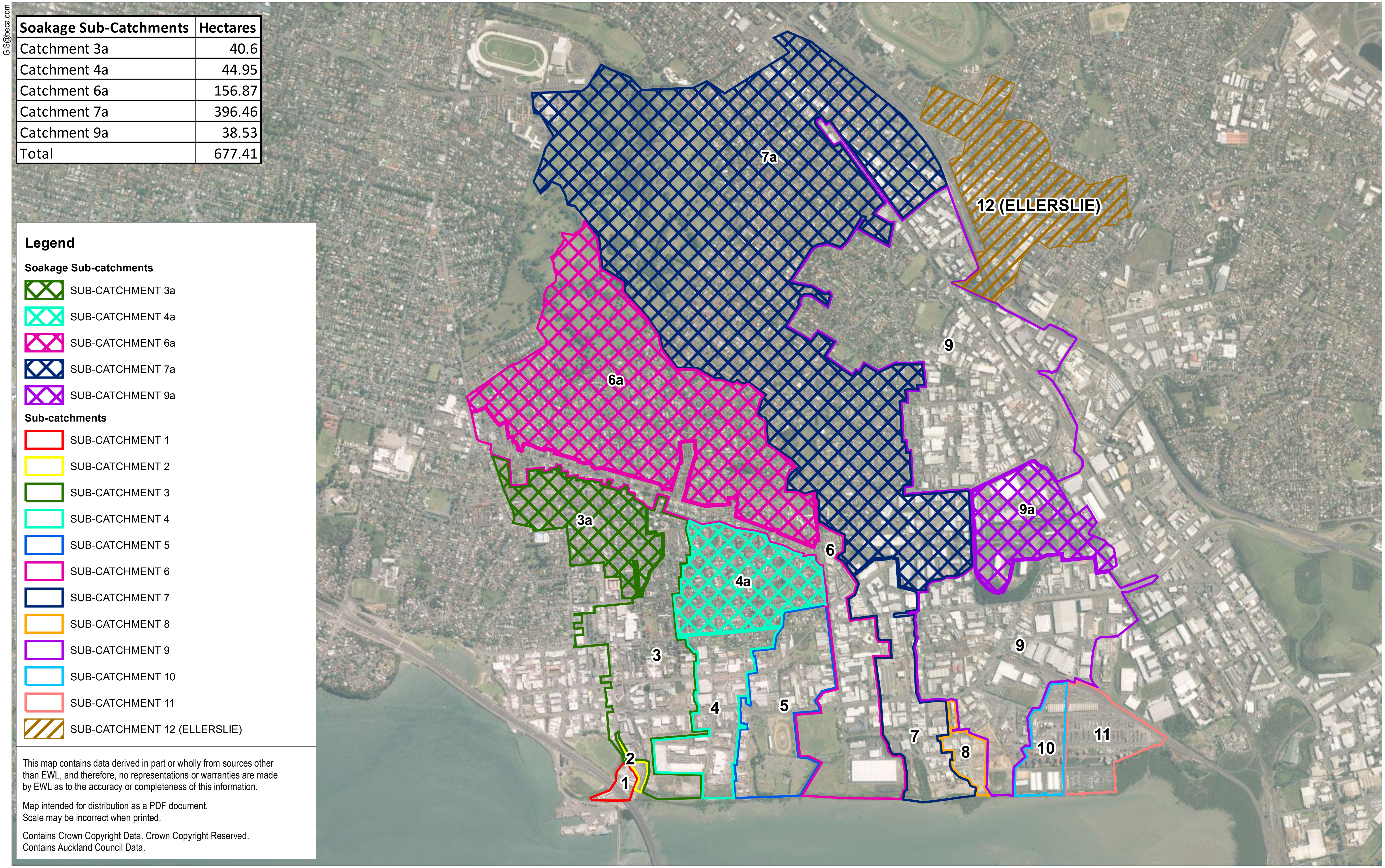
Drawn:	Draft Check:	Reviewed (Design Manager)	Approved (Alliance Manager)
Designed:	Design Check:		
Scale: 1:20,000		Original Size: A3	Contract No PA4041

