I hereby give notice that a hearing by commissioners will be held on:

Date:	**Monday 5, Friday 9 & Monday 12 October 2020** **Friday 16 & Monday 19 October 2020 (overflow days)**
Time:	**9.30am**
Meeting Room:	**Council Chambers**
Venue:	**Level 1, Orewa Service Centre,** **50 Centreway Road, Orewa**

APPLICATION MATERIAL

VOLUME TWO

PRIVATE PLAN CHANGE 40

CLAYDEN ROAD, WARKWORTH

COMMISSIONERS

Chairperson	**Les Simmons**
Commissioners	**Bridget Gilbert**
	Michael Parsonson

Wendy Stephenson
HEARINGS ADVISOR

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Note: The reports contained within this document are for consideration and should not be construed as a decision of Council. Should commissioners require further information relating to any reports, please contact the hearings advisor.

PRIVATE PLAN CHANGE 40, CLAYDEN ROAD, WARKWORTH

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STORMWATER MANAGEMENT PLAN MAVEN

STORMWATER MANAGEMENT PLAN

Clayden Road Warkworth

CIVIL ENGINEERING ▼ SURVEYING ▼ LAND DEVELOPMENT

PROJECT INFORMATION

CLIENT	Warkworth Land Company Ltd
PROJECT	102008

DOCUMENT CONTROL

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1 STORMWATER MANAGEMENT PLAN - OVERVIEW

The purpose of this Stormwater Management Plan (‘SMP’) is to outline the proposed management of stormwater for the Warkworth Clayden Road Development, located near Warkworth. The Warkworth Clayden Road Development is contained within the Future Urban Zone of the Auckland Unitary Plan – Operative in Part (‘AUP – OP’), identified in yellow within Figure 1 below. The site is subject to both public and private plan change; the public plan change encompasses the greater Warkworth areas change from future urban to urban zoning, while the proposed private plan change details the subject site providing a higher yield of residential properties considered necessary to make the development economically and financially viable.

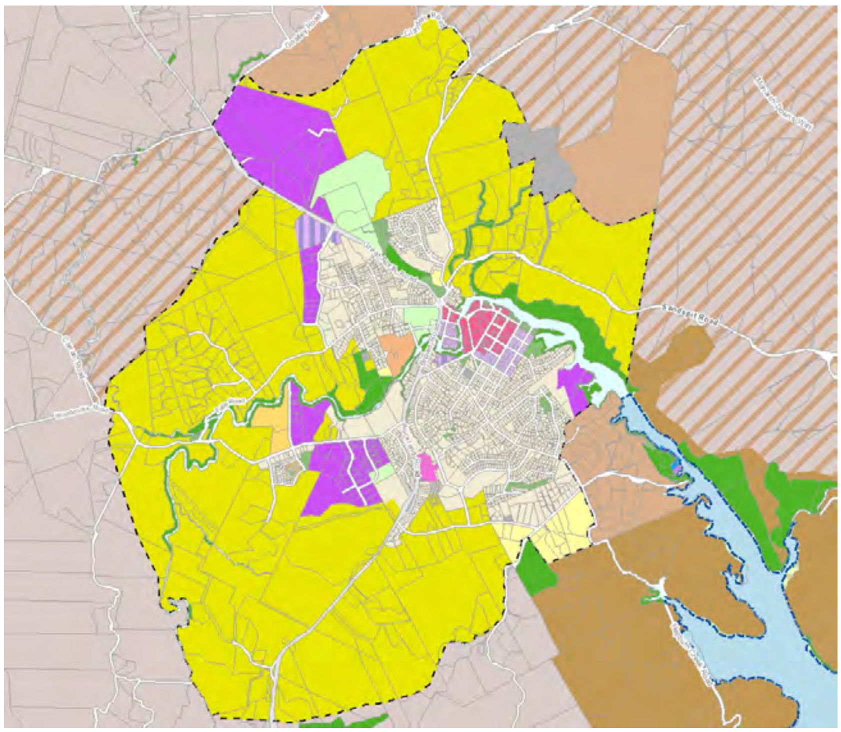


Figure 1: 2019 Warkworth Future Urban Zoning (Yellow)

The proposed Auckland council public structure plan zoning plan change was accompanied by a “Preliminary SMP” completed by Tonkin Taylor (2018). This report has been reviewed and the proposed outcomes, opportunities and effects adopted or further detailed where necessary specifically for the proposed development within the subject site.

The purpose of this SMP is to ensure that the receiving environment is protected and enhanced as it undergoes change from the current rural environment to an urban form. The outcomes of this SMP will also guide the forthcoming Resource Consent (‘RC’) application. The plan generally provides a standard framework consistent with the Auckland Region but ultimately stormwater design layouts are noted as best achieved by the developer based on their development proposals and site-specific constraints.

The strategy for the stormwater management is outcome focused. The stormwater management plan provides a solution-based approach for the receiving environment. The plan sets up a clear process to mitigate the effects on the receiving environment, which consists of the Waitemata harbour, Mahurangi River and upstream unnamed tributaries.

Detention management forms a key part of the mitigation proposed for the receiving environment. Detention forms the main solution for mitigation of erosion and inundation during storm events.

The management plan also requires – where possible – the use of retention and detention through the development. Water sensitive design is a driving component of the management plan, with such elements guiding stormwater management within both public spaces and development lots.

1.1 STAGING, TIMING, RESPONSIBILITY AND FUNDING

1.1.1 TIMING

The development of the Warkworth Clayden Road Development will be undertaken over several years, depending largely on the demand for residential land in the Warkworth area. However, the first stage is to be progressed in the next construction season (2019/2020) in the construction of infrastructure required to support future urban zoning. These works consist of Watercare Services Ltd projects currently underway including wastewater and water supply network improvements and upgrades, a link road being constructed through the subject site by Auckland Transport in coordination with the NZTA.

1.1.2 COSTS, FUNDING AND VESTING OF ASSETS

The development and construction of the stormwater management devices will be undertaken by the consent holder who is developing the Warkworth Clayden Road Development. The stormwater infrastructure will be developed as per the stormwater strategy which includes piped networks, water quality device and at-source propriety devices where required.

Public assets will be vested to council at the appropriate time as the development progresses. Discussions will be undertaken with council as to the design of the infrastructure, location and purpose, with all public infrastructure subject to the Engineering Plan Approval (“EPA”) process.

1.1.3 DEPARTURES

CODE OF PRACTICE

There are no known departures from the Stormwater Code of Practice (“SWCOP”).

Please note, the upstream catchment has been assessed as undeveloped within the stormwater modelling. It is proposed that the outcomes of this SMP can guide development within other areas of the Warkworth Precinct, including the intention of stormwater management and mitigation within each development site / area. Given the Urban zoning, this approach is practical and appropriate.

AUP – OP

There are no known departures from the intention of the AUP – OP.

1.1.4 OPERATION, MAINTENANCE AND MONITORING PLAN

Operation and maintenance plans will be provided for all stormwater management devices that will be vested with Council. This will be required as a condition of any approved RC.

2 CATCHMENT CONTEXT

The greater Warkworth area under assessment by Auckland Council is located within the lower Mahurangi River Catchment which is approximately 5,892ha in area and drains to the Mahurangi Harbour within the Hauraki Gulf. The Warkworth Structure Plan study area comprises approximately 17% of the wider Mahurangi Catchment. The subject site makes up 60 hectares or 1% of that reduced catchment. Within the study area the topography is generally characterised as rolling to moderately sloping with elevations ranging from approximately 100m RL at its northern, western and southern extents to sea level around the existing urban area alongside the Mahurangi River.

The Warkworth Clayden Road Development is approximately 5km North (via State Highway 1) of the Warkworth township and about 65km from downtown Auckland City. The development site is currently accessible directly off SH1, Clayden Road (off Matakana Road) and will be accessible from a proposed link road, referred to as the Matakana Link Road (MLR) that is to be constructed in coordination with Auckland Transport and the NZTA. The location in relation to the greater Auckland Region is illustrated in Figure 1, below.

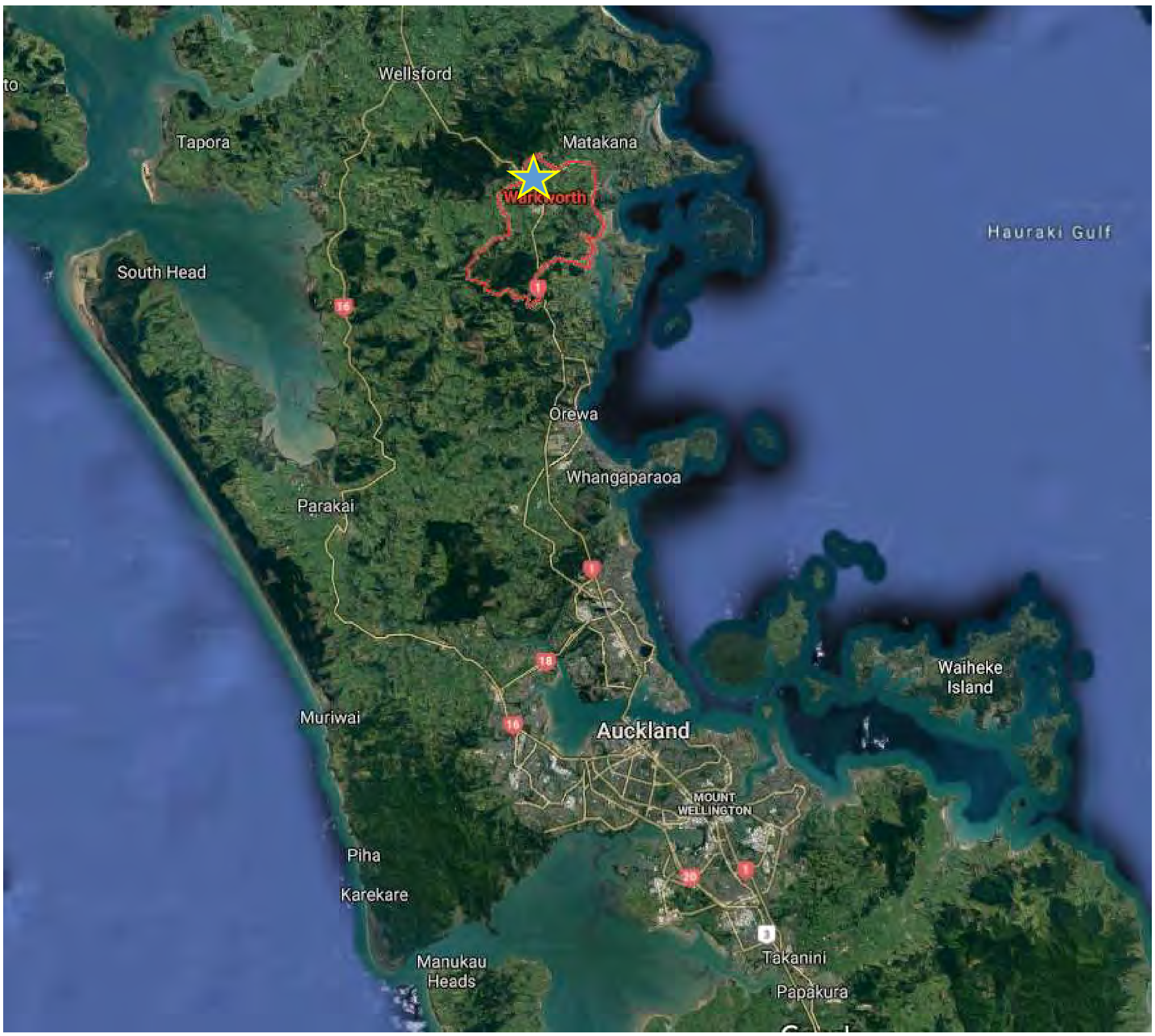


Figure 2: Warkworth Project Location (Star)

The majority of the Clayden Road development site (60ha) is zoned Future Urban under the AUP – OP. To date the is no official Stormwater Management plan for the area although a “Prelim SMP” has been prepared by Tonkin and Taylor in 2018 for and on behalf of Auckland Council in support of the proposed structure plan area for the Warkworth Area.

The Prelim SMP provides the framework for stormwater management in the Warkworth Area. For the most part, the following report is aligned with the recommended approach to stormwater management and that development shall be in accordance with AUP(OP) and Stormwater specific guidance documents (e.g. GD01 and GD04).

2.1 Catchment Assessment

2.1.1 Location and existing conditions

The greater Warkworth Structure Plan Area is located within the lower Mahurangi River Catchment in the north of the Auckland Region. The Mahurangi River Catchment is approximately 5892 ha in area and drains to the Mahurangi Harbour within the Hauraki Gulf. The Warkworth Clayden Road catchment is located within the upper reaches of the Mahurangi Catchment. In total, 60 ha of land is within the scope of this report and development. The total development site is bordered by State Highway and light industrial zoned property to the west – which is currently undeveloped and rural in nature, Goatley and Clayden Road to the North and the Warkworth Showgrounds to the south.

The catchment is undulating, with a predominant fall and gullies developing southwards. The catchment is currently used for agricultural purposes. The extent of the catchment is illustrated in Figure 2, below.

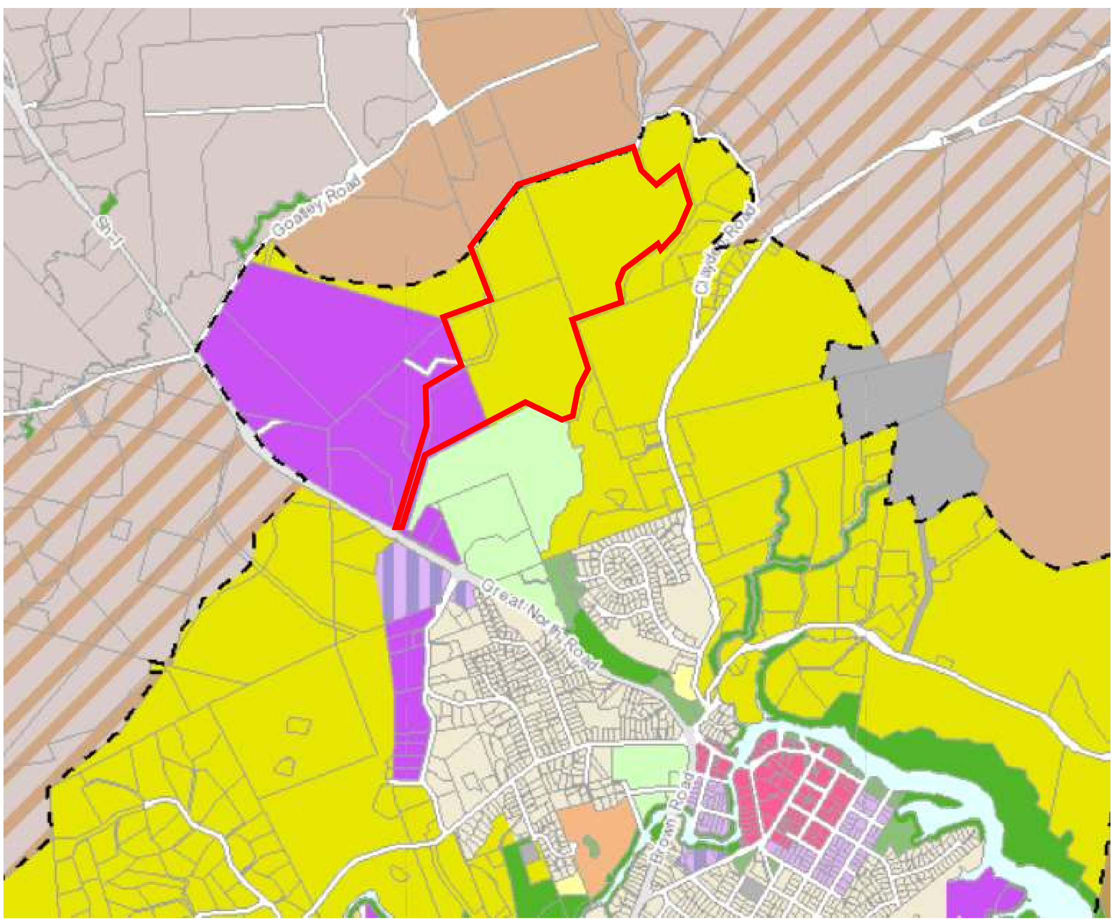


Figure 3: Extent of Development (in red)

2.1.2 NATURAL FEATURES

Streams within the greater Warkworth precinct are all part of the Mahurangi River system. These streams vary from natural streams with good quality indigenous riparian vegetation to farm drains. The north and south branches of the Mahurangi River join at the intersection of Falls Road and Woodcocks Road and the river then travels west to east, bisecting the study area.

The removal of riparian vegetation, livestock access to waterways and pollution from agricultural runoff have all influenced water quality, as well as reduced habitat diversity and biodiversity. However, as the catchment currently has a low extent of impervious surfaces, a low degree of channel modification, and comparatively low pollution from stormwater and wastewater discharge, the water quality overall for the catchment is rated as “good” in Auckland Council’s 2016 freshwater report card.

The Clayden Road site is currently a rural environment, an ecological assessment by Freshwater Solutions (2019) note the watercourses through the site are generally in poor condition representative of longstanding farming use, lack of Riparian planting or Fencing. The Warkworth Clayden Road Development is contained within the Mahurangi Stream catchment and ultimately discharges into the Mahurangi River Please refer to the pre-catchment plans appended within **Appendix A**.

An ecological / watercourse survey has been undertaken by Freshwater Solutions Limited[1]. A copy of the report, inclusive of stream classifications is provided within **Appendix B** to this Report. In summary, the Mahurangi Stream Tributaries catchment the site resides within commences to the north of Elizabeth Street – the main tributary, is identifiable as a permanent stream flow from the north, within the site there is a combination of ephemeral, intermittent and permanent streams. There is a manmade pond, and several artificial farm drains also within the catchment.

2.1.3 SOIL CONDITIONS

Published Geological Maps and CMW Geosciences fieldwork indicate the proposed development site is predominantly underlain by Pakiri Formation of the Waitemata Group. This geological unit is widespread, of early Miocene age and occurs from the north of Hatfields Beach, west to the Kaipara Harbour and north to Mangawhai. Pakiri Formation is dominated by 10-30m thick, graded medium to coarse grained sandstones alternating with thinner, laminated, siltstones and finer sandstones. This material forms the steeper and more elevated slopes on the north and west part of the site and is generally regarded as competent material for subdivision purposes.

Portions on the southern end of the site are also shown to be underlain with Mahurangi Limestones of the Northland Allochthon. The Mahurangi Limestone is represented by blue-grey to white, muddy limestone and weathered clayey residual soils, which forms the less elevated, gently rolling hills towards the southern end of the site[2]. The soil is best described as poorly draining and are reflective of Category C soils for Auckland Council TP108 runoff calculations.

[1] Freshwater Assessment, by Freshwater Solutions Limited, 2019

[2] AKL2018-0228AC Rev 1 by CMW Geosciences, 2019

2.1.4 Hydrology

There are several major and minor overland flow paths ("OLFPs") that originate within or pass through the Clayden Road site. These OLFPs represent the natural gullies and low lying areas classed as ephemeral, intermittent and permanent watercourses. The greater OLFPs are identified within Auckland Council's Geomaps, as illustrated in Figure 4, below.

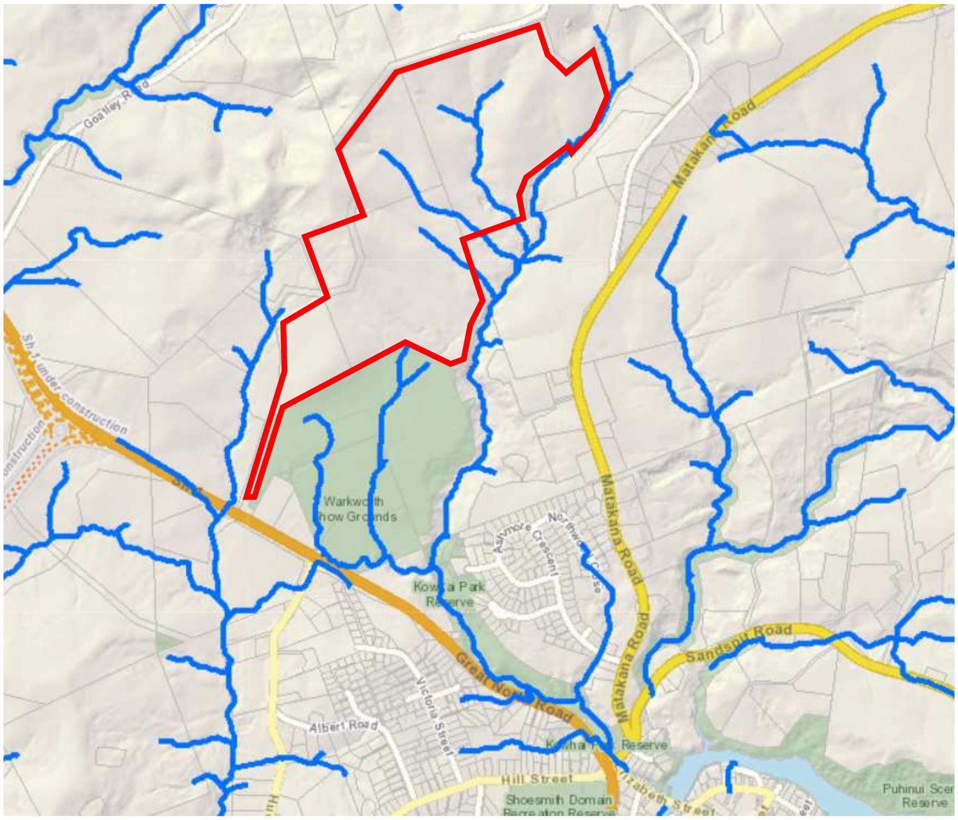


Figure 4: Overland Flow Paths and Streams

The overland flow paths and flows under both existing and fully developed catchment conditions have been modelled in support of the Warkworth Clayden Road Development. Full details of the 1% flow modelling are contained within the Maven Associates report titled "HEC -HMS Modelling Report, Clayden Road, Warkworth" dated Oct 2019.

Hydrological mitigation

Constraints

- The presence of low permeability ultic clays in the structure plan area may preclude the use of infiltration devices in some areas.
- The viability of water reuse as a stormwater management tool is contingent on land use activity and will need to be assessed on a site by site basis.

Opportunities

- The structure plan area is a greenfield site which provides an opportunity to incorporate integrated stormwater management to maintain pre-development hydrology.
- Providing opportunity for on-site infiltration to improve aquifer recharge and stream baseflows.
- Providing opportunities for water reuse especially for housing and for industrial/commercial activities (depending on water demand).

For ease of referencing within the SMP, the existing OLFPs have been named, as per Freshwater Solutions watercourse plan below.

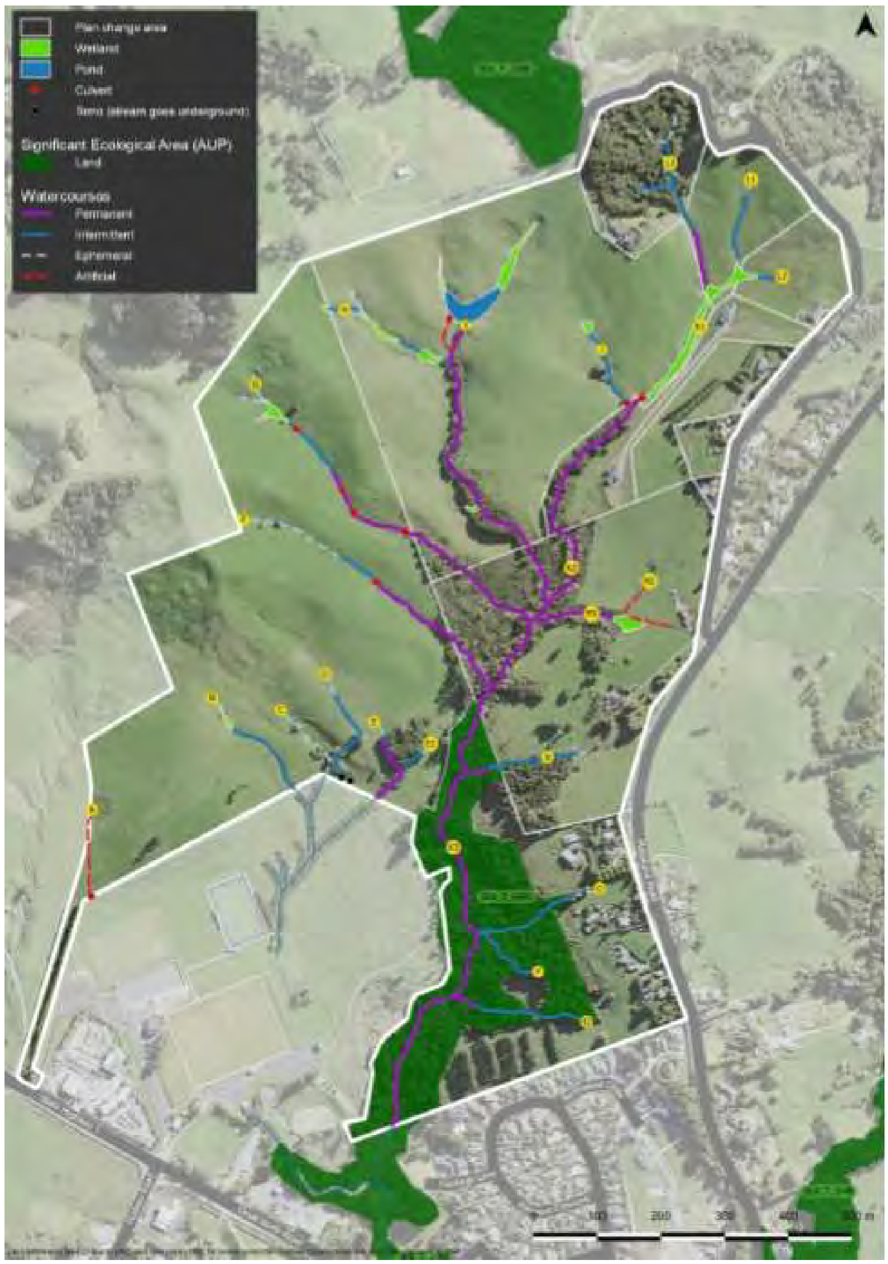


Figure 5: Freshwater Solutions Watercourse Plan

Auckland Council's Mahurangi Catchment model has been used to determine the extent of the 100 year floodplain. In the Warkworth study area the 100 year floodplain will act as a constraint for development as generally buildings and infrastructure should not be located within the floodplain. However, the floodplain as a development constraint may overlap with the requirement for protecting permanent and intermittent streams as well as protecting areas of existing riparian vegetation which is prominent along the Mahurangi River.

Identifying and integrating stormwater constraints and opportunities and infrastructure needs for the intended land use is an integral part of the structure plan process. The following stormwater constraints and opportunities for the study area have been identified:

- Upstream development may increase the flood risk to existing buildings in Warkworth. If this is found to be the case, then catchment scale attenuation devices may be required to avoid increasing flooding to habitable floors.
- Any new development should occur outside of the 100 year floodplain.
- Allow for conveyance of overland flow.

Opportunities

- Protection of 100 year floodplain also provides an opportunity to enhance riparian corridors. This provides enhanced stormwater management functions, contributes to the ecological values of stream corridors and provides public amenity. Green corridors should be considered to manage the flood hazard, protect ecological values, provide amenity and for walking and cycling tracks.

2.2 RECEIVING ENVIRONMENT

The ultimate receiving environment is within the Coastal Marine Area ('CMA') of the Mahurangi Harbour within the Haruaki Gulf, which is fed by the Mahurangi River and upper tributary streams – one of (at least) which flows through the development site.

Immediately downstream of the 245 Matakana Road property the Mahurangi stream tributary is part of a QEII trust and special ecological area.

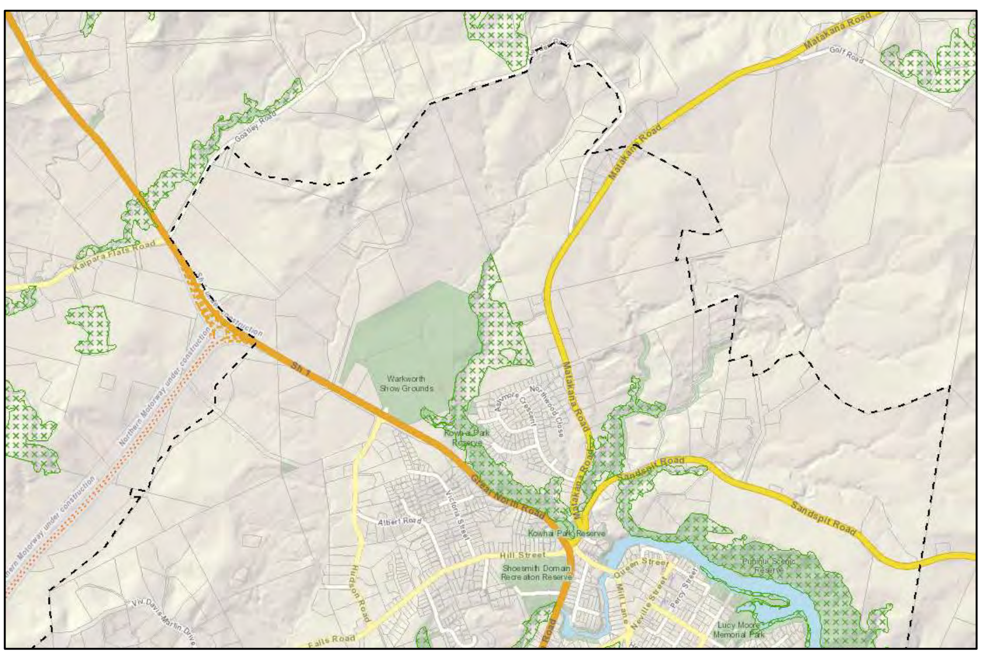


Figure 5A: GEOMAPS S.E.A Overlay Overview

3 TOPOGRAPHY AND CATCHMENT ANALYSIS

3.1 TOPOGRAPHY AND SUB-CATCHMENT BOUNDARIES

The 60ha Clayden Road site and upstream catchment area features a moderate slope towards the south, south-east and south-west. A series of ridgelines to the north of the site and catchment delineate the upper catchment extent before defined gullies collect overland flow as seen in figure 6 below, extracted from Auckland Council GEOMAPS.

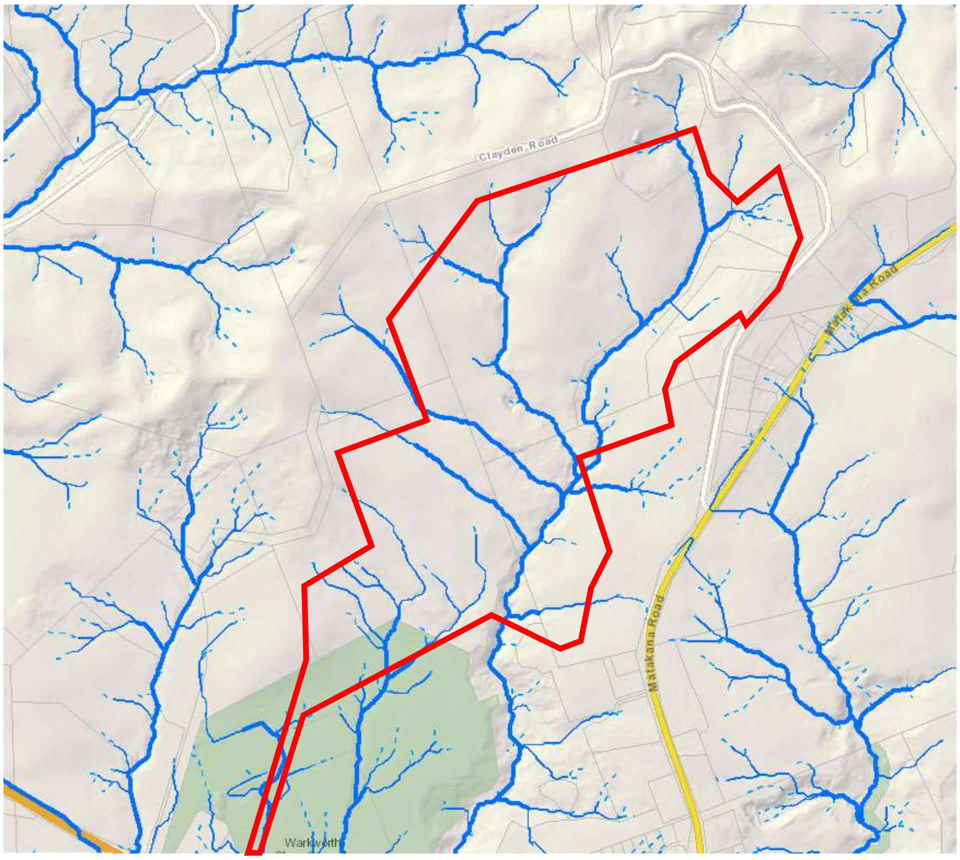


Figure 6: Existing catchment boundaries

A series of ridgelines running north-south generally north of the Warkworth showgrounds diverts flows into 4 catchments of the surrounding area. Catchments of the subject and neighbouring properties can be found defined within figure 7 below:

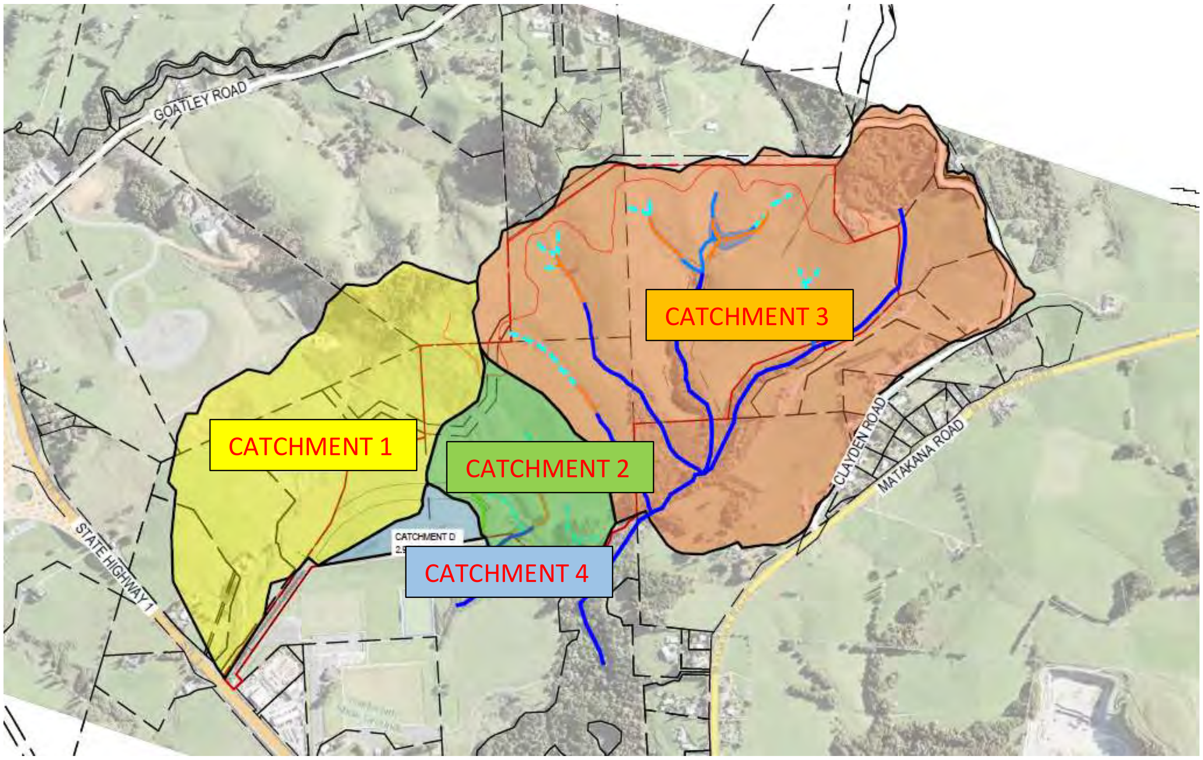


Figure 7: Existing Surround Catchment Extents

Details of each Catchment including the ultimate discharge point and downstream flowpath extents can be found summarised below:

A) Catchment 1, highlighted yellow in figure 7 above, tends to slope south west where runoff accumulates and discharges via in a culvert under State Highway 1 (alongside the subject sites access) west of the site. This OLFP ultimately wraps back around to the east and discharges into the Mahurangi stream as drawn in red within Figure 8 below.

Figure 8: Catchment 1 Downstream Flow

B) Catchment 2 flows to the east of the ridgeline highlighted in green in figure 7, are collected within intermittent and permanent streams upstream and within the showground site, identifiable as they have riparian plating, before stream flows combine with flows of the Showground site. Flow ultimately discharges into the Tributary west of Heritage Lane and north of Great North Road/SH1 as identified on Auckland Council GEOMAPs, see figure 9 below:

Figure 9: Catchment 2 Downstream Flow

C) Catchment 3 is the largest catchment of the subject site, comprising of the northwest portion of the site identified in Orange within Figure 7, major overland flow paths and permanent tributary/streams traversing the eastern boundary of the subject site convey flow south along the natural watercourse discharging to the Mahurangi Stream west of the Warkworth township. Figure 10 below identifies the major flow path and stream (in red) traversing the eastern boundary.

Figure 10: Catchment 3 Overland Flow & Collecting Stream

D) Catchment 4, directly above the Warkworth showgrounds and stream crossing the showgrounds site, as per Figure 7 gently rolls down onto the showground fields. Runoff is classified as sheet flow in this portion of the catchment. The flows in this catchment do not accumulate in a flowpath until combined with flows from the relatively flat showgrounds fields further downstream (originating from Catchment 2).

Ultimately all flow generated within the subject catchment ends up discharging into the Mahurangi River via 1 of 2 significant routes at the extents or 'boundaries' of the area being assessed:

1. "Stream" - via the stream within the S.E.A south of the proposed precinct, accumulating flows from catchments 2,3 and 4 of the above.

2. "Culvert" - via a culvert under SH1 west of the subject site and proposed precinct, or Catchment 1 above.

Assessment below focuses on flows within Watercourses of significance for modelling purposes and then on flows at 'boundary' discharge points; Stream or Culvert for future reference.

3.2 CATCHMENT FLOWS

A development model has been completed to establish the effects of the Clayden Road Development in isolation to set a baseline for other development within the proposed precinct. As such the model does not include the adjacent and downstream properties. Catchments outside of the subject site – for the purpose of ongoing assessment – will require stormwater controls achieving the same outcomes to ensure the effects of development are properly mitigated.

This catchment model has divided into various catchment based on stream names assigned in Freshwater reports, which provides flows for various rainfall events for both the existing and fully developed catchment model scenario.

