Greenhithe Bridge Watermain Duplication and Northern Interceptor Projects

Assessment of Alternatives for Harbour Crossing

July 2015

Watercare
An Auckland Council Organisation

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North-west and north Auckland are well established communities and also contain strategic growth areas. These growth areas include Kumeu, Huapai and Riverhead; Whenuapai; Westgate, Hobsonville Corridor and Hobsonville Point (the North West Transformation area); Massey and Swanson; Silverdale; and Long Bay. The provision of robust and resilient water and wastewater infrastructure is essential to support these existing communities and enable future development in these parts of the region.

The key issues with respect to water supply are;

- current degree of reliance on the existing North Harbour 1 Watermain
- need for increased supply capacity to service growth in the north west, North Shore and North Auckland.

Key issues with regard to wastewater are;

- the need for increased capacity to convey flows from the proposed growth areas
- the need to relieve capacity in the existing trunk sewer system
- the need to divert some flows away from Mangere Wastewater treatment plant and towards the Rosedale wastewater treatment plant.

Watercare have considered various options to address these issues and for providing such a service and as a result are proposing a duplication of the North Harbour 1 watermain with a project known as the Greenhithe Bridge Watermain Duplication (GBWD) and Causeway and the construction of new wastewater interceptors from north-west Auckland to Rosedale Wastewater treatment plant, known as the Northern Interceptor project (NI).

These projects have been progressed in parallel and a key benefit of considering the two projects together is the opportunity to create a combined infrastructure corridor, integrate the development of major infrastructure works, reduce the degree of environmental and community disturbance during construction and provide for Auckland's future infrastructure needs.

The purpose of this report is to compare the possible alternative route options for the water and wastewater pipelines to cross the harbour in the vicinity of the Greenhithe Bridge.

The route alignment, various means of crossing the Waitemata Harbour and construction methodologies for both the GBWD and the NI projects have been considered in some detail and the relative merits of each discussed in this report.

Greenhithe Bridge Watermain Duplication

The construction of the northern Greenhithe Bridge crossing in 2005/6 made structural provision for conveyance of a new watermain across the Upper Waitemata Harbour. The route selection process therefore concentrated on the approach to the western side of the bridge and resulted in the preferred option of widening the existing motorway causeway to accommodate the new watermain via access from Squadron Drive.

The preferred option is for GBWD to be installed in a trench within the widened causeway and transition up onto the Greenhithe Bridge. The pipeline will then be attached to the underside of the bridge in order to cross the harbour and transition back to ground level at Greenhithe end of the bridge.

Northern Interceptor

Phase 1 of the NI project will convey wastewater from Hobsonville to Rosedale WWTP via a crossing of the Upper Waitemata Harbour. The preferred harbour crossing route involves the installation of the wastewater pipelines within a widened causeway within an integrated infrastructure corridor shared with the GBWD. The Greenhithe Bridge does not have structural capacity to support a new wastewater line and hence an alternative crossing methodology was required.

The preferred option is for crossing the harbour between the widened causeway and Rahui Road using either horizontal directional drilling (HDD) or marine trenching. Should HDD be selected a construction platform will be required along the widened causeway to enable the appropriate HDD alignment and drilling equipment placement to be achieved. The preferred method will be confirmed once a contractor has been appointed for the works.

1 INTRODUCTION

Watercare Services Limited (Watercare) is proposing to construct major water and wastewater infrastructure projects to service the north west, North Shore and North Auckland. Resource consent applications will be lodged for the proposed Greenhithe Bridge Watermain Duplication and Causeway project and Phase 1 of the Northern Interceptor wastewater project. Both of these projects involve a crossing of the Upper Waitemata Harbour in the vicinity of the State Highway 18 (SH18) Greenhithe Bridge.

The purpose of this report is to set out the background and context for these projects, and to describe the alternative route options and construction methods that have been considered. The report focuses on the proposed works in the Upper Waitemata Harbour and immediate vicinity, to support resource consent applications for works in the Coastal Marine Area.

2 OVERVIEW OF WATER AND WASTEWATER PROJECTS

2.1 Background

Water and wastewater infrastructure is essential to service existing communities and provide for planned growth.

North-west and north Auckland are well established communities and also contain strategic growth areas. These growth areas include Kumeu, Huapai and Riverhead; Whenuapai; Westgate, Hobsonville Corridor and Hobsonville Point (the North West Transformation area); Massey and Swanson; Silverdale; and Long Bay.

Key infrastructure needed to service growth includes:

- Security of water supply to the North Shore and North Auckland;
- Increased water supply capacity to the North Shore and North Auckland; and
- Increased capacity to convey wastewater flows from north-western parts of Auckland for treatment.

Key water supply issues are:

- The degree of reliance on the existing North Harbour 1 (NH1) Watermain, which crosses the Upper Waitemata Harbour to service the North Shore and North Auckland; and
- The need for increased supply capacity to service growth in the north-west, North Shore and North Auckland.

Key wastewater issues are:

- The need for increased capacity to convey flows from growth areas in north-west Auckland;
- The need to relieve capacity in the existing trunk wastewater network;
- The need to divert some flows from north-western parts of Auckland away from the Mangere Wastewater Treatment Plant (WWTP) in order to provide for growth in other parts of Auckland; and
- The need to optimise treatment capacity at both the Mangere and Rosedale WWTPs.

2.2 Proposed Water and Wastewater Projects

Having considered various options, Watercare is proposing to implement the following major infrastructure projects to service the north-west and north of Auckland:

(i) Duplication of the existing NH1 watermain attached to the Greenhithe Bridge – this project is known as the Greenhithe Bridge Watermain Duplication (GBWD). The primary objective is to increase security of supply to the North Shore and North Auckland.

(ii) Construction of a new watermain from the Huia Water Treatment Plant to the Albany Reservoirs – this project is known as the North Harbour 2 Watermain (NH2). The primary objective is to increase supply capacity to north-west Auckland, the North Shore and North Auckland. The GBWD will eventually connect to and form part of NH2.

(iii) Construction of new wastewater interceptors from north-west Auckland to the Rosedale WWTP in Albany – this project is known as the Northern Interceptor (NI). The primary objectives are to provide for growth in north-west Auckland, increase capacity in the existing trunk wastewater network, and divert some flows away from the Mangere WWTP. Construction of the NI project is

intended to be staged, with the timing of various stages depending on the rate of population growth. Phase 1 of the NI project will convey flows from the existing Hobsonville Pump Station to the Rosedale WWTP. Future phases will extend from Watercare's existing Concourse Storage Tank in Henderson to the Hobsonville Pump Station.

These major water and wastewater infrastructure projects are required within the next 20 years, with the most immediate requirements being to construct the GBWD and Phase 1 of the NI project. The planned construction start dates for these projects are 2016 and 2017, respectively.

Because the GBWD and NI projects all require crossings of the Upper Waitemata Harbour, and are required within similar timeframes, the route options and construction methods for these projects have been considered in parallel.

As identified in the following sections of this report, the preferred outcome for this critical harbour crossing section includes an integrated water and wastewater infrastructure solution within a shared corridor alongside the existing SH18 motorway causeway.

The proposed physical works incorporate widening of the existing causeway and a short extension of the causeway under the Greenhithe Bridge. Widening of the causeway may also include the establishment of a platform to facilitate the construction of pipeline harbour crossing works associated with the NI project. The need for this platform will depend on the confirmed construction method for the NI harbour crossing, which may be either Horizontal Directional Drilling (HDD) or marine trenching. The construction platform is required for HDD, but not for marine trenching. These causeway works would provide for the GBWD (a 1200mm Nominal Diameter (DN) watermain), Phase 1 of the NI project (a 710mm DN wastewater pipeline), and for future phases of NI (twin 1200mm DN wastewater pipelines).

In providing for this key water and wastewater infrastructure, the proposed causeway widening and extension also provides an opportunity to enhance public access and amenity in this part of the coastal environment.

3 GREENHITHE BRIDGE WATERMAIN DUPLICATION

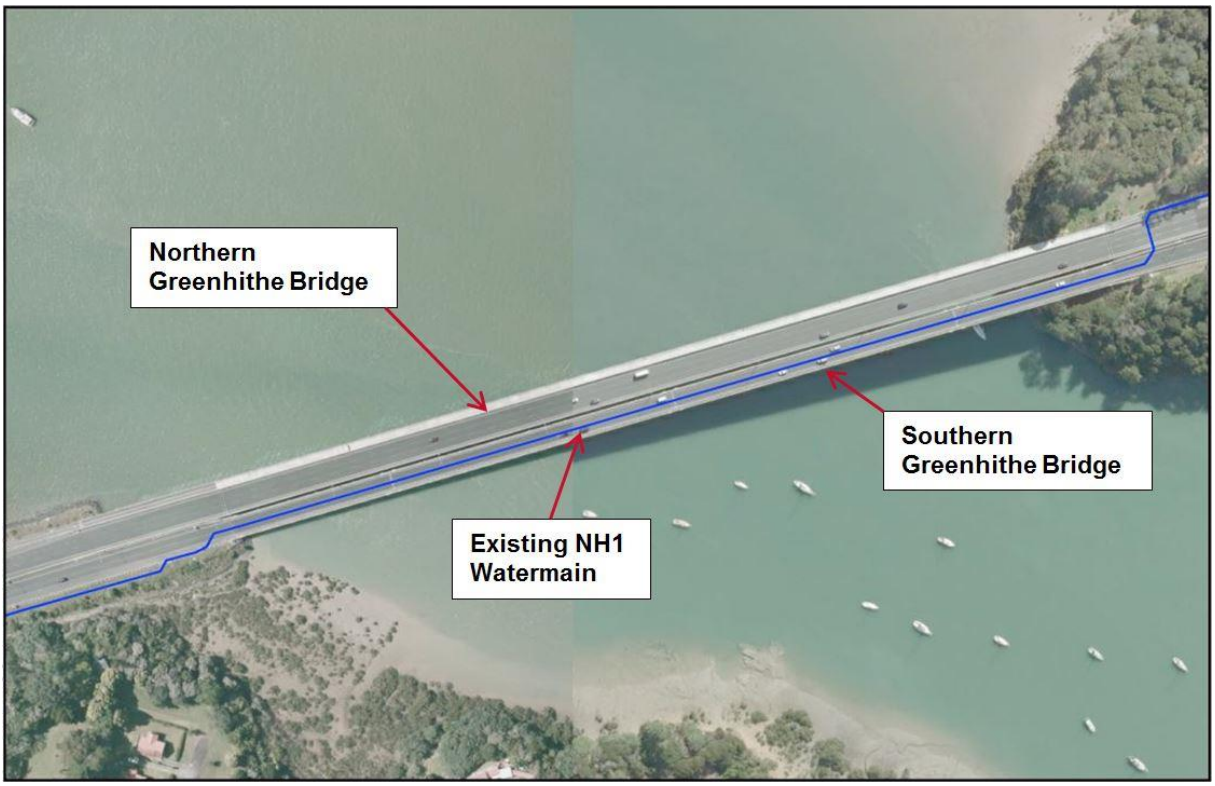
3.1 Background

Watercare's existing NH1 watermain supplies water to the northern parts of the North Shore and to Whangaparaoa and Orewa. The only other supply to the North Shore is via existing watermains crossing the Auckland Harbour Bridge. These latter watermains supply Devonport, Takapuna, Northcote, Birkenhead and East Coast Bays. The areas supplied by NH1 can be supplemented from the Auckland Harbour Bridge watermains. However, this only occurs in the case of emergency repairs or planned shut down for maintenance works, and can only be sustained for one to two days at winter low demand period before reservoir storage is depleted and security of supply is threatened.

NH1 crosses the Upper Waitemata Harbour between Hobsonville Point and Greenhithe, being located within the Greenhithe Bridge. Greenhithe Bridge actually comprises two separate, parallel bridges. NH1 is located within the box girder of the southern bridge (carrying westbound traffic), which was constructed in the 1970s. The northern bridge was constructed in 2005 – 2006.

Figure 3-1 shows the location of the existing NH1 watermain within the southern bridge structure.

Figure 3-1 Existing NH1 Watermain within the Southern Greenhithe Bridge



Technical investigations previously undertaken by or on behalf of Watercare have identified significant risk in relation to the existing section of NH1 within the Greenhithe Bridge.

Significant risks in relation to the section of watermain within the bridge include:

(i) Highly restricted access for inspection and maintenance. In 2006 NZTA retrofitted the original Greenhithe Bridge (i.e. what is now the southern bridge) by the addition of post tensioning to both the external deck edges and mid spans. These retrofitted works have further restricted accessibility for maintenance and remedial work on NH1.

(ii) Cyclic stresses to the pipe and pipe expansion joints caused by movements within the bridge structure, resulting from traffic loading and temperature variations. Whilst there is no immediate risk of failure the likelihood increases with time and should be mitigated as soon as possible.

(iii) External damage and corrosion to the pipe at concrete support structures and diaphragm walls.

(iv) Earthquake deflections in the bridge structure could lead to bending/buckling of the pipeline, resulting in local deformation of the pipe wall with associated damage to the lining. As already identified, access into the existing bridge structure for remedial works to repair the pipeline is highly limited.