Discipline: Stormwater
Title: Foreshore Stormwater Sub-catchments
Drawing No: GIS-AEE-SWE-008 Rev: A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Stormwater (SW-E)\DRAFTS\GIS-SWE-008_Stormwater_EWL_CatchmentAreasRev2.mxd

GIS@beca.com

Soakage Sub-Catchments	Hectares
Catchment 3a	40.6
Catchment 4a	44.95
Catchment 6a	156.87
Catchment 7a	396.46
Catchment 9a	38.53
Total	677.41



Legend

Soakage Sub-catchments

- SUB-CATCHMENT 3a
- SUB-CATCHMENT 4a
- SUB-CATCHMENT 6a
- SUB-CATCHMENT 7a
- SUB-CATCHMENT 9a

Sub-catchments

- SUB-CATCHMENT 1
- SUB-CATCHMENT 2
- SUB-CATCHMENT 3
- SUB-CATCHMENT 4
- SUB-CATCHMENT 5
- SUB-CATCHMENT 6
- SUB-CATCHMENT 7
- SUB-CATCHMENT 8
- SUB-CATCHMENT 9
- SUB-CATCHMENT 10
- SUB-CATCHMENT 11
- SUB-CATCHMENT 12 (ELLERSLIE)

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Scale may be incorrect when printed.

No	Revision	Drawn	Verified	Approved	Date
A	Original Issue	Bap	SO	SO	08/08/16

Note: * indicates signatures on original issue of drawing or last revision of drawing

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NZ TRANSPORT AGENCY
WAKA KOTAHI

East West Link

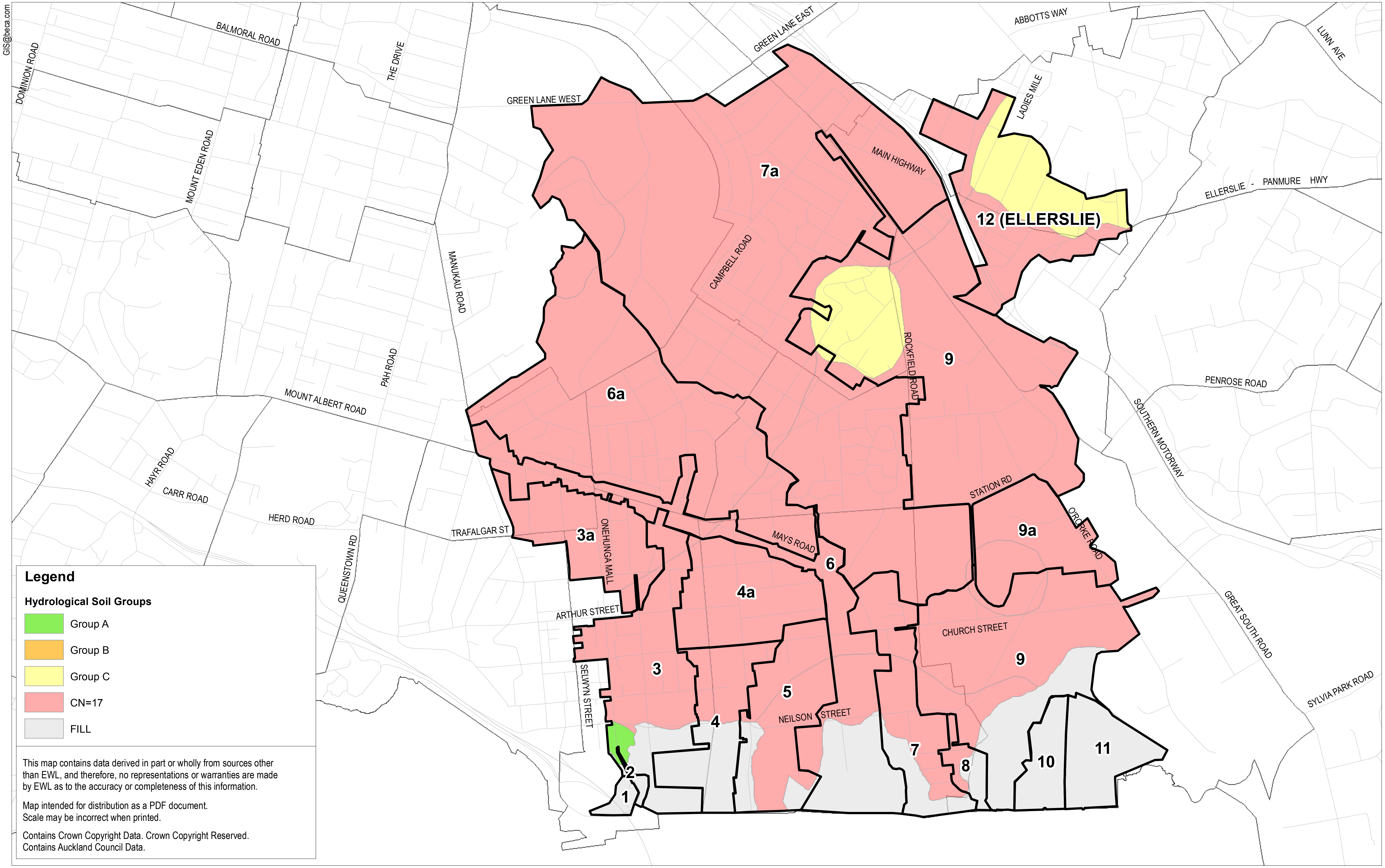
Drawn:	Draft Check:	Reviewed (Design Manager)	Approved (Alliance Manager)
Designed:	Design Check:		
Scale: 1:20,000		Original Size: A3	Contract No PA4041