An overview of the catchment hydrological and hydraulic model inputs, is as follows:

- On-site investigation
- The proposed 10yrcc and 100yrcc (including Climate Change) catchments are the same

The model setup is derived from the following characteristics / assumptions:

- Catchment characteristics as per Auckland Council TP108 parameters.
    - CN numbers
        - Pre-development CN= 74
          (Based on recommendation from CMW Geosciences on the soil types found during investigation)

TABLE 1: PRE DEVELOPMENT SITE CATCHMENT AREA SUMMARY

PRE-DEV	AREA (Ha)
Catchment A	5.461
Catchment B	12.512
Catchment H	15.454
Catchment I	1.656
Catchment J	21.244

- Rainfall application
  - Site specific rainfall depth have been derived using AC-TP108
  - Climate change has been applied in accordance with Auckland Council SWCoP, allowance for climate change effects in accordance with Table 5.2 of Climate Change Effects and Impact Assessment: A Guidance Manual for Local Government in New Zealand (Ministry for the Environment, 2008), using a temperature increase of 2.1 degrees by 2090. As per Table 4.1 below extracted from the Auckland Council Stormwater Code of Practice v2.0.
    - **Table 4.1: Percentage Increase in 24-hour Design Rainfall Depth**

Annual Exceedance Probability (AEP)	Percentage Increase in 24-Hour Design Rainfall Depth Due to Future Climate Change*
50%	9.0%
20%	11.3%
10%	13.2%
5%	15.1%
2%	16.8%
1%	16.8%

* assuming 2.1°C increase in temperature

TABLE 2: RAINFALL DEPTH

Rainfall Depth	TP108	TP108 + CC
10% AEP (10YR)	210	237.7
1% AEP (100YR)	310	362.1

The below flows have been modelled in HEC-HMS and cross checked using HEC-RAS and TP108, pre-development catchment plans can be found appended for reference. See below modelled peak flows at each of the existing watercourses that convey accumulated runoff - as there is no existing stormwater drainage infrastructure.

TABLE 3: STREAM PRE-DEVELOPMENT 10YR AND 100YR PEAK FLOWS

PRE-DEV	Q_{10} (m^3/s)	Q_{100} (m^3/s)
Catchment A	1.542	2.595
Catchment B	3.534	5.945
Catchment H	4.364	7.342
Catchment I	0.467	0.787
Catchment J	6.148	10.213

PRE-DEV	Q_{10} (m^3/s)	Q_{100} (m^3/s)
Culvert	1.542	2.595
Stream	14.365	24.168

3.3 FLOODING

The Clayden Road site (and proposed precinct extents) lay outside of any 1% AEP floodplain, this is likely due to the elevation difference across the site, overland flow paths following the natural gullies and, aside from a manmade pond, there being little upstream catchment or storage. Selected watercourses are to be maintained through the development and provide primary flow paths for the developed area to discharge into.

The secondary OLFPs within the proposed development will be contained within road reserves and right of ways and will convey overland flows to the existing or reclaimed watercourses within the site. In selected locations drainage reserves may be required to convey flow form the road across blocks of residential land to watercourses.

Auckland Council Rapid Flood Hazard assessment maps (Figure 11) concur with the conclusion that there is no major flooding outside of the well-defined watercourses of the subject site (outlined in yellow within Figure 11) or directly downstream of the site

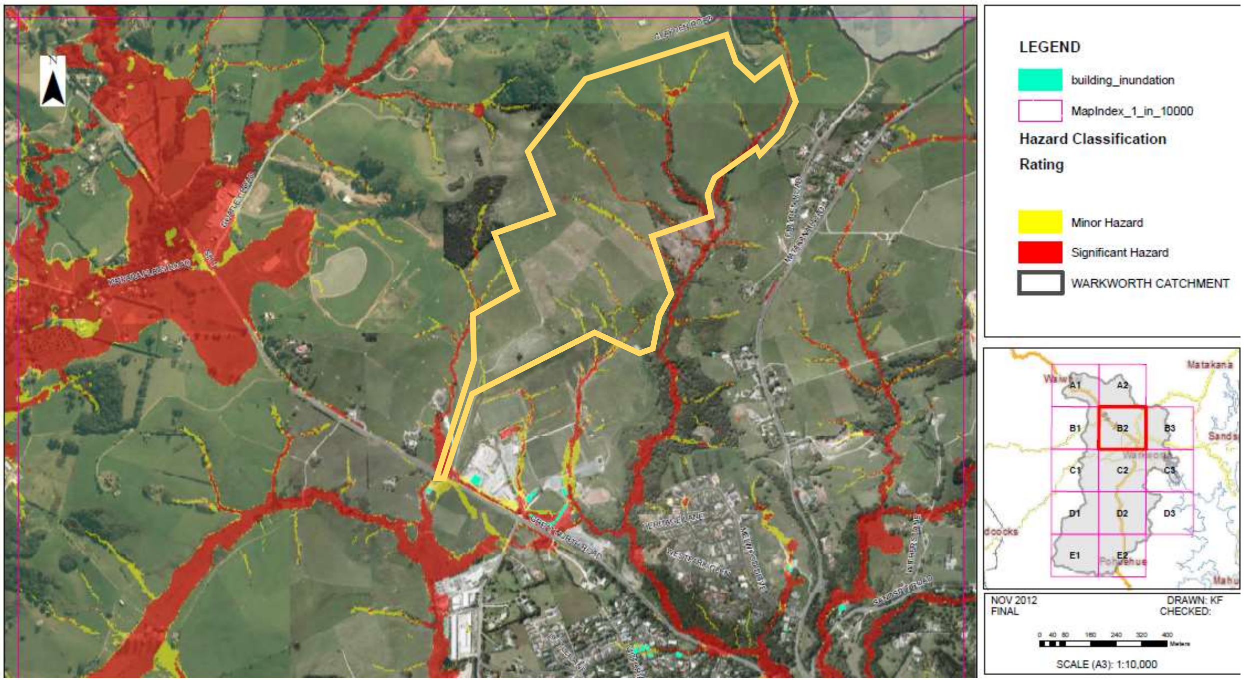


Figure 11: Warkworth North East Rapid Flood Hazard Assessment Map (Auckland Council)

This mapping does identify however the existing downstream flooding issues well documented in various other reports to date, extracts of these areas around the town center of particular interest can be found below:

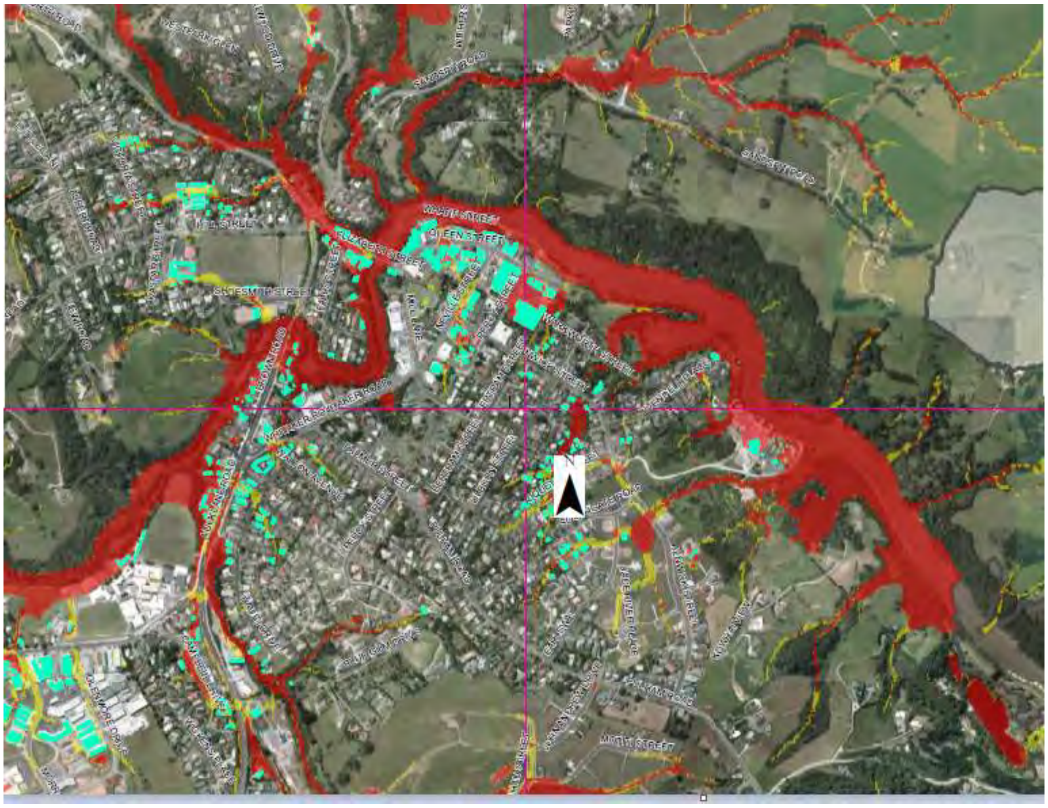


Figure 12: Warkworth Town Center Rapid Flood Hazard Assessment Map (Auckland Council)

3.4 ECOLOGICAL FEATURES

An ecological assessment has been undertaken for the catchment by Freshwater Solutions Environmental Consultants, a copy of which is appended (**Appendix B**). This has identified ephemeral, intermittent and permanent stretches of streams within the Clayden Road site. The permanent reaches are largely contained within the primary tributary of the site. The streams vary in length, quality and status.

Freshwater Solutions have identified that these streams have been affected as part of the historical farming practices. The freshwater habitat is best described as degraded and of low ecological value. Although there are small pockets of native trees in riparian zones that retain value and have potential to be maintained.

The streams and classifications are illustrated in Figure 11, below. Please refer to the Freshwater Solutions report for further detail, within **Appendix B**.

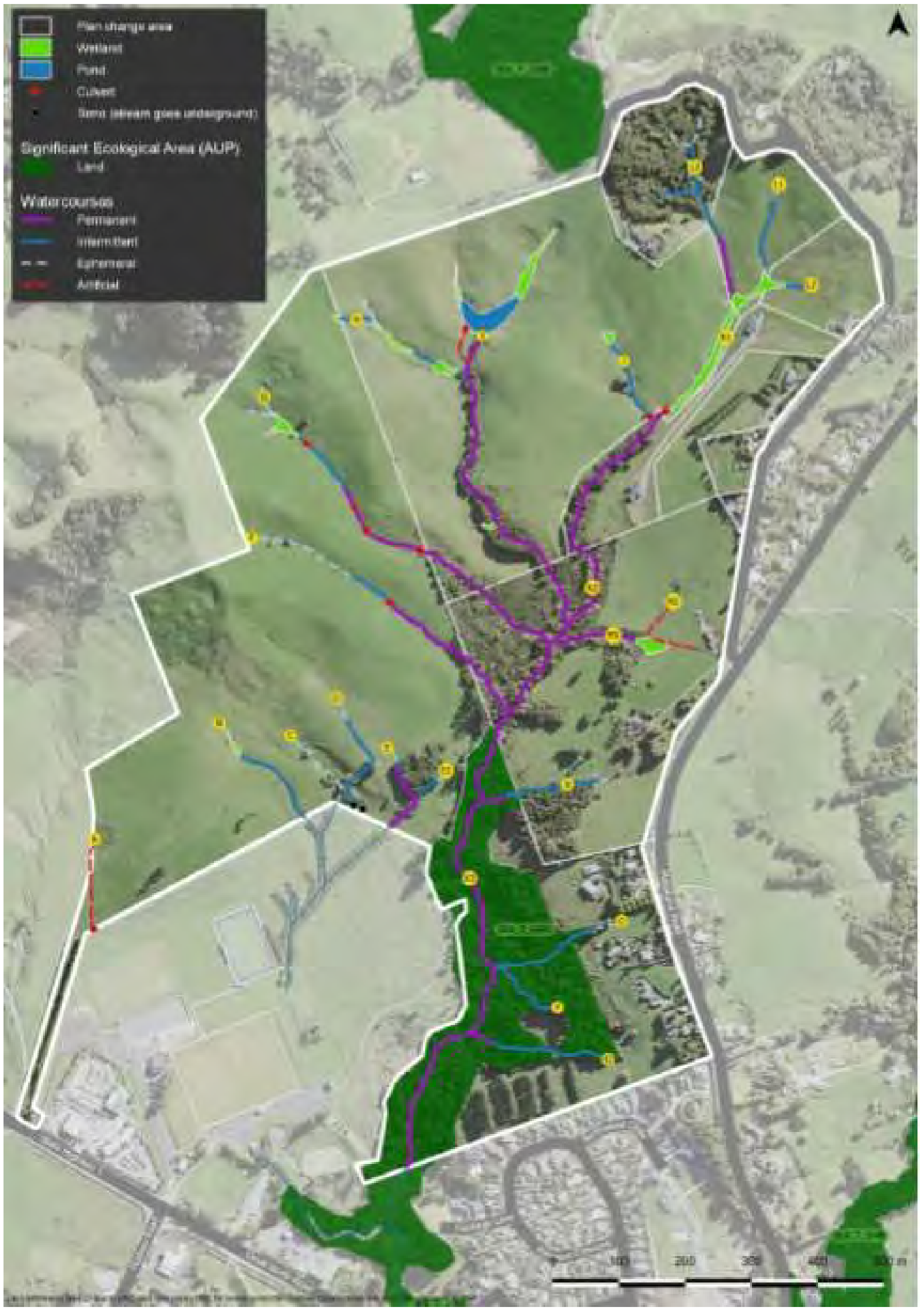


Figure 13: Watercourses within the Clayden Road site

Opportunities to enhance freshwater systems:

<u>Constraints:</u>

- Permanent and intermittent streams will need to be protected.
- Riparian buffer area around streams needs to be included. In some areas existing riparian vegetation has been classified as a terrestrial Significant Ecological Area and must be protected.
- Development of the site to provide sections and roads of complying grade, while maintaining existing watercourses at existing pre-development RL's.

Opportunities:

- Water quality in the water bodies within the structure plan area is currently relatively good for an urban catchment. Use of integrated stormwater management is an opportunity to maintain or enhance water quality.
- Design stormwater management that provides for a high level of water quality to protect the high ecological values and good water quality present in the area.
- Use riparian margins as part of water conveyance and to provide connections to other freshwater systems and other habitat types.
- The change in land use from rural land to urban is an opportunity to reduce sedimentation loading in f reshwater systems and in the harbour

4 WARKWORTH CLAYDEN ROAD DEVELOPMENT – CONCEPT

4.1 STRUCTURE PLAN

A-Studio have prepared a concept masterplan of the Warkworth Clayden Road Development. The structure plan proposes zoning for the Subject Site development Clayden Road and adjoining properties.

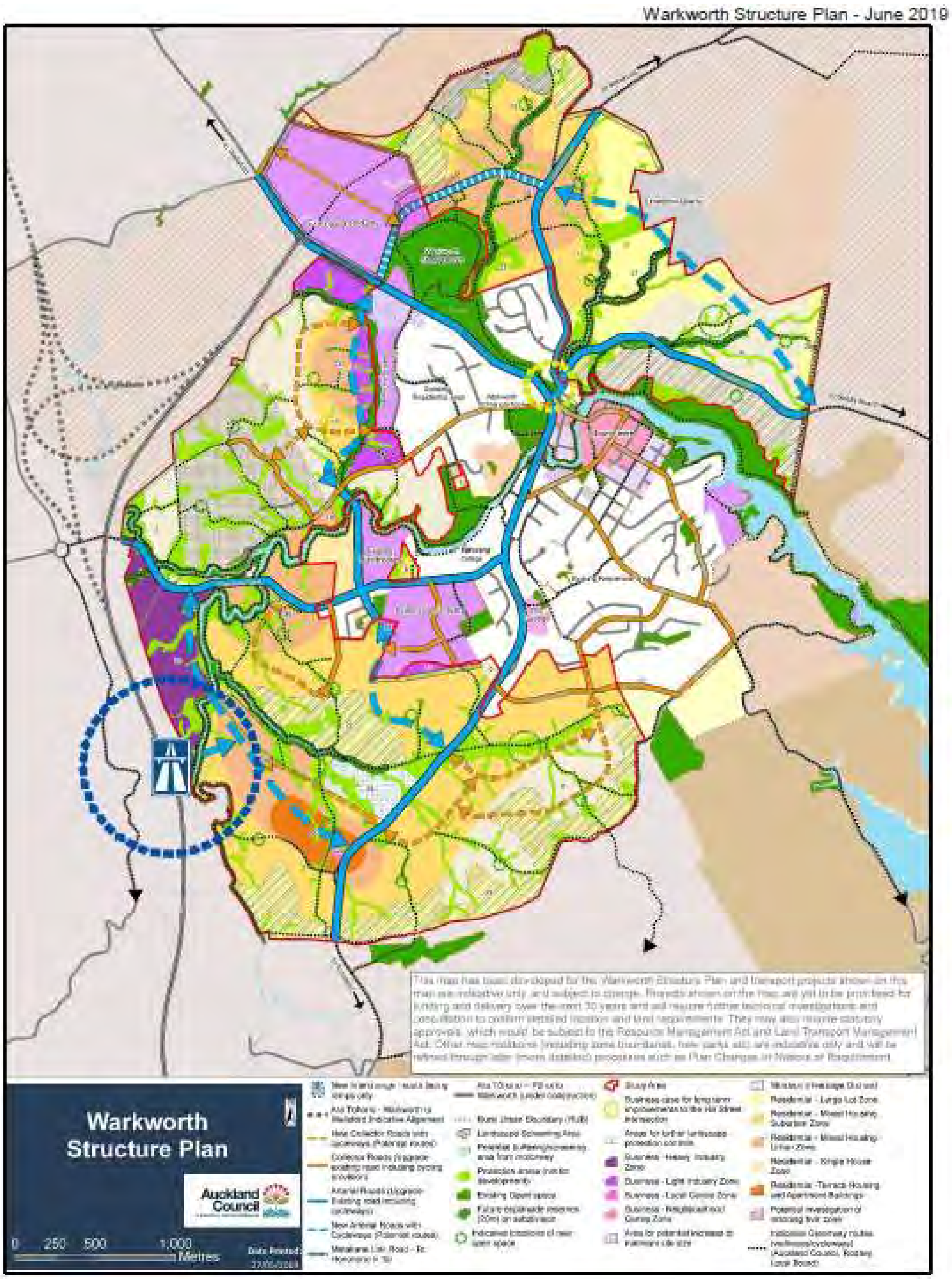


Figure 14: Auckland Council Structure Plan

Flexibility is retained in the eventual size and location of lots although the general zoning areas and impervious coverage as per the AUP are known. The proposed development layout takes account of this need for flexibility as the concept is developed in accordance with Auckland Council recommendations through the plan change to subdivision process.

This development will retain covenanted areas of existing bush and several existing streams. The overall scheme of the development is illustrated in Figure 12, below.

Figure 15: Warkworth Clayden Road Development – Master Plan

4.2 PLANNING CONTROLS

The Clayden Road site is currently located in Future Urban zoning and Auckland Council have released a draft zone overlay as part of public plan change process. This location contains both industrial and residential zoning across the subject site and adjoining properties. Zones proposed include; Light Industry, Single House, Suburban and the Mixed Housing Urban zones. Accordingly, there are varied impervious limits, including within riparian yards, whereby Standard H17.6.3 restricts the maximum impervious area to 10% within the riparian yard, defined as 10m from the edge of all permanent and intermittent streams as per the AUP – OP.

The subject site Clayden Road does not currently or within the proposed structure plan, appear to have any stormwater management overlays, including flow ('SMAF') zoning. Although properties, including the Warkworth showgrounds, immediately downstream are within a SMAF Flow 1 management overlay area. As per Figure 16 below.

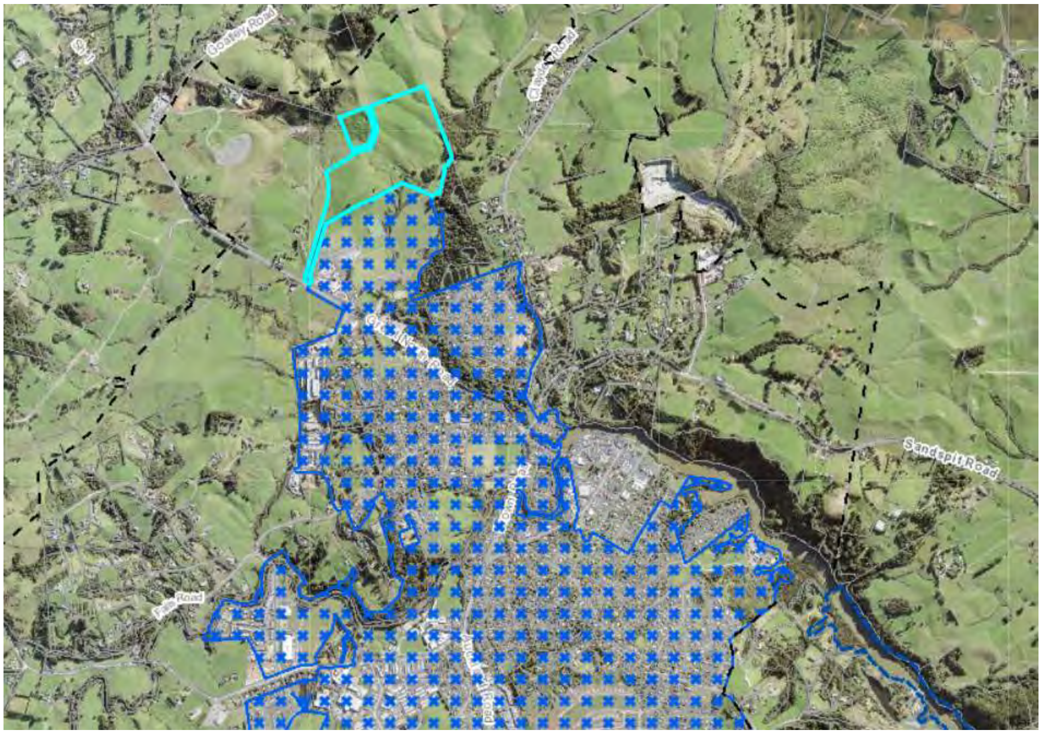


Figure 16: Unitary plan – OP – Stormwater Management Area Control

As the site is directly upstream of a SMAF 1 zone, it is anticipated that any future urban area upstream of this area should be subject to the same stormwater controls. As such applying SMAF 1 level attenuation to control and mitigate additional runoff being generated as a result of the proposed zoning is considered appropriate in providing extended detention for the receiving environment. Further stormwater controls are explored in a report summarising the pre and post development scenarios that can be found appended to this document.[3]

The site is located within the Natural Resources: High-Use Aquifer Management Areas Overlay [rp] – Mahurangi Waitemata.

Development of the Warkworth Clayden Road Development is not dependent on aquifers (with all water to be supplied via public network), and thus these overlays are not considered to be of immediate concern to this SMP.

4.3 EXISTING PUBLIC INFRASTRUCTURE

The subject development is currently not serviced by a public infrastructure network. Stormwater runoff is collected and disposed of via an existing watercourse and stream network consistent with the surrounding undeveloped areas.

Within both sub-catchments of the subject site and precinct, flow must traverse either 1 or 2 culverts that have been identified as under capacity.

1) The Hill Road / Sandspit Road intersection Stormwater Culvert (Identified below in figure 16A.)

[3] HEC-HMS Modelling Report Rev A by Maven Associates, 2019

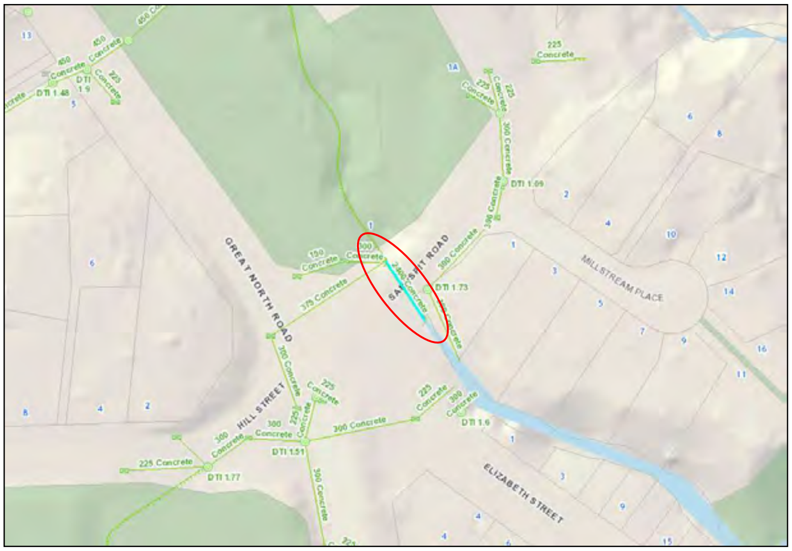


Figure 16A: Sandspit Road Culvert Location

A 2300mm (from GEOMAMPS) culvert is an existing Auckland Council asset that has been assessed independently and found to be severely undersized for the combination of major (10 and 100yr ARI) storm events and the contributing catchment size. As of the date of issue, no plans to upgrade or replace this culvert are known. As such, the proposed development and precinct will be required to attenuate major storm events to pre-development levels.

2) The NZTA/SH1 Culvert (Known as Culvert E530, as part of the NX2 Puhoi to Warkworth Motorway project currently underway).

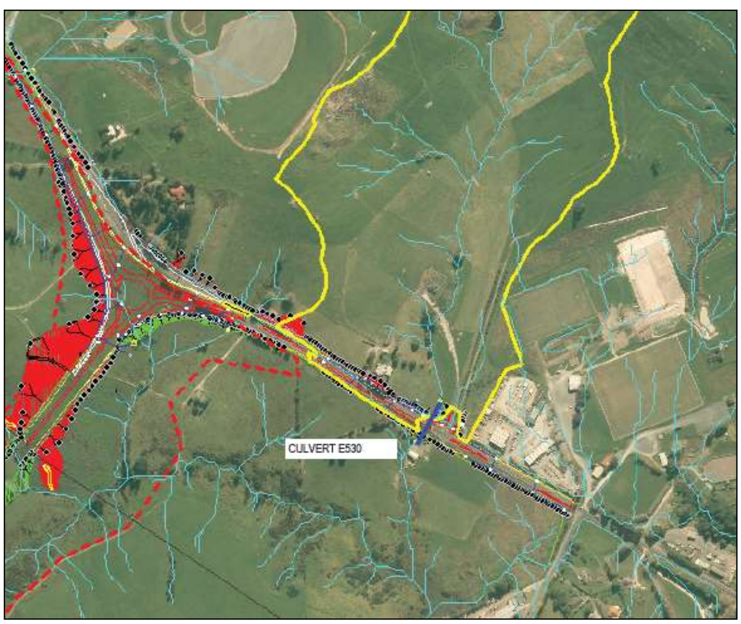


Figure 17a: SH1 E530 Culvert Location

Culvert E530 is being replaced as part of the NX2 Puhoi to Warkowrth Motorway project. Although reports made public as part of the project (51// SH1 widening stormwater memo V6 28-26-2018) completed by Tonkin and Taylor determine that the hydraulic properties of the replacement culvert are to more of less meet the existing flows expected due to risk of increasing downstream properties. The below extract from this memo surmises reasoning:

The concept design for culvert E530 indicated that an 1,800 mm diameter culvert would be required to meet the Project's design requirements. However, the NX2 draft design report states that to provide a culvert larger than 1,200mm diameter would not result in a non-compliance with respect to RC68(b), and that the modelling results indicate that using a culvert larger than 1,200mm would increase flood levels downstream of the culvert at Lot 2 DP 405448 (CT 419127). However, due to the requirement to include fish passage in this culvert the culvert diameter has been increased to 1,350 mm. The NX2 draft report states that due to the increased hydraulic roughness provided by the fish baffles similar hydraulic performance to the existing culvert would be provided.

Again, the proposed development contributing area within the proposed precinct will be required to attenuate major storm events to pre-development levels.

5 STORMWATER MANAGEMENT ISSUES, OPPORTUNITIES AND CONSTRAINTS

The key stormwater management opportunities and constraints are assessed within this section of the Report. Emphasis has been placed on protecting, and where possible enhancing, the receiving environment from the development. The Mahurangi stormwater plan incorporates various elements to ensure a holistic approach to stormwater management within the catchment. Overall it is considered that the land uses identified in the structure plan for the Warkworth Future Urban Area generally respond well to the site specific constraints and opportunities identified in the Stage 1 - Preliminary Stormwater Management Plan dated March 2018 by Tonkin and Taylor.

A Watercourse Assessment Report completed by Morphum Environmental Ltd has more recently been reviewed, that contains a number of recommendations that have been considered to be in general accordance with the below management plan. The proposed precinct catchment in the Morphum report is referred to as Management Zone 2 - Warkworth North – Showgrounds.

Table 9 specifies issues and recommended objectives of Stormwater Management in the area:

Table 9: MZ2 Issues and Objectives

Specific Issues	Suggested Objectives and Actions
Existing rural land use pressures may be remediated through greenfield development within short time scales.	Primary focus on goals and objectives related to future urban land development outlined above.
Matakana Link Road indicative route crosses the north tributary 3 (at approximately MAHN_TRIB3_6).	Reduce fragmentation of riparian corridor, and advocate for a contiguous green belt forming an ecological corridor linking the stream mouth Mahurangi banks and harbour to the Dome.
Extensive parts of the riparian corridor from the headwaters to the stream mouth are forested however some significant gaps in the connectivity of this corridor exist.	Consider potential to form an esplanade reserve between Kowhai Park and the protected headwaters of North Trib 3. Also see EO1.
The native riparian areas and hard stream bottom upstream provide good potential fish habitat, however the 2009 study indicated a fish barrier at the stream mouth (Trib 14 (2007-2009 data) see MZ 9).	Remediate potential fish barriers in lower reaches (MZ 9).
Large headwater farm pond on MAHN_Trib 3b.	Consideration of removal of online pond and restore natural channel morphology and hydrology.

The above issues specific to the precinct extents have been assessed below:

Existing Rurual Land use – as indicated goals and objectives of development associated with urban land development both resolves existing issues while presenting new risks.

Matakana Link Road – Being completed within the precinct area but for which separate consents are being sought by Auckland Transport. Note that the MLR construction poses its own constraints to be dealt with during detailed design.

Connectivity of Riparian Corridor – Riparian zones/Esplanade Zones are being incorporated into the precinct plan, enhancement of which would be beneficial where watercourses are proposed to be maintained through development. Map 7 of the Morphum WAR correctly identifies an area of existing open pasture and wetland with opportunity for enhancement. An extract of which can be found below:

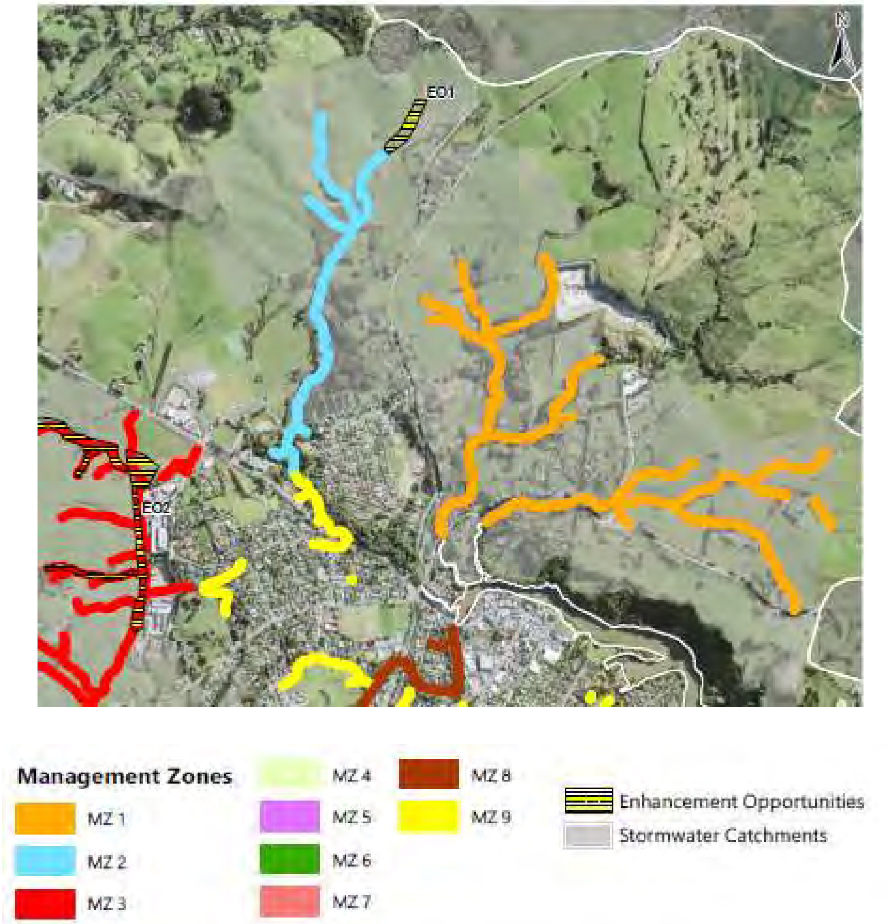


Figure 17b: Morphum FUZ WAR, Map 7 Extract.

Fish barrier – Barrier within 'lower reaches of MZ 9' assumed to be outside of the precinct maps based on the above Figure X.

Large Headwater Farm pond – Proposed to be removed during development as recommended in this and other ecological assessments.

The report also makes mention of the geology being a contributing factor in the current state of stream erosion. Northern Allochthonous rocks are noted to be weak and prone to failure. The resulting deep incisions of watercourses downstream of the subject are contributable to this. Recommendations made in other reports supporting the Structure plan, as well as the proposed precinct geotechnical report, support that this area is subject to Allochthonous rock and ground discharge (soakage) as a form of retention is, as such, not recommended.

Stormwater is to be managed within the subject site and we would recommend in the neighbouring sites using an integrated stormwater management approach involving water sensitive design involving the following components:

- Minimise the generation of stormwater runoff and contaminants with measures such as reducing impervious surfaces and using inert building materials.
- Manage runoff and contaminants as close to source as possible with measures such as rain gardens, permeable pavements and terrestrial revegetation.

- Use swales for stormwater conveyance where possible as an alternative to pipes where practicable, as pre-treatment to downstream treatment devices.
- Enhance the receiving environment by preserving and restoring riparian vegetation along banks including linking areas of riparian vegetation to create continuous green corridors.
- Utilise existing natural systems for stormwater management function including the restoration/enhancement of intermittent stream into wetlands.
- Methods to improve water quality as well as minimising and mitigating hydrological change are proposed.

Some of the key aspects specific to the site are detailed below:

- Ecological enhancement of the Mahurangi tributaries.
- Maintenance of existing overland flowpaths and waterways that flow through the Clayden Road site.
- Stormwater and flood management within the Clayden Road site.
- Provide stormwater quality treatment for proposed impervious and contaminant generating areas.
- Various options for detention of frequent rainfall events to streams, e.g. wetlands, detention ponds, onsite detention devices.
- Flood mitigation for downstream properties, in the absence of an existing piped network.

The following sub-sections provide details on the design elements that are to be incorporated into the development of a robust stormwater strategy which will support and guide the light industrial development within the Warkworth Clayden Road Development.

5.1 POST DEVELOPMENT SUB-CATCHMENTS

Maven Associates have completed post development analysis of the stormwater catchments. The proposed sub-catchments have been aligned with the expected contours and lot areas post the fully developed scenario. Proposed contours have been modelled to achieve a road network of complying grades, while having the best possible outcome in terms of adjustments to existing catchment extents and discharge locations.

Impervious coverage assumptions categorised by proposed urban zoning can be found below:

TABLE 4A: ZONE IMPERVIOUS COVERAGE

PROPOSED PRECINCT ZONE	IMP. COVERAGE (%)
Landscape/Park/Bush	0
Large Lot Zone	35
Single House Zone	60
Mixed Housing Suburban Zone	60
Mixed Housing Urban Zone	70

Note: Urban Zoning modelled as being higher than AUP maximum of 60%, due to likelihood of coverage being increased post occupation in high density housing,

The sub-catchment areas used in stormwater modelling and impervious coverage (which includes the road reserve areas), which are formed by a number of the above zones, are presented in Table 2 below:

TABLE 4B: PROPOSED CATCHMENT AREAS

POST-DEVELOPMENT	AREA (Ha)	IMP. COVERAGE (%)
Catchment (A)	7.254	39.27
Catchment (B)	6.305	67.63
Catchment (H)	16.597	44.82
Catchment (I)	3.557	60.00
Catchment (J)	21.045	48.45

Notes:

Impervious area includes individual lots within Subject Site only

Additional Impervious area expected in road reserves, laneways, access-ways not allowed for.

5.2 CATCHMENT FLOW ANALYSIS

A hydrological and hydraulic model was created to model the fully developed catchment. The proposed modelling scenario has the following characteristics/assumptions:

- The proposed $10yr_{cc}$ and $100yr_{cc}$ (including Climate Change) catchments are the same
- Catchment characteristics as per pre-development TP108 parameters.
  - CN numbers
    - Pervious areas CN= 74
    - Impervious area CN= 98
- Primary network will be installed with capacity to convey 10yr ARI peak flow including Climate Change
- Secondary overland flow paths will be contained within the road reserves, right of ways or drainage reserves and will be directed to existing streams.
  - 50% of the pipe capacity is to be considered blocked in 100yr ARI flood modelling.
- Rainfall application:
  - Site specific rainfall depths have been derived using AC-TP108
  - Climate change has been applied in accordance with Auckland Council with allowances for climate change effects in accordance with Table 5.2 of Climate Change Effects and Impact Assessment: A Guidance Manual for Local Government in New Zealand (Ministry for the Environment, 2008), using a temperature increase of 2.1 degrees by 2090. As per Table 4.1 below extracted from the Auckland Council Stormwater Code of Practice v2.0.

Table 4.1: Percentage Increase in 24-hour Design Rainfall Depth

Annual Exceedance Probability (AEP)	Percentage Increase in 24-Hour Design Rainfall Depth Due to Future Climate Change*
50%	9.0%
20%	11.3%
10%	13.2%
5%	15.1%
2%	16.8%
1%	16.8%

* assuming 2.1°C increase in temperature

TABLE 5: PROPOSED SCENARIO RAINFALL DEPTH

Rainfall Depth	TP108	TP108 + CC
10% AEP (10YR)	210	237.7
1% AEP (100YR)	310	362.1

The outcome of the modelling for rainfall events of 10yr annual recurrence interval ('ARI') and 100yr ARI (including Climate Change) is presented in Table 3, below.

TABLE 6: UNATTENUATED SUB-CATCHMENT PEAK FLOWS

POST-DEVELOPMENT	Q_{10} (m^3/s)	Q_{100} (m^3/s)
Catchment (A)	2.032	3.266
Catchment (B)	2.089	3.274
Catchment (H)	5.225	8.371
Catchment (I)	1.157	1.828
Catchment (J)	6.272	10.010

Note: Flows above are peak flows prior to mitigation

5.3 FLOODING / FLOW MITIGATION

In terms of flood management, the Stormwater Management Plan proposes to:

- Utilise existing streams and their associated riparian margins to provide conveyance to manage flood flows.
- Avoid locating buildings or infrastructure within the 100 year ARI modified floodplain unless it can be designed to be resilient to flood related damage.
- Ensure all development and changes within the 100 year floodplain do not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the site.
- Identify overland flowpaths and ensure that they remain unobstructed and able to safely convey runoff.

The existing site and upstream extents of the neighbouring properties are considered low risk and would only be subject localised minor ponding, as detailed within Section 3.3 of this Report. Rapid flood mapping of the area has been completed and can be found appended (Appendix C) as extracted from the Tonkin Taylor Prelim SMP. The extent of flooding identified has been confirmed via site survey and modelling more so as overland flow paths as areas within the site identified are not subject to downstream flow constraints or area's of low grade that typically pond during large rainfall events. Ponding or flow through the existing watercourses has been modelled and typical sections produced identifying the extents of flow for reference.

Modelling of post development scenario during 10 Year and 100 Year AEP or 10% and 1% ARI events has been carried out to determine what the effect downstream might be. A summary of combined flow that will effectively increase downstream of the site can be found below:

TABLE 7: PEAK FLOW COMPARISON – PRE AND POST DEVELOPMENT (NO MITIGATION)

Pre-Development			Post Development	
Catchment	10yr (m^3/s)	100yr (m^3/s)	$10yr_{CC}$ (m^3/s)	$100yr_{CC}$ (m^3/s)
Culvert	1.542	2.594	2.032	3.266
Stream	14.365	24.286	14.743	23.484

An assessment of options to mitigate the flood risk has been undertaken with details presented in the following sub section.