(v) Shutdown of NH1 for major repairs would result in severe water restrictions being imposed on the whole of North Shore and areas further north. The existing section of NH1 within the Greenhithe Bridge cannot be isolated for a sufficient timeframe to undertake anything more than remedial works of very short duration (24 – 36 hours currently). Regional population growth on the North Shore and areas further north (currently 200,000 and projected to reach 460,000 by 2060) and the corresponding increase in water demand will have the effect of further reducing the window (timeframe) available to undertake any shutdown maintenance activities on NH1.

In summary, the combination of increased wear with age and movement on the existing section of NH1 within Greenhithe Bridge; potential for seismic damage; and limited access to maintain and remediate this section of watermain presents a major supply risk for Watercare. In the event that this section of NH1 fails, the alternative water supply across the Auckland Harbour Bridge is unable to meet the demand of the whole of the North Shore and areas further north.

3.2 Options for Responding to NH1 Risks

In responding to the risks identified in Section 3.1 of this report, the following options are available.

3.2.1 Do Nothing

This option would maintain the status quo. Given that NH1 plays a critical role in supplying water to the North Shore and areas further north, and significant risks relating to the integrity of the existing section of watermain within the Greenhithe Bridge, the status quo is not considered acceptable.

3.2.2 Replace Existing Watermain

This option would involve replacement of the existing section of NH1 within the south side of the Greenhithe Bridge structure. This is not considered feasible for the following reasons:

(i) Replacing the section of NH1 ‘online’ would require an extended shut down of the watermain, possibly in the order of 12 months. There is no alternative water supply to the North Shore, capable of meeting daily demands over an extended period, which would allow the replacement works to be undertaken.

(ii) There is no physical access available to remove the existing section of watermain and install a new pipe within the old bridge structure.

The existing pipe could be remediated in place, but access is extremely difficult and would present an unacceptable supply risk to the network without a alternative supply option. Replacing or repairing the existing watermain without a duplicate supply is therefore considered to be fatally flawed.

3.2.3 Duplicate Existing Watermain

This option would involve the construction of a new watermain, duplicating the section of NH1 within the Greenhithe Bridge.

Providing a duplicate watermain would ensure security of supply, given the significant risks associated with ongoing operation and maintenance of the existing section of watermain. Duplication is therefore considered to be the preferred option.

This preferred option is referred to as the proposed Greenhithe Bridge Watermain Duplication (GBWD). Once the GBWD is completed and the new watermain commissioned, essential maintenance of the existing NH1 watermain can then take place.

Once maintenance on the NH1 watermain is completed, and the proposed North Harbour 2 Watermain (NH2) has been constructed (refer Section 2.2 of this report), the new watermain installed as part of the GBWD project will connect to, and form part of, completed NH2. The connections between NH1 and NH2 will remain in place to allow for periodic maintenance of each pipe.

3.3 Watermain Duplication Options – Greenhithe Bridge Section

Having identified duplication of the existing NH1 watermain as the preferred option, the following options are potentially available for conveying a new watermain across the Upper Harbour channel between Hobsonville Point and Greenhithe (i.e. that part of the channel spanned by the Greenhithe Bridge):

- Attach the new watermain to the north side of the Greenhithe Bridge;
- Place the new watermain under the harbour, with installation by trenched or trenchless construction methods; or
- Construct a new stand-alone pipe bridge.

These options are discussed as follows.

3.3.1 Attachment to Greenhithe Bridge

The need for remediation works on the existing NH1 watermain and for additional supply capacity to meet future water demand associated with population growth in northern parts of the North Shore was identified by Watercare in the early 2000s. The opportunity to incorporate a new watermain as part of the proposed duplication of the Greenhithe Bridge was discussed with the former Transit New Zealand (now NZTA) in the early stages of that project.

In 2005 – 2006 Transit New Zealand duplicated the original Greenhithe Bridge, constructing a parallel bridge on the northern side (to carry eastbound traffic). The design of the new bridge made specific allowance for future installation of a watermain beneath the northern side cantilever (i.e. beneath the cycleway on the northern side of the new bridge).

3.3.2 Alternative Options

The following alternative options are otherwise potentially available for crossing the Upper Harbour channel:

(i) Tunnel or directional drilling.

(ii) Marine trenching.

(iii) Stand-alone pipe bridge.

These options each have significant disadvantages compared to attaching the watermain to the bridge. For example tunnelling and directional drilling options have a greater potential for technical issues and increased and costs compared to attachment to the existing bridge structure. A stand-alone pipe bridge would need to be elevated to a similar height as the Greenhithe Bridge to allow for marine navigation beneath the bridge. Such a substantial structure would be costly and could have an adverse visual impact within the coastal environment that would be difficult to mitigate.

Given that the new Greenhithe Bridge has been specifically designed to accommodate a watermain, this constitutes the most practicable option for duplicating the existing NH1 watermain where it crosses the Upper Harbour channel.

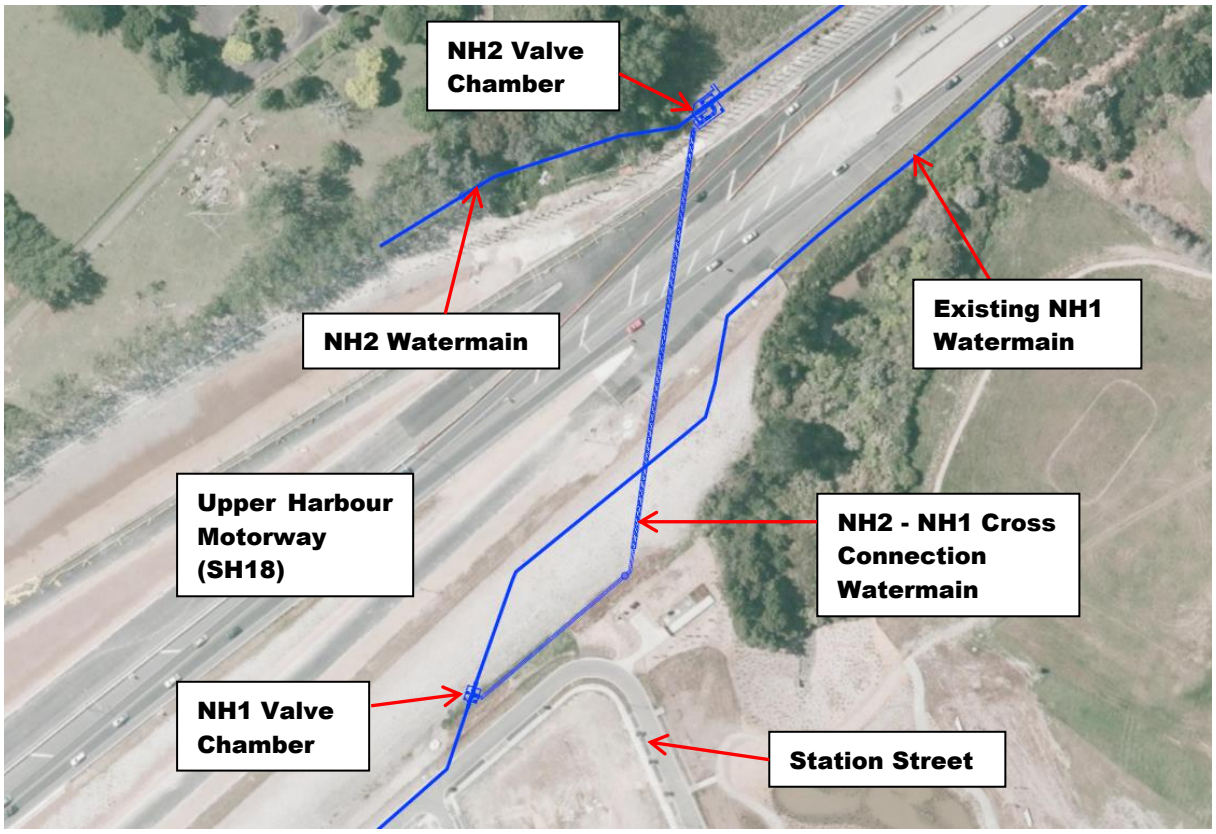
3.4 Watermain Duplication Options – Causeway Section

In order to duplicate the existing section of NH1 within the Greenhithe Bridge, cross-connections are required either side of the harbour. These cross-connections involve connecting into the existing NH1 watermain and the construction of a valve chamber within which the water supply can be diverted between the existing and new watermains.

The necessary cross-connection on the eastern (Greenhithe) side of the harbour can be located immediately adjacent to the bridge abutment, away from motorway traffic and the existing cycleway. However on the western side of the harbour there is minimal space within the existing motorway causeway or in the proposed widened causeway, so the cross-connection chamber would need to be located approximately 500m west of the bridge towards Squadron Drive. This location, near Station Street, provides better construction options and convenient access for future operation and maintenance tasks.

Figure 3-2 shows the required cross-connection arrangement near Station Street.

Figure 3-2 Cross-Connection Arrangement near Station Street



It will therefore be necessary to extend the proposed new watermain along the western approach to Greenhithe Bridge (i.e. over that section currently occupied by the motorway causeway) to the western abutment of the bridge.

3.4.1 Alternative Route Options

The potential route options for the new watermain between Station Street and the western abutment of the Greenhithe Bridge are:

- **Option 1** - Within the existing motorway causeway;
- **Option 2** - South of the motorway causeway, on land and in the Coastal Marine Area (CMA);
- **Option 3** - South of the motorway causeway, entirely on land; or
- **Option 4** - North of the motorway causeway, in the CMA.

These options are discussed as follows.

3.4.1.1 Option 1: Existing Motorway Causeway

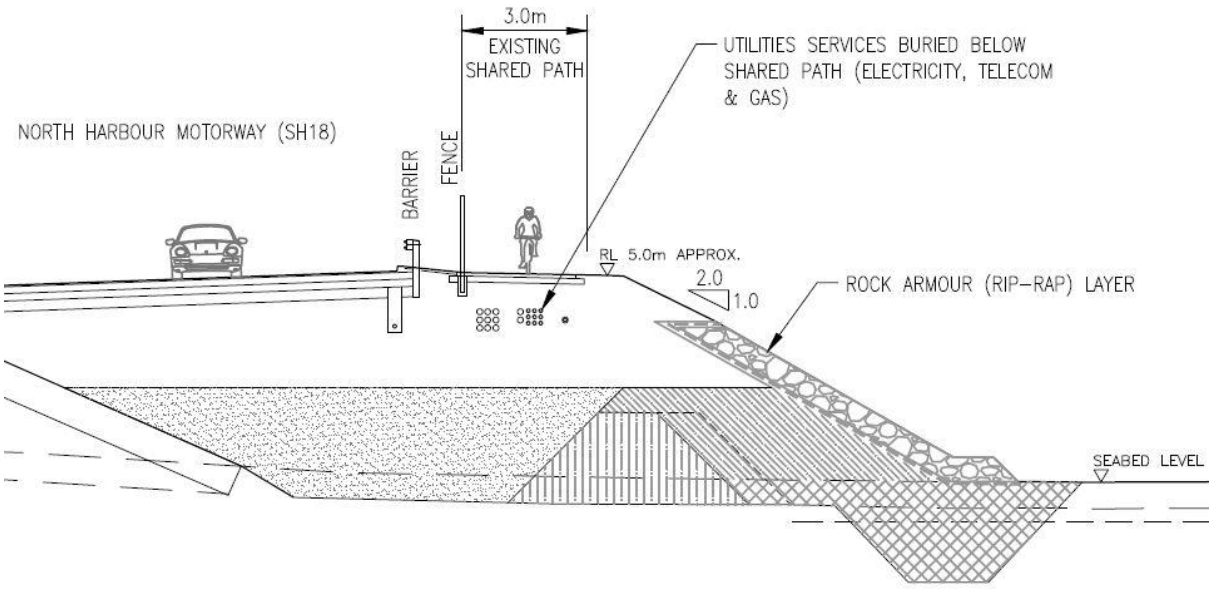
This option would involve placement of the new watermain within the existing motorway causeway (refer **Figure 3-3**).

Figure 3-3 Option 1: Existing Motorway Causeway

Between Squadron Drive and Greenhithe Bridge the SH18 Upper Harbour Motorway has been constructed on a formed reclamation. When the original Greenhithe Bridge was duplicated, the existing reclamation was widened to accommodate additional traffic lanes and a cycleway. It was anticipated at that time that a new watermain (as provided for on the northern side of the new bridge) would pass through the western bridge abutment and continue along this reclaimed causeway beneath the cycleway.

However, subsequent construction of stormwater infrastructure, a high pressure gas main, and other network utility services beneath the cycleway has resulted in a highly constrained corridor that effectively precludes the introduction of a large diameter watermain. **Figure 3-4** provides a cross-section of the existing motorway causeway, showing the current arrangement of services and the location of the cycleway and immediately adjoining motorway carriageway. The extent of excavation required to install the new watermain could also affect the physical integrity of the existing reclamation, potentially destabilising the motorway carriageway or requiring significant support structures to avoid this. In addition, the cycleway would need to be closed for the duration of construction.

Figure 3-4 Cross-Section of Motorway Causeway Showing Existing Services



A possible alternative option would be to install the pipeline on foundations that are piled through the existing causeway embankment, immediately to the north of and adjacent to the cycleway. This location would avoid existing services. This option would, however, have an adverse visual effect and the exposed pipeline could be subject to vandalism. The pipeline would also be exposed to the corrosive marine environment, requiring regular cleaning and maintenance. A possible variation on this option would be to install the pipeline just below the surface of the embankment and supported on piled foundations. However this option is difficult to construct and presents some risks to the existing motorway and causeway foundations

Another option would be to locate the new watermain within the southern side of the existing motorway causeway. On this side of the causeway there is, however, only a narrow embankment adjoining the motorway carriageway and this is already occupied by the existing NH1 watermain. Strategically it is preferable to maintain a degree of physical separation between the existing NH1 and a new watermain, in order to reduce operational risk and increase resilience of supply. For example, co-location of the watermains could result in both being compromised should a localised event such as land instability or rupture of one of the pipelines occur.