Discipline: Stormwater

Title: **Embankment Stormwater Soakage Sub-catchments**

Drawing No: GIS-AEE-SWE-009 Rev: A

Plot Date: 21/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Stormwater (SW-E)\DRAFTS\GIS-SW-E-009_Stormwater_EWL_SoakageAreas.mxd



Legend

Hydrological Soil Groups

- Group A
- Group B
- Group C
- CN=17
- FILL

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A	Original Issue	Bap	SO	SO	08/08/16

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NZ TRANSPORT AGENCY WAKA KOTAHI

East West Link

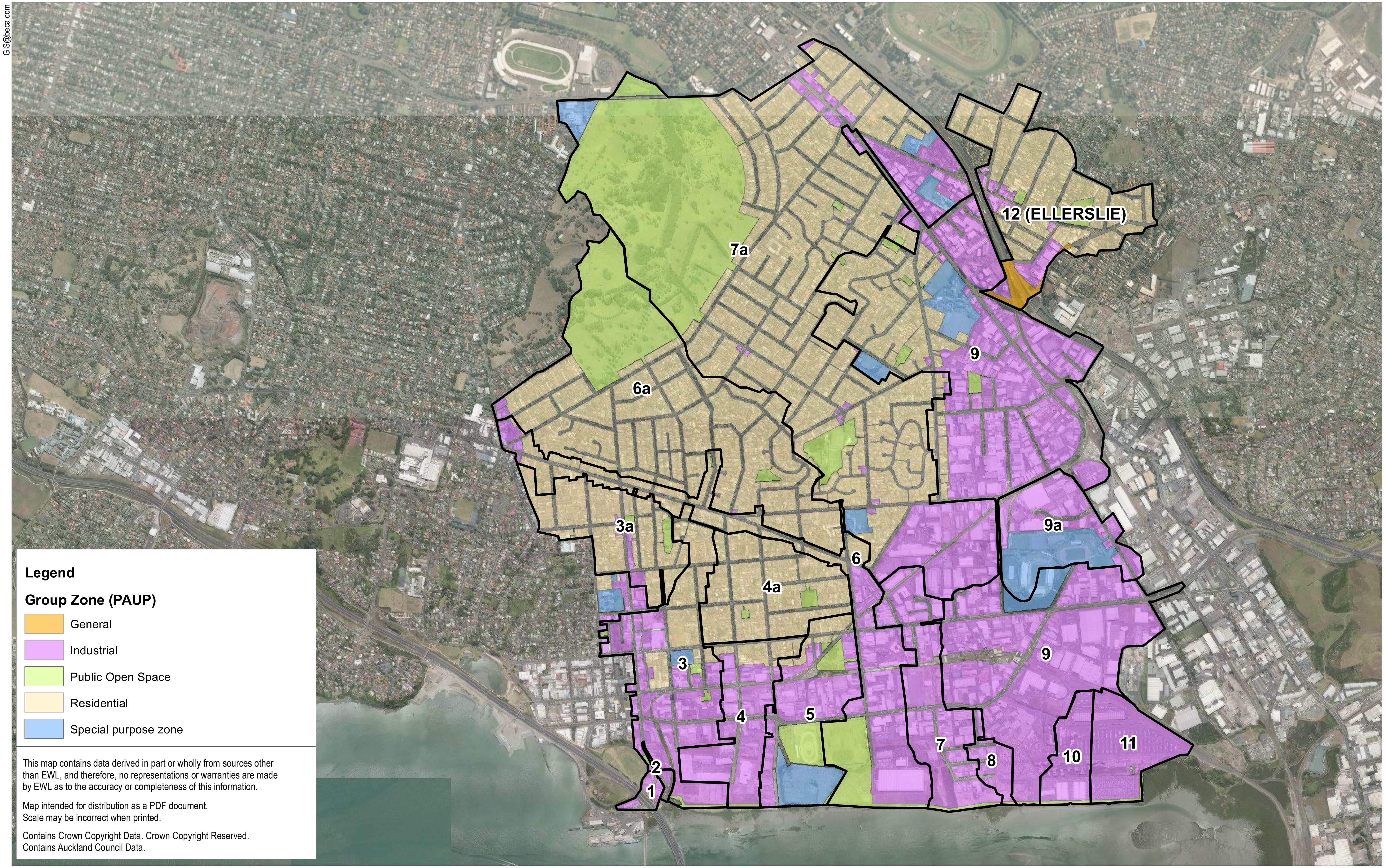
Drawn:	Draft Check:	Reviewed (Design Manager)	Approved (Alliance Manager)
Designed:	Design Check:		
Scale: 1:20,000		Original Size: A3	Contract No PA4041