5.3.1 MITIGATION OPTIONS ASSESSMENT – FLOODING

An options assessment has been undertaken to establish the best practical design criteria for the stormwater design in support of the Warkworth Clayden Road Development. These options included:

- On-site (at source) retention and detention, mirroring the Stormwater Area Management Flow ('SMAF') controls as per section E10 of the AUP – OP.

Stormwater management area control	Hydrology mitigation requirements
(1) Except as provided for in (2) below the following applies:	
Stormwater management area – Flow 1	(a) provide retention (volume reduction) of at least 5mm runoff depth for the impervious area for which hydrology mitigation is required; and (b) provide detention (temporary storage) and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from the 95th percentile, 24 hour rainfall event minus the 5 mm retention volume or any greater retention volume that is achieved, over the impervious area for which hydrology mitigation is required.

(2) Where: (a) a suitably qualified person has confirmed that soil infiltration rates are less than 2mm/hr or there is no area on the site of sufficient size to accommodate all required infiltration that is free of geotechnical limitations (including slope, setback from infrastructure, building structures or boundaries and water table depth); and (b) rainwater reuse is not available because: (i) the quality of the stormwater runoff is not suitable for on-site reuse (i.e. for non-potable water supply, garden/crop irrigation or toilet flushing); or (ii) there are no activities occurring on the site that can re-use the full 5mm retention volume of water. (c) the retention volume can be taken up by detention as follows: (i) provide detention (temporary storage) and a drain down period of 24 hours for the difference between the pre-development and post-development runoff volumes from the 95th percentile (SMAF 1) / 90th percentile (SMAF 2), 24 hour rainfall event minus any retention volume that is achieved, over the impervious area for which hydrology mitigation is required.

- On-site (at source) attenuation for 10yr ARI events to 'pre-development' scenario flows.
- Use streams and their associated riparian margins to provide storage and conveyance to manage flood waters.
- Catchment Specific detention ponds and wetlands to mitigate both 10/100 ARI storm events.
- Avoid locating buildings or infrastructure within the 100 year ARI modified floodplain unless it can be designed to be resilient to flood related damage.
- Ensure all development and changes within the 100 year floodplain do not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the site. Identify overland flowpaths and ensure that they remain unobstructed and able to safely convey runoff.
- In specific sub-catchments; mitigation of flows to pre-development or levels considered acceptable to both the applicant and downstream affected property owners and/or Auckland Council - Healthy

Waters – where existing flooding issues are well known and documented.

5.3.2 Mitigation Option Assessment

A sensitivity assessment against application of only AUP SMAF zone controls has been performed to gauge effectiveness of implementing these controls in relation to peak flows of larger events.

A proposed development model was created to assess the effect of removing the 90th percentile rainfall depth from both 10 and 1 % AEP storm events.

Although the peak flows are reduced, there is an overall increase in downstream accumulated flow, a summary of pre and post development flows including attenuation, and the effect on peak proposed flows with and without attenuation to SMAF level flow mitigation can be found below:

Table 8: Watercourse peak flow comparison – pre and post development (w/ SMAF mitigation)

Pre-Development			Post Development (FLOW 1)			
Watercourse	**10yr (m^3/s)**	**100yr (m^3/s)**	**10yr$_{CC}$ (m^3/s)**	**10yr Difference (%)**	**100yr$_{CC}$ (m^3/s)**	**100yr Difference (%)**
Western (SH1)	5.50	10.04	4.91	- 10.9%	10.98	+ 8.6%
A	0.46	0.84	1.40	+ 67%	2.76	+ 69.6 %
B, C	1.55	2.85	1.40	- 10.9%	1.81	- 57.6%
D	0.58	1.08	0.48	- 21.1%	0.93	-14.7 %
E	1.02	1.88	1.60	+ 36.1 %	3.21	+41.6 %
F	0.89	1.78	0.30	- 501.9%	0.57	- 470.1 %
G	3.31	6.09	3.88	+ 14.9%	8.10	+ 24.8 %
H, I	4.36	8.02	4.51	+ 3.6%	9.90	+ 18.9 %

As a result of the above, modelling was updated to include additional measures to mitigate additional flows from the subject development. These additional controls include:

- Onsite attenuate of 10YR flows to pre-development level.
- Catchment A – Detention basin for 10 & 100 YR ARI storm events.
- Catchment I – Detention basin for 10 & 100 YR ARI storm events
- Catchment H – Basin to provide attenuation for both 10/100 YR events, to offset the lower catchments (J & B) discharging to stream tributaries.

TABLE 9: PEAK FLOW COMPARISON – POST DEVELOPMENT MITIGATION ASSESSMENT

	Post Development		Post Development			
Sub Catchment	10yrcc (m^3/s)	100yrcc	10yrcc (m^3/s)	100yrcc	10yr Difference	100yr Difference
Catchment (A)	1.542	2.595	1.494	2.091	-0.048	-0.504
Catchment (B)	3.534	5.945	2.088	3.273	-1.446	-2.672
Catchment (H)	4.364	7.342	5.090	7.081	0.726	-0.261
Catchment (I)	0.467	0.787	0.973	1.822	0.506	1.035
Catchment (J)	6.148	10.213	6.271	10.001	0.123	-0.212

5.3.3 MITIGATION OPTION OUTCOME

The assessment summarised in section 5.3.2 demonstrates that SMAF zone controls alone do not suffice in mitigating the effects of increased impervious area in less frequent / high intensity storm events, although SMAF zone style controls are proposed for other hydrological reasons, additional controls of the 10% and 1% AEP rainfall runoff is required to ensure there are no negative effects on the downstream receiving environment. Modelling completed confirms the below (Table 10) expected flows if mitigation devices are provided for across the catchment as detailed below:

- All catchments to attenuate of 10YR flows to pre-development level at source/ on-site.
- Catchment A – Detention Ponds for attenuation of 10 & 100 Yr ARI storm events.
- Catchment I – Detention basin for reduction 10 & 100 YR ARI storm event flow.
- Catchment H – Basin to provide attenuation for both 10/100 yr events and to offset the lower catchments (J & B) discharging 1% flows directly to stream tributaries.

TABLE 10: PRELIMINARY SUB-CATCHMENT FLOW & AREA SUMMARY

	Pre-Development		Post Development	
Catchment	10YR (m3/s)	100YR (m3/s)	10YR (m3/s)	100YR (m3/s)
Culvert	1.542	2.595	1.474	2.091
Stream	14.365	24.168	13.961	21.888

The above summary gives a preliminary indication of the allowable flows and areas within the subject site where further mitigation of flow will or will not be required, generally all proposed flows from sub-catchments are reduced, there is opportunity to increase flows within catchments discharging to the Mahurangi Stream, public infrastructure downstream of the wetland could benefit from reduced controls, such that infrastructure required are reduced. This is to be investigated further at resource/engineering approval stage design when detailed coverage figures are available.

5.4 OVERLAND FLOWPATHS (OLFPS)

An assessment of the overland flow paths and flooding within the Clayden Road area has been completed. The outcomes of these assessments are presented in the following sub-section, as they relate to existing and proposed OLFPs.

The Clayden Road area is subject to numerous OLFPs, as per Figure 4 within Section 2.1.4 of this Report. These OLFPs include both minor and major OFLPs. These natural depressions correspond with the natural intermittent and permanent watercourses that exist.

The Clayden Road site will incorporate and allow for all existing OLFPs entering the site. Otherwise existing and proposed watercourses, greenways and roads within the site will convey overland flow through to the closest natural and existing exit point - ensuring any effect on downstream receiving environment is appropriately mitigated.

A summary of preliminary flows can be found above in table 4. These flows do not account for mitigation of flow or volume. Modelling completed to date suggest that a majority of the existing downstream overland flow paths are generally unaffected with minor change to existing flooding or flow extents despite the increase in flow generated as part of the proposed impervious coverage increasing. This is likely due to the deeply defined channels, generous grades and storage available within the riparian zones downstream.

Proposed mitigation of 1% storm events indicates significantly reduced peak flows such that flooding and effects on downstream properties are to be positively influenced by the development or the subject site and greater precinct.

5.4.1 MITIGATION OPTION ASSESSMENT – OFLPS

An options assessment has been undertaken to establish the best practical design criteria for the OLFP design in support of the Warkworth Clayden Road Development. These options included:

- Retention and protection of existing OLFPs through the development area.
- Maintaining the flow of OLFPs for 100yr cc ARI rainfall event under the maximum probable development scenario where downstream scenarios are considered acceptable.
- Directing all internal OFLPs within the proposed roading network, greenways or existing streams where possible.

5.5 STORMWATER QUALITY

The proposed Mahurangi Catchment will be developed for residential land which can generate contaminants. The AUP – OP stipulates under Chapter E9 when stormwater quality treatment is required. Treatment is required for high contaminant generating car parks (more than 30 parking spaces) and/or high use roads (more than 5000 vehicle movements / day). Chapter E9 requires treatment in accordance with TP10 and GD01 (subject to Plan Change 14 being approved).

The AUP – OP does not specifically set quality requirements but rather that high contaminant generating areas are treated by an approved stormwater quality device. Auckland Council's Stormwater Management Devices in the Auckland Region (GD01) provides detailed design considerations for stormwater devices. The ability of Auckland Council's GD01 best management practices to comply with any quality requirements and to provide enhanced treatment is summarised in Table 7 of TR2013/035, an extract of which can be found below:

Table 7. Ability of TP10 BMPs to comply with DEQRs and to provide enhanced treatment

	TSS		Total Copper		Total Zinc		Temperature	
	DEQR Compliant	Enhanced Treatment	DEQR Compliant	Enhanced Treatment	DEQR Compliant	Enhanced Treatment	DEQR Compliant	Enhanced Treatment
Pond	✓		✓	✓	✓			
Wetland	✓	✓	✓	✓	✓		✓[1]	
Swale	✓		✓		✓		✓	
Filter Strip	✓		✓		✓		✓	
Wetland Swale	✓		✓	✓	✓	✓	✓	
Sand Filter	✓	✓	✓		✓	✓	✓	
Bioretention (lined)	✓	✓	✓		✓	✓	✓	
Bioretention (unlined)	✓	✓	✓	✓	✓	✓	✓	✓
Permeable Paving (lined)	✓		✓		✓	✓	✓	
Permeable Paving (unlined)	✓	✓	✓	✓	✓	✓	✓	✓
Living Roof	✓	✓	✓[2]		✓		✓	✓

[1] Providing the wetland is highly vegetated and well shaded
[2] Providing design is compliant with Auckland Council guidance (Fassman, Simcock, & Voyde, 2010)

The Mahurangi catchment discharges into a SEA downstream of the precinct and ultimately to a CMA within the Warkworth Inlet, also a Significant Ecological Area, and requires contaminants of concern including sediment, metals and temperature to be treated from high contaminant generating areas. It is expected traffic modelling completed for future planning and subdivision consents will confirm numbers on both proposed collector and local roads, this will confirm whether VPD limit are reached. Conservatively, devices within the public road reserves will likely be required to meet water quality standards as no bulk treatment options outside of the MLR SW pond are proposed.

5.5.1 Mitigation Options Assessment (Stormwater Quality)

An options assessment has been undertaken to establish the best practical design criteria for the stormwater quality design in support of the Warkworth Clayden Road Development. These options include:

- At source stormwater quality control, where required by the AUP – OP. Lot development supported by approved propriety devices such as raingardens, tree pits, stormwater filters etc.
- Treatment of public roads and or right of ways via approved propriety devices (raingardens, stormwater filters etc) where required by the AUP – OP.
- Sub-catchment wide stormwater quality provision through enhancement of existing riparian zones and utilisation of proposed reclaimed greenways as biofiltration devices.
- Planting of riparian areas and protection of existing bush features within the site.

Opportunities

- Water quality in the water bodies within the structure plan area is currently relatively good for an urban catchment. Use of integrated stormwater management is an opportunity to maintain or enhance water quality.

- Design stormwater management that provides for a high level of water quality to protect the high ecological values and good water quality present in the area.
- Use riparian margins as part of water conveyance and to provide connections to other freshwater systems and other habitat types.
- The change in land use from rural land to urban is an opportunity to reduce sedimentation loading in freshwater systems and in the harbour

5.6 INFRASTRUCTURE

The runoff generated from the developed catchment from the 10-year$_{CC}$ ARI rainfall event will be conveyed by the proposed primary pipe network. The primary reticulated network will be sized to convey the peak discharge for rainfall events up to and including 10-year $_{(cc)}$ ARI to the existing or proposed Watercourses. There is no significant overland flow predicted for the 10-year $_{(cc)}$ ARI event.

During the 100-year $_{(cc)}$ event the stormwater runoff will be conveyed by overland flow paths within the proposed development, which will follow the road reserves, to existing watercourses, via reserves where required, which in turn discharge via or directly to the tributaries of the Mahurangi River.

5.7 OPPORTUNITIES

The Warkworth FUZ Watercourses Assessment report (may, 2019) raises a number of opportunities for enhancement, one of which (EO 1) is contained within the proposed precinct extents.

The area posed can be found identified below (Figure 17b).

Figure 17c: Warkworth FUZ WAR – Enhancement Opportunity 1 Area

The two main tributary of the eastern catchment (Watercourse I and K) provide a natural conveyance corridor for overland flows. This stream environment surrounding Watercourse I is currently protected by an existing covenant and the draft structure plan proposed creates a green corridor through or alongside this location. Watercourse K through EO1 area (as above) also have been assessed and introduction of esplanade reserve through subdivision consent is more than likely, development of which will provide for implementation of vegetation aiding in shading, erosion control connectivity to the upper conservation areas of the area.

Preliminary flow path calculations determine fully developed catchment's flows will not adversely affect the green corridors and watercourses with the appropriate runoff mitigation in place, enhancement of existing understorey planting and armouring of areas of significant erosion. Manning's channel flow calculations (appendix C) show that assumed increases in impervious area do not increase the risk of flooding of flow depths within or immediately downstream of developable area, as flow is contained to the existing channel extents.

Integration of best practice stormwater management principles is of high importance for the successful management of the catchment and deliverance of the overarching goal of protecting – and where possible – improving the quality of stormwater runoff into the receiving environment.

The development of the stormwater strategy is to take these principles into account and apply as the opportunity permits. The following lists the pillars for which the Mahurangi SMP is derived from:

1) Flood Mitigation;
2) Integration of Landscape values;
3) Water Sensitive Design;
4) Treatment of water prior to discharging into the receiving environment;
5) Enhancement and protection of the existing stream and native bush environments; and
6) Fish passage improvements where obstructions are present.

6 MAHURANGI STORMWATER MANAGEMENT PLAN

6.1 STORMWATER MANAGEMENT PRINCIPALS

This stormwater management strategy has been developed for the Warkworth Clayden Road Development and will enable the urbanisation of the live-zoned Residential land. Whilst this SMP relates specifically to the land within the Clayden Road site, the strategy sets a framework for other land owners to follow, within their respective developments as required by the Warkworth North East Precinct.

The following strategy has been developed to ensure compliance with the objectives and policies of the AUP – OP, Chapter E9 (stormwater quality) and the Auckland Council Stormwater Code of Practice.

The key components of the Mahurangi stormwater management strategy are as follows:

- Stormwater conveyance for 10yr $_{cc}$ ARI rainfall event
- Overland flow paths for 100yr $_{cc}$ ARI rainfall event to be accommodated within the site and conveyed to wetlands/detention basins.
- Treatment of runoff prior to discharge into receiving environment in accordance with GD01.
- Detention of 10 and 100 yr cc ARI rainfall events due to known restriction in the downstream network, specifically; culverts at SH1 (E530) and Sandspit Road.
- Detention of 90th Percentile flows to mitigate erosion associated with higher frequency / low intensity rainfall.

The rules for development collectively set out to minimise the effects of urbanisation on the receiving environment by managing the post development hydrology. The following elements have been considered in the formation of the stormwater management options for the Mahurangi catchment:

- Quality treatment required for the entire developable catchment.
- The developed catchment discharge must not result in, or increase, the flooding of properties, or inundation of buildings up to the 1% AEP event.
- The discharge must not cause or increase scouring or erosion at the point of discharge.
- Detention to pre-development stormwater runoff, as per SMAF zone controls as pe section E10 of the Unitary plan and onsite detention to ‘pre-development levels’ for 10% AEP events.
- The developed catchment discharge must not result in, or increase, the flooding of properties, or inundation of buildings up to the 1% AEP event.
- The diversion and discharge must be managed, and where possible dispersed, to minimise erosion and sediment generation.

The proposed stormwater management is considered on both a catchment wide and individual lot basis with respect to the main design elements of:

- Water quality
- Flood management
- Water sensitive design

An outline of the stormwater management options is summarised in the following sections.

6.2 Water Quality

The Clayden Road site will enable the intended residential use of the Warkworth North 2 Precinct. Developed land use can generate contaminants, which requires consideration and treatment as per the guidelines of Chapter E9 of the AUP – OP.

Subject to the AUP – OP, any single carpark specific area, containing 30 or more parking spaces or any road which will generate more than 5,000 vehicle trips per day, requires treatment to TP-10 / GD-01 standards. Traffic modelling completed by TPC as part of the proposed plan Warkworth North 2 application gives indicative vehicle movements at specific levels of roads. Tabled below for reference:

Road Category	Expected Traffic Movements (VPD)
Collector Roads	3500-5000
Local & Recreational Edge Roads	<500

Water sensitive design, appropriately designed in accordance with Auckland Council GD04 would see that water quality devices are incorporated into the treatment train of the stormwater network however, as such the need for at source treatment will include treatment of stormwater runoff from public roads ‘at source’ through green features such as rain gardens designed in accordance with GD01 due to a lack of suitable flat areas at the interface between developable land and the existing watercourses on site

As recommended in the “Prelim SMP” by Tonkin Taylor, treatment is be provided for at source when steep gradients and site constraints do not allow for wetlands or ponds. This provides quality treatment from contaminant generating areas, at a minimum, as required by the AUP – OP.

The overarching principle of the development is to provide treatment of all stormwater runoff upstream of the “Stream” catchment and also, or dependant on the solution agreed between downstream parties, of the SH1 “Culvert” catchment. Several at source and catchment wide treatment options have been considered for this catchment, which include the following;

- Inert or low contaminant generating cladding material for buildings, in accordance with initiatives such as no longer approving unpainted galvanised and zinc/aluminium.
- Sub-catchment quality devices, including:
    - Swales
    - Riparian Zone Enhancement
    - Esplanade Zone Vesting
- On-site propriety devices, including:
    - Raingardens
    - Stormwater filters
    - Tree pits
    - Permeable paving in shared spaces, car parking bays and driveways
- Stormwater quality treatment for all public roads and accessways.
    - Raingardens
    - Stormwater filters

- Swales
- Tree pits
- Permeable paving in shared spaces, car parking bays and driveways

6.3 STORMWATER / FLOOD MANAGEMENT

The detention components of the proposed primary and secondary networks should generally be provided at source (within each lot, or roadway) while flood mitigation be on catchment specific basis achieving outcomes equivalent to those in modelling undertaken - where net pre-post development discharge is achieved before discharging to the downstream receiving environment. Initial assessments based on singular detention devices on a precinct wide level was not favourable due to the known site topographical constraints, including; an expected esplanade reserve dividing the precinct, multiple watercourse (and therefore discharge points) dividing catchments, steep terrain, an SEA at the base of the precinct and issues with uncontrolled ground recharge resulting in slope stability.

The overarching principle of the development is to mitigate effects of increasing stormwater discharge up to the 10 and 100yr $_{cc}$ ARI event. Several practical at source and catchment wide treatment options are considered necessary for this catchment, which include the following;

- Sub-catchment specific devices for 1% AEP flood mitigation, including
  - Detention Basins (Dry)

Note: At source detention of 10% AEP flows has been shown to provide mitigation for a significant initial portion of the 1% rainfall volume.

- On-site/at source propriety devices for 10% AEP flow mitigation, including:
  - Raingardens, treepits, swales
  - Detention / Rainwater tanks
  - Permeable paving in shared spaces, car parks and driveways

Catchment specific attenuation details and requirements can be found in the appended stormwater modelling report by Maven Associates Ltd, a summary of which, based on receiving watercourses as identified below:

CATCHMENT	**SMAF 1 CONTROLS** ***(Detention Only)***	**ONSITE 10% AEP CONTROLS**	**1% AEP DETENTION BASIN**
Catchment (A)	✓	✓	✓
Catchment (B)	✓	✓	
Catchment (H)	✓	✓	✓
Catchment (I)	✓	✓	✓
Catchment (J)	✓	✓	

Note: Due to onsite ground disposal not being recommended for geotechnical reasons, retention volumes in a SMAF assessment are to be included in the detention volumes as per Table E10.6.3.1.1 Hydrology mitigation requirements, (2) (c) (i)

6.4 Erosion & Sedimentation

Erosion within the existing watercourses and solutions proposed during reclamation or introduced conveyance channels will need to be carefully designed and managed due to known geological issues.

Enhancement of existing watercourses is a priority, revegetation of lengths of currently unprotected streams is to be provided, as recommended in the 2019 Warkworth FUZ WAR, along the upper reach of Watercourse K1 (naming nominated by Freshwater Solutions) where an existing wetland is present.

Application of Riparian zones and Esplanade reserves, in combination with enhancement of riparian offsets via planting and/or engineered solutions aim to reduce existing watercourse erosion it documented in both specific upper and lower reaches or the precinct.

SMAF zone controls are proposed to act in an extended detention-like manor, aiding in reduction of flow volumes from higher frequency / lower intensity storm events attributable to long term erosion. While all outlet and discharge points proposed from developed areas shall include flow velocity mitigation measures such as but not limited to: level spreaders, outfall rip rap or scour control solutions and inbuilt network mitigation measures practically included, such as; minimum grades on discharging pipes, manhole sumps and baffles plates to mitigate increased flow velocities as a results of piping runoff.

6.5 Hydraulic Connectivity

Primary conveyance systems shall make use of the topography and natural watercourses, making sure that water quality and flow velocity is mitigated in accordance with recommendations outlined throughout this plan. Generally off-line wetlands are designed with high-flow bypasses incorporated into the design, for bioretention and water quality devices this methodology shall, where practical, remain the case as recommended in GD01.

Connectivity of the secondary conveyance systems and floodplains throughout the proposed development, due to elevation change across the various catchments, shall be maintained. Floodplains, more common in low lying, flat plains, are unlikely due to the topography and natural watercourses throughout the precinct.

It should be noted as a majority of the downstream watercourses, where floodplains may be present, are located in protected native bush or covenanted areas, modification as a result of development in unlikely. Connectivity issues outside of the scope of this precinct has not been assessed in detail, although aside from existing culvert restrictions already identified, flow to the coastline is more or less free flowing. Ecological Connectivity through enhancement of Watercourse K1, noted in section 6.4, also provides for defragmentation of significant conservation area north of the precinct and the SEA in the southern portions of the precinct extents.

6.6 GREENWAYS

The Auckland Council Structure plan urban design proposes multiple greenway routes through and within the site, which have potential to double as flow paths and detention basins for flood management.

Figure 18: Auckland Council Structure Plan Green Space

Existing ephemeral, intermittent and permanent watercourses within the site are to be maintained where practical, reclaimed stream will otherwise provide opportunity to add and fulfil several urban design and stormwater management outcomes:

- Stormwater Quality – GD01 / TP10
- Water Sensitive Design – GD04
- Ecological connectivity through the development site
- Green corridor connectivity
- Flood storage (detention), ensuring additional flood storage and retention of pre-development flow rates for upstream/downstream properties.

The existing or proposed watercourses receive stormwater runoff from the existing undeveloped upstream catchment, alongside the developed catchment of the Warkworth Clayden Road Development. The proposed piped network will discharge into the closest enhanced or reclaimed watercourse, whilst all OLFPs are designed to discharge into these features or be kept within road carriageways.

6.7 OVERLAND FLOWPATHS (OLFPS)

The Clayden Road site is dissected by a number of natural OLFPs, all of which need consideration as part of this stormwater strategy. A number of options have been explored with respect to the management and protection of the OLFPs as they are to be maintained in their current form, and consideration of the intended development (Predominantly residential land use) to take place around them.

The overarching principle of the development is to provide for all existing OLFPs to remain unaltered where practical, , whilst reducing the risk or effects of erosion, contamination and leaching. Several practical options are proposed for the Warkworth North 2 precinct, including:

- Primary collection and conveyance of runoff via public road carriageways.
- Discharge from the road corridors to natural conveyance channels, either directly or via reserves specifically designed for such use.
- Retention and protection of natural OLFPs and where possible; enhancement, through introduction of green Corridors, pest species control and replanting
- Piping of OLF, where retention of natural paths is not practical (If required and approved).
- Onsite Detention via ponds or Wetlands to neutralise any effects downstream due to increased runoff from impervious areas.
- Under both options, the conveyance of the OLFPs must be retained though the development site, ensuring no upstream flooding or downstream erosion effects.

An overland flow path plan has been generated based on preliminary design contours completed during feasibility and infrastructure assessments of the Clayden Road Site. The primary conveyance system for overland flow is the public road carriageways intercepting sheet flow from blocks of residentially zoned areas. The road networks generally follow the existing, but modified, contours that are to ultimately discharge into either headwaters of watercourses or via detention basins spilling over into lower reaches of specific watercourses.

7 IMPLANTATION STRATEGY

The outcomes of this SMP – whilst limited to the properties owned by the Applicant– provides a framework for the subject site and Clayden Road Development. Whilst the upstream catchment has been assessed as un-developed, controls consistent with the proposed will enable connection to shared watercourses enable the intended development of these properties. In no way, does this SMP implicate or impede the development of the wider Warkworth North-East Precinct.

The development of the wider catchment can be enabled through the adoption of the preferred outcome. Subject to the inclusion of catchment wide quality and detention control (within the respective ownership / resource consent applications), there will be no effects on the Clayden Road site, or indeed the receiving environment.

The SMP provides a clear framework that can guide the development of the sites sub-catchments, subject to detailed engineering design and ongoing Auckland Council and Healthy Waters input.

7.1 ASSET OWNERSHIP

It is proposed that all local and collector primary stormwater networks, including any stormwater detention and quality devices within road or stormwater reserves be vested to Healthy Waters, Auckland council or Auckland Transport as required.

Lot connections will be the interface between private and public asset ownership as per the Stormwater Code of Practice, the locations of which will be detailed and subject to approval during resource consent and furthermore engineering approval stage.

Stormwater devices located within private property for the purpose of mitigating flow from impervious areas are to be owned and maintained by the landowner.

7.2 ONGOING MAINTENANCE REQUIREMENTS

Provided that all assets are designed in accordance with Auckland council design guidelines, with future proofing and allowances for access and maintenance. It is considered that this requirement would be mandatory and assessed at the relevant design stages through the consenting phases of development

7.3 IMPLEMENTATION OF STORMWATER NETWORK

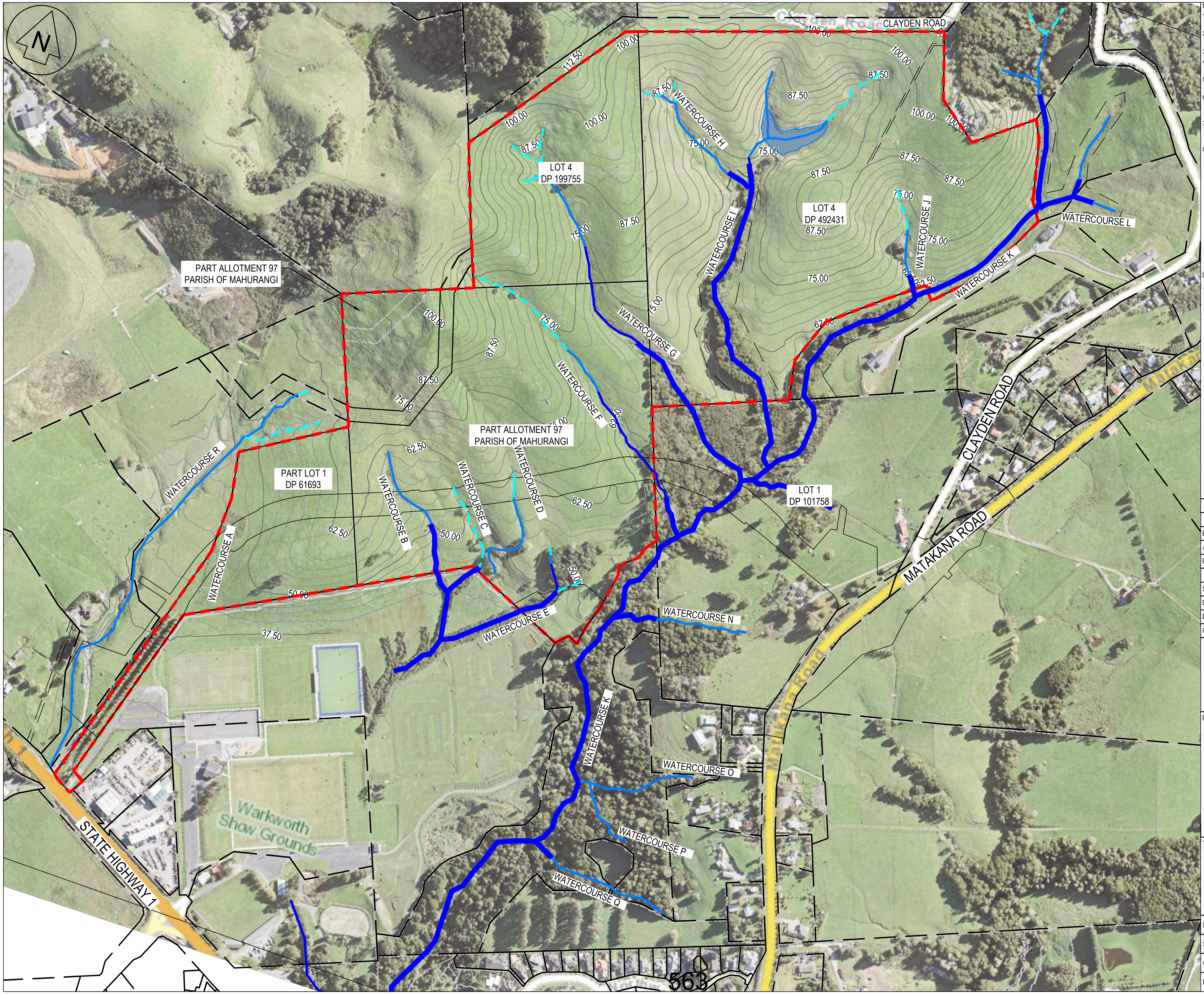
The driving requirement for stormwater controls to be built will come from a combination of both bulk earthworks; recontouring the site, reclamation of streams, major overland flow paths and detention basins. While the construction of public road systems will entail; local stormwater devices, catch pits and secondary flow networks to controls flows along carriageways and though what will initially be green field development.

Public assets built will be vested with council in accordance with council regulations and be subject to any land-use, subdivision and special engineering consent conditions, ensuring compliance with the NDC.

Private systems, more likely required for servicing of jointly owned accessways, commercial lots and carparks will be constructed and maintained, by the relevant land owners, at the time of construction. Requirements of compliance of which are outlined in this document.

APPENDIX A

ENGINEERING PLANS & DETAILS



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. It is the contractors responsibility to locate all services that may be affected by his operations.
5. The contractor shall comply with all relevant OSH and Health and Safety requirements.
6. The contractor shall obtain all necessary approval from utility operators before commencing work under or near their services.
7. Sediment control shall be installed and operational before earthworks start onsite in accordance with council standards.
8. Contractor shall provide asbuilt of working sediment control devices and confirmation of pond/decent volumes to engineer.

Legend

- EX BDY
- SITE EXTENTS
- 12.50 EX MAJOR CONTOUR
- EX MINOR CONTOUR
- PERMANENT FLOW
- INTERMITTENT FLOW
- EPHEMERAL FLOW
- EX POND

B	PPC	LC	10/19
A	STRUCTURE PLAN	JK	03/19
Rev	Description	By	Date

	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

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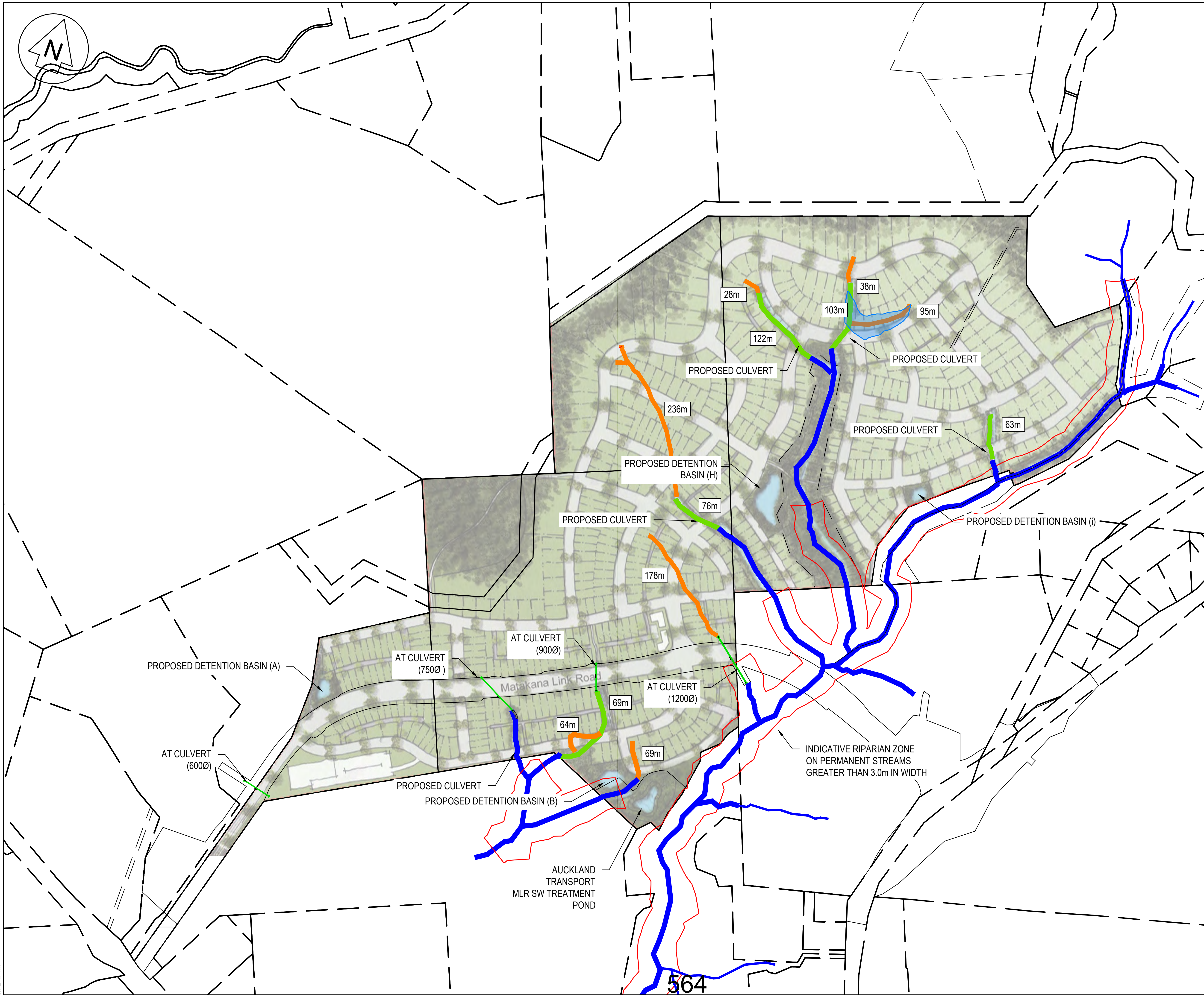
Project
CLAYDEN ROAD WARKWORTH PLAN CHANGE FOR WARKWORTH LAND LTD

Title
EXISTING WATERCOURSE PLAN

Project no.	102008
Scale	1:5000 @ A3
Cad file	102008 C060 SITE PLAN.DWG
Drawing no.	C450
Rev	B



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Total watercourse removed = 688m
6. Total watercourse reclaimed = 386m

Legend
- EX BDY
- EX EASEMENT
- PR BDY
- AT CULVERTS
- EX WATERCOURSE (MAINTAINED)
- EX WATERCOURSE (RECLAIMED)
- EX WATERCOURSE (REMOVED)
- EX WATERCOURSE (REMOVED VIA MLR)

Rev	Description	By	Date
C	PPC UPDATE	LC	12/19
B	PPC UPDATE	LC	10/19
A	PLAN CHANGE	JK	07/19

	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

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Project
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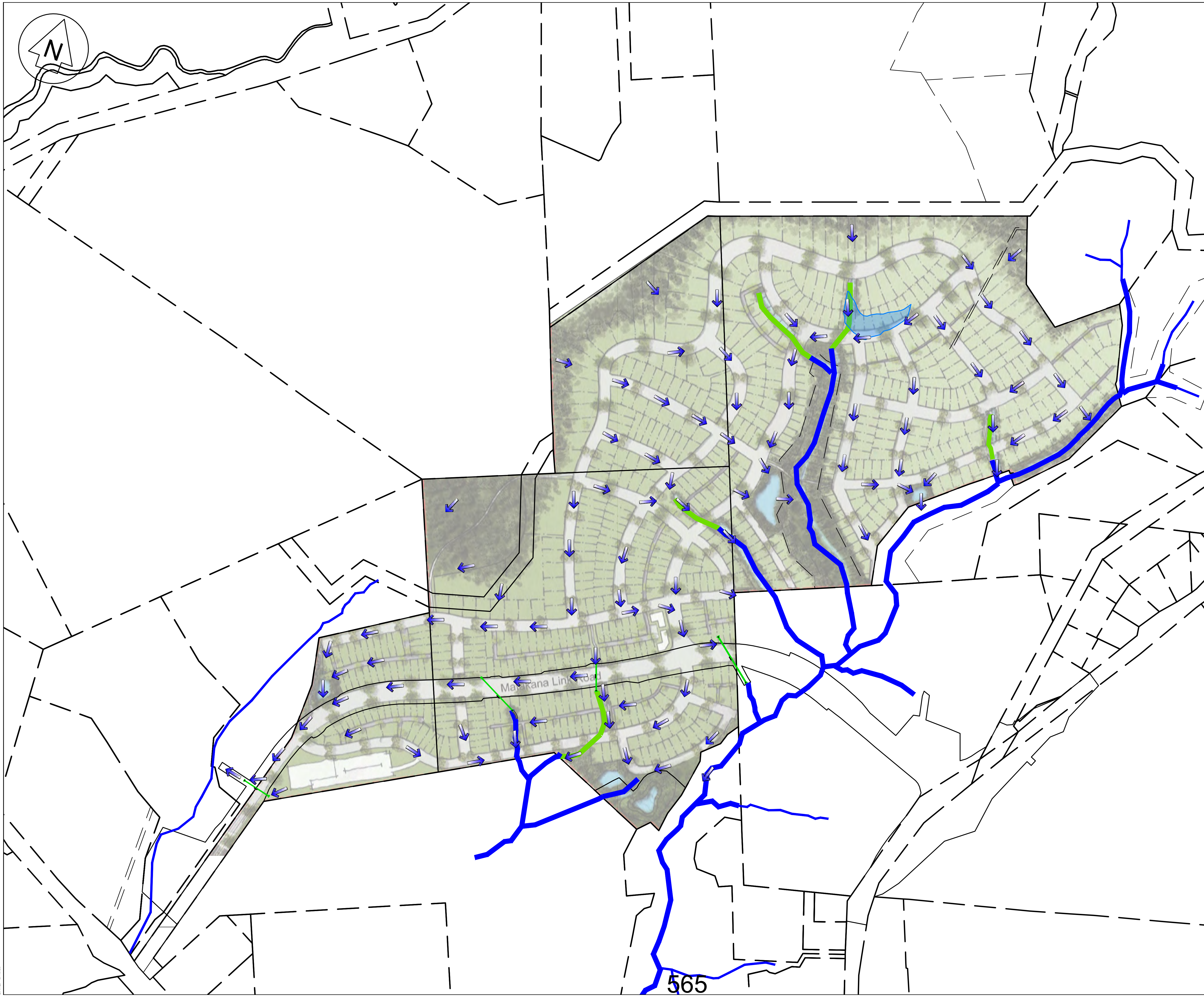
Title
PROPOSED WATERCOURSE PLAN

Project no.	102008
Scale	1:5000 @ A3
Cad file	102008 C451 STREAMS.DWG
Drawing no.	C451
Rev	B

DATE: 12/17/19



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.