A further option would be to install the new watermain in a trench within the motorway carriageway. This would, however, result in significant disruption to motorway traffic during construction and require further disruption should the pipeline subsequently need to be accessed for maintenance purposes. There would likely be some differential settlement of fill material following back-filling of the trench, resulting in an uneven pavement surface. This option is unacceptable to NZTA and Watercare.

3.4.1.2 Option 2: South of Motorway Causeway – On Land and in the CMA

This option would involve placement of the new watermain immediately adjoining the southern side of the existing motorway causeway, partly on land and partly in the CMA (refer **Figure 3-5**).

Figure 3-5 Option 2: South of Motorway Causeway - On Land and in the CMA

There is significant existing stormwater infrastructure adjoining the southern side of the causeway, which services both the motorway and neighbouring land at Hobsonville Point. This includes a constructed stormwater pond and large treatment device.

In the operative Auckland Council Regional Plan: Coastal (ACRP:C) the area immediately adjoining the southern side of the causeway does not form part of the CMA (refer ACRP:C Map Series 1 – Sheet 28). In contrast, in the Proposed Auckland Unitary Plan (PAUP) part of this same area has a General Coastal Marine zoning - indicating that it forms part of the CMA. The PAUP Natural Resources overlay identifies the area as a Significant Ecological Area - Land. The area in question is tidally influenced and comprises mangrove vegetation. Subject to resolution of the conflicting notations in the relevant planning instruments, the most conservative interpretation is that the area in question is within the CMA and is a Significant Ecological Area.

Depending on the method of construction, including the need to provide ongoing maintenance access, the establishment of a watermain in this location could significantly adversely affect coastal ecological values. It may also require additional works in land and the CMA in order to maintain existing levels of stormwater detention and treatment.

If the new watermain was installed along the southern side of the causeway, it would then have to cross over to the northern side in order to be attached to the Greenhithe Bridge. This cross-over would need to occur either beneath the Greenhithe Bridge or within the motorway causeway west of the bridge. Either option has significant disadvantages, as explained in Section 3.4.1.3 of this report.

3.4.1.3 Option 3: South of Motorway Causeway – Entirely on Land

This option would involve placement of the new watermain further to the south on Hobsonville Point. The most likely option would be to construct the new watermain within Buckley Avenue, and then Beach Road in order to convey the watermain down towards the Greenhithe Bridge (refer **Figure 3-6)**

Figure 3-6 Option 3: South of Motorway Causeway - Entirely on Land

Buckley Avenue now provides access to intensive housing development at Hobsonville Point (a large new residential community) and major pipeline construction works within the narrow road corridor would be disruptive.

If the new watermain was installed along Beach Road and down towards the SH18 motorway, it would be necessary for the pipeline to cross over to the northern side of the motorway for attachment to the Greenhithe Bridge (as for Option 2). If this cross-over were to occur beneath the Greenhithe Bridge, then attachment of the pipeline would 'structurally connect' the two separate bridges. Such a connection could have adverse consequences during a seismic event, with the structural integrity of the bridges and the pipeline potentially being compromised. As an alternative option the new watermain could cross the motorway west of the Greenhithe Bridge. This would require micro-tunnelling through the existing causeway beneath the motorway carriageway (the limited available construction area on either side of the causeway precludes directional drilling). Valve chambers would be required on each side of the causeway, with some form of reclamation likely being required to accommodate the chamber on the northern side. The chambers could be accessed from the SH18 motorway and ongoing maintenance access would therefore disrupt traffic flows on the motorway. Whilst access to the chambers on the north side is possible from the cycleway it would involve temporarily closing the cycleway.

3.4.1.4 Option 4: North of Motorway Causeway – In CMA

This option would involve placement of the new watermain within the CMA to the north of the existing motorway causeway (refer **Figure 3-7**).

Figure 3-7 Option 4: North of Motorway Causeway - In CMA

Installation of the new watermain in this location avoids the issues identified for Options 1 – 3 and is the preferred route option for the following reasons:

(i) There would be no conflict with existing network utility services in the motorway causeway.

(ii) Significant ecological values and stormwater infrastructure on the southern side of the causeway can be avoided.

(iii) The required pipeline length for the GBWD would be shorter (compared to an option entirely on land via Hobsonville Point), with commensurate cost savings.

(iv) It would not be necessary for the new watermain to cross from the southern to the northern side of the causeway, thereby avoiding the constraints associated with limited available construction and maintenance areas on the causeway, and there would be minimal disruption to SH18 motorway traffic.

(vi) A degree of physical separation is achieved between the existing NH1 and new watermain, thereby reducing operational risk and increasing resilience of supply.

(vii) Depending on the chosen construction methodology, this option could also facilitate installation of the proposed Northern Interceptor wastewater pipelines across the Upper Harbour.

3.4.2 Alternative Construction Methods for Preferred Route Option

A range of alternative construction methods are potentially available for installing the new watermain within the CMA to the north of the existing motorway causeway (Option 4, the preferred route). These options are:

- Tunnel or directional drilling;
- Marine trenching;
- Stand-alone pipe bridge;
- Causeway widening.

These options are compared, in terms of their advantages and disadvantages, in **Table 3-1**.

Table 3-1 GBWD - Alternative Construction Methods for Preferred Route Option (Causeway Section)

Construction Methods	Advantages	Disadvantages
Tunnel or Directional Drilling	**Construction** – Smaller construction set up areas are required and there would be reduced construction traffic impacts (compared to causeway widening by means of reclamation, for example, which would require a large construction area and a significant number of truck movements to import fill material). **Visual Impact** – Once completed, there would be no visible structures within the CMA. **Environment** – The works would take place largely beneath the seabed and there would be a lower risk of sediment release into the marine environment compared to other construction methods such as marine trenching.	**Geotechnical** – The geology of the seabed adjoining the causeway is variable. There are deep former channels infilled with weak alluvial sediments cutting into the sandstone shore platform that is visible along sections of the causeway. In order to access suitable material for tunnelling or drilling, the pipeline would need to be installed at least 9m below the existing seabed at the western end rising up towards the eastern end of the causeway. This would increase engineering risks associated with striking unforeseen geology. Tunnelling would therefore require a relatively deep access shaft at each end of the causeway (particularly the western end), and this would in turn require the establishment of a reclaimed work platform at the eastern end in order to vertically transition the pipeline up out of the seabed for attachment to the Greenhithe Bridge. Accessing this platform from the SH18 causeway would be difficult. Watercare's preference is to use steel pipe rather than polyethylene ('PE') pipe for the new watermain, and steel pipe is less flexible than PE pipe. If both steel pipe and directional drilling were utilised, then drilling would need to commence further back towards Squadron Drive in order to achieve the required depth over the length of the causeway. Commencing drilling in this location would be difficult, however, due to the 13m deep weak alluvial soils below Squadron Drive. Establishing a drilling launch site in this location could also be problematic given the presence of the Squadron Drive SH18 motorway on-ramp. **Construction** – As discussed above, limited set up areas are available. This situation would be compounded if the working area at the western end of the causeway was also utilised for construction of the proposed Northern Interceptor wastewater pipelines.

Construction Methods	Advantages	Disadvantages
		The construction costs of HDD and microtunnelling are relatively high compared to trenching. **Operations/Maintenance** – The watermain would be constructed beneath the seabed and there would be no opportunity for future access to the pipeline for inspections and maintenance.
Marine Trenching	**Construction** – Shorter construction timeframe required, and there would be limited construction traffic impacts.	**Environment** – Because of tidal velocities resulting from the adjoining narrow harbour channel, additional management methods would be required to contain sediment release. **Construction** - Limited set up areas are available. This situation would be compounded if the working area at the western end of the causeway was also utilised for construction of the proposed Northern Interceptor wastewater pipelines. In the latter case, a temporary reclamation may be required at the western end to facilitate construction. Marine trenching would, in any case, require the establishment of a reclaimed work platform at the eastern end of the causeway in order to vertically transition the pipeline up out of the seabed for attachment to the Greenhithe Bridge. Accessing this platform from the SH18 causeway would be difficult. **Operations/Maintenance** – The watermain would be constructed beneath the seabed and there would be no opportunity for future access to the pipeline for inspections and maintenance.
Stand-Alone Pipe Bridge	**Other Services** – Avoids reclamation in the CMA and presents an opportunity to convey other services across the harbour and the design could incorporate appropriate loadings as required. The construction of a pipe bridge could also incorporate pedestrian access, providing an additional opportunity for	**Construction** The pipe bridge would only extend as far as the eastern end of the causeway. There is capacity to accommodate the GBWD pipeline on Greenhithe Bridge, but due to structural limitations, it would be necessary to convey any other services across the harbour channel by some other means.

Construction Methods	Advantages	Disadvantages
	recreational activities such as fishing.	**Visual Impact** – The watermain (and any other services accommodated) and support structure could have an adverse visual impact within the coastal environment. This could potentially be mitigated by the placement of a boardwalk or similar structure on top of the pipeline. **Operations/Maintenance** – The watermain would be exposed to the corrosive marine environment, requiring regular cleaning and maintenance and access way of sufficient width to allow for vehicle access.. Access to the watermain to complete operation and maintenance tasks would be within the CMA, resulting in additional health, safety and environmental requirements. **Other Services** – While a stand-alone pipe bridge could be designed to accommodate the proposed Northern Interceptor wastewater pipelines in addition to the new watermain, the pipe bridge required for the watermain would terminate at the eastern end of the motorway causeway and a solution would then need to found for conveying the wastewater pipelines across the Upper Harbour channel.
Causeway Widening	**Construction** – Low engineering risk, utilising proven construction methodology. The methods that would be adopted to widen the existing SH18 motorway causeway have been successfully used to widen the same section of causeway in the past and are currently being used for the SH16 North Western Motorway causeway upgrade project. Causeway widening could be undertaken without the need for construction access directly off the SH18 motorway. **Other Services** - Presents an opportunity to convey other services across the harbour, including the proposed Northern Interceptor wastewater pipelines. Construction	**Construction** – Large construction area required, with construction traffic impacts on the adjoining local road network. **Environment** - The PAUP Natural Resources overlay identifies a Significant Ecological Area (SEA) - Land along the rock embankment on the northern side of the existing causeway, and this area would be completely covered by causeway widening. However, an Ecological Assessment undertaken for the Greenhithe Bridge Watermain Duplication and Causeway project (Tonkin & Taylor, 2015) states that although classified in the PAUP as an SEA, the ecological values of this area are low. Causeway widening would otherwise result in ecological (particularly avifauna) and visual and landscape effects. These effects have been assessed as minor to moderate . .provided that appropriate

Construction Methods	Advantages	Disadvantages
	of the GBWD and NI projects could be undertaken as an integrated infrastructure development, avoiding some of the potential adverse effects that could result from constructing the projects in isolation and using different methods. Simplifies cross-connection between the new watermain and existing NH1 watermain. **Cycleway and Access** – Further access to the causeway will be provided for pedestrians and cyclists in addition to the existing cycleway. All weather access will be provided to the proposed infrastructure and possibly to existing utility services on the Greenhithe Bridge. Provision of access via the widened causeway, away from live traffic lanes on the adjoining motorway - improves safety for cyclists, pedestrians and utility operators. **Visual Impact** – A Landscape and Visual Assessment undertaken for the Greenhithe Bridge Watermain Duplication and Causeway project (Boffa Miskell, 2015) concludes that the overall adverse effect of further widening on the existing landscape and visual amenity would be low/moderate – provided that appropriate landscape mitigation works are implemented. **Amenity** – Provides an opportunity for increased public use (e.g. passive recreation, fishing). **Operations/Maintenance** – Enables unconstrained access to the new watermain for inspections and maintenance, without causing disruption to SH18 motorway traffic.	mitigation by way of habitat replacement and appropriate landscape treatment is provided.

3.4.2.1 Cost of Alternative Construction Methods

Based on the discussion provided in previous sections of this report, a range of alternative route options were considered and installation of the new watermain within the CMA to the north of the existing motorway causeway was preferred.

Table 3-1 presented the pros and cons of a range of construction methodologies. Based on engineering risk, opportunities for synergy with other projects through construction of an integrated infrastructure corridor, ongoing operation and maintenance access and future opportunities for improved recreational and amenity values, options for marine trenching, directional drilling were not considered further.

On this basis the alternative installation options for the pipeline approaches from Squadron Drive to the transition onto the Greenhithe Bridge are:

- Installation of the pipeline on an standalone pipe bridge immediately adjacent to the existing causeway and;
- Installation of the pipeline within a widened causeway;

Construction of a standalone pipe bridge along the motorway causeway would likely be a lower cost option because it has lower construction material costs and will have a shorter construction timeframe.

Reclamation works in the CMA are a comparatively higher cost option because of the amount of construction materials required, the length of construction period and the relative complexity of construction.

The causeway option presents an opportunity to incorporate other infrastructure in a combined infrastructure corridor, in this case the NI pipelines. This creates cost efficiencies and reduces environmental and social disturbance during initial and future construction phases. This option also provides for better maintenance access and long term asset durability.