Discipline: Stormwater

Title: Hydrological Soil Groups Stormwater Catchment

Drawing No: GIS-AEE-SWE-010 Rev: A

Plot Date: 21/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Stormwater (SW-E)\DRAFTS\GIS-SW-E-010_Stormwater_EWL_GeoTech.mxd



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A	Original Issue		Bap	SO	SO	08/08/16

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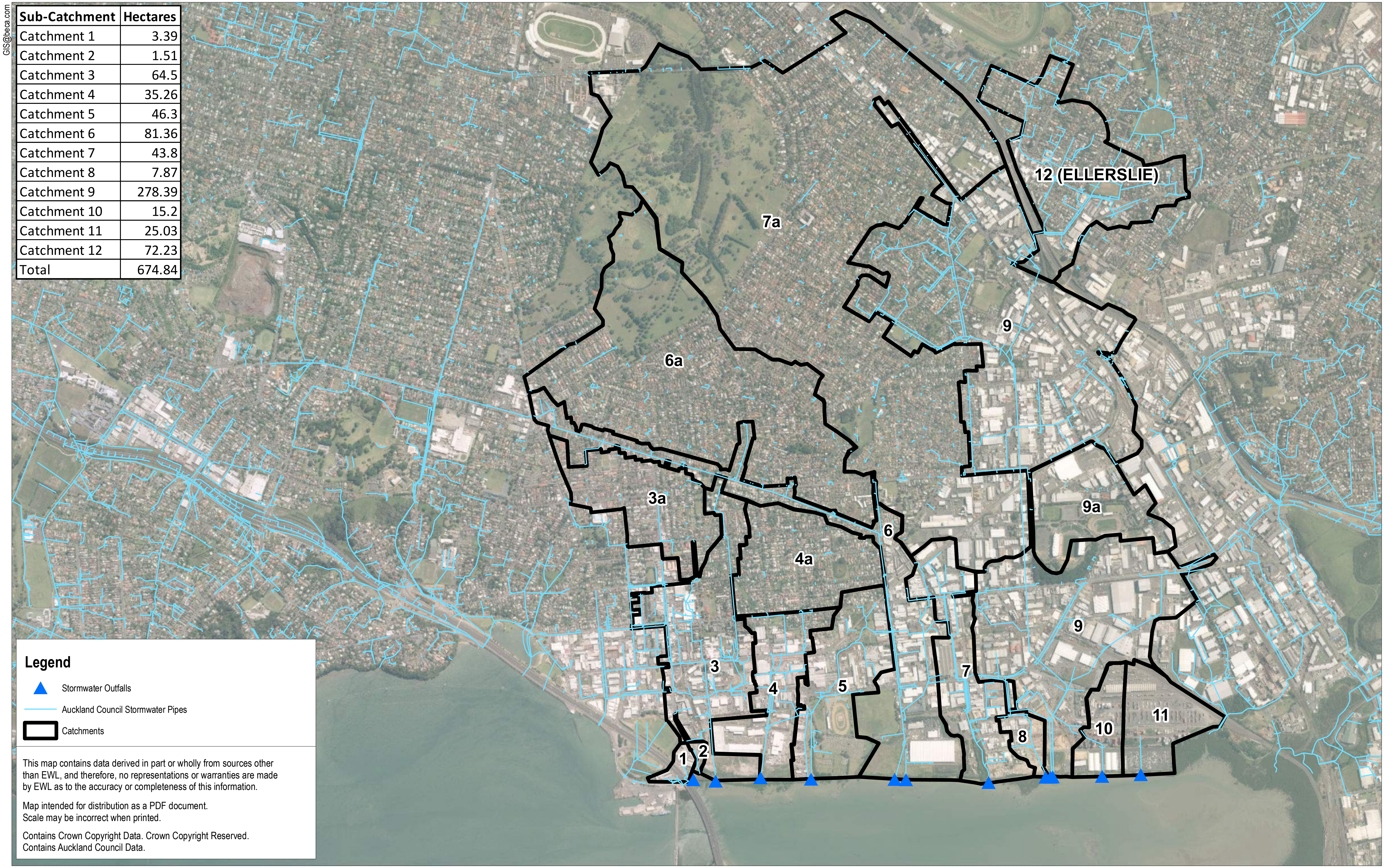
WAKA KOTAHI

East West Link

Drawn:	**Draft Check:**	**Reviewed** (Design Manager)	**Approved** (Alliance Manager)	**Discipline:** Stormwater
Designed:	**Design Check:**			**Title:** Embankment Stormwater Catchment Zoning
Scale: 1:20,000		Original Size: A3	Contract No PA4041	**Drawing No:** GIS-AEE-SWE-011 **Rev:** A

Plot Date: 21/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Stormwater (SW-E)\DRAFTS\GIS-SW-E-011_Stormwater_EWL_PAUP.mxd



Sub-Catchment	Hectares
Catchment 1	3.39
Catchment 2	1.51
Catchment 3	64.5
Catchment 4	35.26
Catchment 5	46.3
Catchment 6	81.36
Catchment 7	43.8
Catchment 8	7.87
Catchment 9	278.39
Catchment 10	15.2
Catchment 11	25.03
Catchment 12	72.23
Total	674.84

Legend

- Stormwater Outfalls
- Auckland Council Stormwater Pipes
- Catchments

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No	Revision	Drawn	Verified	Approved	Date
A	Original Issue	Bap	LB	LB	26/10/16

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Drawn:	Draft Check:	Reviewed (Design Manager)	Approved (Alliance Manager)
Designed:	Design Check:		
Scale: 1:20,000		Original Size: A3	Contract No PA4041