Legend

EX BDY
EX EASEMENT
PR BDY
PR OLF DIRECTION
AT CULVERTS
EX WATERCOURSE (MAINTAINED)
EX WATERCOURSE (RECLAIMED)

Rev	Description	By	Date
A	PPC UPDATE	LC	10/19

	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

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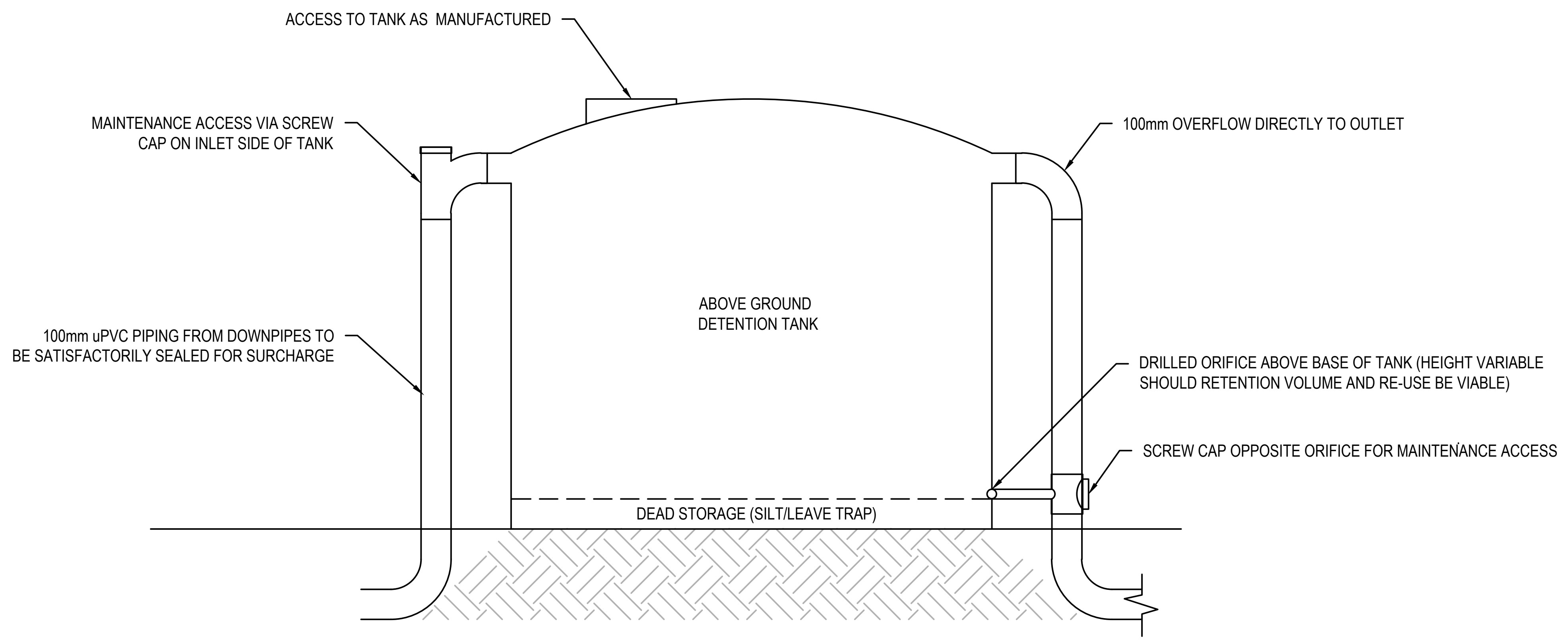
Project

CLAYDEN ROAD WARKWORTH PLAN CHANGE FOR WARKWORTH LAND LTD

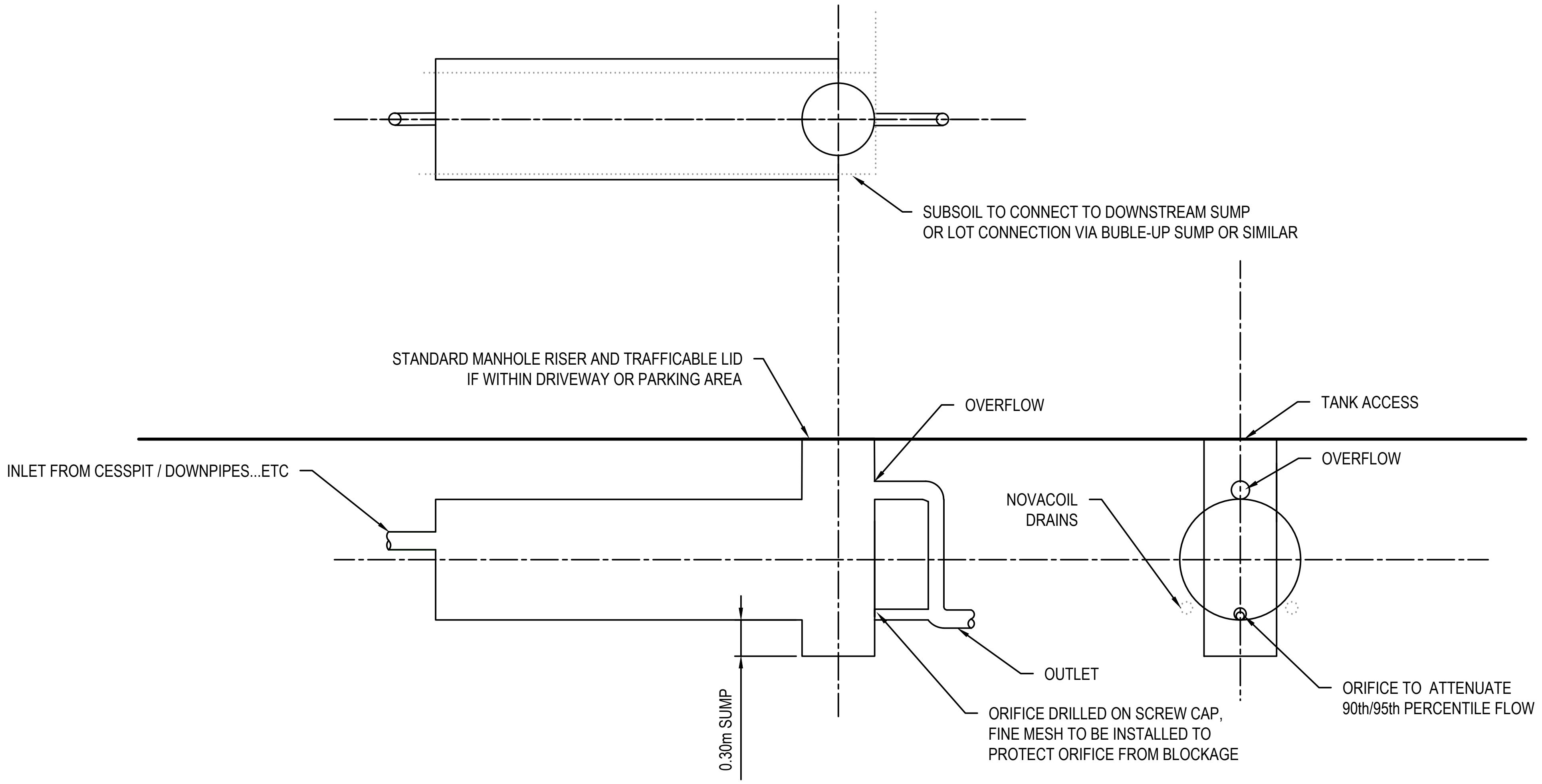
Title

PRELIMINARY OVERLAND FLOWPATH PLAN

Project no.	102008
Scale	1:5000 @ A3
Cad file	102008 C451 STREAMS.DWG
Drawing no.	C455
Rev	A



ABOVE GROUND TANK STANDARD DETAIL
SCALE 1:20 @ A3



UNDER GROUND TANK STANDARD DETAIL
SCALE 1:50 @ A3

Rev	Description	By	Date
A	PLAN CHANGE	AS	2019

	By	Date
Survey	C420	-
Design	GB	01/19
Drawn	AS	01/19
Checked	BV	01/19

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Project
CLAYDEN ROAD WARKWORTH PLAN CHANGE FOR WARKWORTH LAND LTD

Title
STORMWATER DETENTION TANK EXAMPLES

Project no.	102008
Scale	-
Cad file	102008 C430 TANKS.DWG
Drawing no.	C430
Rev	A

APPENDIX B

FRESHWATER SOLUTIONS REPORT EXTRACTS

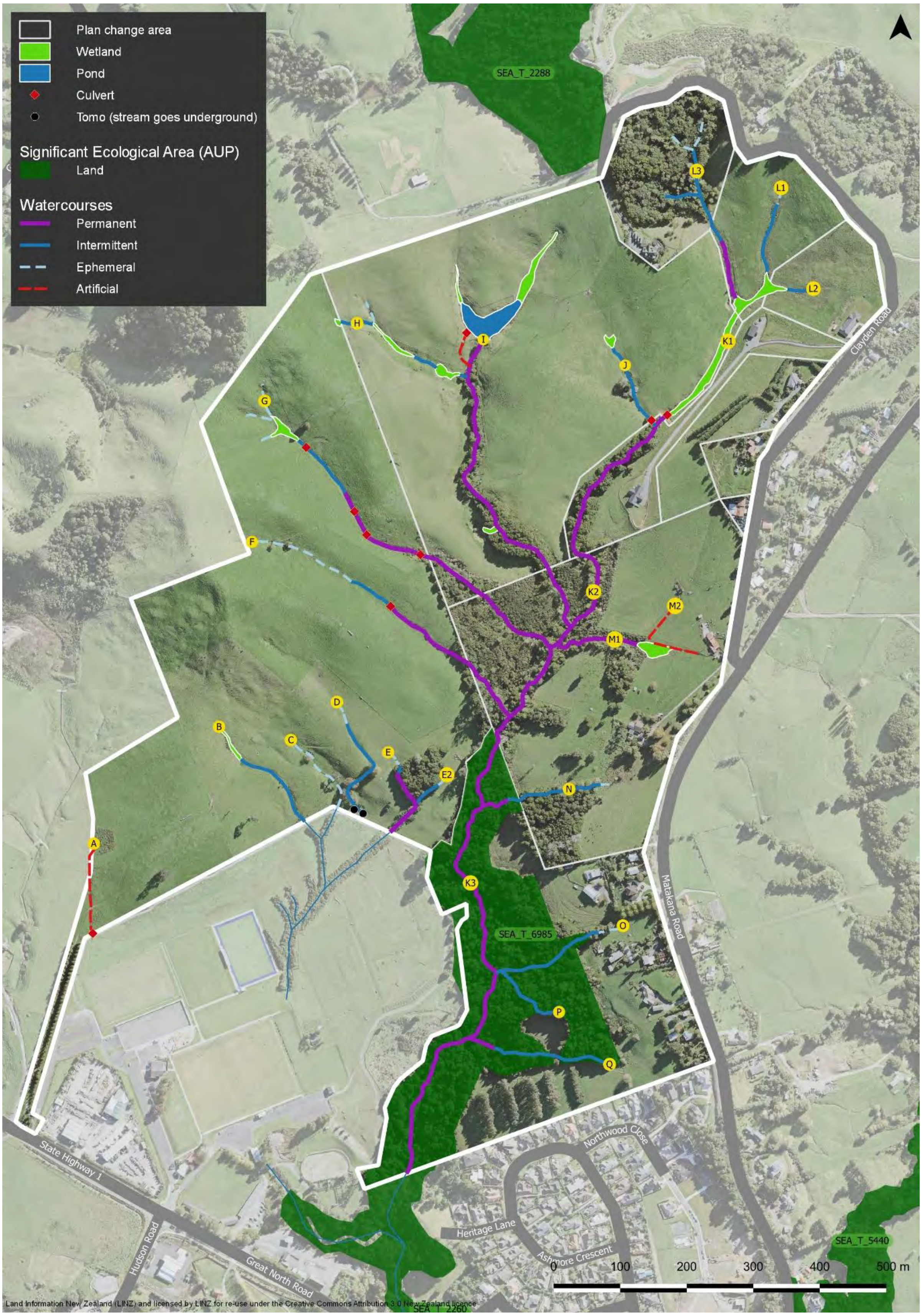


Figure 15: Stream classifications, ponds and wetlands within plan change area.

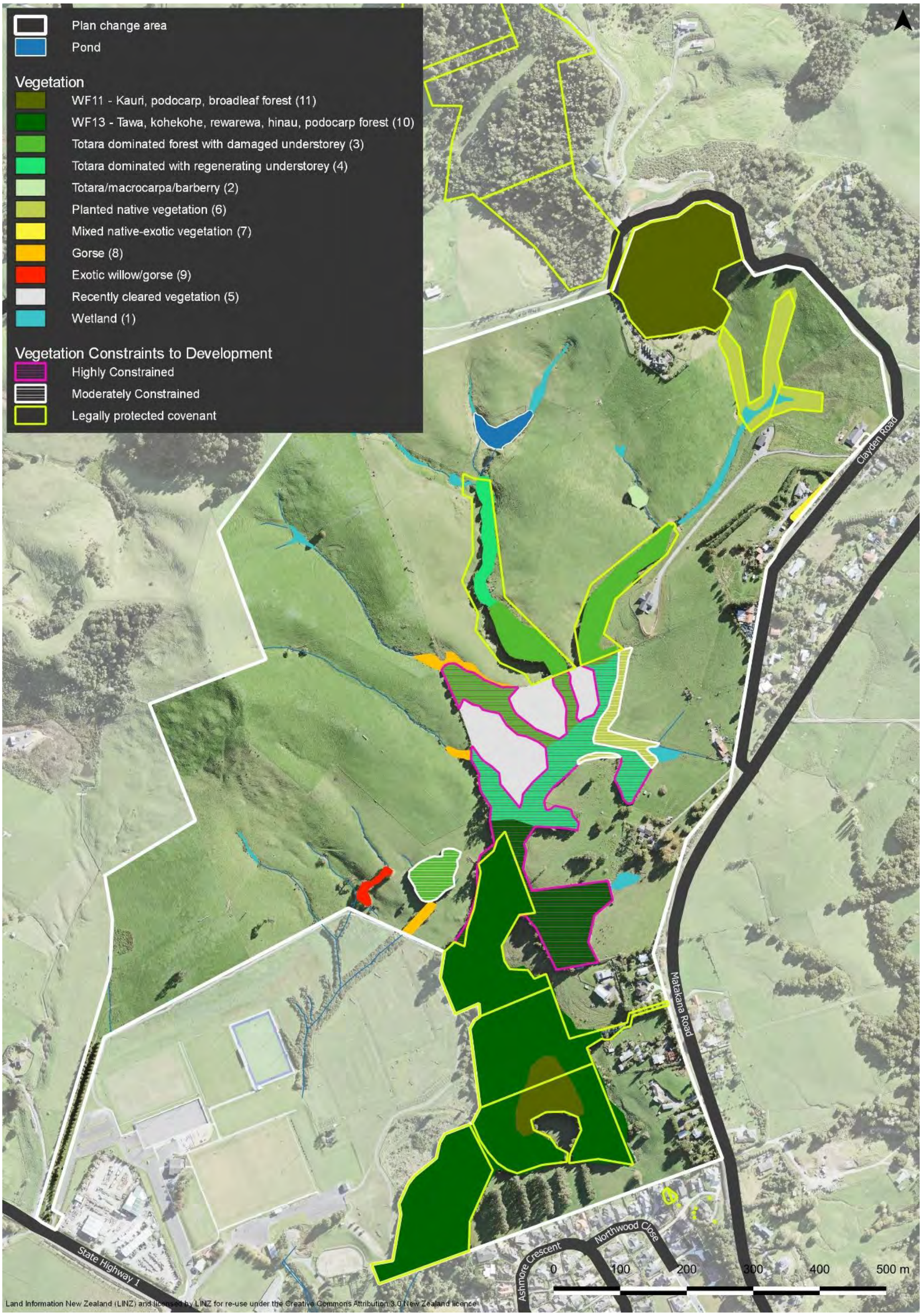


Figure 50: Areas of vegetation and constraints for future development.

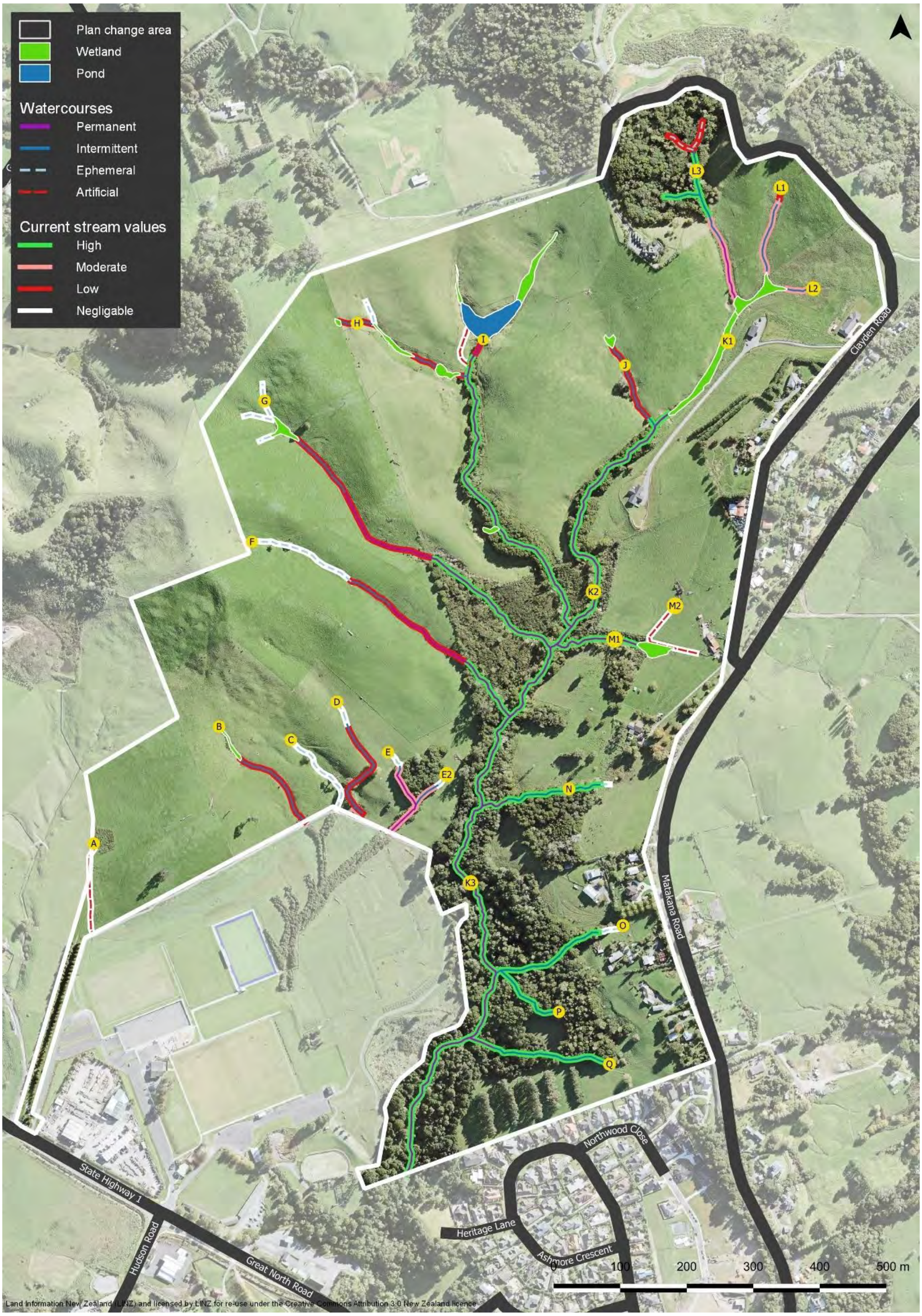


Figure 51: The current values of streams within the plan change area.

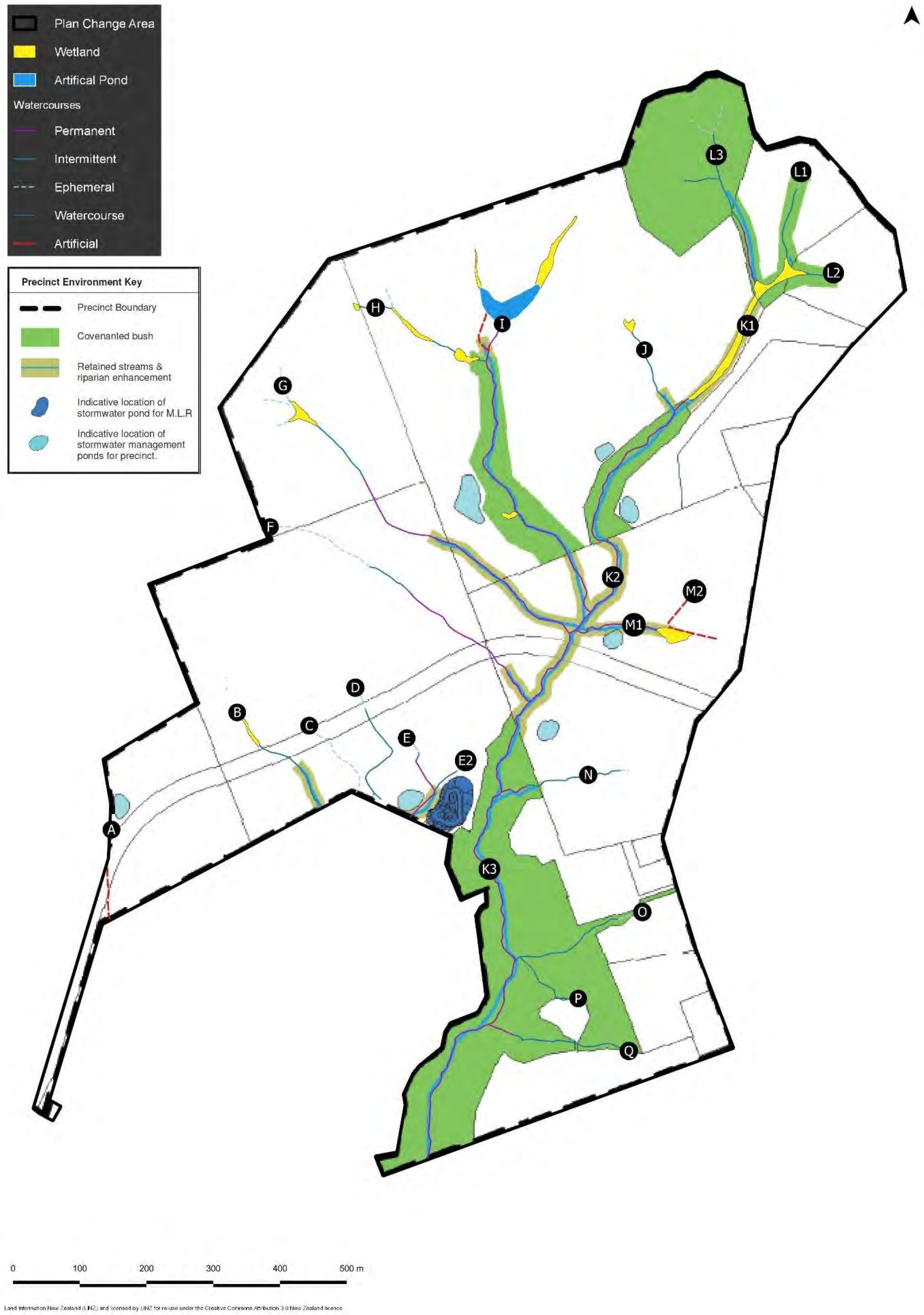


Figure 52: Precinct Plan 4 – Environment (A Studio Architects Revision E).

APPENDIX C

HEC-HMS MODELLING REPORT

HEC-HMS MODELLING REPORT

CLAYDEN ROAD, WARKWORTH

FOR

WARKWORTH LAND COMPANY

Maven Associates	Job Number 102008		Rev C
Job Title Clayden Road, Warkworth **Title** Stormwater Modelling Report	**Author** LC	**Date** 16.12.19	**Checked** GB

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to determine the existing flows and the effects of increased impervious coverage from within the Clayden Road development due to both currently proposed Auckland Council zoning and the subsequent private plan change application, in order to determine appropriate mitigation controls to be implements across the Clayden Road, Warkworth precinct. This methodology is considered appropriate as the precinct is contained wholly within the upper catchment of the identified Mahurangi Stream tributary located within the precinct boundary.

We note that a portion of the western precinct is part of a sperate catchment discharging westwards via a culvert under SH1.

This report is to accompany the Precinct Stormwater Management Plan, which outlines the stormwater management objectives, policies and mitigation methods of future development within the proposed precinct.

1.2 CATCHMENT RESTRICTIONS

Auckland Council have made the applicant aware of existing restrictions downstream of the subject site; in particular:

1) The Hill Road / Sandspit Road intersection Stormwater Culvert (Identified below in figure 1.)

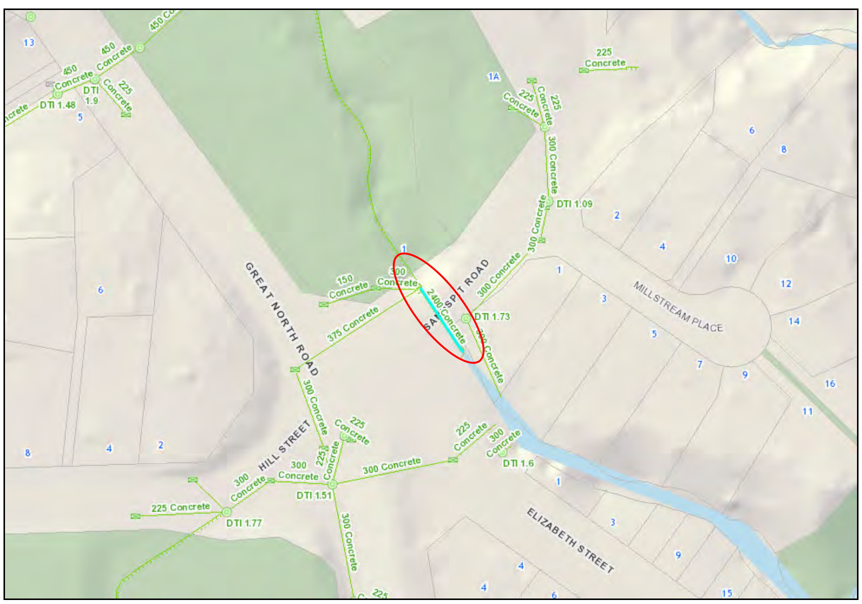


Figure 1: Sandspit Road Culvert Location

A 2300mm (from GEOMAMPS) culvert is an existing Auckland Council asset that has been assessed independently and found to be severely undersized for the combination of major (10 and 100yr ARI) storm events and the contributing catchment size. As of the date of issue, no plans to upgrade or replace this culvert are known. As such, the proposed development and precinct will be required to attenuate major storm events to pre-development levels.

2) The NZTA/SH1 Culvert (Known as Culvert E530, as part of the NX2 Puhoi to Warkworth Motorway project currently underway).

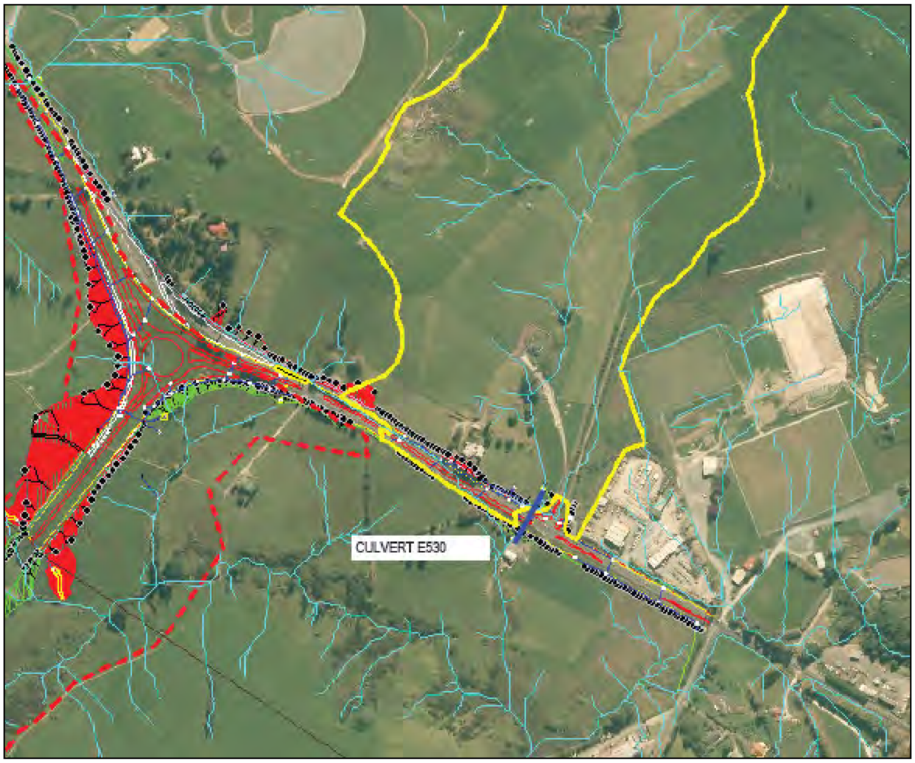


Figure 2: SH1 E530 Culvert Location

Culvert E530 is being replaced as part of the NX2 Puhoi to Warkowrth Motorway project. Although reports made public as part of the project (*51// SH1 widening stormwater memo V6 28-26-2018*) completed by Tonkin and Taylor determine that the hydraulic properties of the replacement culvert are to more of less meet the existing flows expected due to risk of increasing downstream properties. The below extract from this memo surmises reasoning:

The concept design for culvert E530 indicated that an 1,800 mm diameter culvert would be required to meet the Project's design requirements. However, the NX2 draft design report states that to provide a culvert larger than 1,200mm diameter would not result in a non-compliance with respect to RC68(b), and that the modelling results indicate that using a culvert larger than 1,200mm would increase flood levels downstream of the culvert at Lot 2 DP 405448 (CT 419127). However, due to the requirement to include fish passage in this culvert the culvert diameter has been increased to 1,350 mm. The NX2 draft report states that due to the increased hydraulic roughness provided by the fish baffles similar hydraulic performance to the existing culvert would be provided.

Again, the proposed development contributing area within the proposed precinct will be required to attenuate major storm events to pre-development levels.

1.3 STORMWATER MODELLING METHODOLOGY

Modelling within this report determines what current (existing) flows can be expected in both 10- and 100-year Annual Return Interval (ARI) storm events as a baseline for future pre to post development mitigation requirements.

The modelling completed then assesses proposed post development peak flows from 10 and 100 ARI storm events within the various existing watercourses and catchments, the Mahurangi tributaries, immediately downstream of the precinct area and development.

Stormwater modelling has been completed using HEC-HMS version 4.3 in conjunction with Auckland Council TP108, as per Auckland Council SWCoP recommendations; for both the existing and proposed development scenarios - allowing for climate change and assumed increased impervious coverage due to development in accordance with proposed urban zone changes.

TP108 calculations, allows for Climate change in post development scenarios which comprises of both an increase in the rainfall depth for a given event, as per SWcoP tables found below:

- **Table 4.1: Percentage Increase in 24-hour Design Rainfall Depth**

Annual Exceedance Probability (AEP)	Percentage Increase in 24-Hour Design Rainfall Depth Due to Future Climate Change*
50%	9.0%
20%	11.3%
10%	13.2%
5%	15.1%
2%	16.8%
1%	16.8%

* assuming 2.1°C increase in temperature

Table 4.2: TP108 Normalised 24-hour Temporal Rainfall Intensity Profile

Time (hrs:mins)	Time Interval (min)	TP108 Normalised Rainfall Intensity (I/I24)	
		Existing Condition	Future Climate Change*
0:00 – 6:00	360	0.34	0.33
6:00 – 9:00	180	0.74	0.73
9:00 – 10:00	60	0.96	0.95
10:00 – 11:00	60	1.40	1.40
11:00 – 11:30	30	2.20	2.20
11:30 – 11:40	10	3.80	3.82
11:40 – 11:50	10	4.80	4.86
11:50 – 12:00	10	8.70	8.86
12:00 – 12:10	10	16.20	16.65
12:10 – 12:20	10	5.90	5.95
12:20 – 12:30	10	4.20	4.24
12:30 – 13:00	30	2.90	2.92
13:00 – 14:00	60	1.70	1.70
14:00 – 15:00	60	1.20	1.19
15:00 – 18:00	180	0.75	0.75
18:00 – 24:00	360	0.40	0.39

* assuming 2.1°C increase in temperature

Rainfall data for the project has been obtained from the below from TP108.

Climate change has been applied as per the SWcoP:

10 YR ARI	210mm (x1.132) =	237.7mm
100YR ARI	310mm (x1.168) =	362.1mm

2.0 STORMWATER MODELLING

2.1 EXISTING SITE (PRE-DEVELOPMENT)

Currently the site is undeveloped and runoff from the site traverses one of 2 greater catchments of the Warkworth area, routes that ultimately discharge into the Mahurangi Stream. Several existing ridgelines and gullies delineate the site, watercourses across the site have been accessed by Freshwater solutions, there naming convention has been adopted in the naming of catchments and/or watercourses.

Most of the catchment accumulates and discharges into a permanent stream (Watercourse K) via various watercourses in defined gullies flowing southwards. The 'main' stream (K) traverses south via an Special Ecological Area and QE2 protected property below both; the subject site and the neighbouring 245 Matakana Road property, east of the Warkworth Showgrounds. This catchment eventually flows to the Sandspit Road Culvert identified in section 1 of this report.

A secondary catchment discharges to a culvert under SH1 – Great North Road to the west of the proposed development, modelling for this catchment has been completed in the same scenario, but is not linked to the same 'sink' due to the complicated flow path route and length, time of concentrations for the 2 catchment flows are not considered to coincide in any significant way downstream.

As a result of the above, the development has been split into several catchments - a pre-development catchment plan can be found appended. After an initial iteration of modelling the proposed scenario, the permanent stream (identified and known as Stream H & I, see appended Freshwater Stream plan) has be broken into multiple catchments to determine flows at the head of the proposed detention basins and base of uncaptured catchments separately.