The cost differential must be considered along with other factors such as construction risks, infrastructure resilience, operational factors, environmental, social and cultural effects.

On balance, the apparent cost differential is outweighed by the opportunity to construct an integrated infrastructure corridor which will reduce the need for future installation of water or wastewater infrastructure along the causeway and thus reduce the potential for future adverse environmental and social effects.

3.4.3 Preferred Construction Method

Based on the foregoing assessment, widening of the existing causeway is considered to be the preferred construction method for installing the new watermain within the CMA to the north of the SH18 motorway causeway.

The principal reasons for this are:

(i) Lower construction risk, with the existing causeway having previously been widened using the same reclamation techniques.

(ii) Pipeline installation within a widened causeway would enable unconstrained access to the new watermain for inspections and maintenance, and avoids exposure of the pipeline to the corrosive marine environment as much as possible.

(iii) Causeway widening provides a significant opportunity for enhanced public access to the coastal edge, including for activities such as passive recreation and fishing.

(iv) Causeway widening provides the opportunity for construction of the GBWD and NI projects to be undertaken as an integrated infrastructure development, avoiding some of the potential adverse effects that could result from constructing the projects in isolation and using different methods.

4 NORTHERN INTERCEPTOR

4.1 Background

Population forecasts indicate significant growth in north-west Auckland over the next 50 years. This includes growth in the following areas:

- Kumeu, Huapai, and Riverhead;
- Whenuapai;
- Westgate, Hobsonville Corridor, and Hobsonville Point (which together constitute Auckland Council's 'North West Transformation' area);
- Massey and Swanson.

Watercare has assessed the existing capacity of the wastewater network and options for responding to an increase in wastewater flows from these growth areas. This assessment has identified that wastewater infrastructure currently serving Northern Waitakere and South Rodney has limited remaining capacity and cannot accommodate projected future growth.

Wastewater flows from north-west parts of Auckland are currently conveyed to the Mangere WWTP and, with increasing flows, will limit Mangere's capacity to provide for growth in other parts of Auckland.

Watercare's assessment indicates that by around 2020 the existing wastewater network capacity will need to be increased to service growth in north-west Auckland.

4.2 Options for Responding to Wastewater Issues

In responding to the wastewater network capacity issues identified in Section 4.1 of this report, the following options are available:

(i) Do Nothing – no additional wastewater conveyance or treatment capacity is provided to service growth in north-west Auckland. This would ultimately result in an increased risk of overflow events due to insufficient capacity in the existing network to accommodate the increase in wastewater flows as population grows.

(ii) Upgrade the capacity of the existing wastewater network to convey flows from north-west Auckland to the Mangere WWTP.

(iii) Construct a new Northern Interceptor to convey wastewater from parts of north-west Auckland to the Rosedale WWTP, and upgrade the capacity of the existing network to convey wastewater from the remainder of north-west Auckland to the Mangere WWTP.

(iv) Construct a new Northern Interceptor to convey wastewater from north-west Auckland to the Rosedale WWTP.

(v) Construct a new north-western regional WWTP and associated conveyance network to service the wastewater needs of north-west Auckland.

The preferred option (Option (iv)) is to collect wastewater flows from north-west Auckland and convey these to the Rosedale WWTP via a new interceptor – i.e. the proposed Northern Interceptor (NI) project.

This was identified as the preferred option because it:

- Provides for the most efficient utilisation of existing capacity at the Rosedale WWTP, while reducing flows to the Mangere WWTP. This frees up capacity at the Mangere WWTP to service growth in other parts of Auckland;
- Has the lowest overall risk in terms of treatment requirements, given available capacity at the Rosedale WWTP and ability to utilise the Rosedale marine outfall;
- Results in lower environmental, social and cultural effects than the other options given the use of the Rosedale WWTP and smaller area of construction impacts;
- Provides the most flexibility in terms of the ability to stage construction; and
- Has the lowest overall cost in terms of the 50-year net present value.

4.3 Population Growth and Project Staging

Having identified the Northern Interceptor (NI) as the preferred option for responding to wastewater issues in north-west Auckland, operational issues and a range of possible route options were identified for the new interceptor and assessed.

Future population and wastewater flow estimates were updated during option assessment and design development for the NI project. The updated estimates indicated that initial wastewater flows would be too low to maintain adequate flow velocities in a large diameter interceptor pipeline that would be required to service long-term growth. Without adequate flushing flow velocities, operational issues would arise including the potential for septicity (due to the long retention time of raw wastewater within the network) and associated odour and corrosion. To most efficiently address the expected growth rates it is therefore necessary to stage implementation of the NI project, with a smaller pipeline in the initial stage to service short-term growth. This also avoids unnecessary capital expenditure for the installation of a larger diameter pipe some years before it is actually required. Pipeline capacity will be increased when contributing catchment populations have grown sufficiently.

It is proposed to implement the NI project in stages as follows:

NI Phase 1 A new wastewater pipeline planned for completion by 2020 to service short-term growth. Phase 1 will convey wastewater flows from the existing Hobsonville Pump Station to the Rosedale WWTP, via a crossing of the Upper Waitemata Harbour and then through the suburbs of Greenhithe, Schnapper Rock, Albany and Rosedale. Construction of Phase 1 is expected to begin in 2017.

NI Future Phases Future phases will include new pump stations and pipelines, and a connection to the existing Concourse Storage Tank in Henderson and the Westgate commercial development area. The timing of these future phases will depend on the rate of population growth in north-western parts of Auckland.

Resource consents are now being sought for the proposed NI Phase 1 works. Apart from consideration of the harbour crossing alignment for the NI future phases, the Phase 1 route alignment and implementation is a relatively stand-alone project. The alternatives assessment provided in Sections 4.4 and 4.5 of this report focusses on alternatives for the harbour crossing section of Phase 1, with some consideration also being given to the future phases.

4.4 Alternative Harbour Crossing Route Options

Both the NI Phase 1 works and the NI future phases require a crossing of the Upper Waitemata Harbour in the vicinity of the Greenhithe Bridge. It is necessary to cross the harbour in this locality as the Hobsonville Pump Station is the critical location for collection of wastewater flows from north-western parts of Auckland so that they can be conveyed to the Rosedale WWTP.

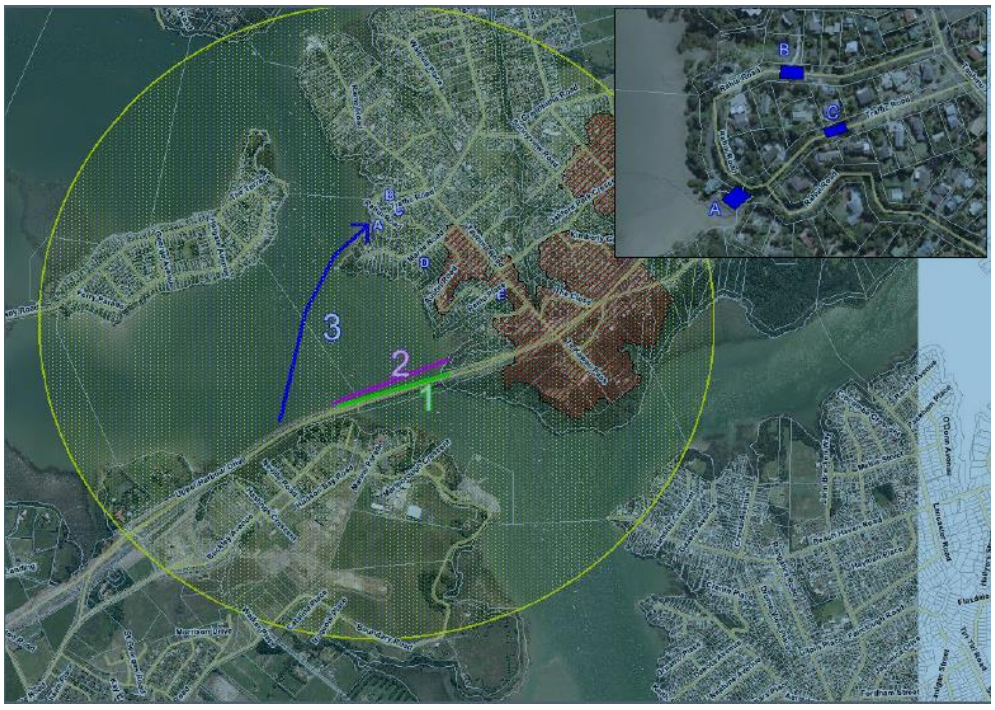
Sections 4.4 and 4.5 of this report assess alternative route options and construction methods for the Phase 1 works in, and in the immediate vicinity of, the Upper Waitemata Harbour.

Resource consents are not currently being sought for the harbour crossing or land-based sections of the NI future phases, as the land-based route options for these future phases are yet to be confirmed and project implementation is many years away.

However the likely alignment of the harbour crossing for the future phases is directly relevant to the consideration of options for the Phase 1 works, as there is an opportunity for these works to also make provision for the future phase harbour crossing. At this stage it is envisaged that the Phase 1 harbour crossing would begin construction in 2017, and the more substantive future phase harbour crossing would be constructed around 2035.

Figure 4-1 shows potential route options for the NI Phase 1 harbour crossing, and these options are discussed as follows.

Figure 4-1 Alternative Harbour Crossing Routes



4.4.1 Options 1, 2: Harbour Crossing on Same Alignment as Greenhithe Bridge

There are two potential sub-options:

Option 1 **Attachment of pipeline to the Greenhithe Bridge** – As explained in Section 3.3.1 of this report, the design of the northern Greenhithe Bridge made specific allowance for

future installation of a watermain. Installation of a new watermain beneath the northern side cantilever has been identified as the preferred option for the GBWD where it crosses the Upper Harbour channel. The bridge does not have structural design capacity for the attachment of a second new pipeline.

Option 2 **Separate Pipe Bridge adjacent to Greenhithe Bridge** – A stand-alone pipe bridge would need to be elevated to a similar height as the Greenhithe Bridge to allow for marine navigation beneath the bridge. Such a substantial structure would be costly and could have an adverse visual impact within the coastal environment that would be difficult to mitigate.

Due to technical issues associated with pumping along steep gradients when using smaller diameter pipelines, the NI Phase 1 pipeline route between the Hobsonville Pump Station and Rosedale WWTP cannot have an elevation higher than 42m RL. The area shown in red on the Greenhithe side of the harbour in **Figure 4-1** indicates land having an elevation higher than 40m RL. The route for both Options 1 and 2 would coincide with the Greenhithe ridgeline and exceed 40m RL. For Option 2 this could potentially be avoided by landing the pipeline further to the north on the Greenhithe side of the harbour, but this would likely have a more adverse visual impact and would also have a higher construction cost due to a longer pipe bridge being required.

Future phases of the NI project do not face this technical issue as it will be overcome by the use of multiple pump stations associated with larger diameter pipelines.

4.4.2 Option 3: Harbour Crossing North of Greenhithe Bridge

Under Option 3, the Phase 1 pipeline would cross the Upper Harbour channel north of Greenhithe Bridge and, depending on the landing location on the Greenhithe side, this option would avoid the hydraulic issues identified for Options 1 and 2.

4.4.2.1 Alternative Route Options – Pump Station to Upper Harbour Channel Section

For Option 3 the most direct route from the Hobsonville Pump Station to a suitable location for crossing the Upper Harbour channel would involve installation of the Phase 1 pipeline along the same alignment as the SH18 motorway. The potential options include installation of the pipeline:

Within the existing motorway causeway

As outlined in Section 3.4.1.1 of this report, there are limitations on installing another pipeline within the existing SH18 motorway causeway. In particular, the presence of other network utility services has resulted in a highly constrained corridor and this effectively precludes the introduction of a wastewater pipeline within the northern or southern sides of the existing causeway (refer **Figure 3-4**). As previously discussed it is anticipated that installation of the pipeline in a trench within the motorway carriageway would be unacceptable to NZTA.

These issues would also preclude subsequent installation of larger diameter wastewater pipelines for future phases of the NI project.

South of the motorway causeway, on land and in the CMA

For the reasons outlined in Section 3.4.1.2 of this report, installation of a wastewater pipeline immediately adjoining the southern side of the existing motorway causeway could adversely affect significant ecological values and would disrupt existing major stormwater infrastructure. It would also

be necessary for the pipeline to cross over to the northern side of the causeway in order to the cross the Upper Harbour channel. As previously discussed, a pipeline crossing beneath the motorway carriageway has significant disadvantages from both a construction and ongoing maintenance point of view and that crossing further west as proposed presents relatively fewer risks..

Again these issues would preclude subsequent installation of larger diameter pipelines for future phases of the NI project.

North of the motorway causeway, in the CMA

This option would involve placement of the Phase 1 pipeline within the CMA to the north of the existing motorway causeway, and is the preferred option for the following reasons:

(i) There would be no conflict with existing network utility services in the motorway causeway.

(ii) Significant ecological values and stormwater infrastructure on the southern side of the causeway can be avoided.

(iii) It would not be necessary for the wastewater pipeline to cross beneath the motorway carriageway within the causeway.

(iv) Subsequent installation of larger diameter wastewater pipelines for future phases of the NI project can be accommodated.