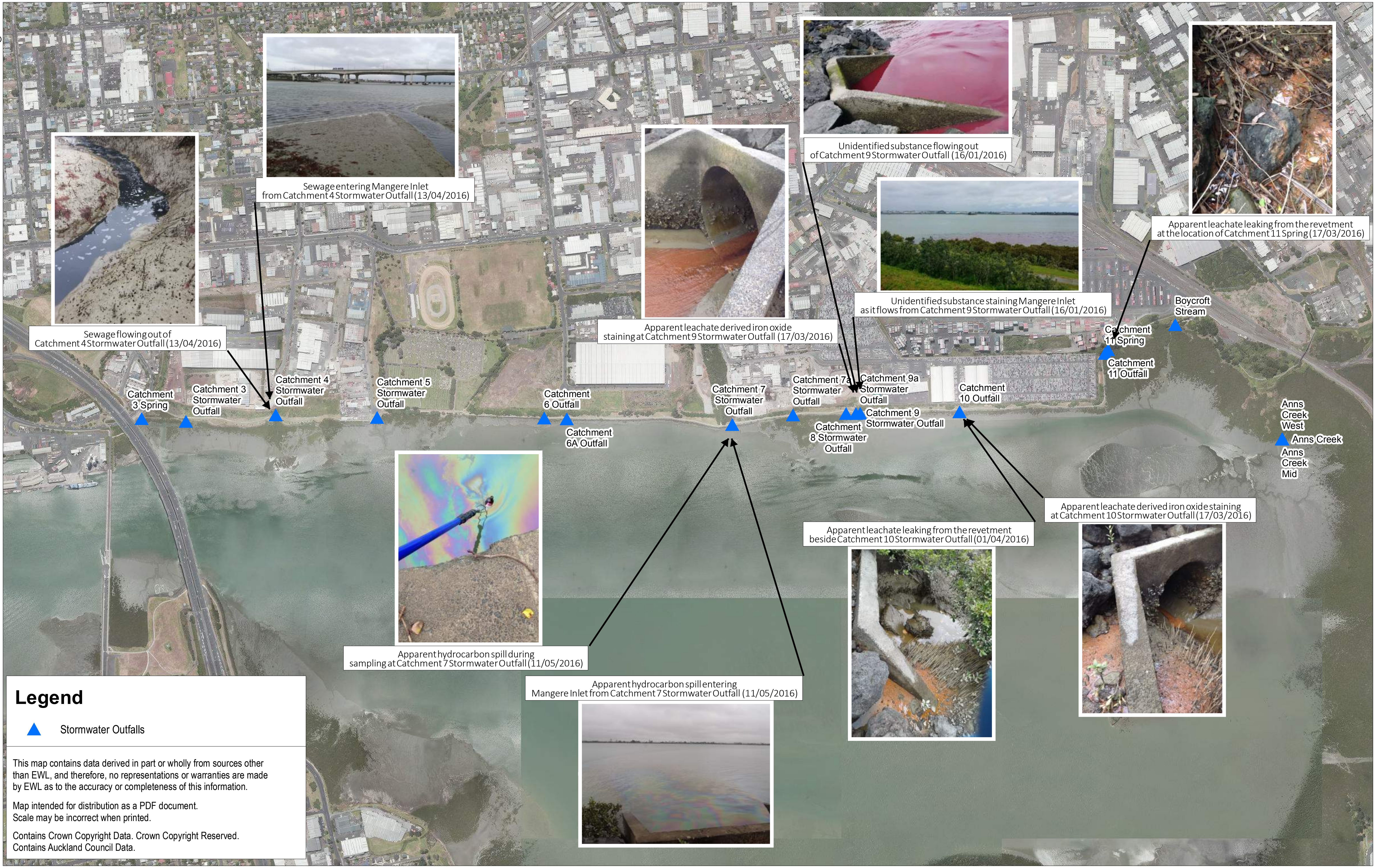
Discipline: Stormwater

Title: Foreshore Stormwater Sub-catchments & Existing Stormwater network

Drawing No: GIS-AEE-SWE-039 **Rev:** A

Plot Date: 27/10/2016 Plotted by: Ben Peyton File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Stormwater (SW-E)\DRAFTS\GIS-SW-E-039_CatchmentAreas_AC_SW_Pipes.mxd

GIS@beca.com



No	Revision	Drawn	Verified	Approved	Date
A	Original Issue	RJL	BAP	LB	24/03/15

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Drawn:	Draft Check:	Reviewed (Design Manager)	Approved (Alliance Manager)
Designed:	Design Check:		
Scale: 1:10,000		Original Size: A3	Contract No PA4041

Discipline: Environment

Title: **Spills and Seepages along the Onehunga Foreshore**

Drawing No: GIS-SW-E-007 Rev: A

Plot Date: 21/10/2016 Plotted by: Rod Lockie File: W:\CAD\ArcGIS\TGI\55_Workspaces\01_mxd\Environmental\WORKING\GIS-EC-AEE-003_StormwaterOutfalls.mxd