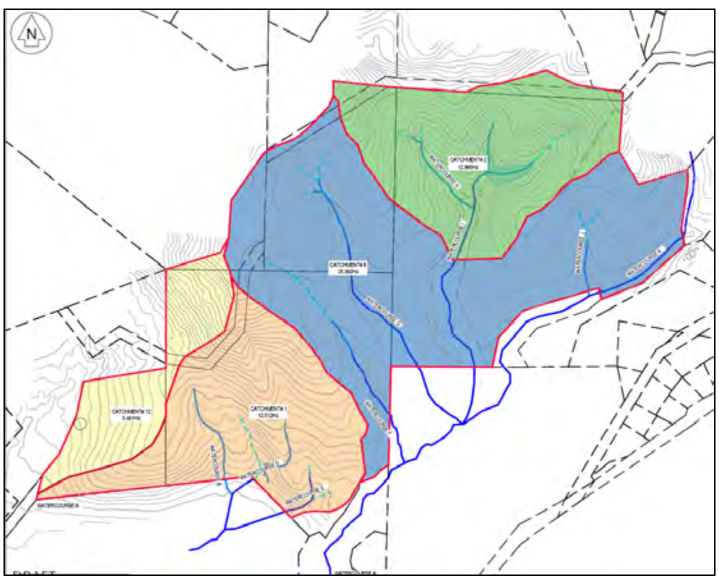


Figure 3: Site Catchment Plan

Runoff Factors

On the basis of validation against gauged catchments in the Region, the following Hydrological Soil Groups should be used:

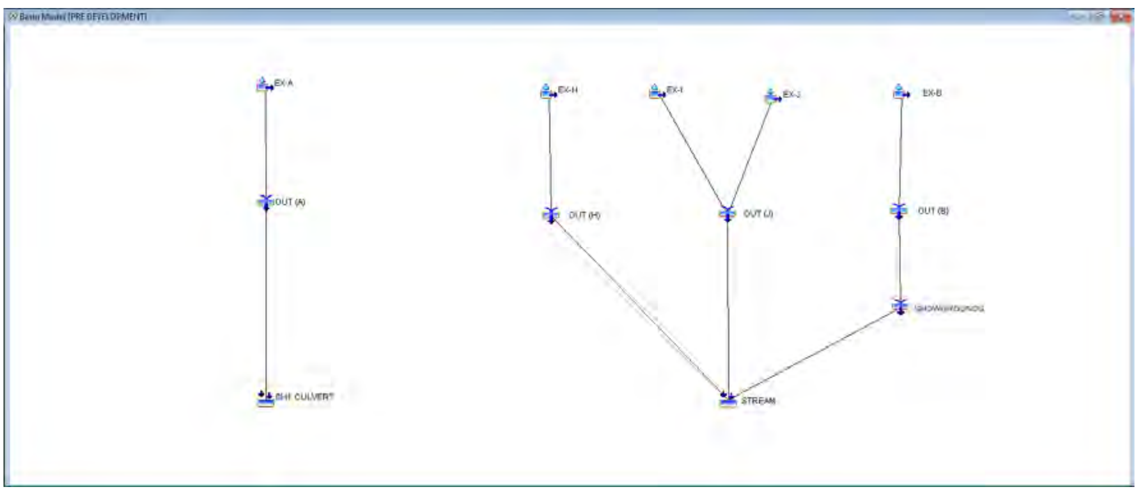
Table 3.2 - Hydrological Soil Classifications for prevalent Auckland Soils	
Auckland Soil	**SCS Hydrological Soil Group**
Weathered mudstone and sandstone (Waitemata and Onerahi Series)	Group C
Alluvial sediments	Group B
Granular volcanic loam (ash, tuff, scoria)	Group A
Granular volcanic loam underlain by free-draining basalt	use CN = 17 for all pervious areas

SCS Hydrological Soil Group — C - (As advised by CMW Geosciences)

Impervious Area — CN = 98 (Nil)

Pervious Area — CN = 74

2.2 HEC Model Overview:



Pre development catchment area summary:

PRE-DEV	AREA (Ha)
Catchment A	5.461
Catchment B	12.512
Catchment H	15.454
Catchment I	1.656
Catchment J	21.244

Table 1: Pre-Development Catchment Areas

Catchment A Areas discharging to the NZTA Culvert "E530"

Catchment B Area discharging directly to via sheet flow or into contributing watercourses crossings onto/in the Warkworth showgrounds

Catchment H Future Detention Basin Catchment, upstream of Watercourse I and H

Catchment I Future Detention Basin catchment discharging below watercourse K and above 245 Matakana Road

Catchment J Area downstream and contributing directly to the Mahurangi Stream Tributary

10YR – PREDEVELOPMENT SITE DISCHARGE

Rainfall Depth = 237.7mm

Global Summary Results for Run "10YR PRE"

Project: WLC - No DET Simulation Run: 10YR PRE

Start of Run: 01Jan2000, 00:00
End of Run: 02Jan2000, 00:00
Compute Time: 02Dec2019, 15:10:52

Basin Model: PRE DEVELOPMENT
Meteorologic Model: MET 10YR EX
Control Specifications: Control 1

Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
EX-A	0.05461	1.54226	01Jan2000, 12:05	9.14169
EX-B	0.12512	3.53357	01Jan2000, 12:05	20.94503
EX-H	0.15454	4.36443	01Jan2000, 12:05	25.86992
EX-I	0.01656	0.46768	01Jan2000, 12:05	2.77214
EX-J	0.21244	5.99961	01Jan2000, 12:05	35.56236
OUT (A)	0.05461	1.54226	01Jan2000, 12:05	9.14169
OUT (B)	0.12512	3.53357	01Jan2000, 12:05	20.94503
OUT (H)	0.15454	4.36443	01Jan2000, 12:05	25.86992
OUT (J)	0.22900	6.46729	01Jan2000, 12:05	38.33449
SHOWGROUNDS	0.12512	3.53357	01Jan2000, 12:05	20.94503
SH1 CULVERT	0.05461	1.54226	01Jan2000, 12:04	9.14169
STREAM	0.50866	14.36529	01Jan2000, 12:04	85.14945

Pre development 10YR Discharge Summary:

PRE-DEV	Q_{10} (m3/s)
Catchment A	1.542
Catchment B	3.534
Catchment H	4.364
Catchment I	0.468
Catchment J	6.000

Table 2:10YR Pre Development Peak Flows

Pre-Development 10YR Combined Flows

POST-DEVELOPMENT	Q_{10} (m3/s)
E530 Culvert	1.542
Mahurangi Tributary	14.365

Table 3:10YR Pre Development Combined Peak Flows

100YR – PREDEVELOPMENT SITE DISCHARGE

Rainfall Depth = 362.1mm

Global Summary Results for Run "100 YR PRE"

Project: WLC - No DET   Simulation Run: 100 YR PRE

Start of Run: 01Jan2000, 00:00   Basin Model: PRE DEVELOPMENT
End of Run: 02Jan2000, 00:00   Meteorologic Model: 100YR +CC
Compute Time:02Dec2019, 15:12:55   Control Specifications:Control 1

Show Elements: All Elements   Volume Units: MM 1000 M3   Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
EX-A	0.05461	2.59455	01Jan2000, 12:05	15.53326
EX-B	0.12512	5.94452	01Jan2000, 12:05	35.58911
EX-H	0.15454	7.34228	01Jan2000, 12:05	43.95732
EX-I	0.01656	0.78677	01Jan2000, 12:05	4.71032
EX-J	0.21244	10.09314	01Jan2000, 12:05	60.42639
OUT (A)	0.05461	2.59455	01Jan2000, 12:05	15.53326
OUT (B)	0.12512	5.94452	01Jan2000, 12:05	35.58911
OUT (H)	0.15454	7.34228	01Jan2000, 12:05	43.95732
OUT (J)	0.22900	10.87991	01Jan2000, 12:05	65.13671
SHOWGROUNDS	0.12512	5.94452	01Jan2000, 12:05	35.58911
SH1 CULVERT	0.05461	2.59455	01Jan2000, 12:04	15.53326
STREAM	0.50866	24.16671	01Jan2000, 12:04	144.68314

Pre Development Peak Discharge Summary:

PRE-DEV	Q_{100} (m3/s)
Catchment A	2.595
Catchment B	5.945
Catchment H	7.342
Catchment I	0.787
Catchment J	10.880

Table 4:100YR Pre Development Peak Flows

Pre-Development 100YR Combined Flows

POST-DEVELOPMENT	Q_{100} (m3/s)
E530 Culvert	2.595
Mahurangi Tributary	24.168

Table 5:100YR Pre Development Combined Peak Flows

2.4 POST DEVELOPMENT

The proposed precinct plan is divided into zones that have varying impervious coverage requirements.

As the catchments cross these boundaries several sub-catchments contribute to the overall catchment impervious coverage. A summary of the impervious coverage for each of the proposed developments catchment plan can be found in section 2.7 below:

Notes that these coverage calculations consider all pervious upstream catchments. HEC_HMS modelling completed also separates these catchment areas into contributing sub-catchment classes of either; Proposed Impervious Area, Proposed Permeable Areas, Existing Permeable Area.

2.7 MODEL SUMMARY – POST DEVELOPMENT

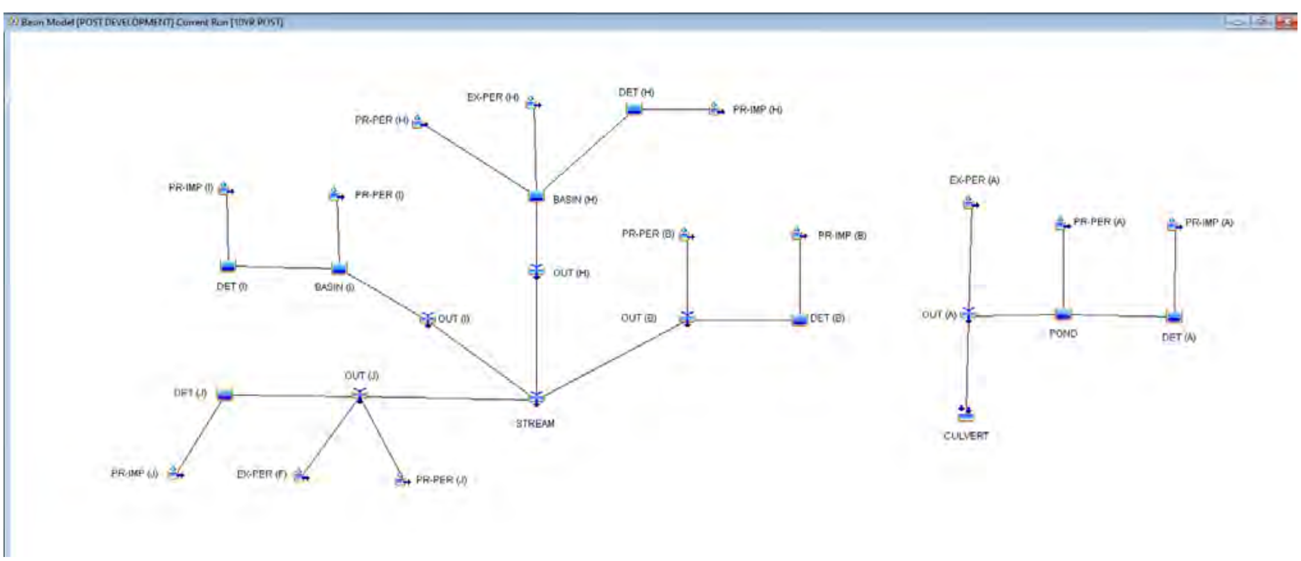
The proposed development modelled contain a number of mitigation measures to reduce the effects of increased flows from the built environment. Options assessed and included can be found summarised below:

1. Attenuation of 10YR flows resulting from additional impervious areas (Pre-Post onsite mitigation) – Future development Condition.
2. Pond/s or Basin/s capturing the 10 and 100 flows from Catchment A, upstream of Culvert E530,
3. Basins at the base Watercourses H & I to attenuate 10/100yr peak flows (offsetting development wide peak flows discharging to the Mahurangi Stream Tributary.

SCS Hydrological Soil Group	C - (As advised by CMW Geosciences)
Impervious Area	CN = 98 (Nil)
Pervious Area	CN = 74

2.8 HEC-HMS STORMWATER MODELLING

HEC Model Overview:



POST-DEVELOPMENT	AREA (Ha)	IMP. COVERAGE (%)
Catchment A	7.484	39.3%
Catchment B	6.305	67.6%
Catchment H	16.597	44.8%
Catchment I	3.557	60.0%
Catchment J	19.755	48.5%

Table 6: Post Development Impervious Coverage

Pond A Details:

A pond/basin has been modelled due to an initial sizing exercise determined an area of approximately 1000m2 and up to 2.0m depth to confirm the required volume to attenuate flows to pre-development levels.

Elevation storage table from HEC-HMS modelling:

Elevation (M)	Storage (1000 M3)
0.0	0.000
0.5	0.100
1.0	0.300
1.5	0.678
2.0	1.200

A weir/orifice will control flows rising above this is lesser storm events.

The wetland flow is to be controlled via outlet control, modelling completed verified this via use of weir and spillway, an orifice or similar would achieve the same result.

Weir Length: (1) 0.61m (2) 0.30m
Weir Elevation: (1) 0.00m (2) 1.37m (Above Base)
Spillway Elevation: 2.00m

Depth/flow/storage results can be found within section 2.8.

Basin H Details:

A detention basin is proposed at the base Watercourse H.

Elevation storage table from HEC-HMS modelling:

Elevation (M)	Storage (1000 M3)
0.00	0.0000
0.10	0.0375
1.50	1.0150
1.75	1.2500

A weir/orifice will control flows rising above this is lesser storm events.

The wetland flow is to be controlled via outlet control, modelling completed verified this via use of weir and spillway, an orifice or similar would achieve the same result.

Weir Length: 3.50m
Weir Elevation: 0.00m
Spillway Elevation: 1.75m

Basin I Details:

A detention basin is proposed at the base of Watercourse K/J.

Elevation storage table from HEC-HMS modelling:

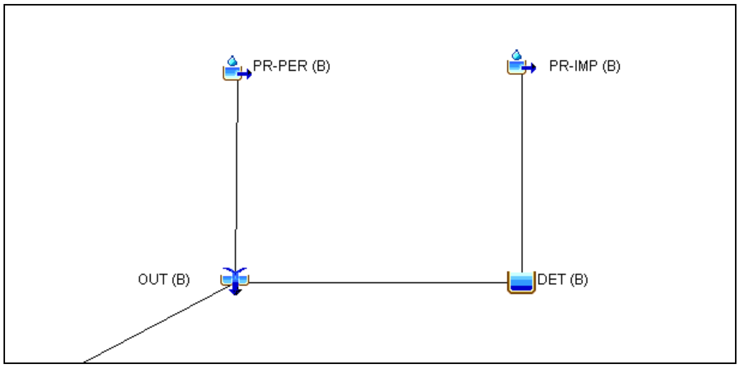
Elevation (M)	Storage (1000 M3)
0.0	0.000
1.3	0.105
2.3	0.376
2.5	0.458

The wetland flow is to be controlled via outlet control, modelling completed verified this via use of an orifice and spillway, a weir or similar would achieve an equivalent result.

Orifice Diameter: 0.45m(Dia)
Orifice Elevation: 0.00m
Spillway Elevation: 1.75m

Onsite Detention Details:

Future impervious coverage within each lot will require detention of peak flows above pre-developments levels. Each catchments future impervious area has been modelled separately to model attenuation of these sub-catchments, an example of this is catchment B can be found below:



The modelling competed is theoretical in nature only, to include the attenuation benefits of onsite mitigation on the downstream ponds and wetlands and greater catchment.

POST-DEVELOPMENT	AREA (Ha)	IMP. COVERAGE (%)	IMP AREA (Ha)
Catchment A	7.484	39.3%	2.939
Catchment B	6.305	67.6%	4.264
Catchment H	16.597	44.8%	7.438
Catchment I	3.557	60.0%	2.134
Catchment J	19.755	48.5%	9.572

Table 7: Post Development Catchment Areas

Each of the above impervious areas had a “pre-development” model ran to determine a theoretical volume and orifice sizing in order to attenuate flows onsite. Results of the modelling can be identified at each “DET” node downstream of catchments Impervious node.

10YR Post development Discharge

Rainfall Depth = 237.7mm

Global Summary Results for Run "10 YR POST"

Project: WLC - No DET   Simulation Run: 10 YR POST

Start of Run: 01Jan2000, 00:00   Basin Model: POST DEVELOPMENT
End of Run: 02Jan2000, 00:00   Meteorologic Model: Met 10YR
Compute Time: 02Dec2019, 15:20:16   Control Specifications: Control 1

Show Elements: All Elements   Volume Units: MM 1000 M3   Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
BASIN (H)	0.16597	5.09032	01Jan2000, 12:07	32.82155
BASIN (I)	0.03557	0.97283	01Jan2000, 12:11	7.33302
CULVERT	0.07254	1.49423	01Jan2000, 12:14	14.04225
DET (A)	0.02848	1.01413	01Jan2000, 12:06	6.73322
DET (B)	0.04264	1.51178	01Jan2000, 12:06	10.09443
DET (H)	0.07438	2.63721	01Jan2000, 12:06	17.63338
DET (i)	0.02134	0.76593	01Jan2000, 12:05	4.95167
DET (J)	0.09572	3.39804	01Jan2000, 12:06	22.65351
EX-PER (A)	0.02134	0.46317	01Jan2000, 12:14	3.55654
EX-PER (F)	0.03288	0.92858	01Jan2000, 12:05	5.50410
EX-PER (H)	0.01858	0.52473	01Jan2000, 12:05	3.11028
OUT (A)	0.07254	1.49423	01Jan2000, 12:15	14.04225
OUT (B)	0.06305	2.08772	01Jan2000, 12:06	13.51105
OUT (H)	0.16597	5.09032	01Jan2000, 12:07	32.82155
OUT (I)	0.03557	0.97283	01Jan2000, 12:11	7.33302
OUT (J)	0.19755	6.27149	01Jan2000, 12:06	39.69981
POND	0.05120	1.03285	01Jan2000, 12:16	10.48571
PR-IMP (A)	0.02848	1.01036	01Jan2000, 12:05	6.74514
PR-IMP (B)	0.04264	1.51269	01Jan2000, 12:05	10.09877
PR-IMP (H)	0.07438	2.63870	01Jan2000, 12:05	17.61600
PR-IMP (I)	0.02134	0.75559	01Jan2000, 12:05	4.94587
PR-IMP (J)	0.09572	3.39576	01Jan2000, 12:05	22.67013
PR-PER (A)	0.02272	0.64165	01Jan2000, 12:05	3.80332
PR-PER (B)	0.02041	0.57641	01Jan2000, 12:05	3.41662
PR-PER (H)	0.07301	2.06191	01Jan2000, 12:05	12.22184
PR-PER (I)	0.01423	0.40188	01Jan2000, 12:05	2.38210
PR-PER (J)	0.06895	1.94725	01Jan2000, 12:05	11.54220
STREAM	0.46214	13.96149	01Jan2000, 12:06	93.36543

Overall Summary

POST-DEVELOPMENT	Q_{10} (m3/s)	Δ Q (+/-)
Catchment A	1.494	-0.048
Catchment B	2.088	-1.446
Catchment H	5.090	0.726
Catchment I	0.973	0.505
Catchment J	6.271	0.271

Table 8: 10YR Post Development Peak Flows

All Q10 flows modelled are less than pre-development Q10 flows determined earlier.

Combined Catchment Discharge:

POST-DEVELOPMENT	Q_{10} (m3/s)	Δ Q (+/-)
E530 Culvert	1.474	-0.068
Mahurangi Tributary	13.961	-0.404

Table 9: 10YR Post Development Combined Peak Flows

100YR Post Development Discharge

Rainfall Depth = 362.1mm

Discharge Details

Global Summary Results for Run "100 YR POST"

Project: WLC - No DET Simulation Run: 100 YR POST

Start of Run: 01Jan2000, 00:00 Basin Model: POST DEVELOPMENT
End of Run: 02Jan2000, 00:00 Meteorologic Model: 100YR +CC
Compute Time:02Dec2019, 15:24:04 Control Specifications:Control 1

Show Elements: All Elements Volume Units: MM 1000 M3 Sorting: Alphabetic

Hydrologic Element	Drainage Area (KM2)	Peak Discharge (M3/S)	Time of Peak	Volume (1000 M3)
BASIN (H)	0.16597	7.08130	01Jan2000, 12:11	52.67310
BASIN (I)	0.03557	1.82180	01Jan2000, 12:06	11.63429
CULVERT	0.07254	2.09135	01Jan2000, 12:14	22.69888
DET (A)	0.02848	1.54714	01Jan2000, 12:05	10.25970
DET (B)	0.04264	2.30291	01Jan2000, 12:05	15.36935
DET (H)	0.07438	4.01179	01Jan2000, 12:06	26.82974
DET (i)	0.02134	1.14998	01Jan2000, 12:06	7.58805
DET (J)	0.09572	5.17386	01Jan2000, 12:06	34.49127
EX-PER (A)	0.02134	0.78110	01Jan2000, 12:14	6.04495
EX-PER (F)	0.03288	1.56215	01Jan2000, 12:05	9.35238
EX-PER (H)	0.01858	0.88275	01Jan2000, 12:05	5.28489
OUT (A)	0.07254	2.09135	01Jan2000, 12:15	22.69888
OUT (B)	0.06305	3.27260	01Jan2000, 12:05	21.17477
OUT (H)	0.16597	7.08130	01Jan2000, 12:11	52.67310
OUT (I)	0.03557	1.82180	01Jan2000, 12:06	11.63429
OUT (J)	0.19755	10.00126	01Jan2000, 12:06	63.45578
POND	0.05120	1.31463	01Jan2000, 12:20	16.65392
PR-IMP (A)	0.02848	1.53912	01Jan2000, 12:05	10.27521
PR-IMP (B)	0.04264	2.30436	01Jan2000, 12:05	15.38395
PR-IMP (H)	0.07438	4.01966	01Jan2000, 12:05	26.83532
PR-IMP (I)	0.02134	1.15227	01Jan2000, 12:05	7.59014
PR-IMP (J)	0.09572	5.17292	01Jan2000, 12:05	34.53451
PR-PER (A)	0.02272	1.07944	01Jan2000, 12:05	6.46247
PR-PER (B)	0.02041	0.96969	01Jan2000, 12:05	5.80542
PR-PER (H)	0.07301	3.46874	01Jan2000, 12:05	20.76695
PR-PER (I)	0.01423	0.67607	01Jan2000, 12:05	4.04758
PR-PER (J)	0.06895	3.27585	01Jan2000, 12:05	19.61212
STREAM	0.46214	21.88781	01Jan2000, 12:06	148.93794

POST-DEVELOPMENT	Q_{100} (m3/s)	Δ Q (+/-)
Catchment A	2.091	-0.504
Catchment B	3.273	-2.672
Catchment H	7.081	+0.261
Catchment I	1.822	+1.035
Catchment J	10.001	-0.887

Table 10: 100YR Post Development Peak Flows

Combined Catchment Discharge:

POST-DEVELOPMENT	Q_{100} (m3/s)	Δ Q (+/-)
E530 Culvert	2.091	-0.504
Mahurangi Tributary	21.888	-2.280

Table 11: 100YR Post Development Combined Peak Flows

3.0 ESPLANADE RESERVE ASSESSMENT

3.1 INTRODUCTION & RATIONALE

Under the Resource Management Act 1991, a 20m wide esplanade reserve is required to be set aside if land is subdivided to allotments of less than 4 hectares and is adjacent to a stream of 3m or greater in width. The definition in the RMA requires the stream bed to be more than 3m wide “at its annual fullest flow without overtopping its banks”.

The method requested by Healthy Waters is to model flows for the 2.33 year storm event to determine whether or not the ‘annual’ flows are greater than 3.0m in width - very conservative when considering the purpose of the esplanade reserve, the ecological specialists classifications and the state of the current ‘watercourses’.

Regardless, this assessment has been completed in compliance with that request. It is note-worthy that TP108 rainfall in the area north or Auckland does not marry well with historical data available from NIWA (TP108 determines rainfall as 130mm for a 2YR event at the subject site, whereas NIWA historical data shows rainfall is closer to 95mm)

It should also be noted that no assessment of overtopping banks is included, as intermittent and ephemeral watercourses that form part of this assessment failed, during site topographical survey, to always define a top and/or bottom of bank either side of the sites watercourses in the upper reaches of the catchment.

3.2 MODELLING METHODOLOGY

Stormwater runoff from the catchment, equivalent to the catchments used with section 2.0 of this report, were modelled across the various watercourses using TP108.
Each watercourse assessed was split into sections and a peak flow and time of concentration determined at each section was calculated using TP108.

HEC-RAS, updated within current survey data of stream topography and peak flows determined for the applicable catchment, watercourse and storm event model channel flows, depths and widths.

3.3 MODEL RESULTS

Topographical survey of the site watercourses has been completed and the base model of the site updated from previous LiDAR and Drone data to define the watercourse features more clearly along critical portions of the watercourse network.

Flow extents from the model have been extracted and plotted over the site plan, sections where flow width have preliminarily been offset 20m to identify the maximum extent of esplanade reserve reach into the precinct. Through subdivision process these areas will be refined to determine whether the requirements of the RMA are met in that 1) the stream bed is greater than 3.0m in width and, 2) the annual fullest flows are contained without overtopping stream banks – or any further such criteria required by the relevant authority.

A snapshot of the sitewide model can be found below for reference:

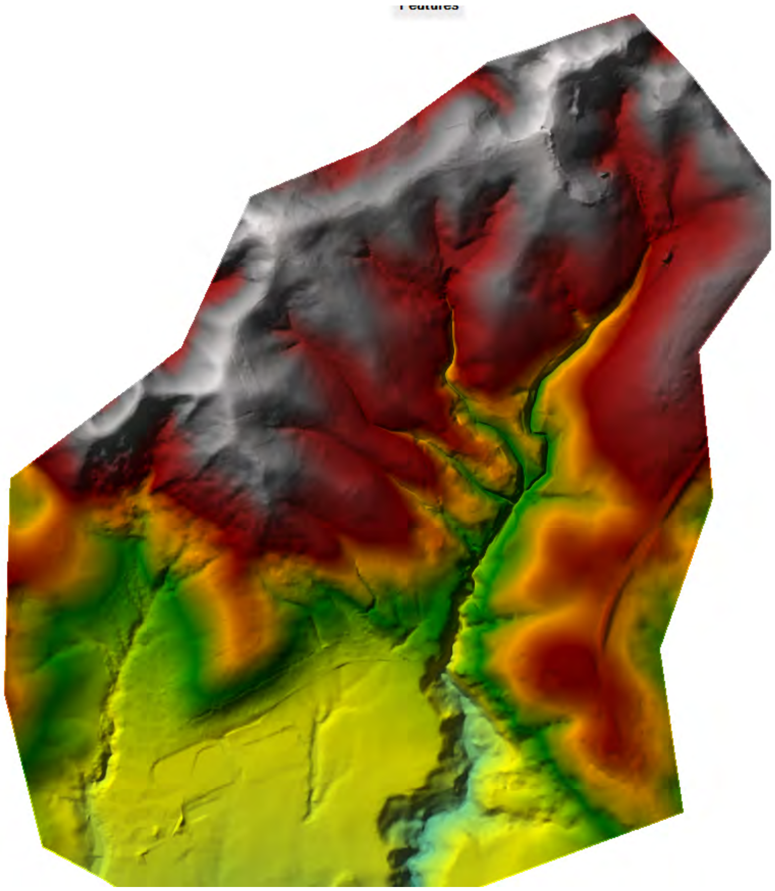


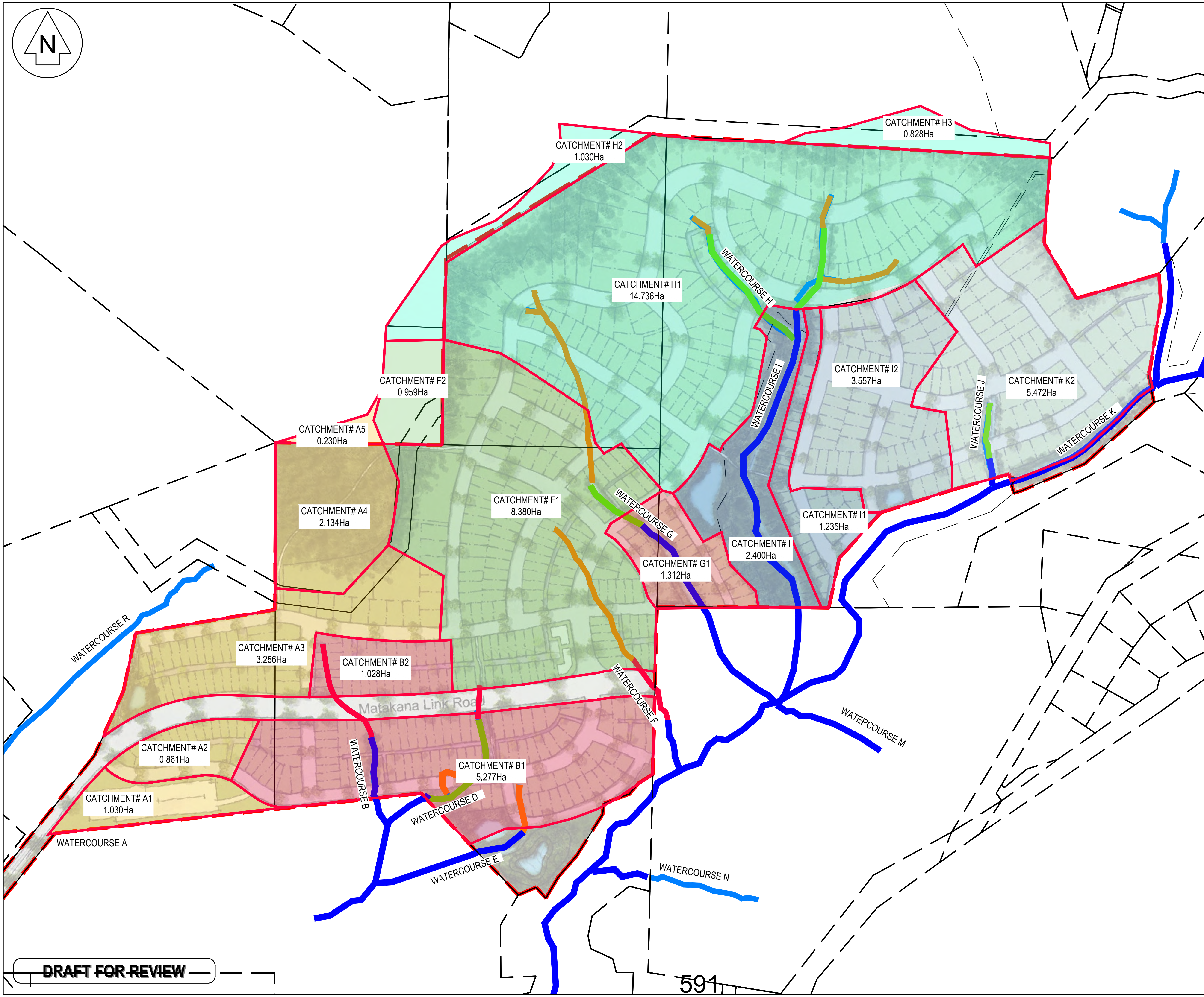
Figure 4: HEC-RAS Base Model

Flow data can be found summarised below:

Tributary	Reach	RS/CH	Area (Km2)	OLFP Length	T_c (Min)	2.33 Q (m3/s)
Watercourse B/C	B	140	0.010192	208	5.4	0.124
	C	390	0.020606	313	7.2	0.268
	C	150	0.068995	554	11.4	0.857
	C	80	0.120139	704	13.8	1.376
Watercourse D	D	181	0.025608	330	8.4	0.333
Watercourse E	E	514	0.004647	130	3.6	0.056
	E	80	0.044237	559	11.4	0.549
Watercourse F	F	584	0.013026	131	3.6	0.159
	F	251	0.058313	490	10.8	0.688
Watercourse G	G	463	0.109277	416	9	1.334
	G	225	0.157035	915	18	1.516
Watercourse H&I	H	796	0.042791	221	5.4	0.523
	H	433	0.158706	584	12.6	1.778
	H	250	0.233068	766	15	2.432
Watercourse J	J	925	0.573107	1176	22.2	5.384
	J	800	0.646961	1320	24.6	5.753

Flow widths at specified chainage intervals have been exported to .dwg and plotted in the appended plan C453 and reserve areas drafted. Watercourse alignment sections generated in HEC-RAS can also be found appended (Appendix C)

APPENDIX A – CATCHMENT PLANS



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.

Legend
- EX BDY
- EX EASEMENT
- PR BDY
- EX WATERCOURSE (PERM)
- EX WATERCOURSE (INT)
- PR RECLAIMED
- PR REMOVED
- REMOVED (MLR by AT)

Rev	Description	By	Date

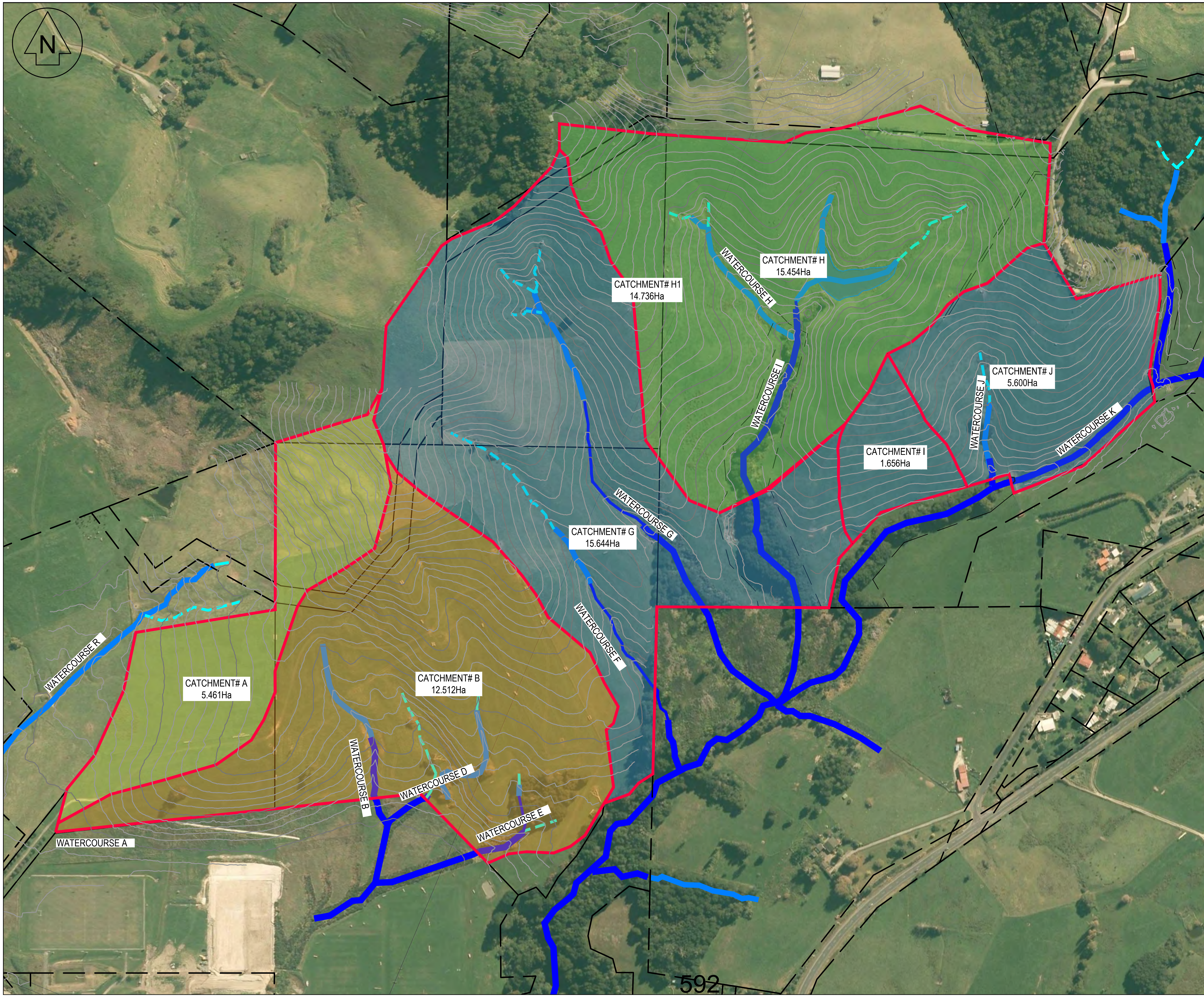
	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

M A V E N
Maven Associates
09 571 0050
info@maven.co.nz
www.maven.co.nz
12-14 Walls Road, Penrose

Project
CLAYDEN ROAD WARKWORTH PLAN CHANGE FOR WARKWORTH LAND LTD

Title
PRELIMINARY PROPOSED STORMWATER CATCHMENT PLAN

Project no.	102008
Scale	1:7500 @ A3
Cad file	WLC HEC CATCH.DWG
Drawing no.	C4501
Rev	A



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.

Legend

- EX BDY
- EX EASEMENT
- SITE BDY
- EX STREAM (EPHEM)
- EX STREAM (INTERM)
- EX STREAM (PERM)

Rev	Description	By	Date

	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

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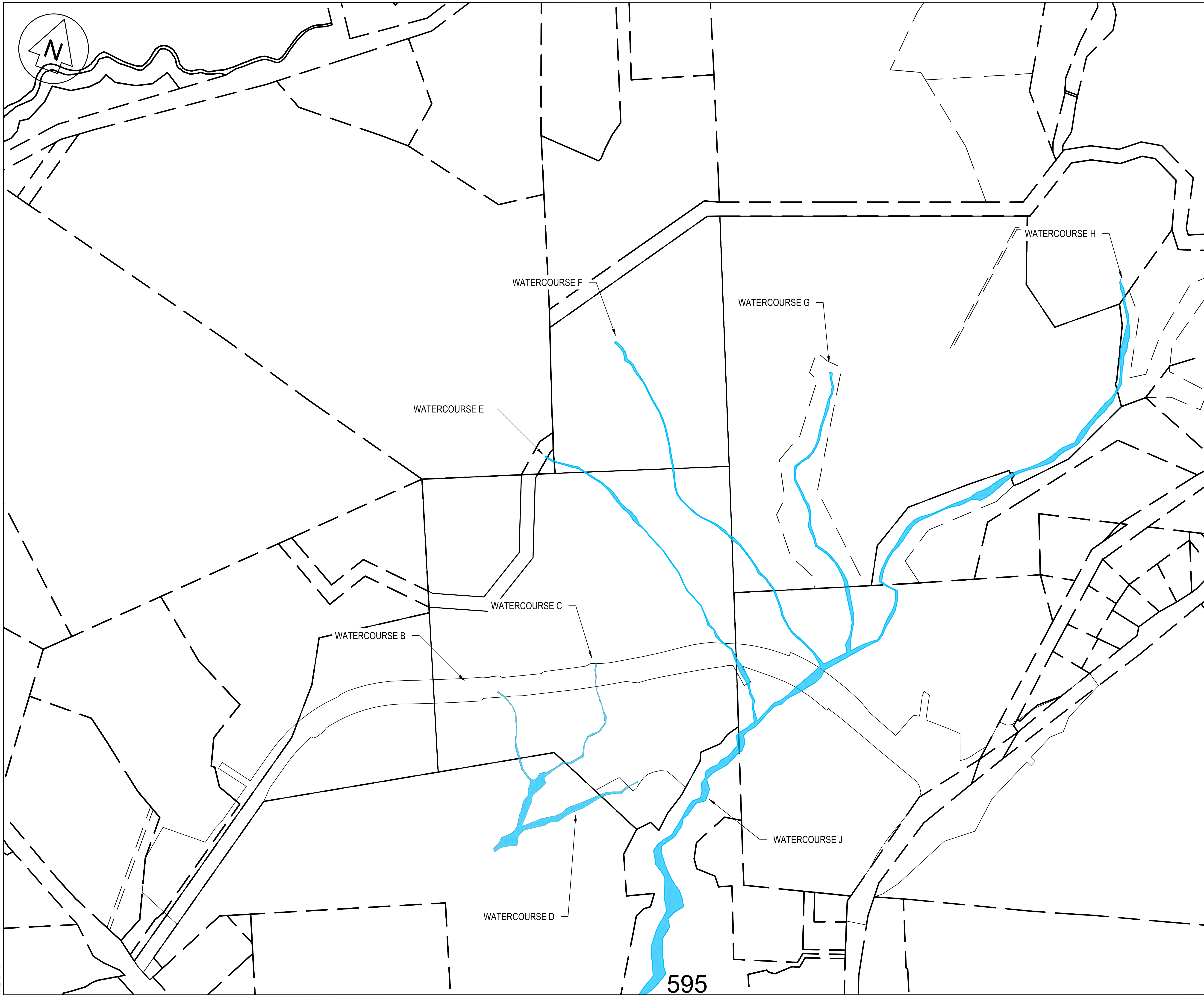
www.maven.co.nz
12-14 Walls Road, Penrose

Project
CLAYDEN ROAD WARKWORTH PLAN CHANGE FOR WARKWORTH LAND LTD

Title
EXISTING STORMWATER CATCHMENT PLAN

Project no.	102008
Scale	1:7500 @ A3
Cad file	WLC HEC CATCH.DWG
Drawing no.	C4500 Rev A

APPENDIX B – HEC-RAS OUTPUT & ESPLANADE EXTENTS



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Total watercourse removed = 688m
6. Total watercourse reclaimed = 386m

Legend
- EX BDY
- EX EASEMENT
- PR BDY
- FLOW EXTENTS

Rev	Description	By	Date
B	PPC UPDATE	LC	10/19
A	PLAN CHANGE	JK	07/19

	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

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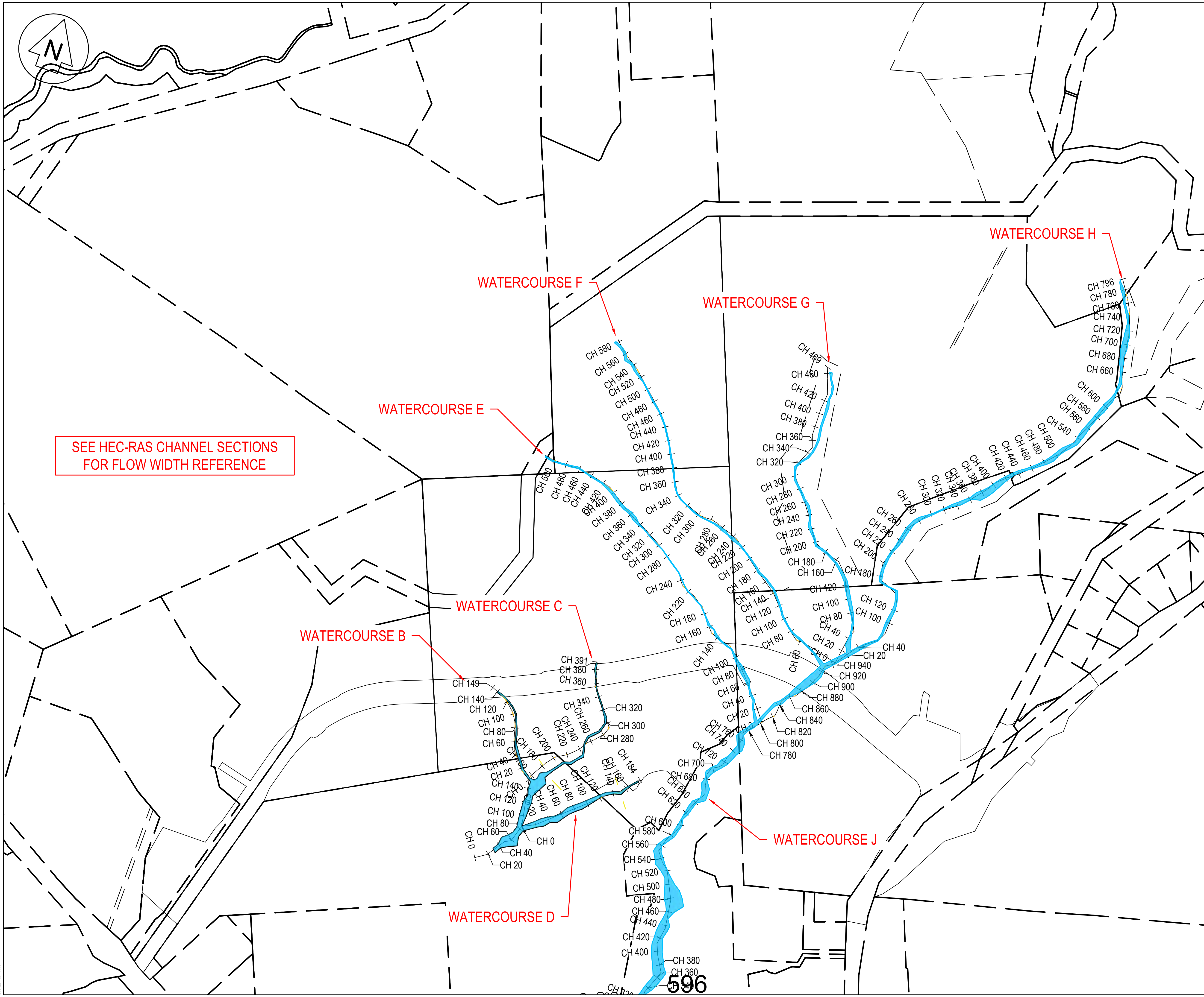
12-14 Walls Road, Penrose