4.4.2.2 Alternative Pipeline Landing Locations at Greenhithe

Five different pipeline landing locations have been identified at Greenhithe. These are discussed as follows:

A **Rahui Road (Southern Option):** Landing in an open area adjacent to the toilet block on the harbour edge at the bottom of Rahui Road. This would provide a larger off-road construction area, and having a low elevation would avoid pipeline hydraulic issues. Rahui Road can be entered from either Marae Road or Rame Road and, with traffic management in place, closing a section of the road during construction would have minimal impact on access for residents. This option provides a viable landing area for both horizontal directional drilling (HDD) or marine trenching methodologies.

B **Rahui Road (Northern Option):** Landing in an open area adjoining the northern end of Rahui Road. The area has a steep grade and this creates difficulty and risk for construction work. This option is only viable for HDD.

C **Traffic Road:** Landing at the western end (cul-de-sac head) of Traffic Road. This is a no-exit road with a narrow carriageway, and access to adjoining properties would be disrupted during construction. The difference in elevation between Traffic Road and the SH18 motorway causeway end of the Phase 1 pipeline route (approximately 30m) is steep and depending on the chosen pipeline construction method will have technical and cost implications. This option is only viable for HDD.

D **Koki/Marae Road:** Landing at the bottom of Koki Road, with the pipeline then being installed along Marae Road up to the Tauhinu Road ridge. Koki and Marae Roads have a steep grade (particularly Koki Road) and narrow carriageway, and this creates difficulty for construction work. Trenching at the top of Marae Road would need to be deep in order for the pipeline to pass under

the Tauhinu Road ridgeline which would otherwise limit pipeline capacity. Koki and Marae Roads are both no-exit and property access would be disrupted during construction. This option is only viable for HDD.

E **Remu Place:** This location also has a higher elevation and a booster pumping station would be required for the pipeline. There is insufficient space available for the construction of such a pump station. This option is only viable for HDD.

4.4.3 Preferred Route Option

Based on the foregoing assessment, Option 3 from the causeway to Rahui Road is the preferred route option for the NI Phase 1 harbour crossing with a variation in the starting point along the causeway depending on the harbour crossing method selected. (see **Figure 4-1**)

Different sections of the preferred route are summarised as follows:

(i) From the Hobsonville Pump Station the wastewater pipeline would be installed along the same alignment as the SH18 motorway, with the pipeline being placed within the CMA to the north of the existing motorway causeway;

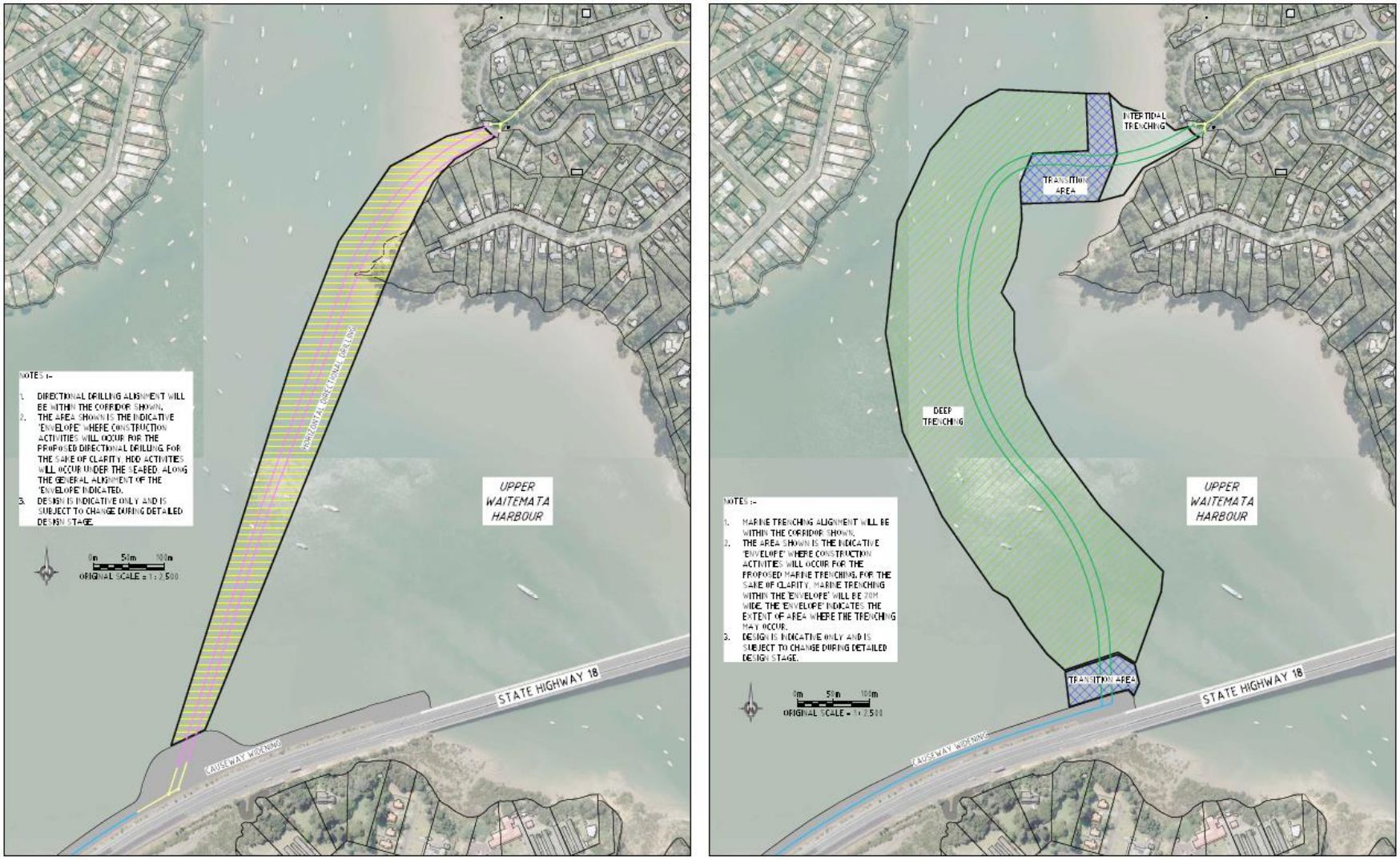
(ii) The pipeline would then cross the Upper Harbour channel north of Greenhithe Bridge; and

(iii) On the Greenhithe side of the harbour the pipeline would land at Rahui Road (Southern Option).

This was identified as the preferred option because it:

- Constitutes the most direct route for the NI Phase 1 harbour crossing, while avoiding the pipeline hydraulic issues associated with other routes that coincide with more elevated land on the Greenhithe ridgeline;
- Avoids the need for pipeline construction activity within residential areas at Hobsonville Point or Herald Island;
- Provides an opportunity for construction of part of the NI Phase 1 harbour crossing to be combined with construction of the GBWD, within a combined infrastructure corridor; and
- Enables the installation of larger diameter wastewater pipelines for future phases of the NI project within the same infrastructure corridor.

Figure 4-1 NI Harbour Crossing Routes



4.5 Alternative Construction Methods for Preferred Route Option

4.5.1 NI Phase 1 Pipeline – Causeway Section

A range of alternative construction methods are potentially available for installing the NI Phase 1 pipeline within the CMA to the north of the existing SH18 motorway causeway, to a location from which the pipeline can begin crossing the Upper Harbour channel. These options are:

- Tunnel or Horizontal Directional Drilling (HDD);
- Submarine trenching;
- Stand-alone pipe bridge;
- Causeway Widening.

As identified in Sections 3.4.2 and 3.4.3 of this report, causeway widening is the preferred construction method for installing a new watermain within the CMA to the north of the existing motorway causeway as part of the GBWD project. Utilising the same reclamation for installation of a wastewater pipeline would enable construction of the NI Phase 1 harbour crossing to be combined with construction of the GBWD, within a combined infrastructure corridor. This would avoid the constraints and potential adverse effects that could result from constructing the projects in isolation and using different methods.

The same widened causeway could also be utilised for installation of larger diameter wastewater pipelines required for the harbour crossing associated with future phases of the NI project.

4.5.2 NI Phase 1 Pipeline – Upper Harbour Channel Section

Where it crosses the Upper Harbour channel north of Greenhithe Bridge, the NI Phase 1 pipeline (710mm ND) would be bifurcated into twin 550mm DN pipelines to provide resilience and enable maintenance activities such as flushing of the pipeline.

The following construction methods are potentially available for installing the twin Phase 1 pipelines across the Upper Harbour channel:

- Pipe installation in a conduit installed by micro-tunnelling- this method would involve boring a tunnel and jacking the pipes between two shafts installed to the required depth in the seabed. A concrete pipe would be installed in the first instance and will act as a sleeve for the pressurised polyethylene sewer line which will be installed within it. Shafts are spaced at between 300m and 400m apart and at least 3 shafts would need to be installed to span the 1100m crossing of the harbour.
- Horizontal Directional Drilling – HDD is a trenchless technology which involves drilling a bore along the pipeline route and then pulling the pipeline through from the launching site to the end point. The twin 550 DN pipes will be installed in sections at depths of between 4 and 30m under the seabed using a drill rig set up on the NI construction platform located along the widened causeway and progressing to an end point at Rahui Rd.
- Marine trenching – This activity will occur from two starting points – Rahui Rd and the end of the widened causeway. In the intertidal areas, the trench will be excavated and pipe will be laid and fitted with concrete collars to counteract buoyancy. The pipe installation will transition from the shallower intertidal area into deeper waters where trenching will continue towards Greenhithe Bridge using a barge mounted dredge system, a jet trenching/fluidisation method or mass flow excavation.

These options are compared, in terms of their advantages and disadvantages, in **Table 4-1**.

Table 4-1 NI - Alternative Construction Methods for Preferred Route Option (Upper Harbour Channel Section)

Construction Method	Advantages	Disadvantages
Pipe installation in a Conduit installed by Micro-tunnelling	**Visual Impact** – Once completed, there would be no visible structures within the CMA.	**Construction** – Intermediate construction shafts would be required at approximately 300m to 400m intervals. Given the length of the harbour crossing (approximately 1100m), this would require at least two shafts to be built within the Upper Harbour channel. Construction of these shafts would be by boat or cofferdam and would be disruptive (including encroachment within the main navigation channel) and high risk from an engineering perspective. Geotechnical investigations have identified that suitable conditions for micro-tunnelling exist at a depth of approximately 27m below sea level, meaning that shafts would need to be at least 30m deep. Micro-tunnelling can only be constructed using concrete pipe, because polyethylene (PE) pipe does not have the compressive strength required for pipe jacking. Concrete pipe cannot, however, be pressurised for the purposes of a wastewater rising main and it would be necessary to thread a PE pipeline within the concrete pipeline. This doubles the amount of pipe material required and hence material costs are increased. Given the engineering risk, depths of the shafts and need for both concrete and PE pipelines this option would prove extremely costly.
Horizontal Directional Drilling (HDD)	**Construction** – No construction activity in the harbour as HDD pipes will be installed beneath the sea floor from land based launch and receiving sites. **Environment** – The works would take place beneath the seabed and there would be no sediment release into the marine environment, disturbance of the foreshore and seabed is minimised. **Visual Impact** – Once completed, there would be no	**Construction** – A large staging area is required in order to set up the drilling rig and ancillary equipment, and for stringing the pipe sections together. For HDD this involves the construction of the NI construction platform on which to locate the drill rig. The required crossing length for the Upper Harbour channel section is near to the recognised limits for HDD technology and beyond the capability of the local construction market. This would require specialist contractors and equipment to be brought in from overseas.

Construction Method	Advantages	Disadvantages
	visible structures within the CMA. **Navigation** No effects on boating or fishing activities	The possibility that the HDD operation may encounter unsuitable geology as it progresses across the harbour poses a construction risk. It is possible that drilling fluid may be released during the installation process due to the build-up of excessive pressure. This will need to be managed through the use of suitable drill fluids and a range of engineering measures to reduce the on-site risk of occurrence. However these fluids do not typically contain toxic additives which could lead to adverse environmental effects and construction activities can be closely monitored and managed to reduce the risk of fluid release. **Environment** The operation of the drill rig during construction has the potential to generate noise nuisance. The construction and use of the NI construction platform (approximately 4300m^2) has the potential to generate dust nuisance at the nearest properties to the south west. **Operations/Maintenance** – The wastewater pipelines would be constructed deep beneath the seabed and there would be no opportunity for future access for inspections and maintenance.
Marine Trenching	**Construction –** Less causeway area required as not requirement for construction platform. **Environmental** – Lower risk of night time noise disturbance **Visual Impact** – Once completed, there would be no visible structures within the CMA.	**Construction** – Because of the weak bedding material encountered on the harbour floor, the trench would need to be wide enough to ensure trench stabilisation. Consequently trenching could affect an area of the seabed 20m wide along the Phase 1 pipeline alignment, resulting in greater disturbance and potential for sediment release. The use of jet fluidisation or mass flow trenching will require the use of specialised equipment which will likely be more costly than simple marine trenching methods.

Construction Method	Advantages	Disadvantages
		A laydown area is required for stringing the pipe sections together, prior to being towed across the channel and positioned on the harbour floor. This will be accommodated on the widened causeway. Timeframes for land based construction are 3 to 5 months. Construction activities in the CMA are expected to take 4 – 6 weeks. **Environment** – Significant seabed disturbance along the trenching footprint but ecological effects are relatively short lived – in the order of 12 months. The use of jet/fluidisation or mass flow excavation methods will generate and stir up significant amounts of seabed sediments and result in increased levels of suspended sediment in the harbour channel and intertidal areas. Ecological effects are likely in both the water column and due to settlement of sediments on the seabed.The Assessment of Environmental Effects concludes that these effects are temporary and no more than minor in the longer term. Noise disturbance is possible when construction activity is occurring in the intertidal areas. Effects on marine animals due to underwater noise are expected to include short term behavioural responses to avoid the activity areas. **Navigation and Recreation** Maine trenching will result in temporary adverse effects on navigation and recreation due to waterborne construction equipment and lengths of floating pipeline. Moorings will also be temporarily removed near Rahui Rd.

4.5.2.1 Cost of Alternative Construction Methods

Table 4-1 documents a range of possible alternative harbour crossing methodologies for Phase 1 of the NI project. Micro tunnelling is not preferred due to the technical issues and engineering risk.

Watercare is legally obliged to keep overall costs of water supply and wastewater services to customers at minimum levels, the costs of developing new infrastructure is a major consideration.

Initial cost comparisons show harbour crossing construction by trenching to be a lower cost option because it uses a lessor amount of construction materials and requires a smaller area of causeway widening. However should jet/fluidisation or mass flow methods be used, costs may increase due to the use of specialised equipment.

HDD is a comparatively higher cost option because it requires specialised equipment which will install both a concrete “sleeve “and internal PE pipeline. It requires that a construction platform be built along the widened causeway and is predicted to have a slightly longer overall construction timeframe and construction risk profile.

Only preliminary design has been carried out to date, and a contractor has not yet been sought, therefore the final likely costs and price differential between trenched and HDD construction methods cannot be confirmed. Therefore Watercare is retaining both options at this stage for the consenting process. The final cost estimates will be a key determinant in the selection of the construction method for crossing the harbour, also taking into account potential construction risks and management of potential construction and permanent effects.

4.5.3 Preferred Construction Method

Based on the above assessment, micro-tunnelling is not considered to be a viable method because of increased construction difficulty.

Both HDD and marine trenching have been identified as feasible construction methods and Watercare is seeking resource consent for each method. Both methods will be progressed to detailed design stage for the NI Phase 1 project and canvassed with specialist construction contractors (including identification of the cost , potential environmental effects and associated construction management measures to manage these effects for each method) before the preferred method is selected.

5 CAUSEWAY WIDENING

Sections 3 and 4 of this report have considered different route options for the proposed new watermain (GBWD project) and wastewater pipelines (Phase 1 of the NI project), concluding that placement of the pipelines within the CMA to the north of the existing SH18 motorway causeway is the preferred option for crossing the Upper Waitemata Harbour in each case.

This provides the opportunity for a combined infrastructure corridor for the GBWD and NI projects in this location, including provision for future phases of the NI project.

The GBWD and NI (Phase 1 and future phases) projects collectively require four pipelines to be installed along that part of the CMA adjoining the northern side of the existing causeway. Reclamation provides the opportunity for this to be undertaken as an integrated infrastructure development, avoiding some of the constraints and potential adverse effects that could result from constructing the projects in isolation and using different methods.

Drawing Nos. 2010673.006 - 007 Issue 3 in **Appendix A** show a proposed widened causeway layout to accommodate both the GBWD and NI projects. The shape and extent of the reclamation is determined by the construction, operation and maintenance requirements for each project. This is described as follows, with reference to each element of the reclamation.

5.1 Causeway Widening

To the west of the construction platform required for the NI project (refer Section 5.2 of this report), the width of the reclamation is determined by the need to accommodate the new watermain and three wastewater pipelines – refer Drawing No. 2010673.006 Issue 3 in **Appendix A**.

Drawing No. 2010673.852 Issue 3 in **Appendix A** provides a cross-section showing how the existing motorway causeway could be widened along the northern side to accommodate the new watermain and NI wastewater pipelines.

A total causeway widening of 15m is proposed to accommodate both the GBWD pipeline and the NI wastewater pipelines, with the possible addition of a construction platform for the HDD option for NI Phase 1.

To the east of the NI construction platform, the width of the reclamation is determined by the need for construction access and ongoing maintenance access for the new watermain.

The NI marine trenching option would require a construction area at the end of the causeway. This can be accommodated within the proposed widened causeway as shown on Drawing No 2012101.004, Issue 3, **Appendix A.**

5.2 NI Construction Platform

The use of Horizontal Directional Drilling (HDD) to install the twin NI Phase 1 pipelines and future phase pipelines across the Upper Harbour channel requires a staging area to set up the drilling rig and ancillary equipment. It is proposed to establish a construction platform (4300m^2 approximately) for this purpose as part of the reclamation, and the location and dimensions of the platform are shown on

Drawing No. 2010673.007 Issue 3 (**Appendix A**). Following construction, sufficient area is also required for ongoing pipeline operations and maintenance purposes.

It is noted that if marine trenching is the selected as the preferred option for the NI Phase 1 harbour crossing, this construction platform will not be required.

The factors which have determined the proposed location and dimensions of the construction platform are summarised as follows.

5.2.1 Platform Location

The location of the construction platform is determined by the following factors:

Geology

The proposed location of the construction platform coincides with an underlying 'rock outcrop', providing both a stable foundation for reclamation and competent material for the purposes of directional drilling. As part of the drilling operation the drill bore is pressurised with fluid, and a possible location for fluid escape during drilling is along the first 100m section of the borehole. It is therefore critical that the geological material in this section is competent and therefore a significant set- back is required.

Pipe String Layout Area

HDD would involve the drilling of a borehole from the construction platform across to the preferred landing site at Rahui Road on the Greenhithe side of the harbour. A pre-welded pipe string would then be pulled through the borehole from the Rahui Road side. This process would be repeated for installation of the second Phase 1 pipeline.

The length of the proposed Phase 1 harbour crossing is approximately 1100m, and ideally this full length of pipe string would be welded together and laid out in preparation for being pulled through the borehole. If there is insufficient layout area to accommodate the full length, then the pipe string needs to be joined in sections - with pipeline installation being delayed while the different sections are welded together. The risk of borehole collapse increases the longer that pipeline installation is delayed.

It is therefore desirable to maximise the length of the pipe string layout area on the western (causeway) side of the harbour, so that the number of different sections required to be joined together and pulled through the borehole is minimised.

The construction platform has been located to enable the pipe string to be joined in two sections (i.e. 2 x 550m), utilising the widened section of causeway to the west of the platform for layout purposes.

The landing site at Rahui Road is much smaller in comparison, and pipe stringing on this side of the harbour would require eight separate sections of pipeline to be joined – significantly increasing the risk of delay and borehole collapse.

Vertical Angles for Drilling

Geotechnical investigations have identified an historic stream channel along the eastern side of the harbour. It is estimated that this channel is approximately 27m deep and has since been filled by weak marine sediments. Each directionally drilled borehole needs to be deeper than this because the marine sediments do not constitute competent material for drilling purposes.

This is particularly an issue for installation of two of the future phase NI pipelines, which may cross the Upper Harbour channel adjacent to the Greenhithe Bridge.

The directional drill for these pipelines needs to maintain a constant entry/exit angle, while also maintaining a constant vertical curve. Given these constraints, and in order to achieve clearance below the deep channel, the construction platform needs to be located a sufficient distance back from the channel.

Horizontal Curvature Limitations

HDD can accommodate some curvature in horizontal alignment, but for practical purposes any such curvature is limited to a 400m radius. A straighter alignment reduces friction and therefore pulling forces during installation of the pipe string.

As indicated above, the proposed pipelines already require large vertical curves to clear the deep historic channel and this will increase friction as shown on Figure 5-1 It is therefore desirable to limit horizontal curves wherever practical in order to reduce the risk of even larger frictional forces. The construction platform has been located to enable this curvature to be achieved and the required location of the platform is shown in Figure 5-2.

Figure 5-1 Required Vertical Curvature

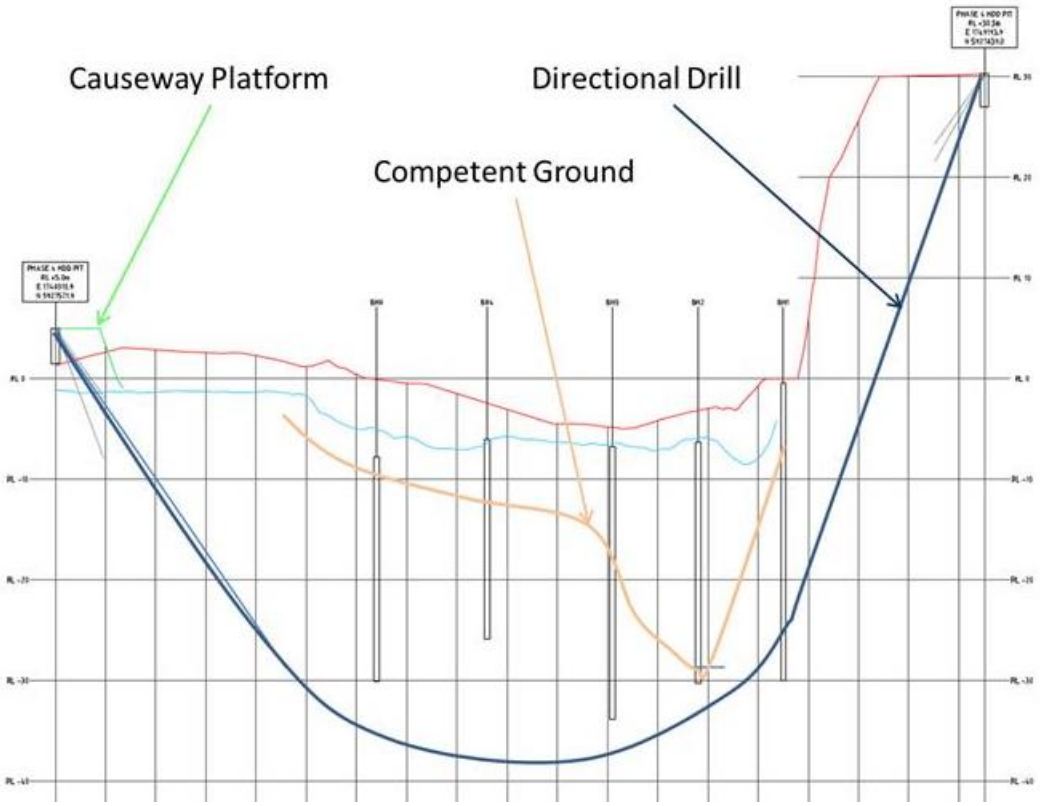
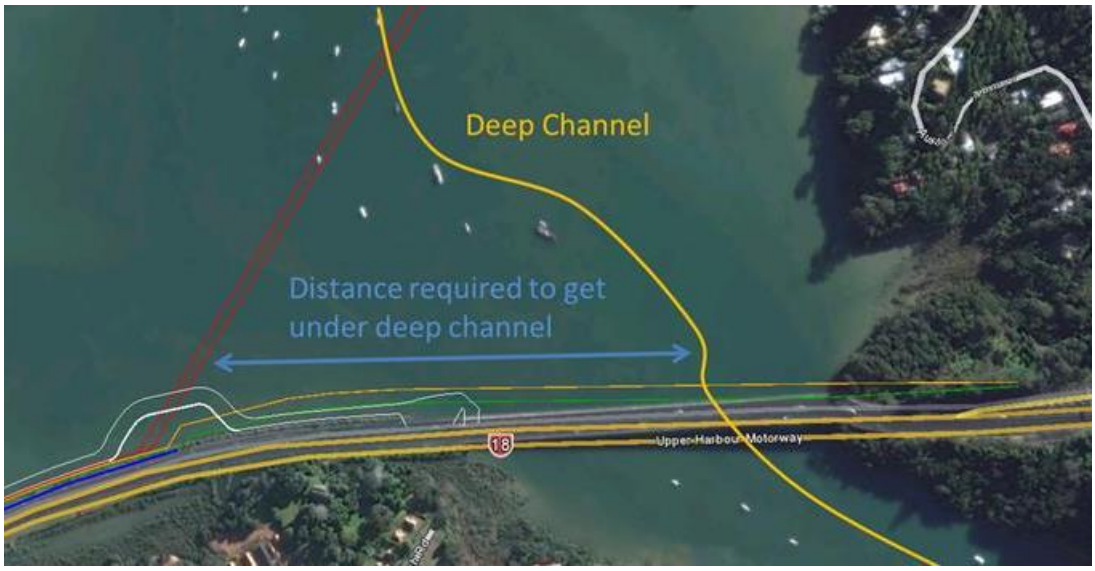


Figure 5-2 Required Location of Construction Platform



5.2.2 Platform Dimensions

The size and shape of the construction platform is determined by both construction and ongoing operations/maintenance requirements. It is intended that the platform be minimised as much as possible and noted that the final size and shape will be determined once a contractor is appointed to carry out the works.

Construction Requirements

Drawing No. 2012101.003 Issue 3 in **Appendix A** shows the required construction layout within the footprint of the platform.

The operating requirements for the directional drilling rig are a key factor in determining the dimensions of the construction platform. HDD utilises pressurised fluid to hold the borehole open. This pressurised fluid has the potential to break to the surface if there is not enough vertical cover. The critical point for this would occur at the toe of the reclamation and, depending on drilling entry angles, the minimum cover achievable is 4m. In order to achieve this, the drilling rig will need to be positioned at least 54m back from the crest of the reclamation along the direction of the pipeline to ensure adequate vertical cover is achieved.