Project
CLAYDEN ROAD WARKWORTH PLAN CHANGE FOR WARKWORTH LAND LTD

Title
EXISTING ANNUAL FLOW OVERVIEW

Project no.	102008
Scale	1:5000 @ A3
Cad file	102008 C451 STREAMS.DWG
Drawing no.	C452
Rev	A



Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Total watercourse removed = 688m
6. Total watercourse reclaimed = 386m

Legend

- EX BDY
- EX EASEMENT
- PR BDY
- FLOW EXTENTS

Rev	Description	By	Date
B	PPC UPDATE	LC	10/19
A	PLAN CHANGE	JK	07/19

	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

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12-14 Walls Road, Penrose

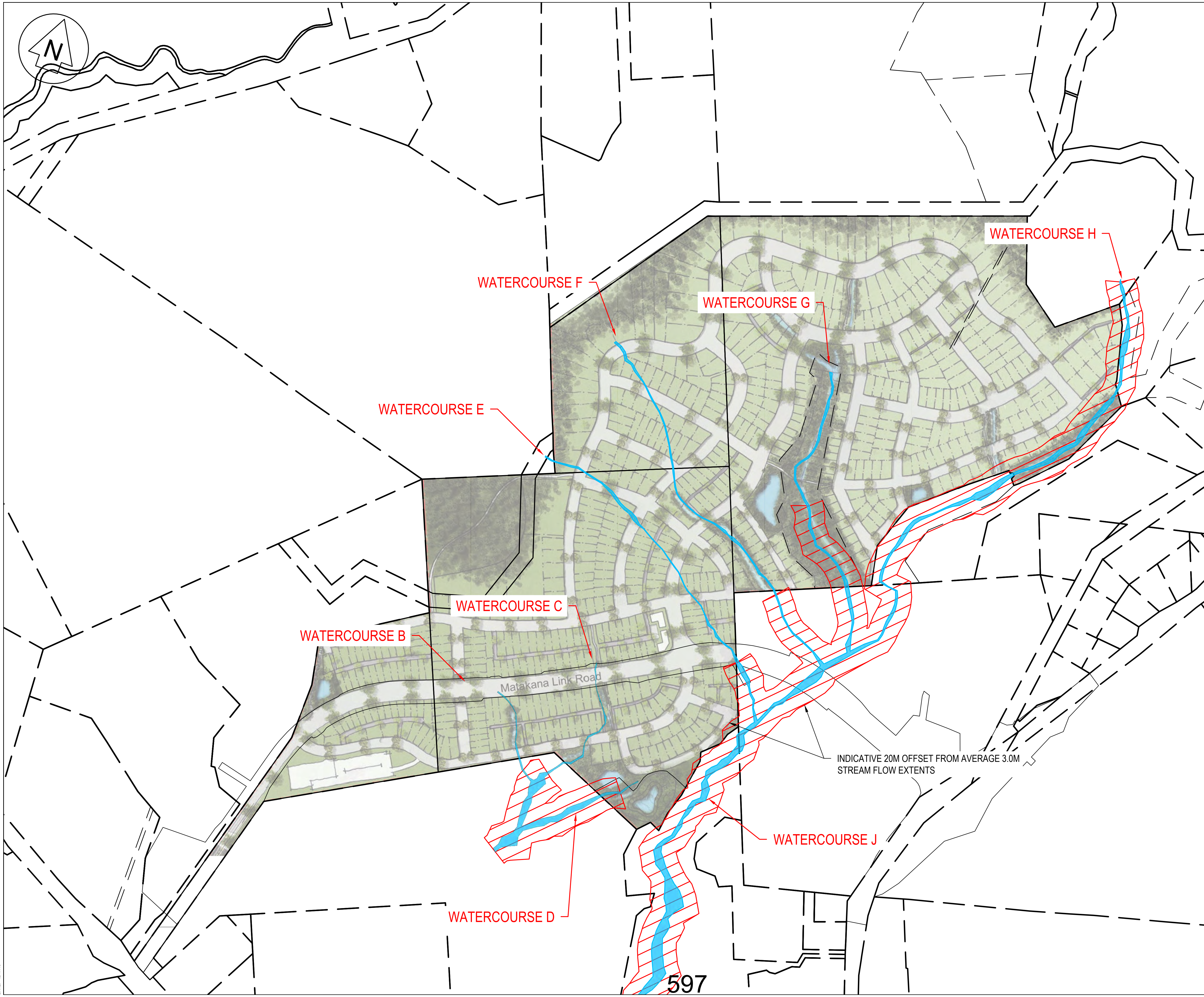
Project

CLAYDEN ROAD WARKWORTH PLAN CHANGE FOR WARKWORTH LAND LTD

Title

PRELIMINARY MODELLING RESULTS OVERVIEW

Project no.	102008
Scale	1:5000 @ A3
Cad file	102008 C451 STREAMS.DWG
Drawing no.	C453
Rev	A



Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Total watercourse removed = 688m
6. Total watercourse reclaimed = 386m

Legend

- EX BDY
- EX EASEMENT
- PR BDY
- PR ESPLANADE RES

Rev	Description	By	Date
B	PPC UPDATE	LC	10/19
A	PLAN CHANGE	JK	07/19

	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

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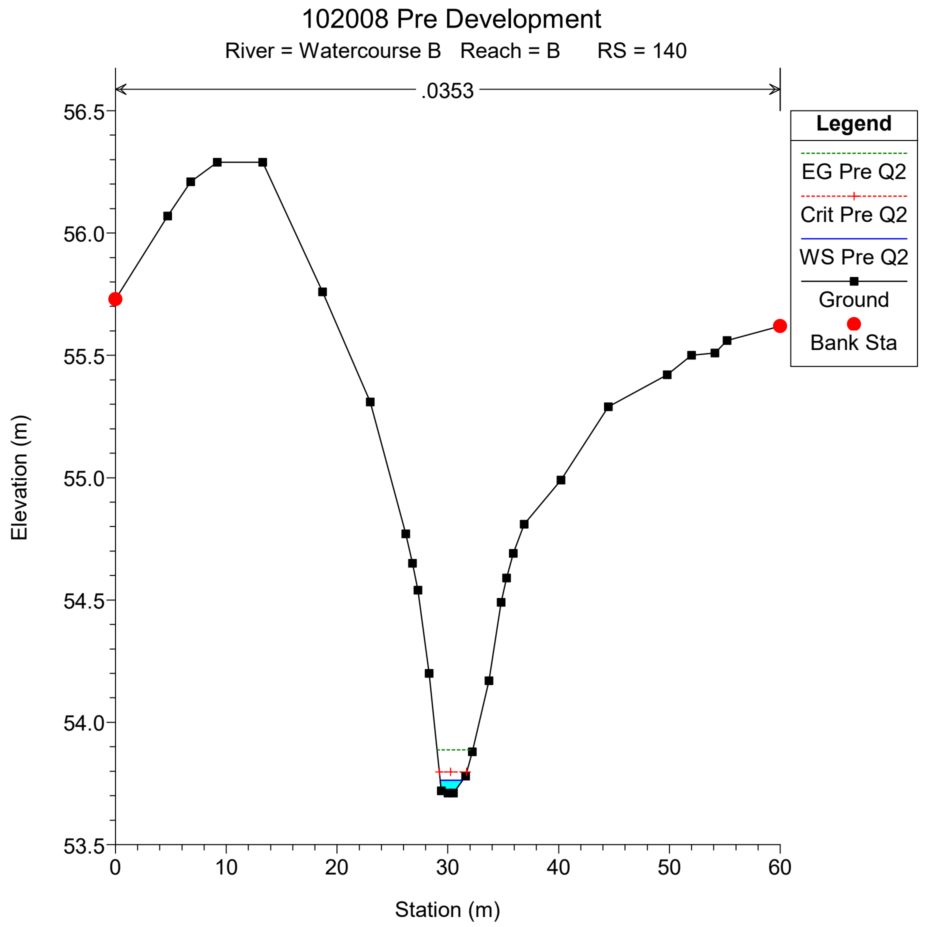
Project

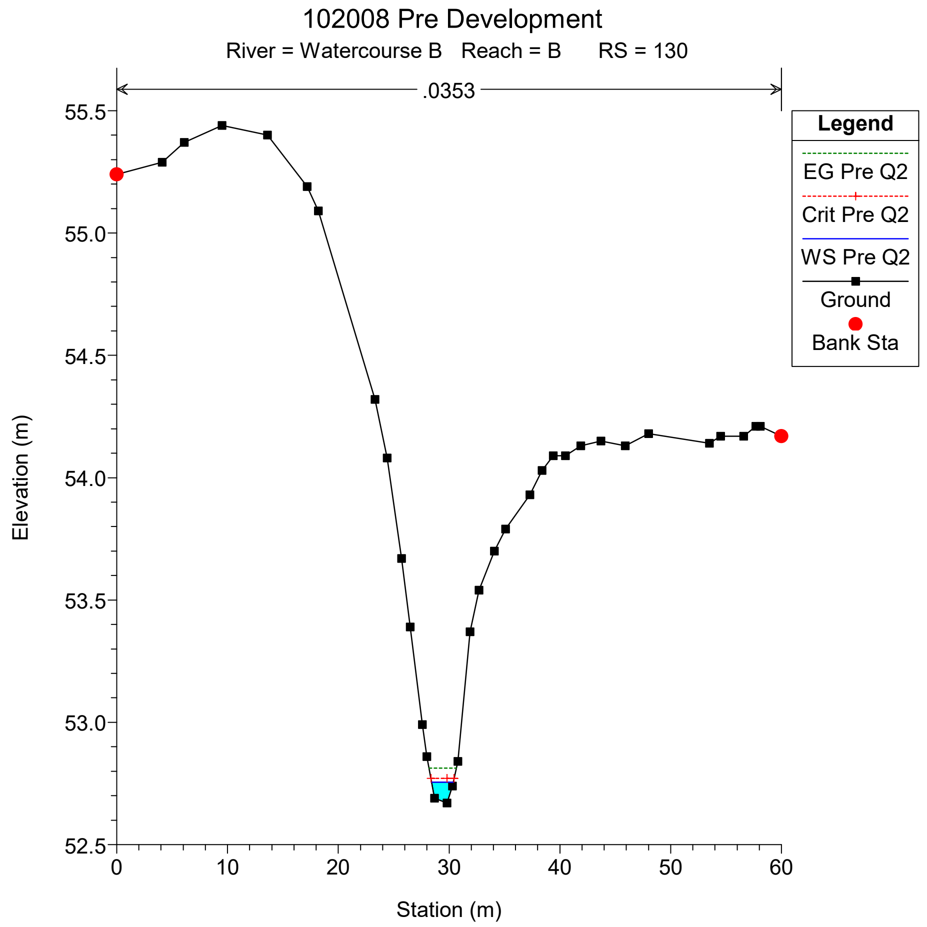
CLAYDEN ROAD WARKWORTH PLAN CHANGE FOR WARKWORTH LAND LTD

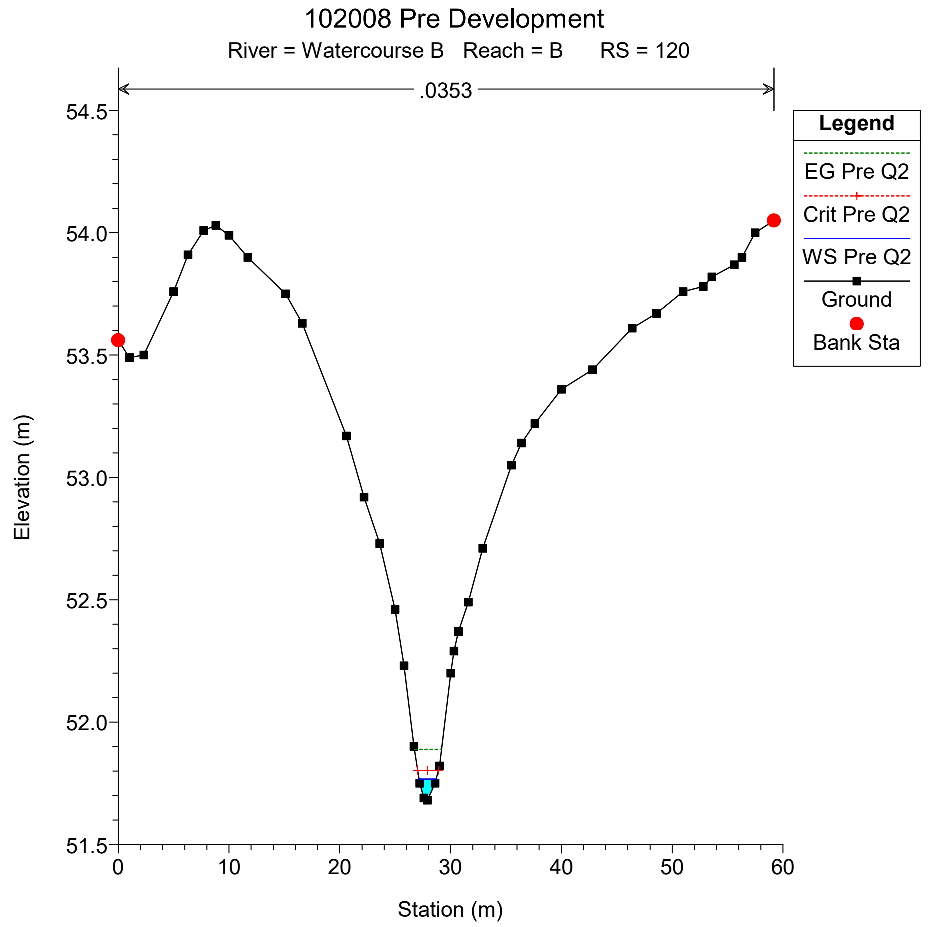
Title

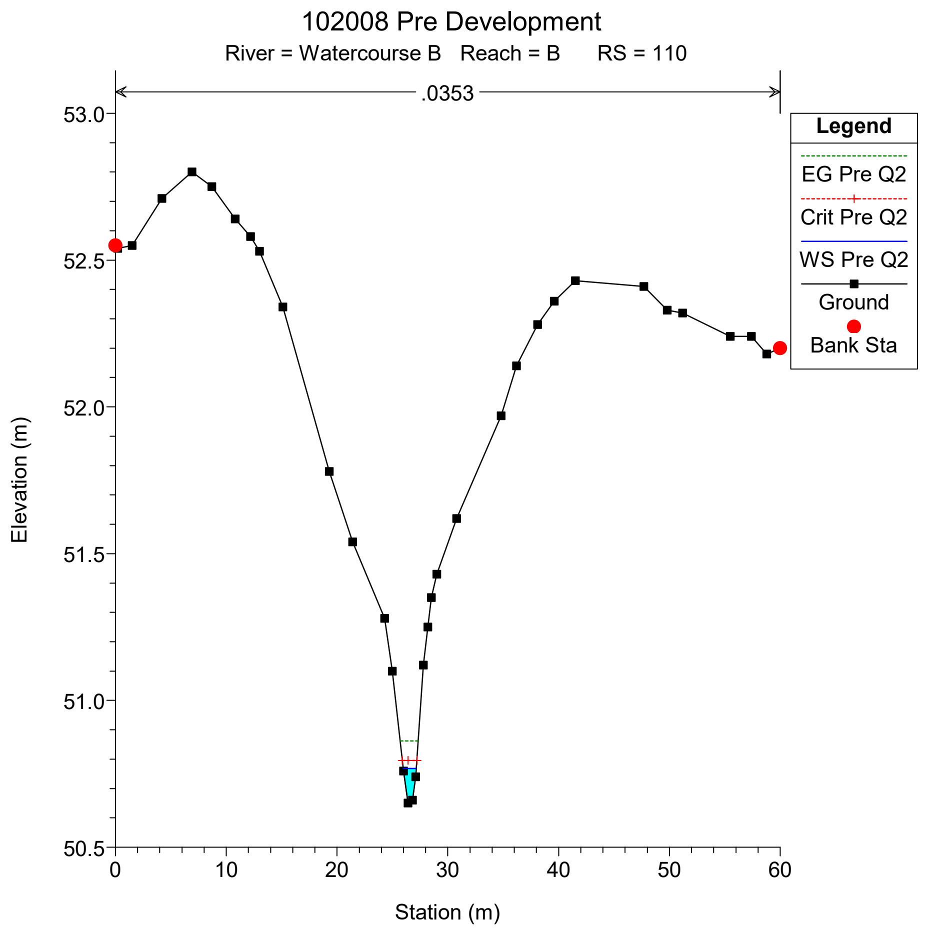
PRELIMINARY ESPLANADE OVERVIEW

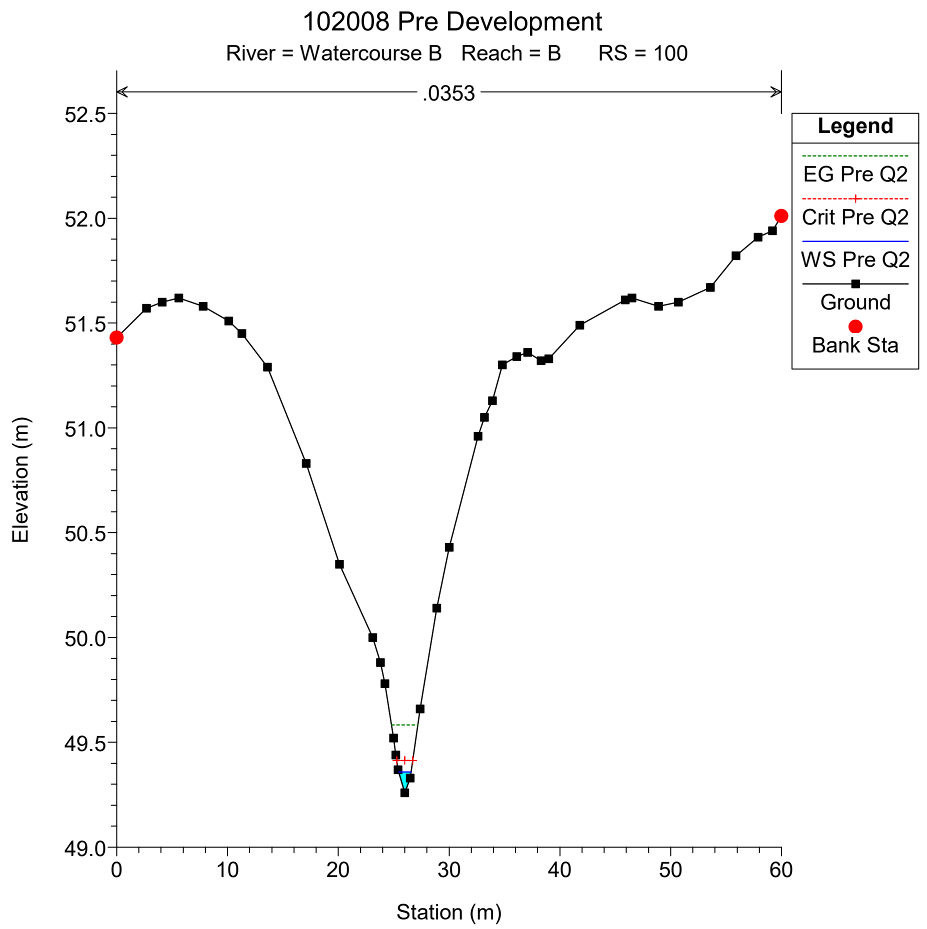
Project no.	102008
Scale	1:5000 @ A3
Cad file	102008 C451 STREAMS.DWG
Drawing no.	C454 — Rev A

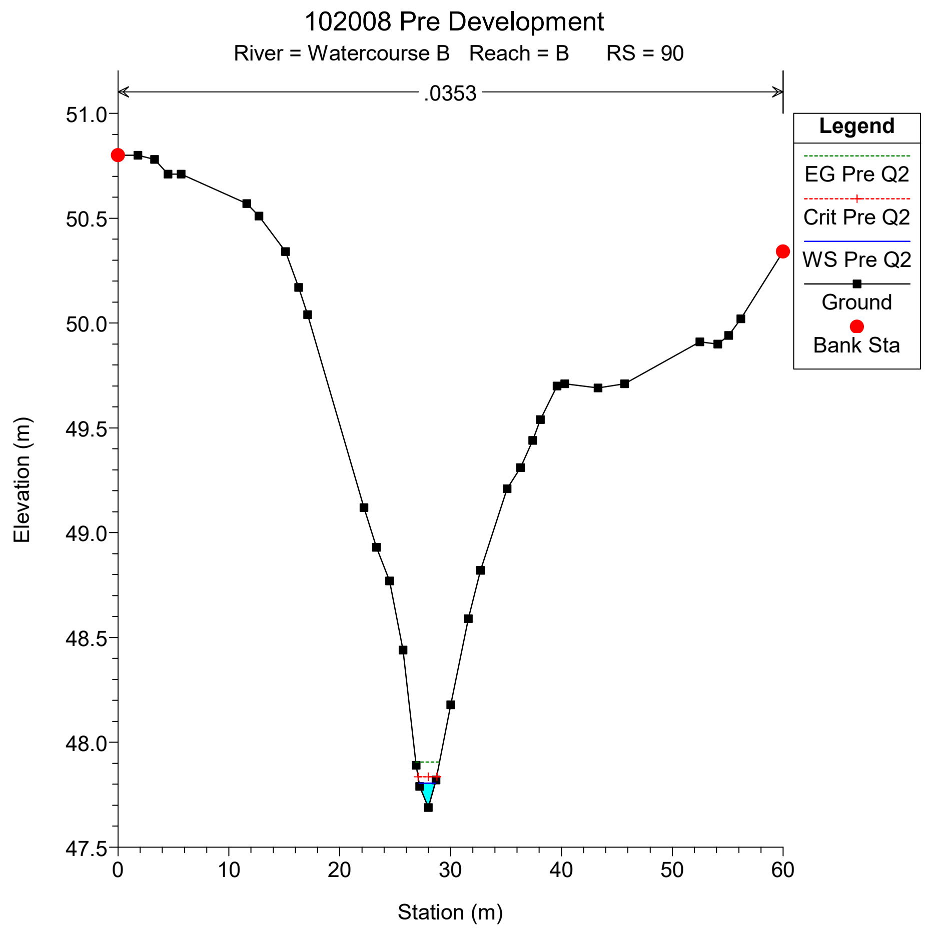

102008 Pre Development
River = Watercourse B Reach = B RS = 140
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
53.5
54.0
54.5
55.0
55.5
56.0
56.5
0 10 20 30 40 50 60

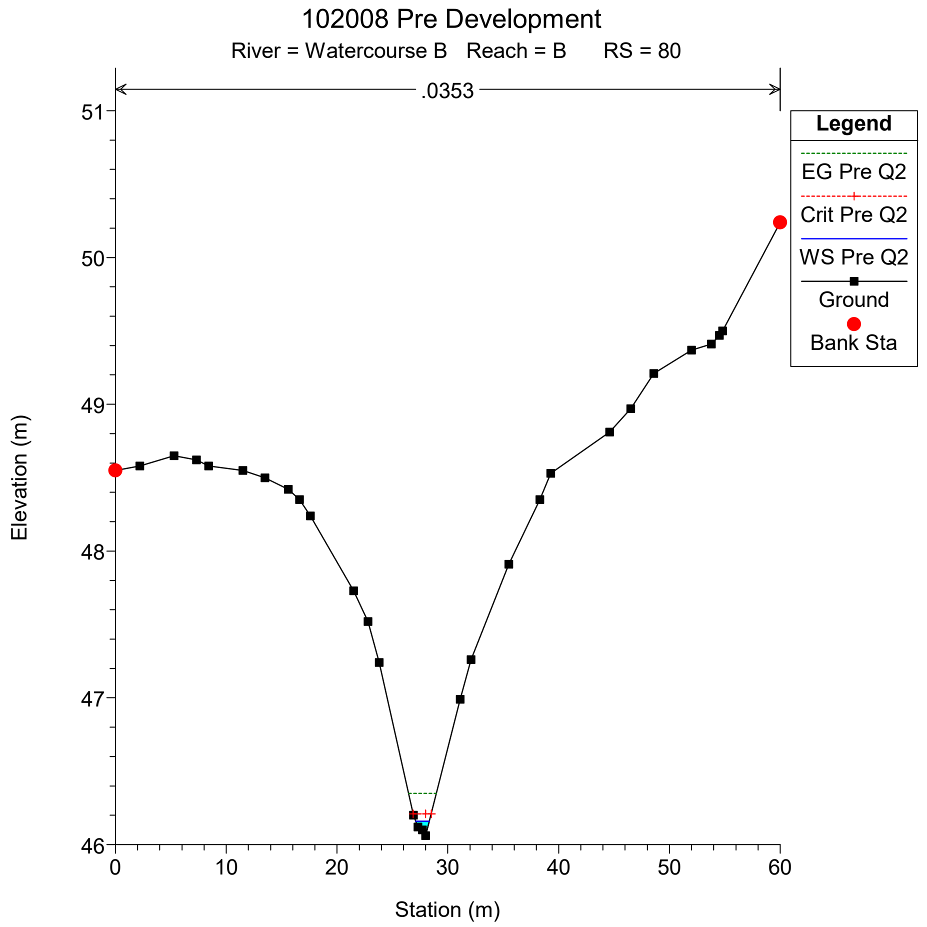

102008 Pre Development
River = Watercourse B Reach = B RS = 130
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
52.5
53.0
53.5
54.0
54.5
55.0
55.5
0 10 20 30 40 50 60

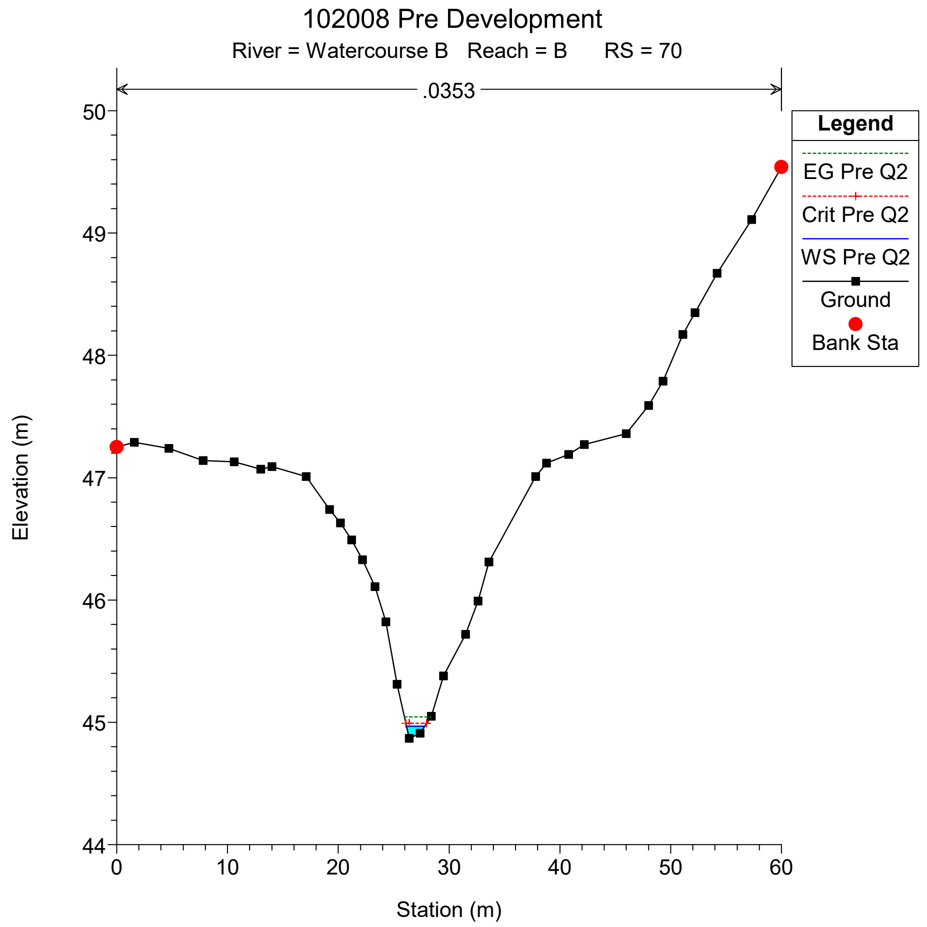

102008 Pre Development
River = Watercourse B Reach = B RS = 120
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
51.5
52.0
52.5
53.0
53.5
54.0
54.5
0 10 20 30 40 50 60

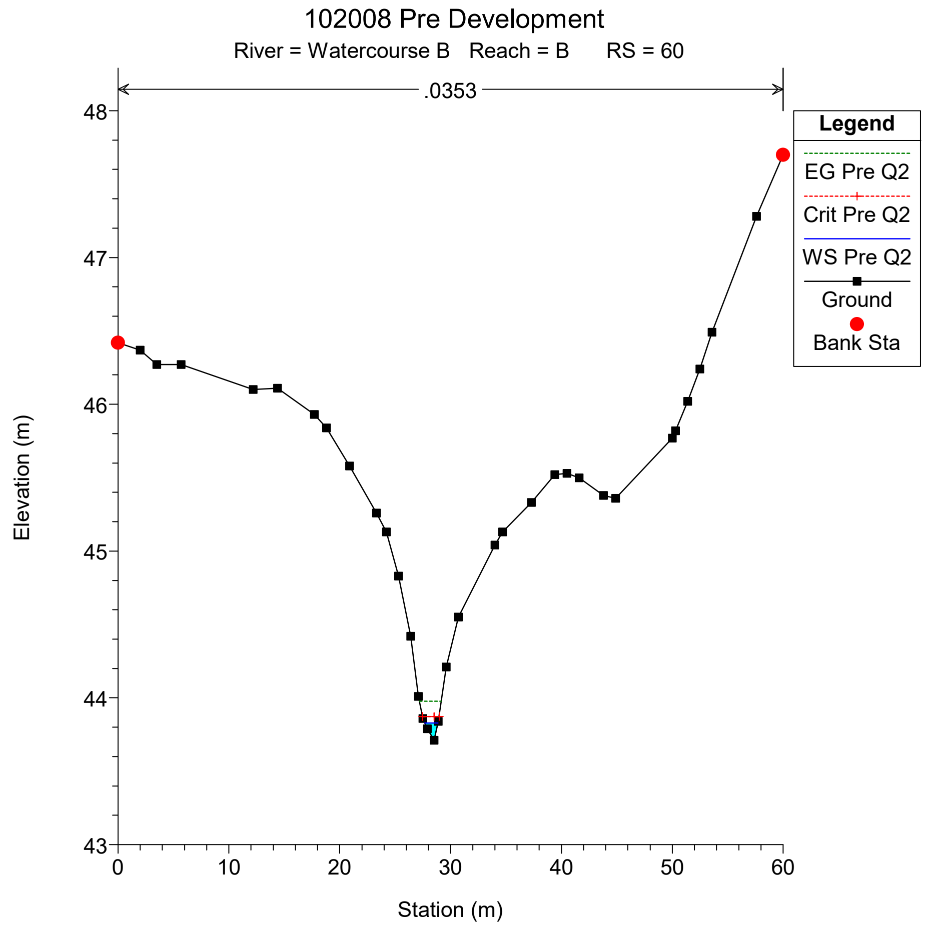

102008 Pre Development
River = Watercourse B Reach = B RS = 110
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
50.5
51.0
51.5
52.0
52.5
53.0
0 10 20 30 40 50 60

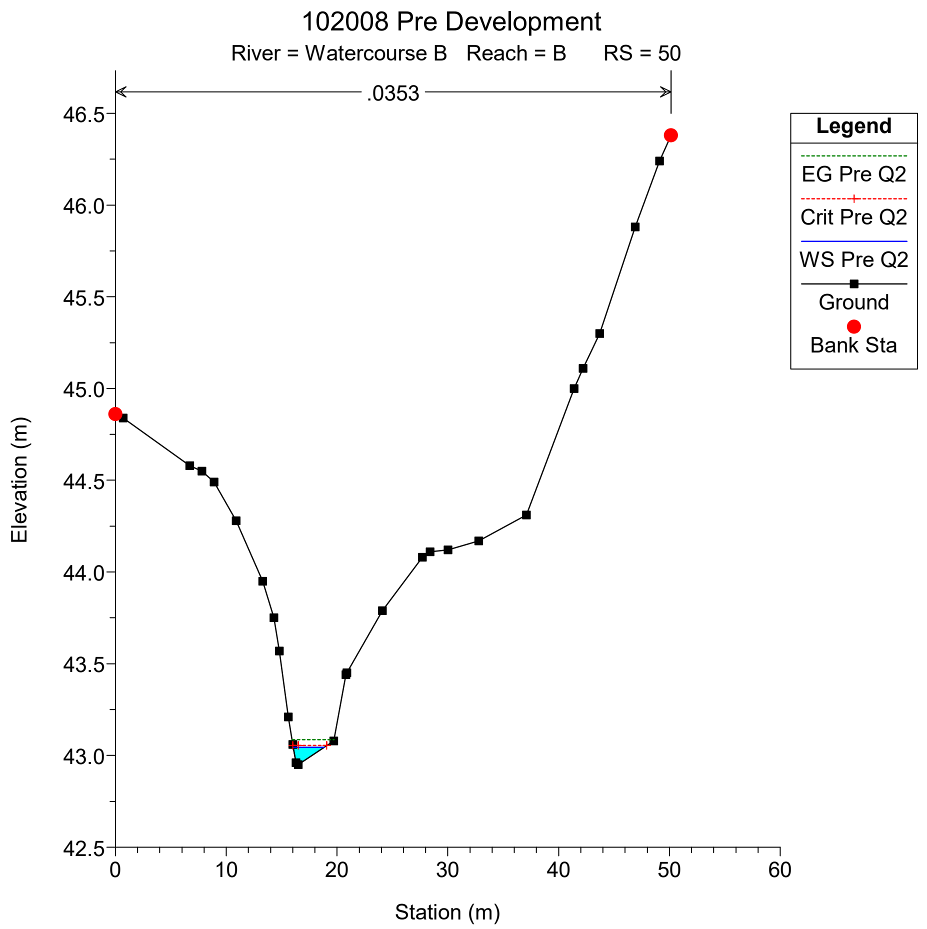

102008 Pre Development
River = Watercourse B Reach = B RS = 100
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
49.0
49.5
50.0
50.5
51.0
51.5
52.0
52.5
0 10 20 30 40 50 60

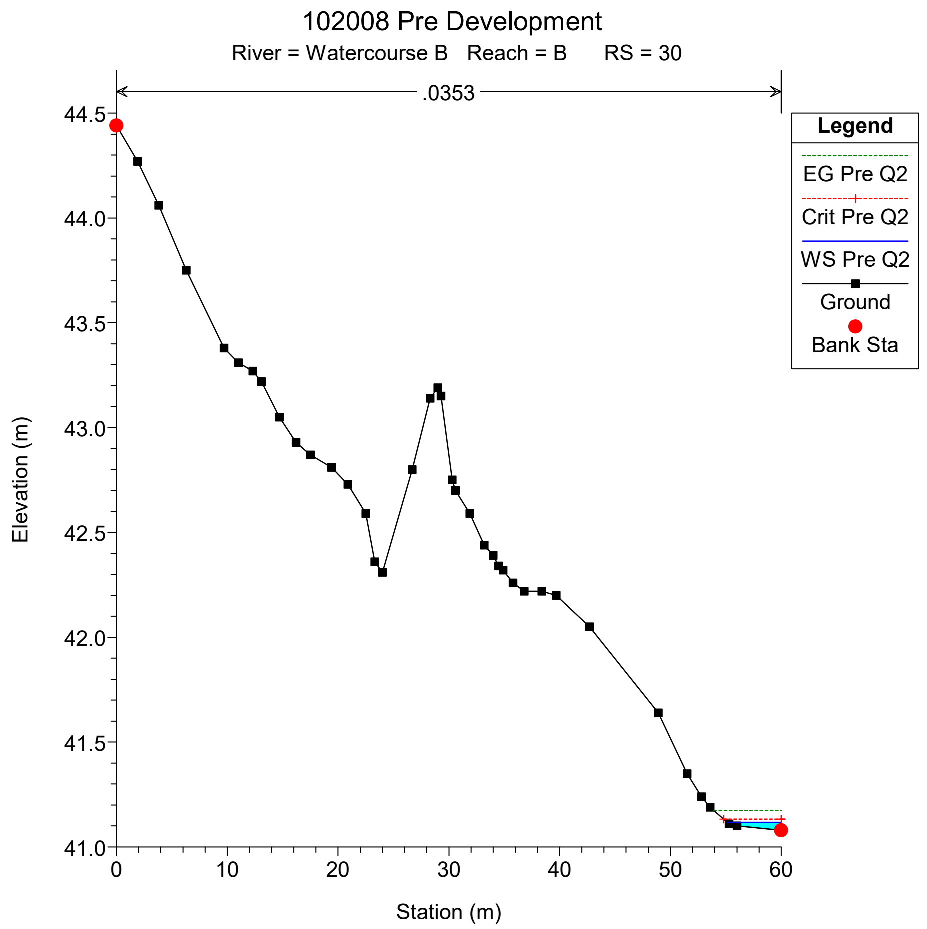

102008 Pre Development
River = Watercourse B Reach = B RS = 90
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
47.5
48.0
48.5
49.0
49.5
50.0
50.5
51.0
0 10 20 30 40 50 60