This requirement applies to both NI Phase 1 and future phase pipeline installation if the HDD option is selected, and collectively this determines the minimum width and length of the platform for construction of the different phases.

Operations/Maintenance Requirements

In order to maintain operational flexibility, each pipeline will require a valve chamber containing a sluice valve and air valve. This will enable the flow to be controlled in each pipe. The valve chambers will require access for maintenance vehicles.

5.3 Causeway Extension (GBWD)

Because of the design of the northern Greenhithe Bridge, it will be necessary to extend the new watermain along past the western abutment and first three piers before being able to transition the pipeline up underneath the northern side cantilever of the bridge This transition also requires the construction of a substantial reinforced concrete support structure. To enable this, the length of the causeway reclamation needs to be extended in an easterly direction for a commensurate distance. The extended causeway will also allow ongoing access to the new watermain for maintenance purposes.

The extended length of the causeway means that the reclamation will encroach for a short distance into the Upper Harbour channel. This will require the end of the reclamation to be constructed in deeper water, with rock being end-tipped into the water. In these circumstances it will be more difficult to compact the rock and this will result in shallower slopes around the edge of the reclamation in order to achieve stability. The net result is that the footprint of the reclamation will ‘bulge out’ at the eastern end of the causeway.

6 CONCLUSION

North-west and north Auckland are well established communities and also contain strategic growth areas. These growth areas include Kumeu, Huapai and Riverhead; Whenuapai; Westgate, Hobsonville Corridor and Hobsonville Point (the North West Transformation area); Massey and Swanson; Silverdale; and Long Bay. The provision of robust and resilient water and wastewater infrastructure is essential to support these existing communities and enable future development in these parts of the region. Watercare have considered various options for providing such a service and as a result are proposing a duplication of the North Harbour 1 watermain with a project known as the Greenhithe Bridge Watermain Duplication (GBWD) and the construction of new wastewater interceptors from north-west Auckland to Rosedale Wastewater treatment plant, known as the Northern Interceptor project (NI).

These projects have been progressed in parallel and a key benefit of considering the two projects together is the opportunity to create a combined infrastructure corridor, integrate the development of major infrastructure works,reduce the degree of environmental and community disturbance during construction and provide for Auckland's future infrastructure needs.

The route alignment and construction methodologies for both the GBWD and the NI projects have been considered in some detail and the relative merits of each discussed in this report. The outcomes of this assessment of alternatives process are summarised below.

6.1 Greenhithe Bridge Watermain Duplication

The construction of the northern Greenhithe Bridge crossing in 2005/6 made structural provision for conveyance of a new watermain across the Upper Waitemata Harbour. The route selection process therefore concentrated on the approach to the western side of the bridge and resulted in the preferred option of widening the existing motorway causeway to accommodate the new watermain via access from Squadron Drive.

The preferred option is for GBWD to be installed in a trench within the widened causeway and transition up onto the Greenhithe Bridge. The pipeline will then be attached to the underside of the bridge in order to cross the harbour and transition back to ground level at Greenhithe end of the bridge.

6.2 Northern Interceptor

Phase 1 of the NI project will convey wastewater from Hobsonville to Rosedale WWTP via a crossing of the Upper Waitemata Harbour. The preferred harbour crossing route involves the installation of the wastewater pipelines within a widened causeway within an integrated infrastructure corridor shared with the GBWD. The Greenhithe Bridge does not have structural capacity to support a new wastewater line and hence an alternative crossing methodology was required.

The preferred option is for crossing the harbour between the widened causeway and Rahui Road using either horizontal directional drilling (HDD) or marine trenching. Should HDD be selected a construction platform will be required along the widened causeway to enable the appropriate HDD alignment and drilling equipment placement to be achieved. The preferred method will be confirmed once a contractor has been appointed for the works.

A key benefit of considering the two projects together is the opportunity to create a combined infrastructure corridor, integrate the development of major infrastructure works, reduce environmental disturbance during construction and provide for Auckland's future infrastructure needs.

7 LIMITATIONS

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APPENDIX A DRAWINGS

UPPER WAITEMATA HARBOUR

PROPOSED NORTHERN INTERCEPTOR WASTEWATER PROJECT (PHASE 1). TWIN DN 550 PE PIPELINES ALIGNMENT (MARINE TRENCHING OPTION). (NI PHASE 1 CONSENT APPLICATION)

END OF PROPOSED DN 900 CLS WATERMAIN

LIMIT OF LAND USE CONSENTS

PROPOSED WATERMAIN CROSS CONNECTION VALVE ARRANGEMENT IN CHAMBER (EAST CONNECTION)

STATE HIGHWAY 18

PROPOSED NORTHERN INTERCEPTOR WASTEWATER PROJECT (PHASE 1). TWIN DN 550 PE PIPELINES ALIGNMENT (HDD OPTION). (NI PHASE 1 CONSENT APPLICATION)

MLWS AFTER PROPOSED CAUSEWAY EMBANKMENT CONSTRUCTION

PROPOSED DN 800 CLS WATERMAIN

MHWS AFTER PROPOSED CAUSEWAY EMBANKMENT CONSTRUCTION

EXTENT OF COASTAL PERMIT

NOTE:–
SITE LAYOUT AND DESIGNS INDICATIVE ONLY AND SUBJECT TO CHANGE DURING DETAILED DESIGN DEVELOPMENT

PROPOSED NORTHERN INTERCEPTOR PROJECT CONSTRUCTION PLATFORM

EXISTING MHWS

GREENHITHE BRIDGE

EXISTING DN 900 CLS WATERMAIN (NH1)

EXISTING MLWS

PROPOSED CAUSEWAY WIDENING (15m WIDE)

TE OKARIKI INLET

PROPOSED NORTHERN INTERCEPTOR WASTEWATER PROJECT (PHASE 1). DN 710 PE PIPELINE ALIGNMENT (NI PHASE 1 CONSENT APPLICATION)

CAUSEWAY WESTERN EMBAYMENT

LIMIT OF LAND USE CONSENTS

EXISTING STORMWATER DRAINAGE PIPES

EXISTING DN 900 CLS WATERMAIN (NH1)

PROPOSED WATERMAIN CROSS CONNECTION VALVE ARRANGEMENT IN CHAMBER (WEST–NORTH CONNECTION)

START OF PROPOSED DN 1200 CLS WATERMAIN

EXISTING STORMWATER DRAINAGE STRUCTURES

PROPOSED DN 800 CLS CARRIER PIPE WITHIN DN 1200 RC SLEEVE PIPE FOR WATERMAIN CROSS CONNECTION

STATE HIGHWAY 18

PROPOSED WATERMAIN CROSS CONNECTION VALVE ARRANGEMENT IN CHAMBER (WEST–SOUTH CONNECTION)

STATION STREET

HOBSONVILLE

PROPOSED DN 710 PE PIPELINE. NORTHERN INTERCEPTOR WASTEWATER PROJECT (PHASE 1). (NI PHASE 1 CONSENT APPLICATION)

PROPOSED TWIN DN 1200 PE PIPELINES. NORTHERN INTERCEPTOR WASTEWATER PROJECT (PHASES 4 AND 6). (PHASE 1 CONSENT APPLICATION)

PROPOSED DN 1200 CLS WATERMAIN

FOR CONSENT

ISSUE	DATE	AMENDMENT	BY	APPD.
3	01.07.15	ISSUED FOR CONSENT	A.T.S.	M.A.E.
2	09.03.15	ISSUED FOR CONSENT	H.L.A.	M.A.E.
1	13.02.15	ISSUED FOR CONSENT	P.K.	M.A.E

DESIGNED	A.T.S.	02.15
DES. CHECKED	A.H.	02.15
DRAWN	H.L.A.	02.15
DWG. CHECKED	A.T.S.	02.15
PROJECT LEADER	M.A.E.	02.15
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

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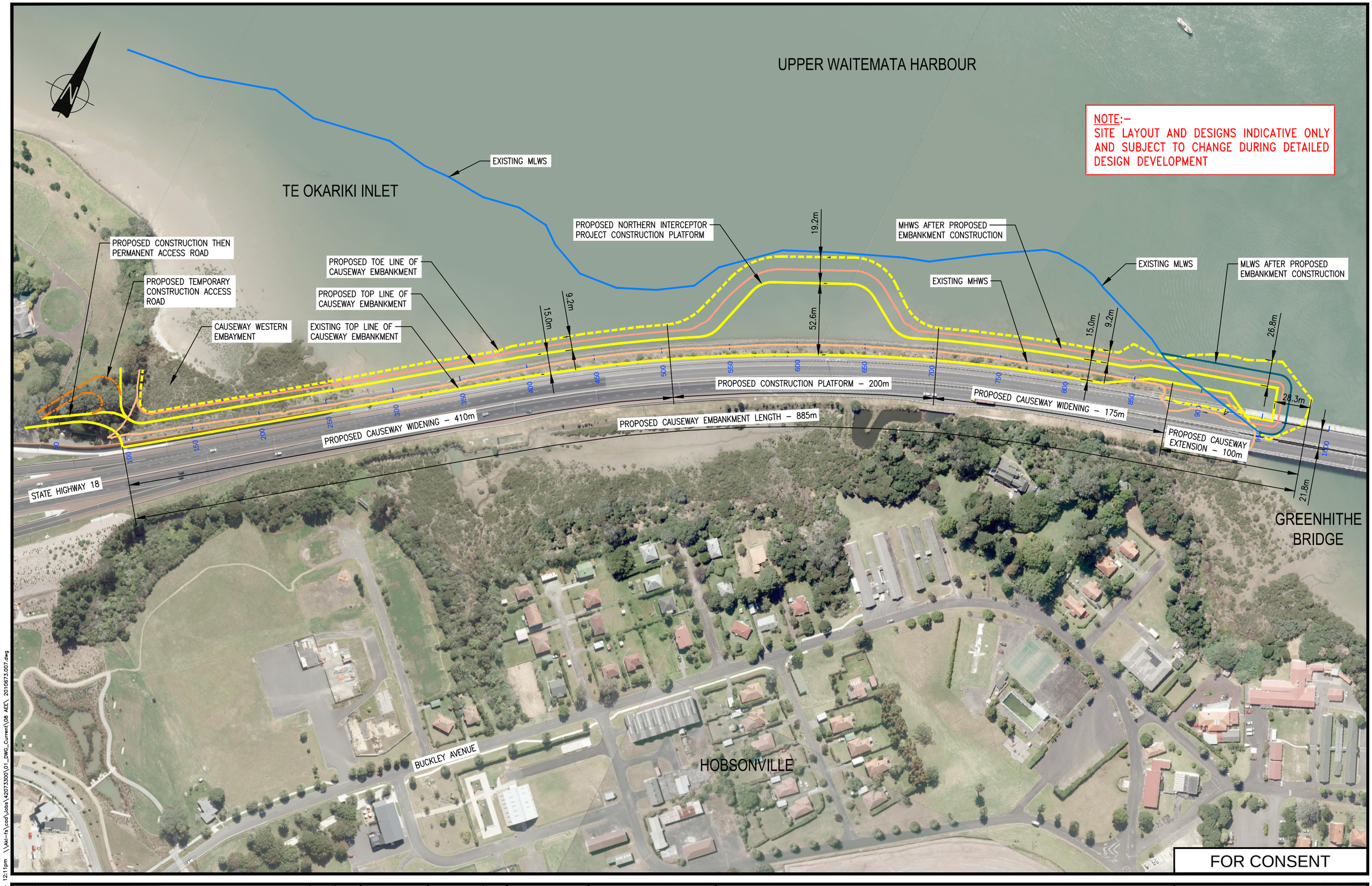
GREENHITHE BRIDGE WATERMAIN DUPLICATION AND CAUSEWAY SCOPE OF RESOURCE CONSENTS

CAD FILE 2010673.850–851 | DATE 01.07.15
ORIGINAL SCALE A3 1:4,000 & 1:500 | CONTRACT No. –
REF No. – | ISSUE –
DWG No. 2010673.006 | 3

Plot Date: Jul 09, 2015 – 12:00pm \\Akl-fs\cad\Jobs\42073300\01_DWG_Current\08 AEE\ 2010673.006.dwg



NOTE:–
SITE LAYOUT AND DESIGNS INDICATIVE ONLY AND SUBJECT TO CHANGE DURING DETAILED DESIGN DEVELOPMENT

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1	13.02.15	ISSUED FOR CONSENT	P.K.	M.A.E.