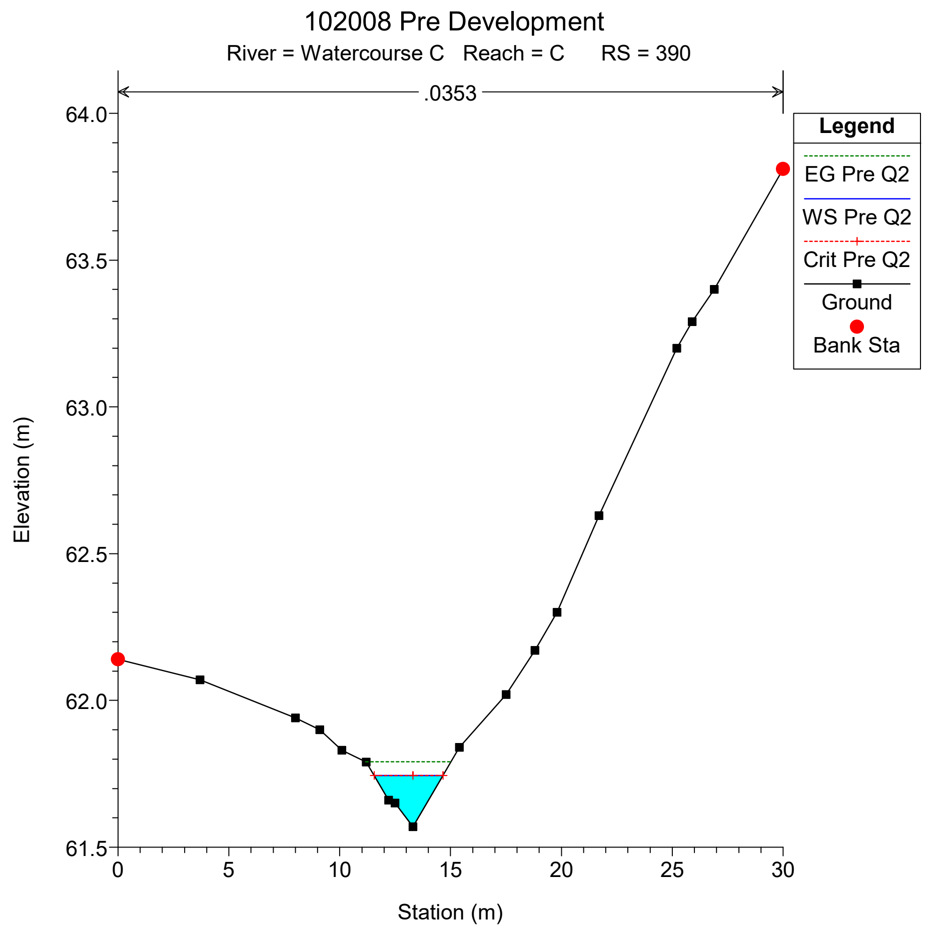

102008 Pre Development
River = Watercourse B   Reach = B   RS = 80
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

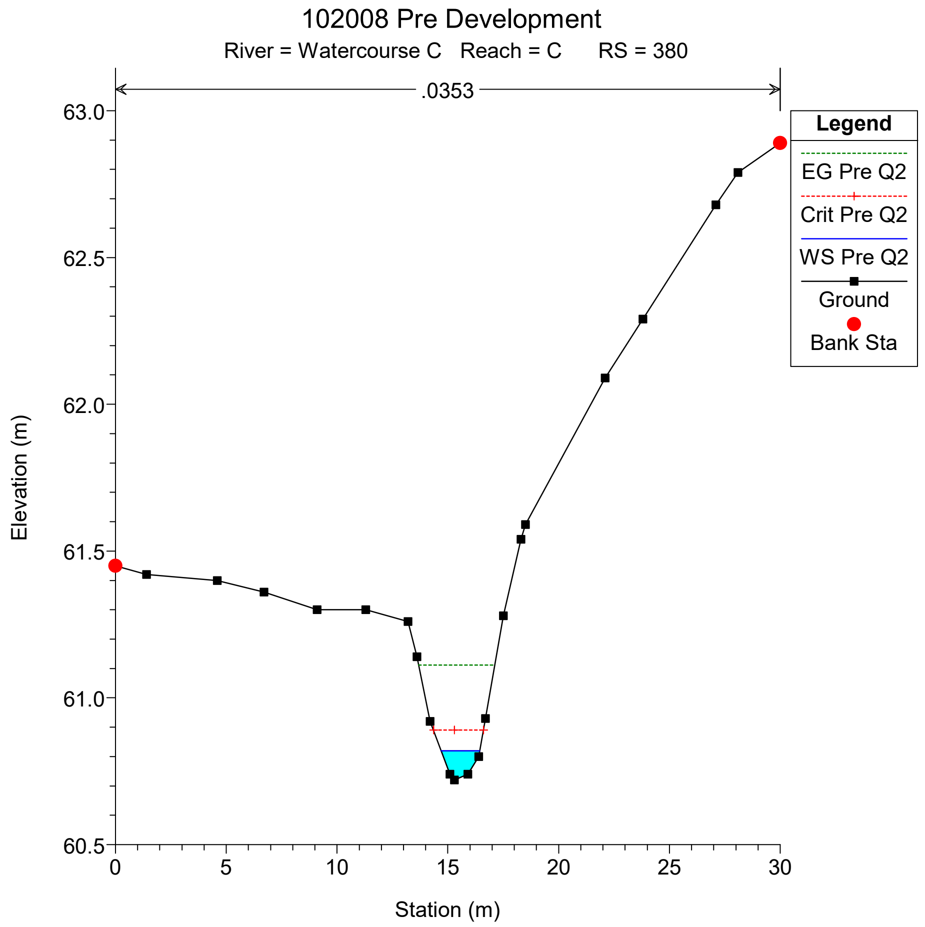

102008 Pre Development
River = Watercourse B   Reach = B   RS = 70
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

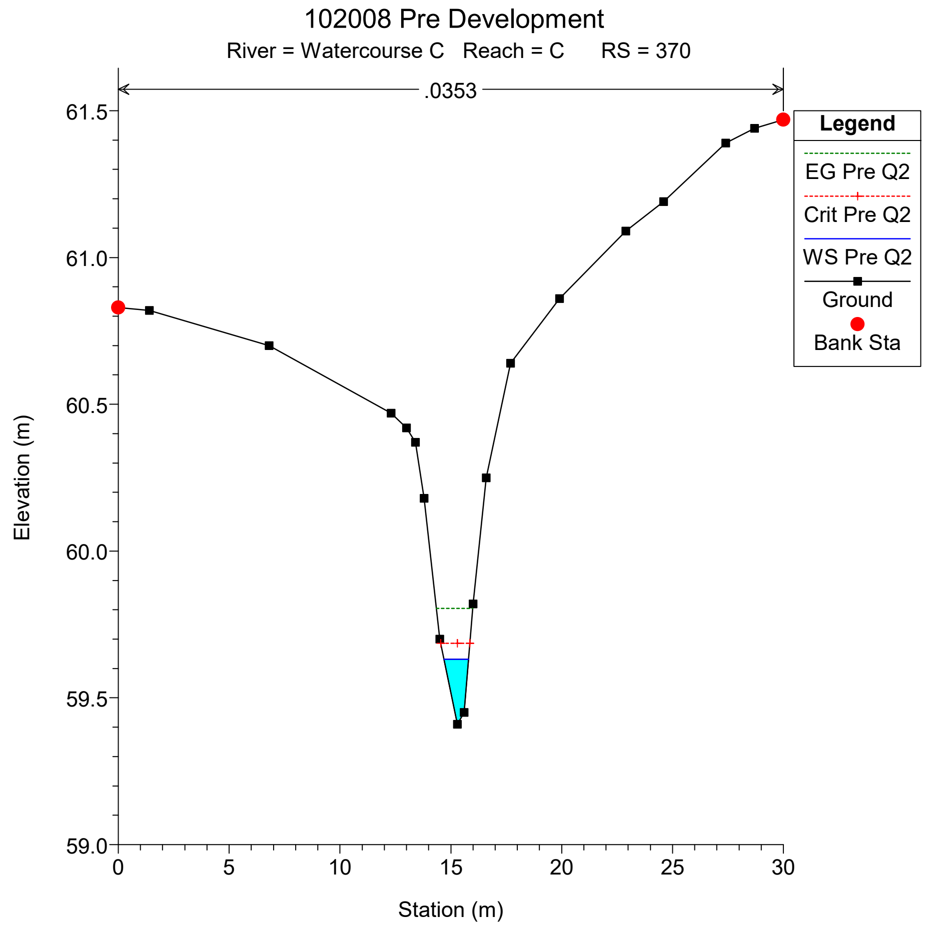

102008 Pre Development
River = Watercourse B   Reach = B   RS = 60
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

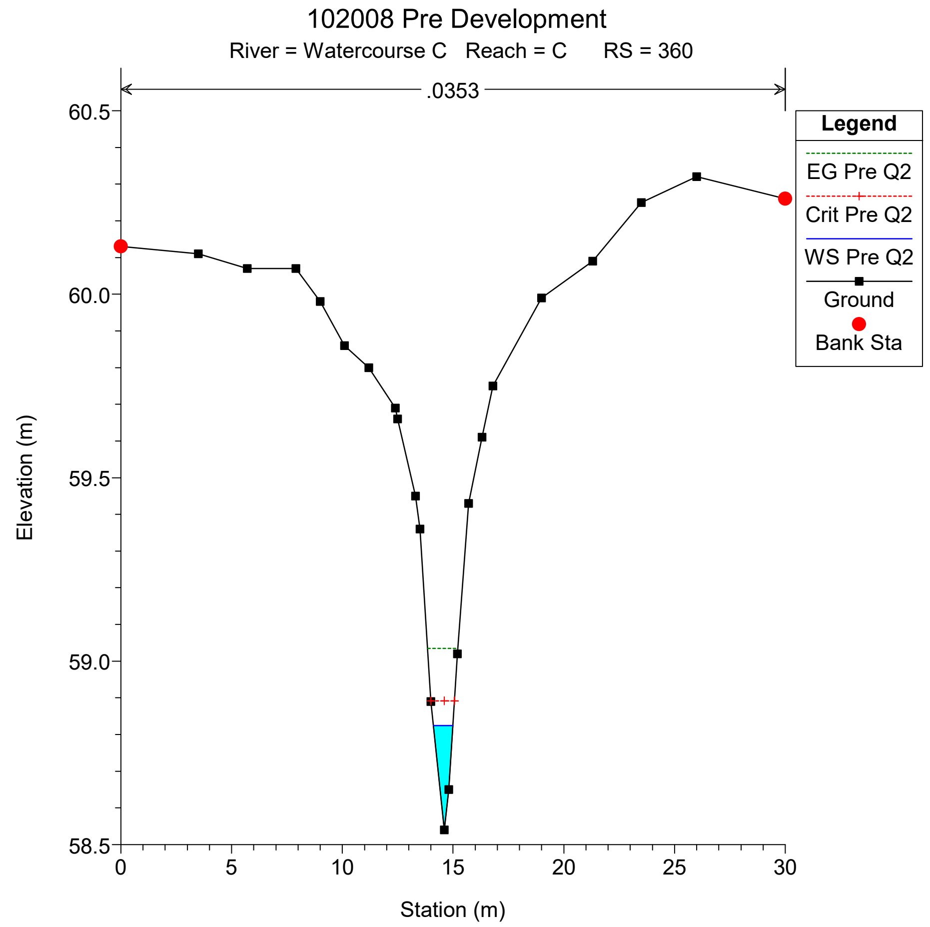

102008 Pre Development
River = Watercourse B   Reach = B   RS = 50
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

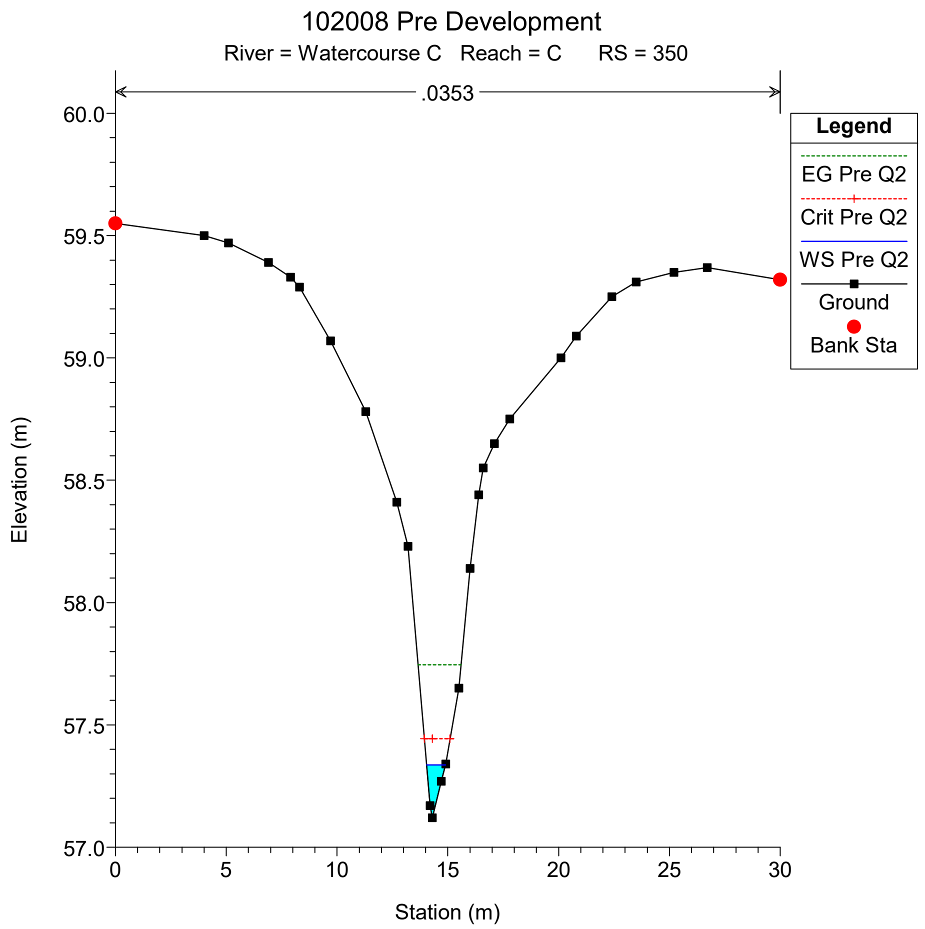

102008 Pre Development
River = Watercourse B   Reach = B   RS = 30
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

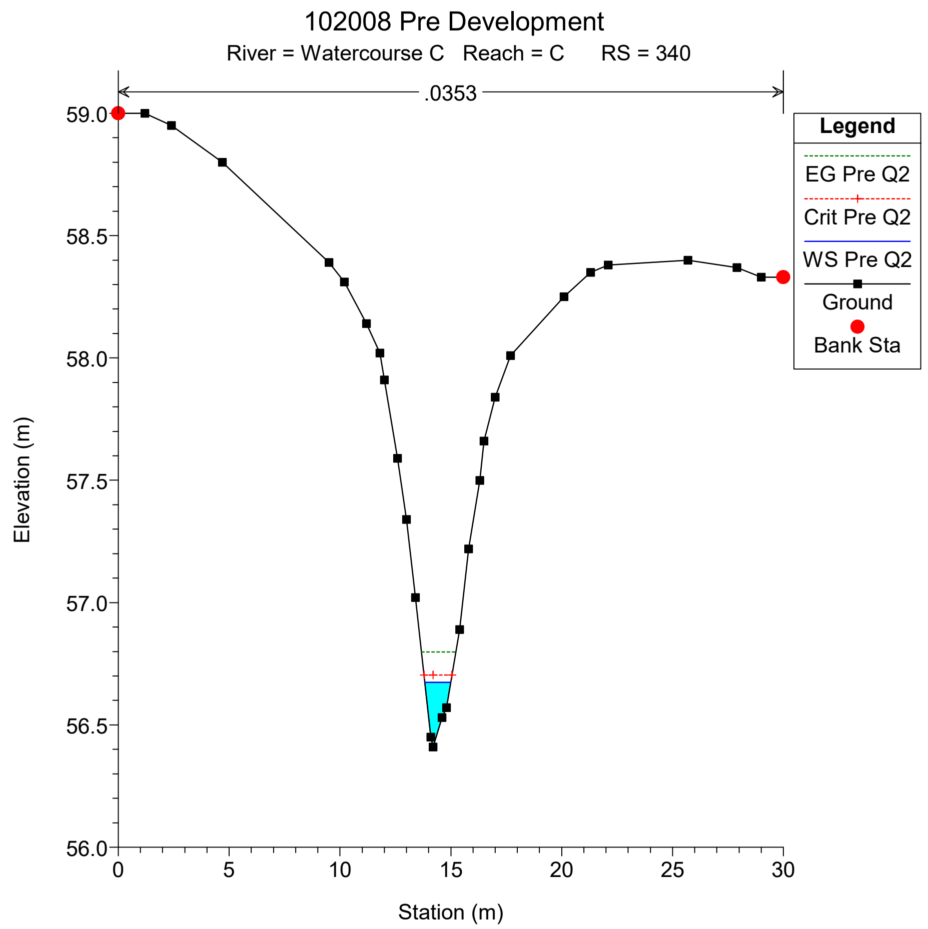

102008 Pre Development
River = Watercourse C   Reach = C   RS = 390
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

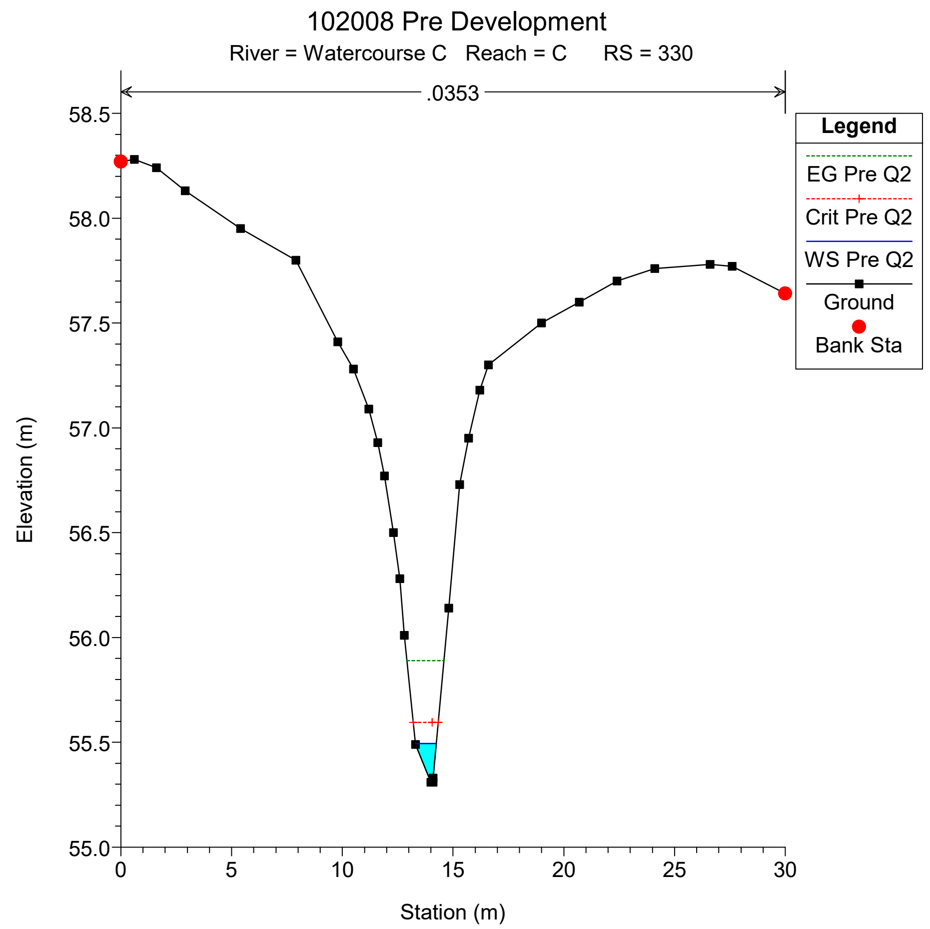

102008 Pre Development
River = Watercourse C Reach = C RS = 380
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

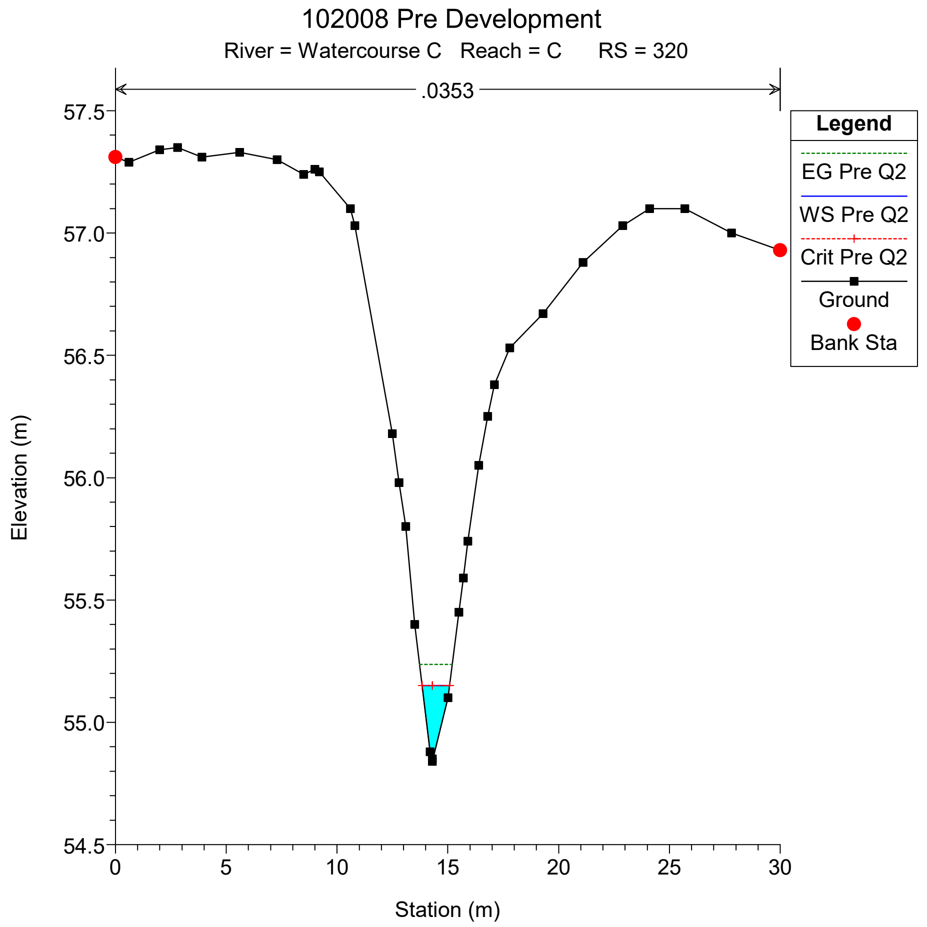

102008 Pre Development
River = Watercourse C Reach = C RS = 370
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

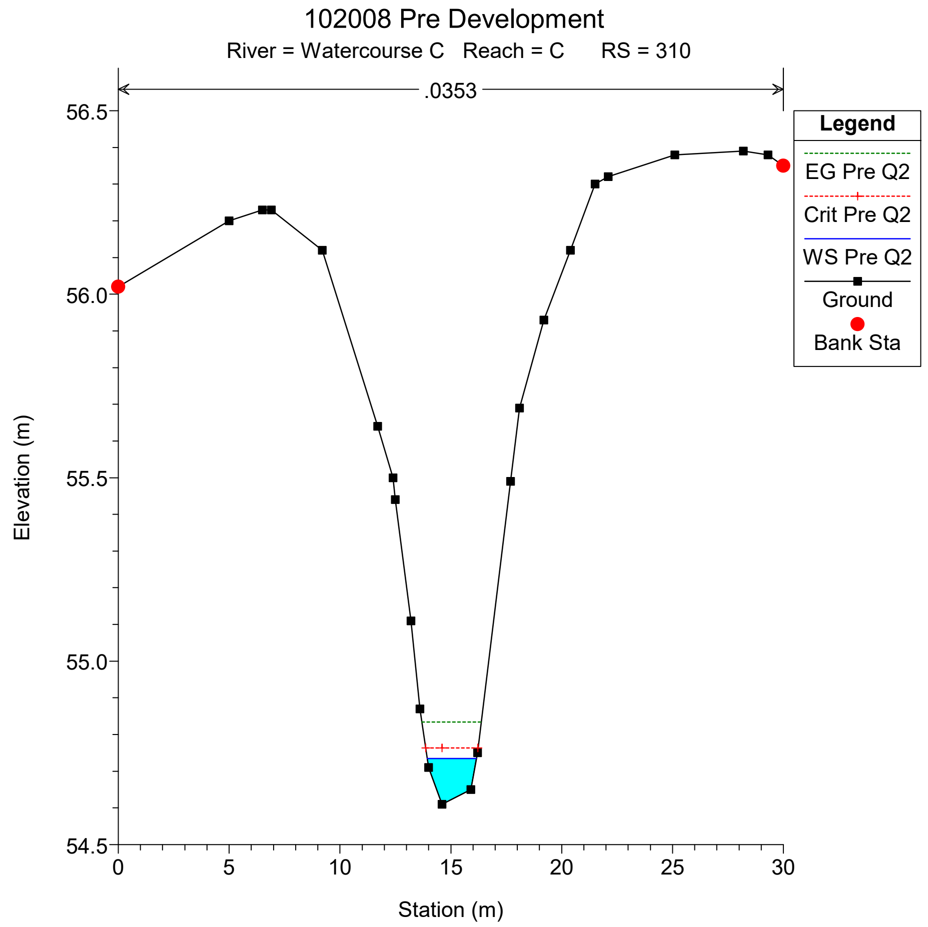

102008 Pre Development
River = Watercourse C Reach = C RS = 360
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

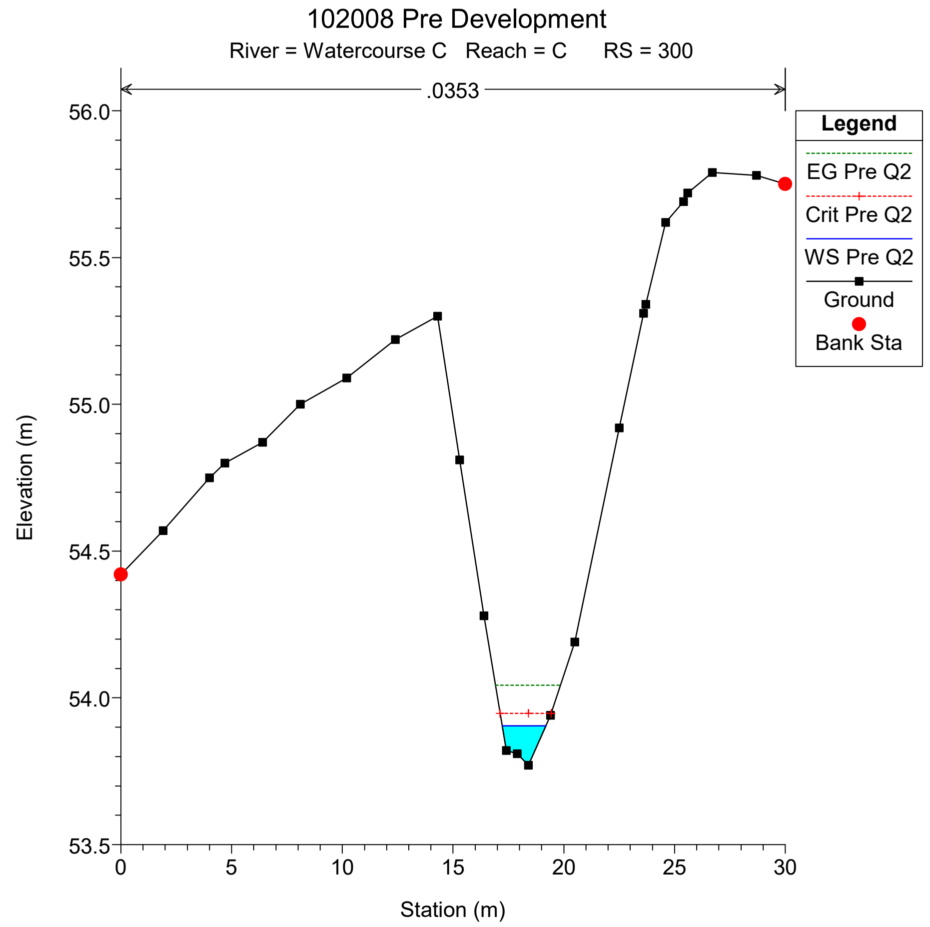

102008 Pre Development
River = Watercourse C Reach = C RS = 350
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

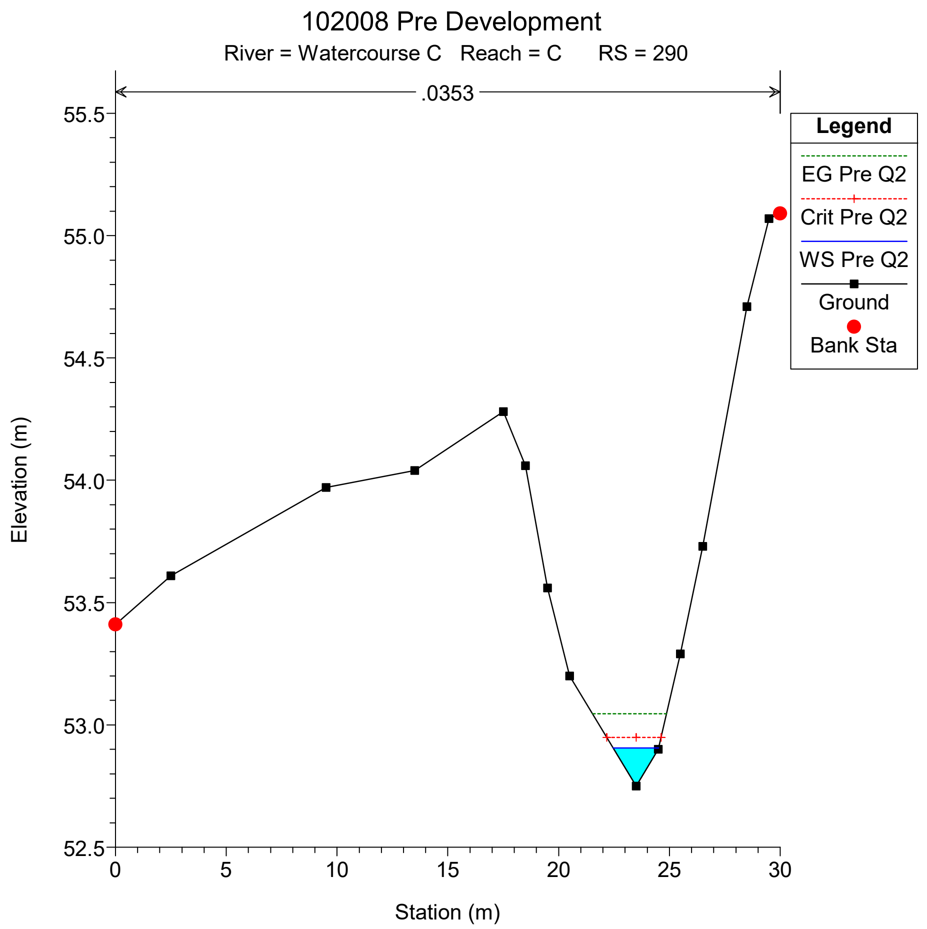

102008 Pre Development
River = Watercourse C Reach = C RS = 340
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

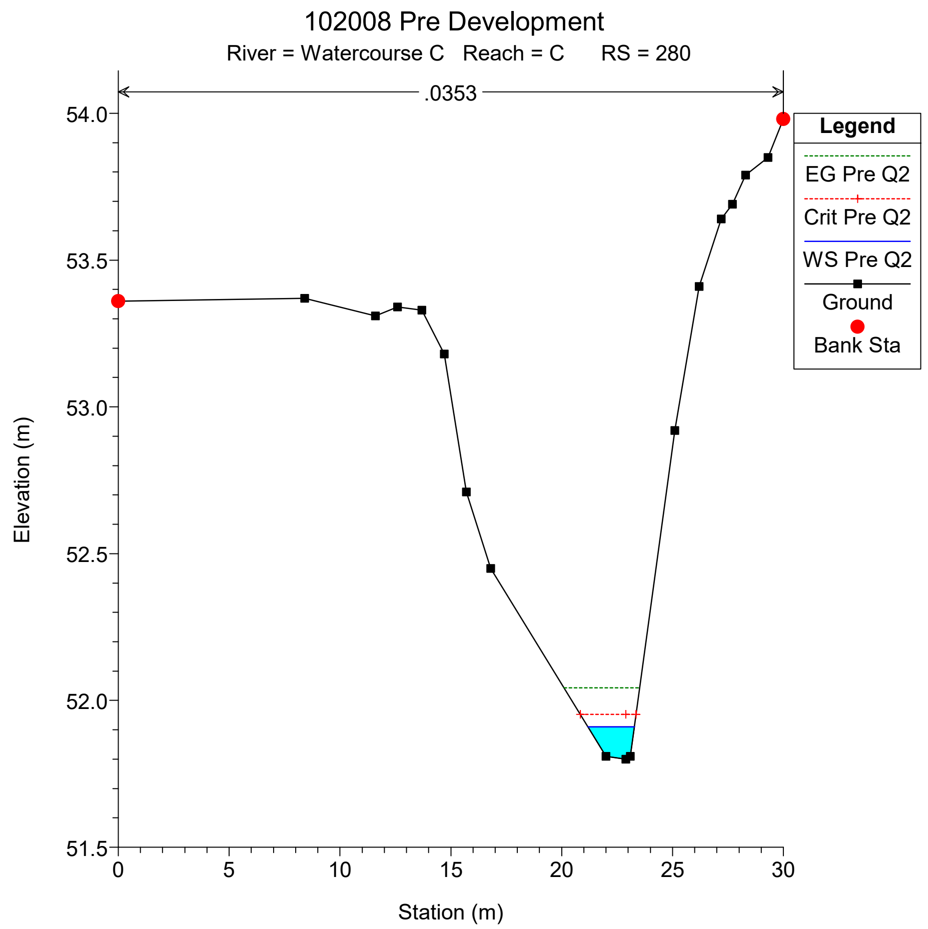

102008 Pre Development
River = Watercourse C Reach = C RS = 330
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

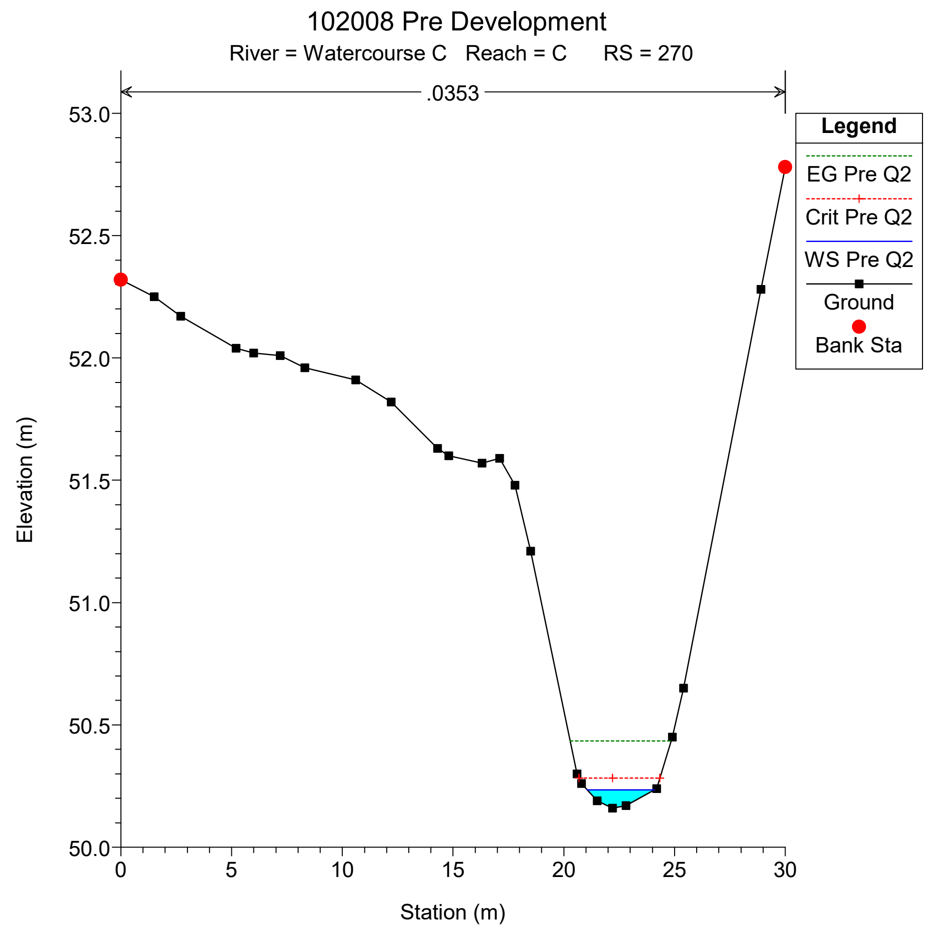

102008 Pre Development
River = Watercourse C   Reach = C   RS = 320
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

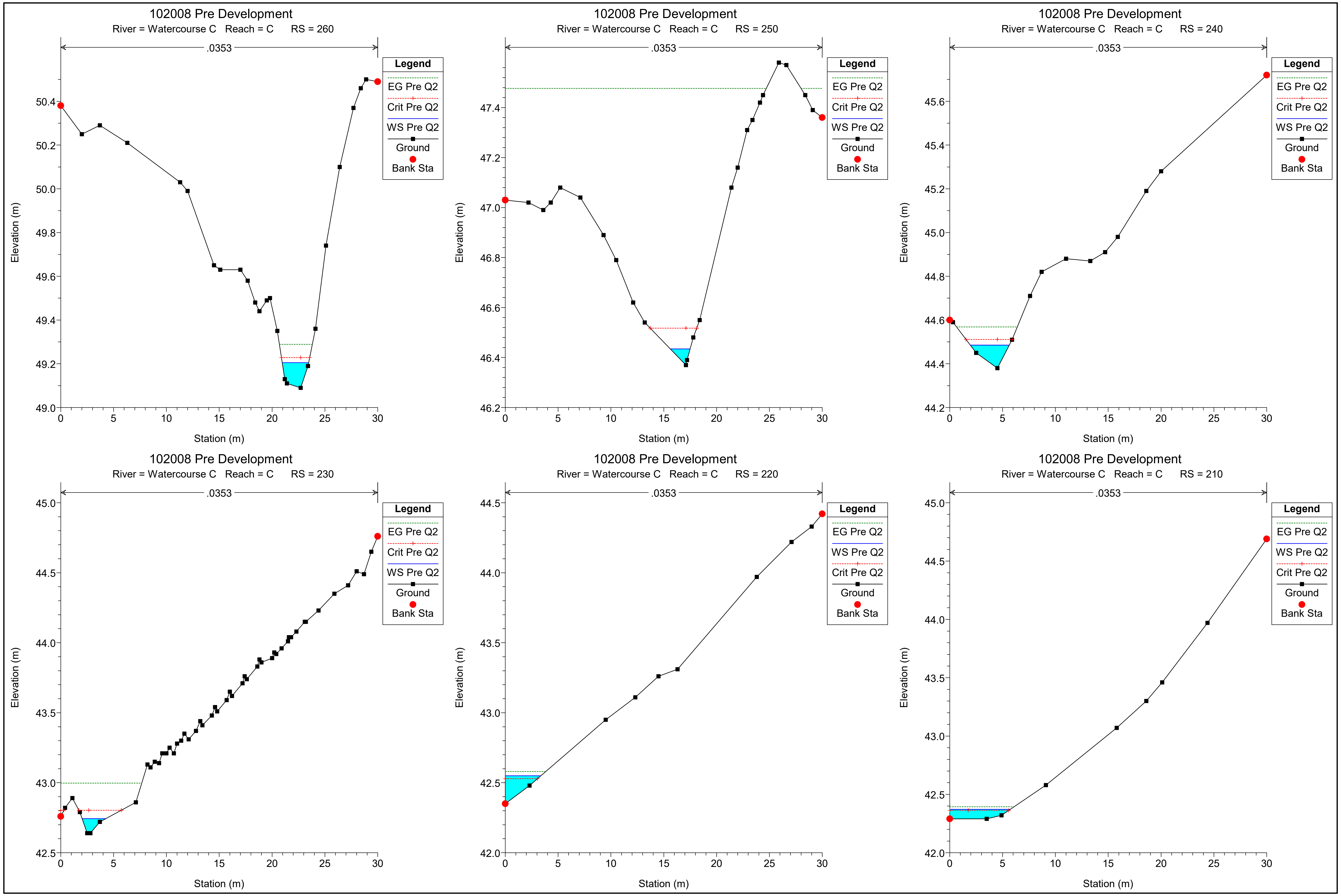

102008 Pre Development
River = Watercourse C   Reach = C   RS = 310
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