DESIGNED	Y.T.	02.15
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DRAWN	H.L.A.	02.15
DWG. CHECKED	Y.T.	02.15
PROJECT LEADER	M.A.E.	02.15
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OPERATIONS

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GREENHITHE BRIDGE WATERMAIN DUPLICATION AND CAUSEWAY
CAUSEWAY LAYOUT

CAD FILE 2010673.007	DATE 01.07.15
ORIGINAL SCALE A3 1:2,500	CONTRACT No. –
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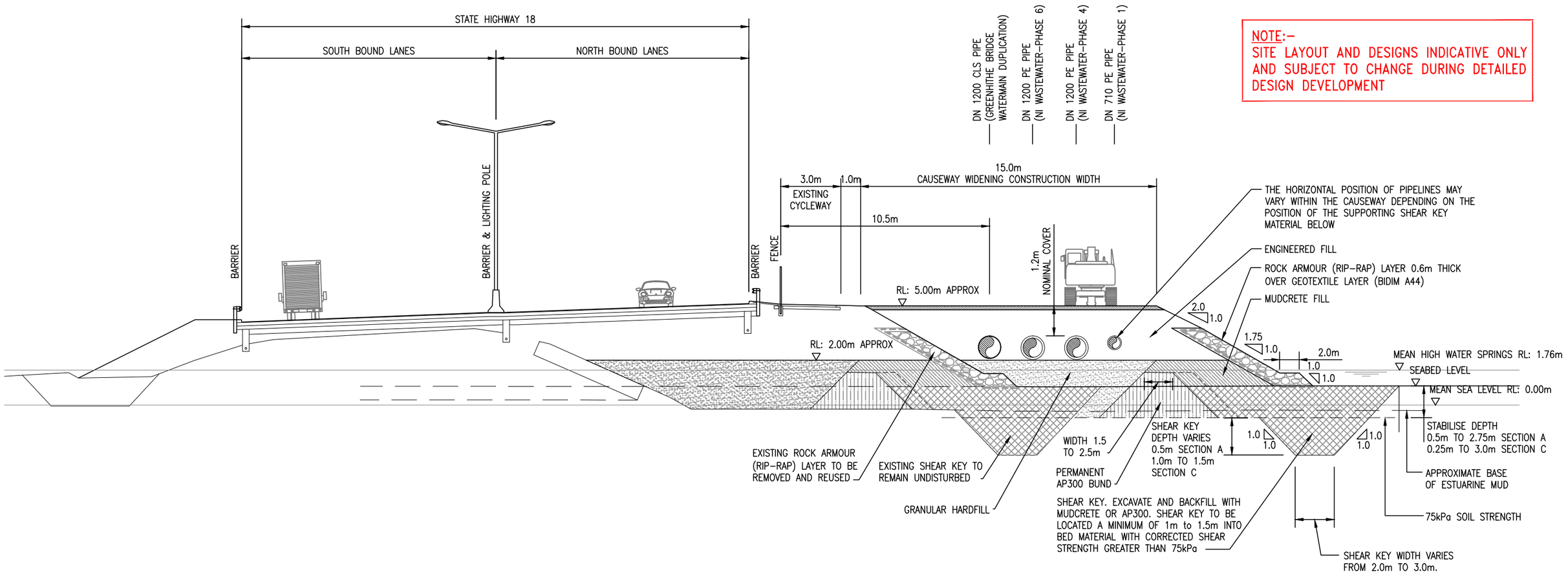
SOUTH SIDE

NORTH SIDE



NOTE:-
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SECTION A/C
SCALE: 1:200 –

CAUSEWAY WIDENING FOR PIPELINES
TYPICAL CROSS SECTION VIEW TO WEST
AT SECTION A – PIPELINE DISTANCE 96m TO 270m (MOTORWAY CHAINAGE 7800m–7974m)
AT SECTION C – PIPELINE DISTANCE 371m TO 574m (MOTORWAY CHAINAGE 7500m–7700m)

NOTE:

REFER TO DRAWING 2010673.850 TO 851 FOR DESIGN SECTION LOCATIONS.

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3	01.07.15	ISSUED FOR CONSENT	A.T.S.	M.A.E.
2	09.03.15	ISSUED FOR CONSENT	H.L.A.	M.A.E.
1	13.02.15	ISSUED FOR CONSENT	P.K.	M.A.E.

DESIGNED	M.J.	10.14
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DRAWN	G.W.	10.14
DWG. CHECKED	N.H.	10.14
PROJECT LEADER	M.A.E.	10.14
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SIGNATORY 1 — OPERATIONS

SIGNATORY 2 — INFRASTRUCTURE

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GREENHITHE BRIDGE WATERMAIN DUPLICATION AND CAUSEWAY GEOTECHNICAL DESIGN

CAUSEWAY DESIGN SECTIONS A & C

CAD FILE 2010673.852–855 DATE 01.07.15
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ISSUE –
DWG No. 2010673.852
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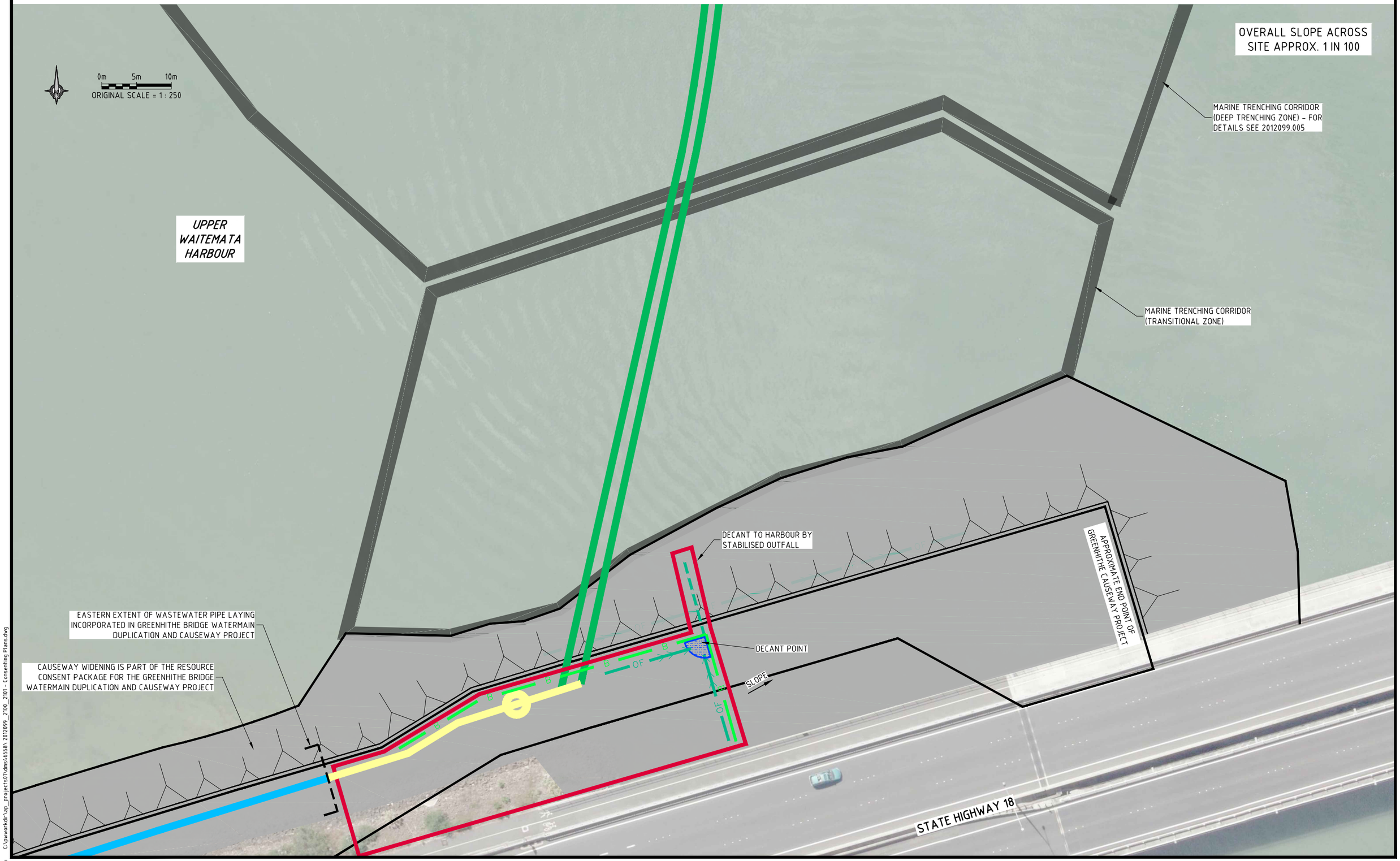
NOTE : SITE LAYOUT AND DESIGN IS INDICATIVE ONLY AND IS SUBJECT TO CHANGE DURING DETAILED DESIGN STAGE

FOR GENERAL NOTES AND LEGEND SEE DRAWING 2012099.004



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2	13.05.15	ISSUED FOR A.E.E. INFORMATION	JB	JB
1	20.03.15	ISSUED FOR A.E.E. INFORMATION	JB	JB
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DESIGNED	J BURGESS	02-15
DESIGN CHECK	C POVEY	06-15
DRAWN	J BURKE	02-15
CAD REVIEW	J BURKE	06-15
DESIGN REVIEW	C van der BOOM	06-15
MWH APPROVED	C van der BOOM	06-15
	BY	DATE

–
OPERATIONS
–
INFRASTRUCTURE

Watercare

MWH

Northern Interceptor Preliminary Design, Phase 1
Existing Hobsonville PS To Rosedale WWTP
Consent : Causeway Marine Trenching Launch Point

DRAFT

CAD FILE 2012099_2100_2101 DATE JUNE 2015

ORIGINAL SCALE A1: AS SHOWN

CONTRACT No.: 1374

REF. No.:

ISSUE: 3

DWG. No.: 2012101 .004

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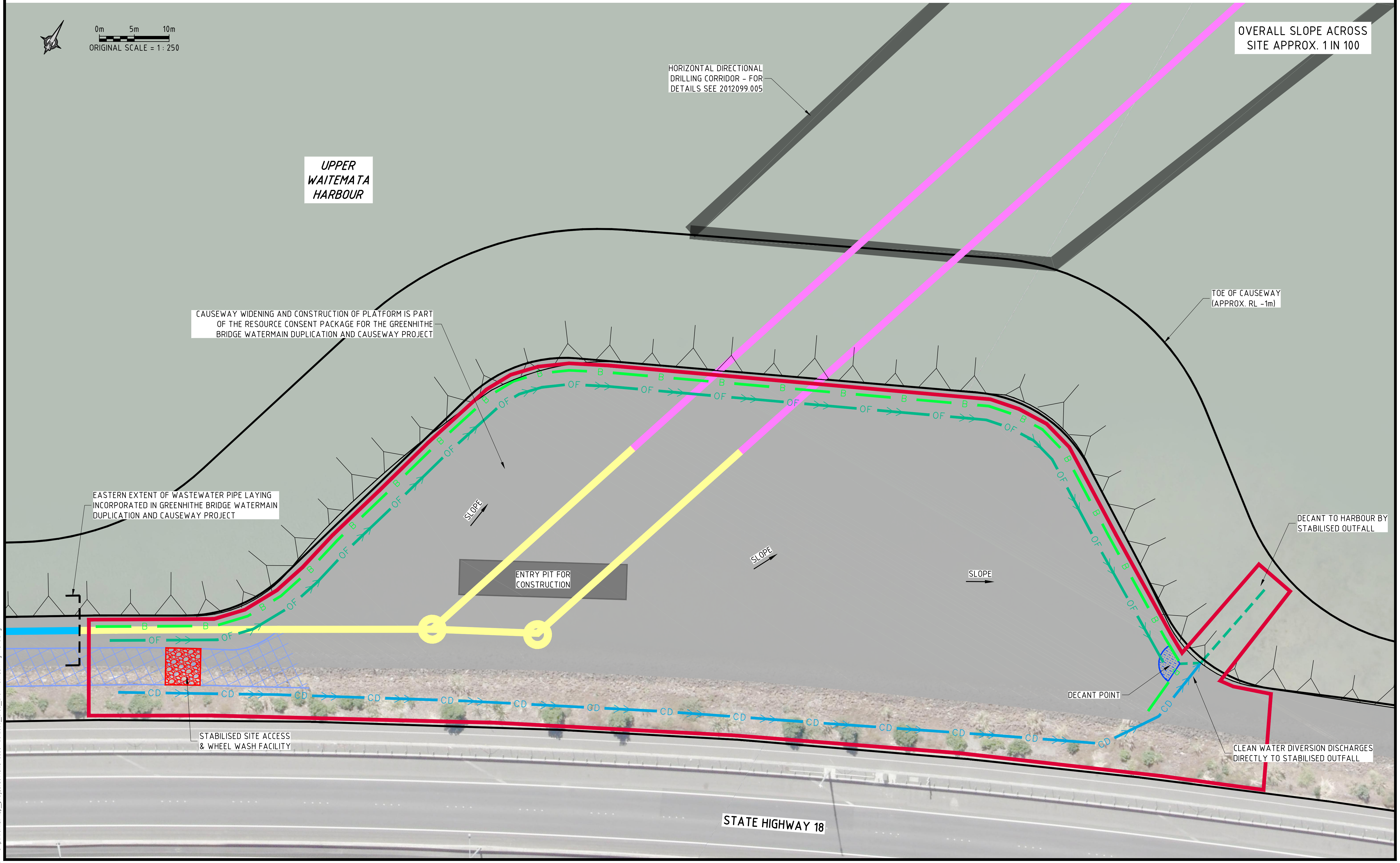

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	BY	DATE
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DESIGN CHECK	C POVEY	06–15
DRAWN	J BURKE	02–15
CAD REVIEW	J BURKE	06–15
DESIGN REVIEW	C van der BOOM	06–15
MWH APPROVED	C van der BOOM	06–15

– OPERATIONS

– INFRASTRUCTURE

Watercare

MWH.

Northern Interceptor Preliminary Design, Phase 1
Existing Hobsonville PS To Rosedale WWTP
Consent : Causeway HDD Launch Point

DRAFT

CAD FILE 2012099_2100_2101 DATE JUNE 2015
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