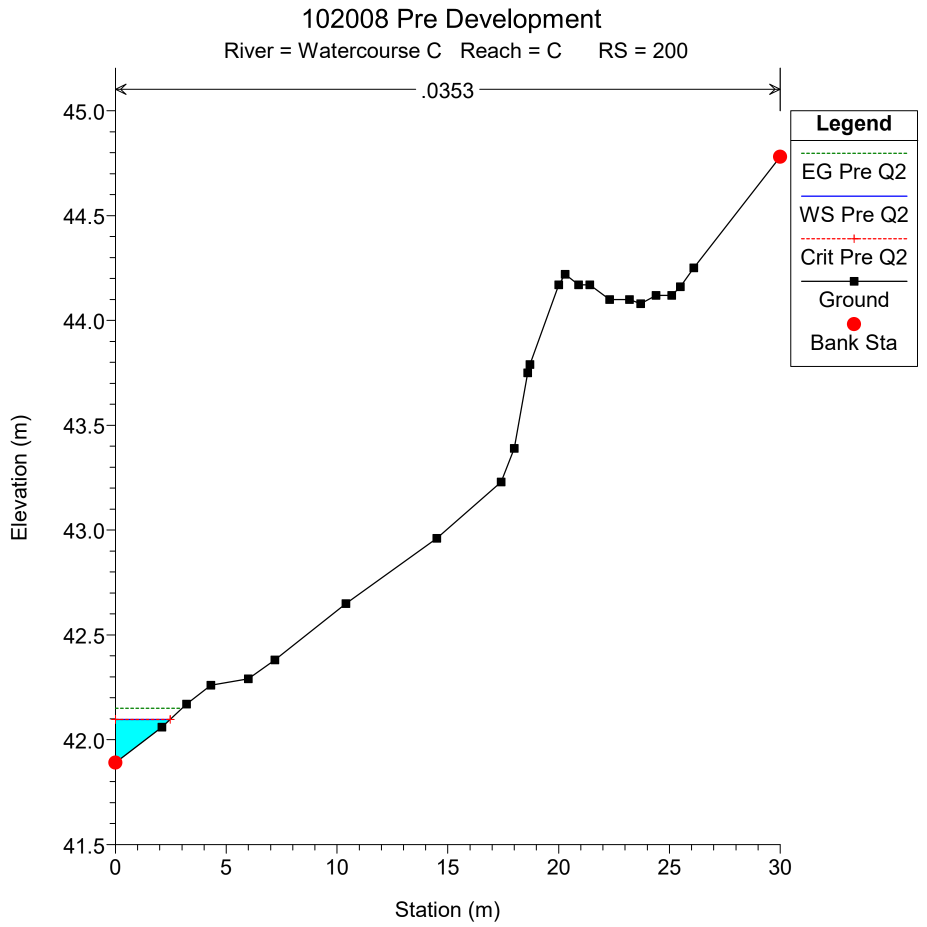

102008 Pre Development
River = Watercourse C   Reach = C   RS = 300
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

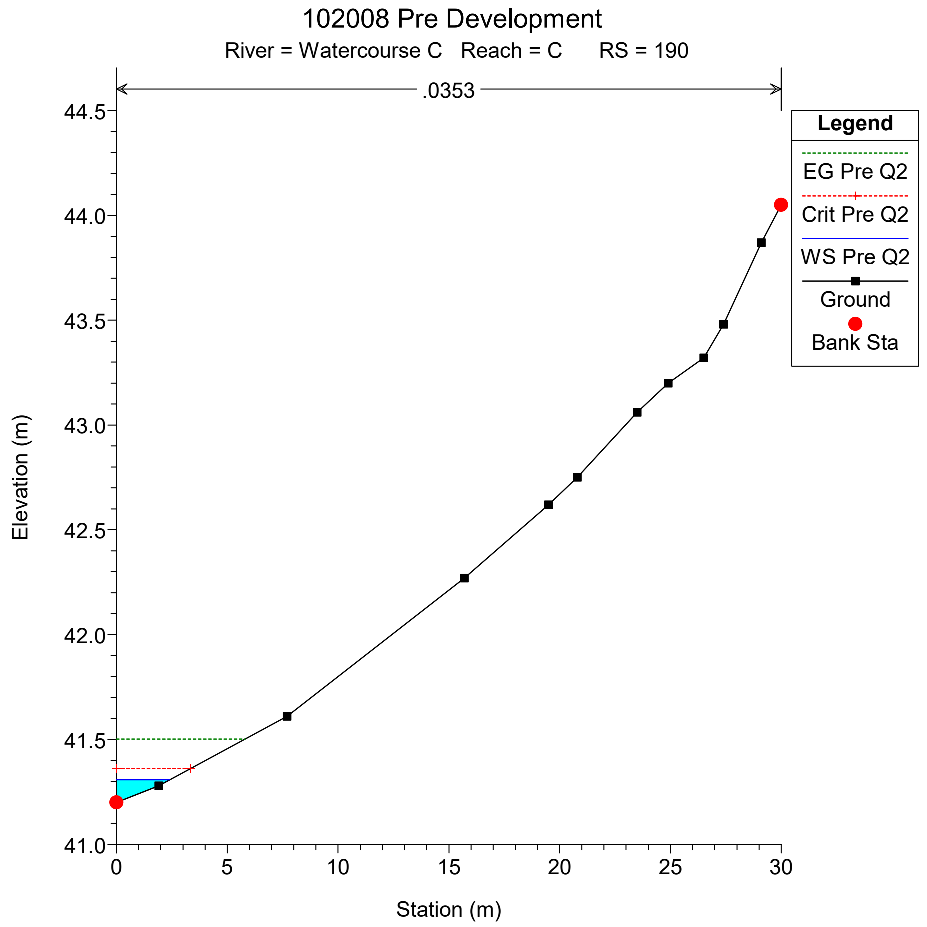

102008 Pre Development
River = Watercourse C   Reach = C   RS = 290
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

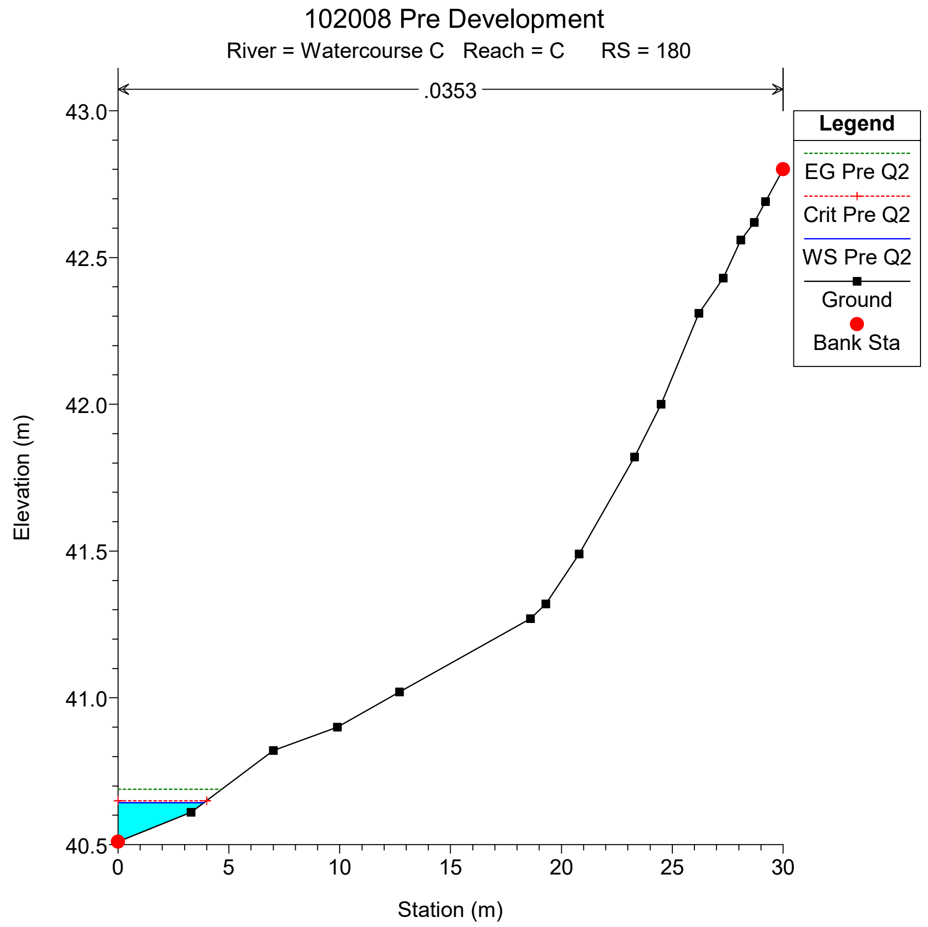

102008 Pre Development
River = Watercourse C   Reach = C   RS = 280
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

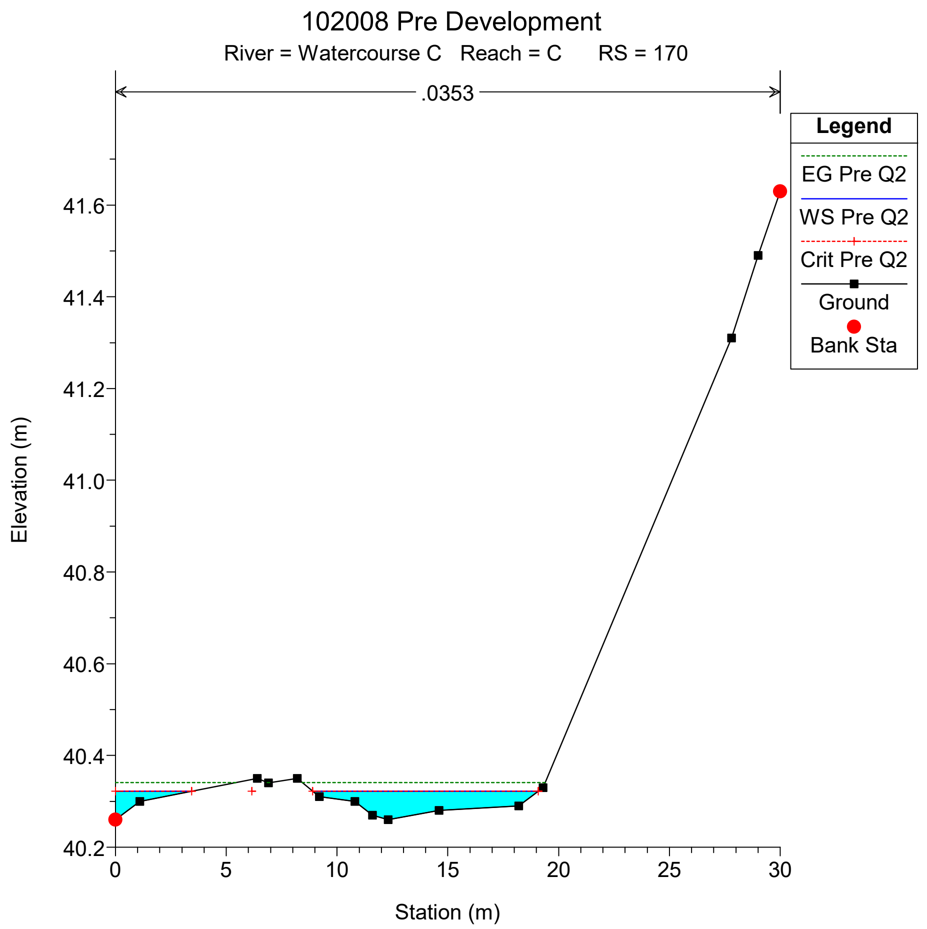

102008 Pre Development
River = Watercourse C   Reach = C   RS = 270
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

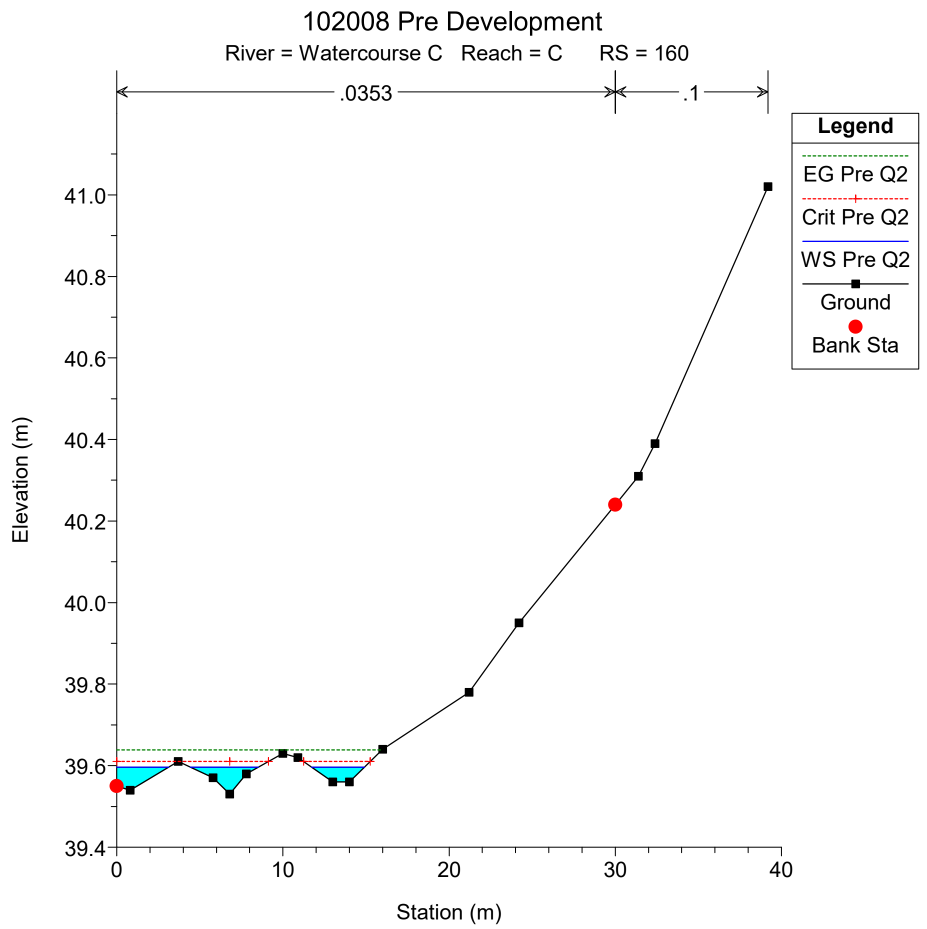

102008 Pre Development
River = Watercourse C Reach = C RS = 260
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse C Reach = C RS = 250
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse C Reach = C RS = 240
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse C Reach = C RS = 230
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse C Reach = C RS = 220
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse C Reach = C RS = 210
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

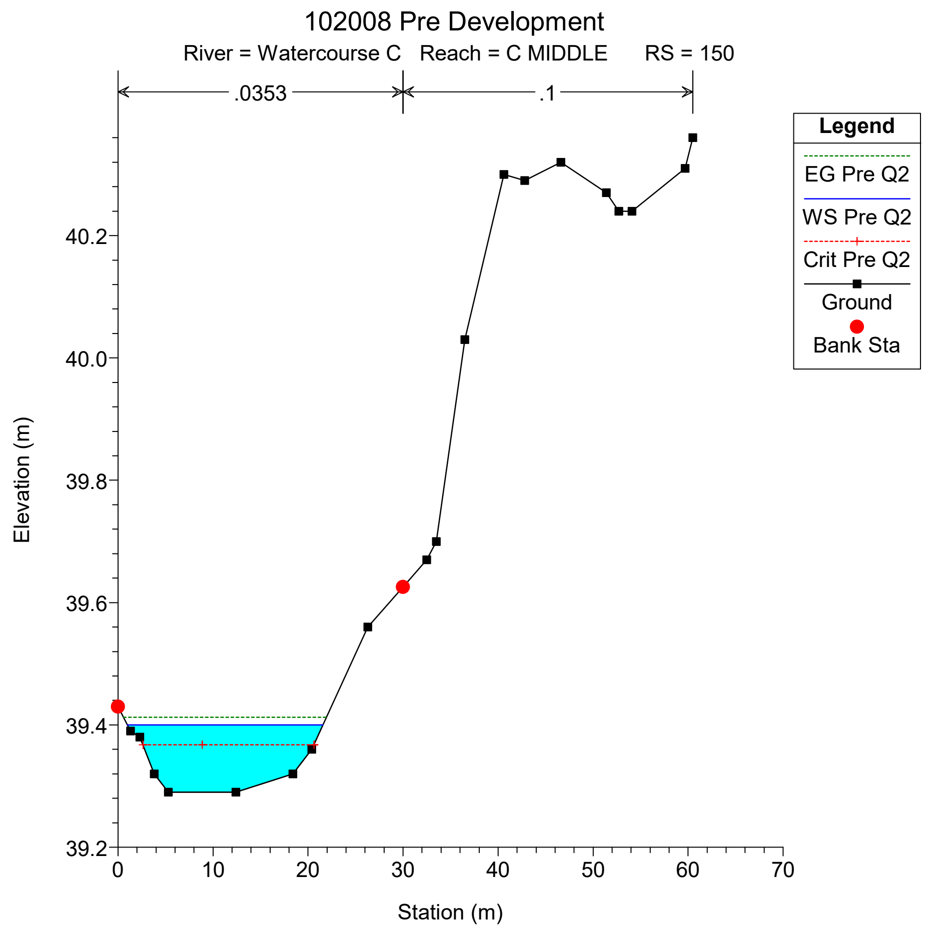

102008 Pre Development
River = Watercourse C Reach = C RS = 200
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
41.5
42.0
42.5
43.0
43.5
44.0
44.5
45.0
0
5
10
15
20
25
30

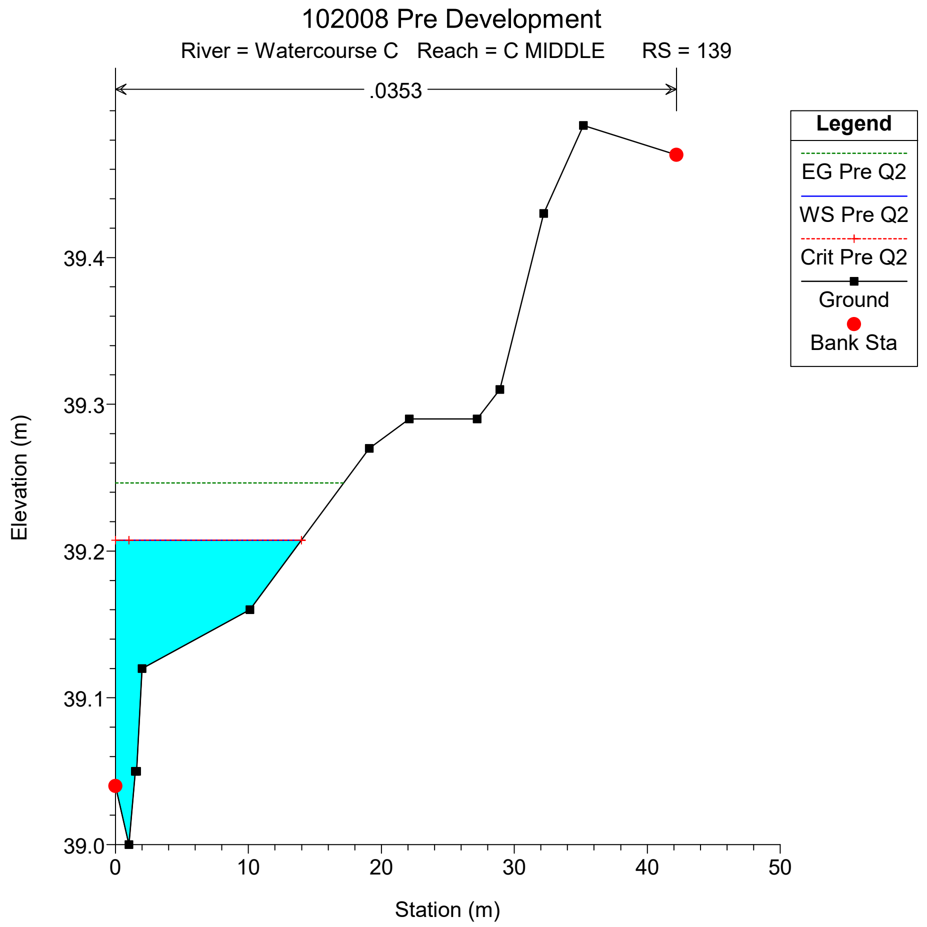

102008 Pre Development
River = Watercourse C Reach = C RS = 190
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
41.0
41.5
42.0
42.5
43.0
43.5
44.0
44.5
0
5
10
15
20
25
30

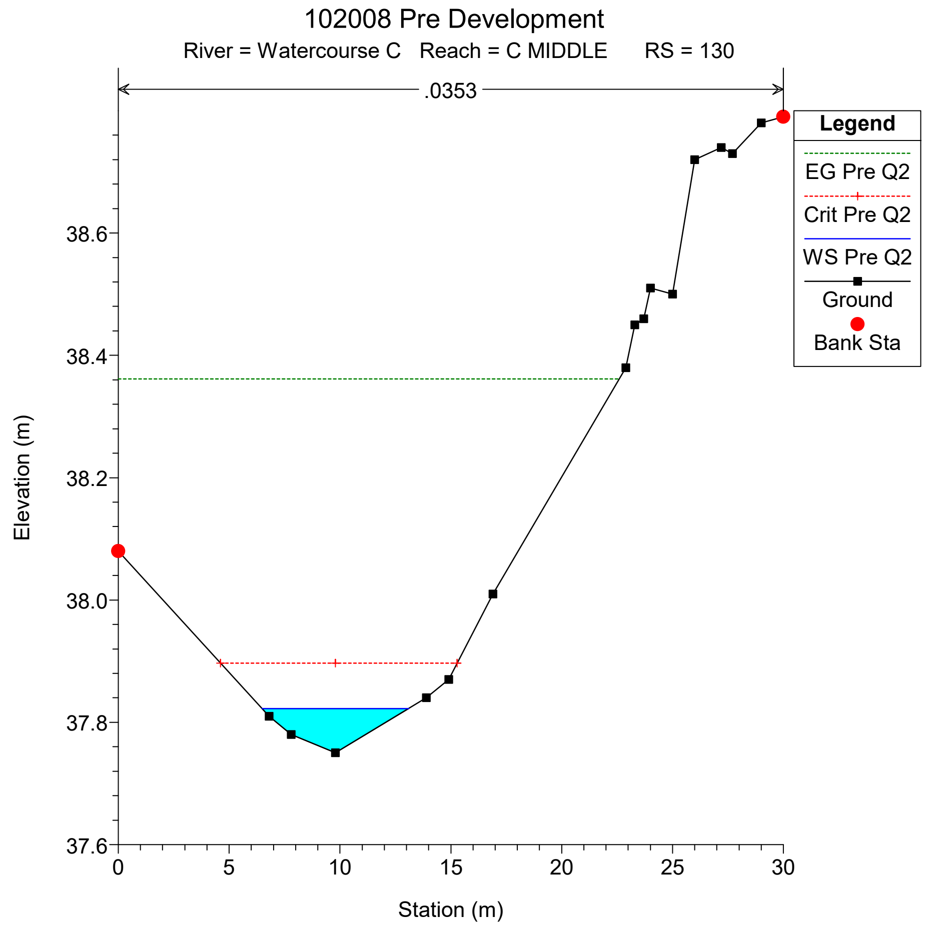

102008 Pre Development
River = Watercourse C Reach = C RS = 180
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
40.5
41.0
41.5
42.0
42.5
43.0
0
5
10
15
20
25
30

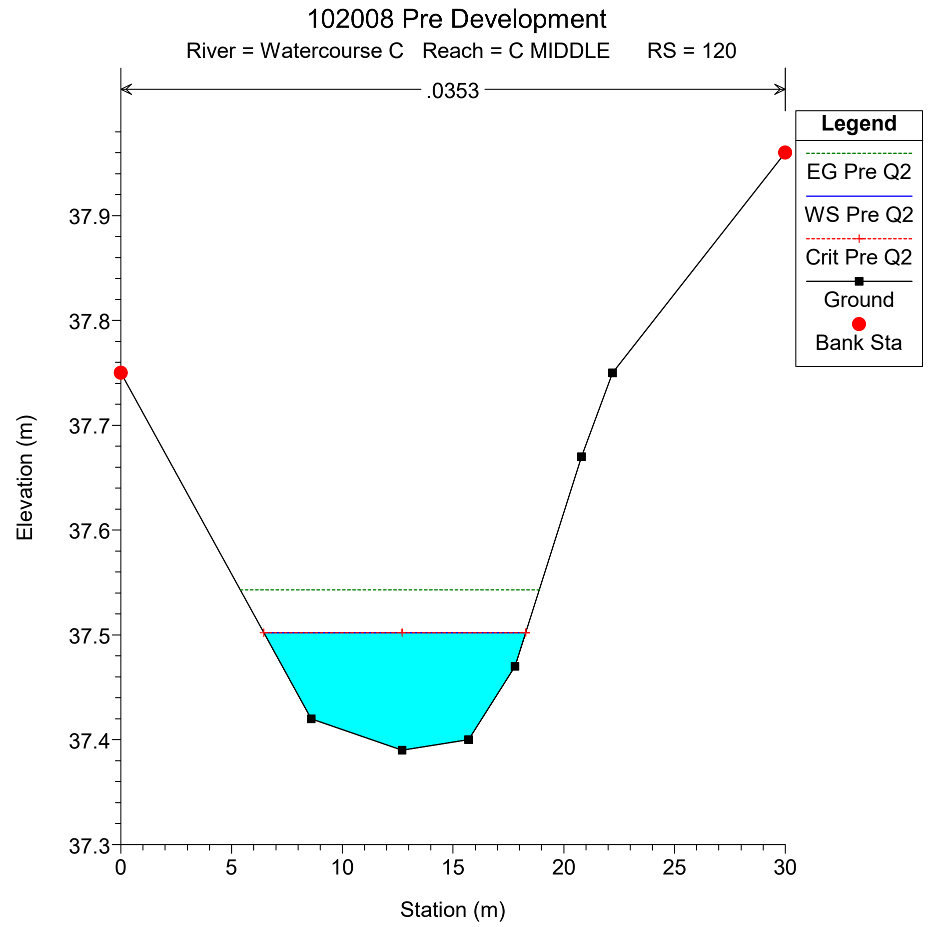

102008 Pre Development
River = Watercourse C Reach = C RS = 170
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
40.2
40.4
40.6
40.8
41.0
41.2
41.4
41.6
0
5
10
15
20
25
30

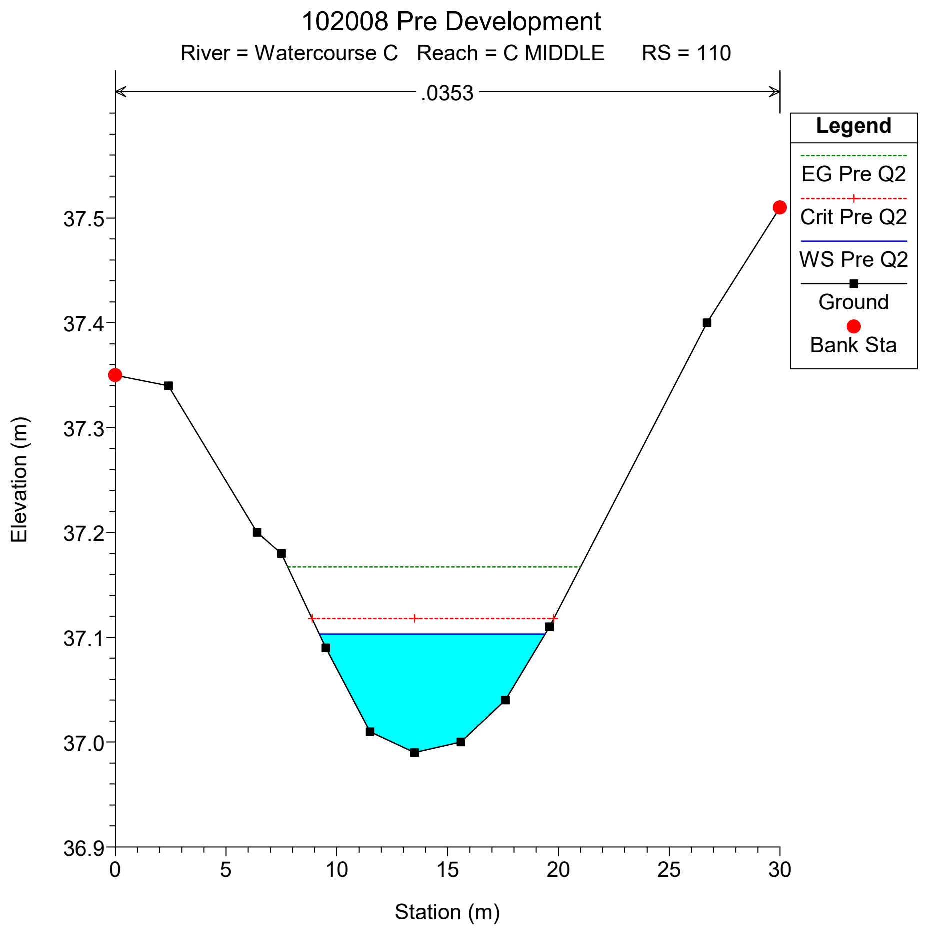

102008 Pre Development
River = Watercourse C Reach = C RS = 160
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
39.4
39.6
39.8
40.0
40.2
40.4
40.6
40.8
41.0
0
10
20
30
40

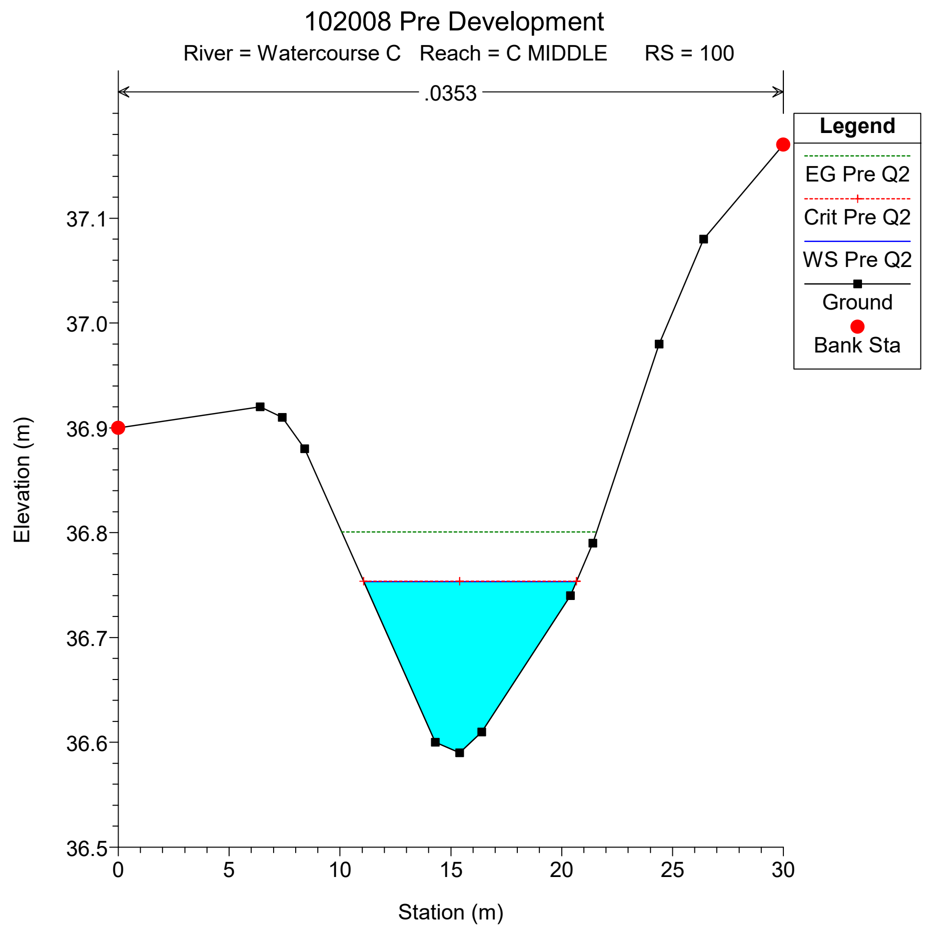

102008 Pre Development
River = Watercourse C Reach = C MIDDLE RS = 150
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
39.2
39.4
39.6
39.8
40.0
40.2
0
10
20
30
40
50
60
70

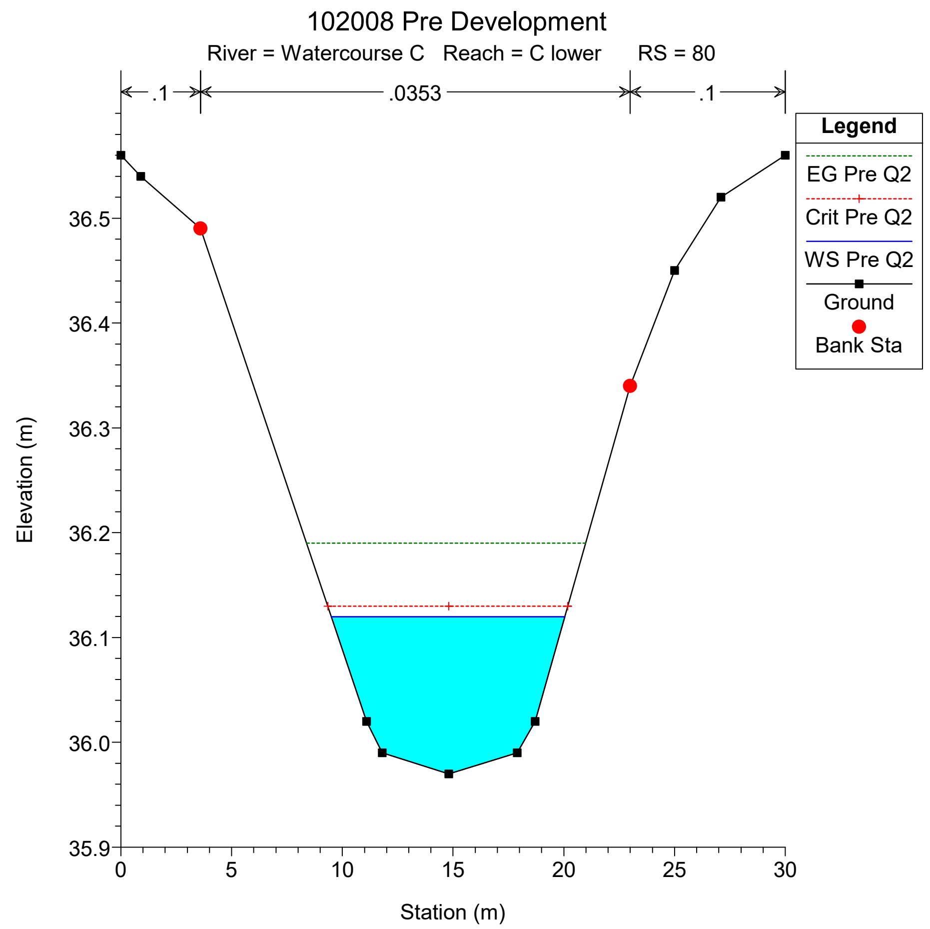

102008 Pre Development
River = Watercourse C Reach = C MIDDLE RS = 139
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
39.0
39.1
39.2
39.3
39.4
0
10
20
30
40
50

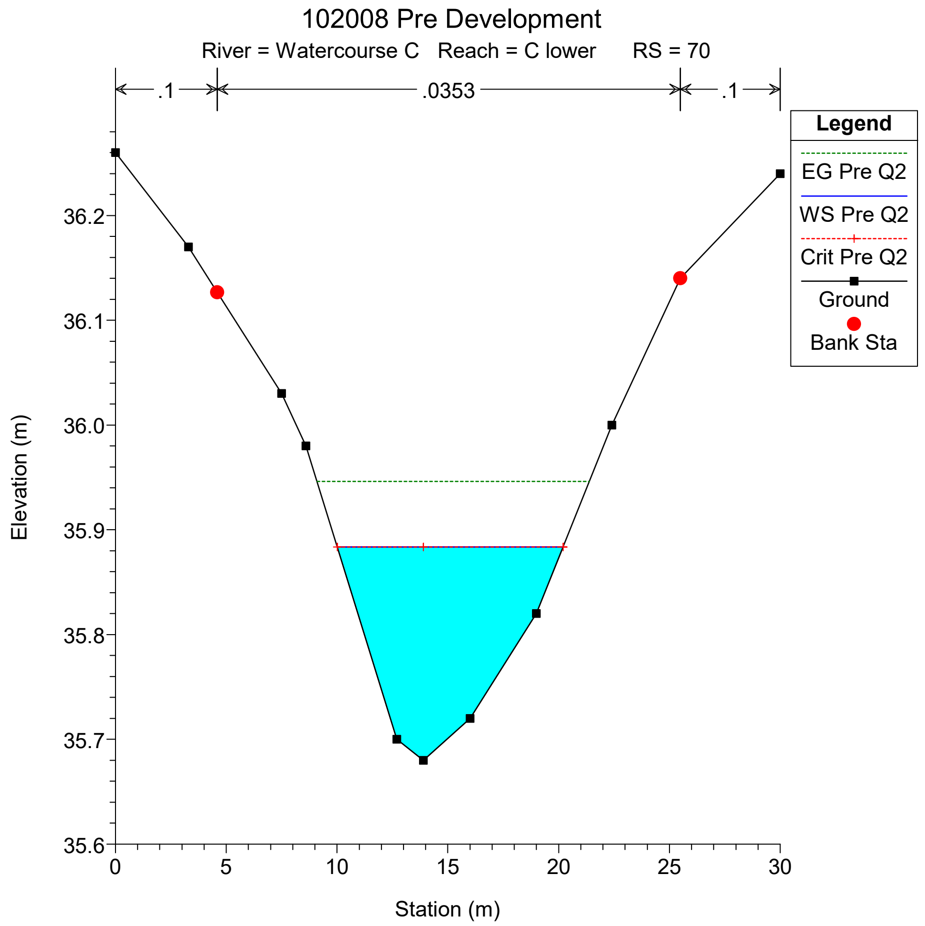

102008 Pre Development
River = Watercourse C Reach = C MIDDLE RS = 130
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
37.6
37.8
38.0
38.2
38.4
38.6
0
5
10
15
20
25
30

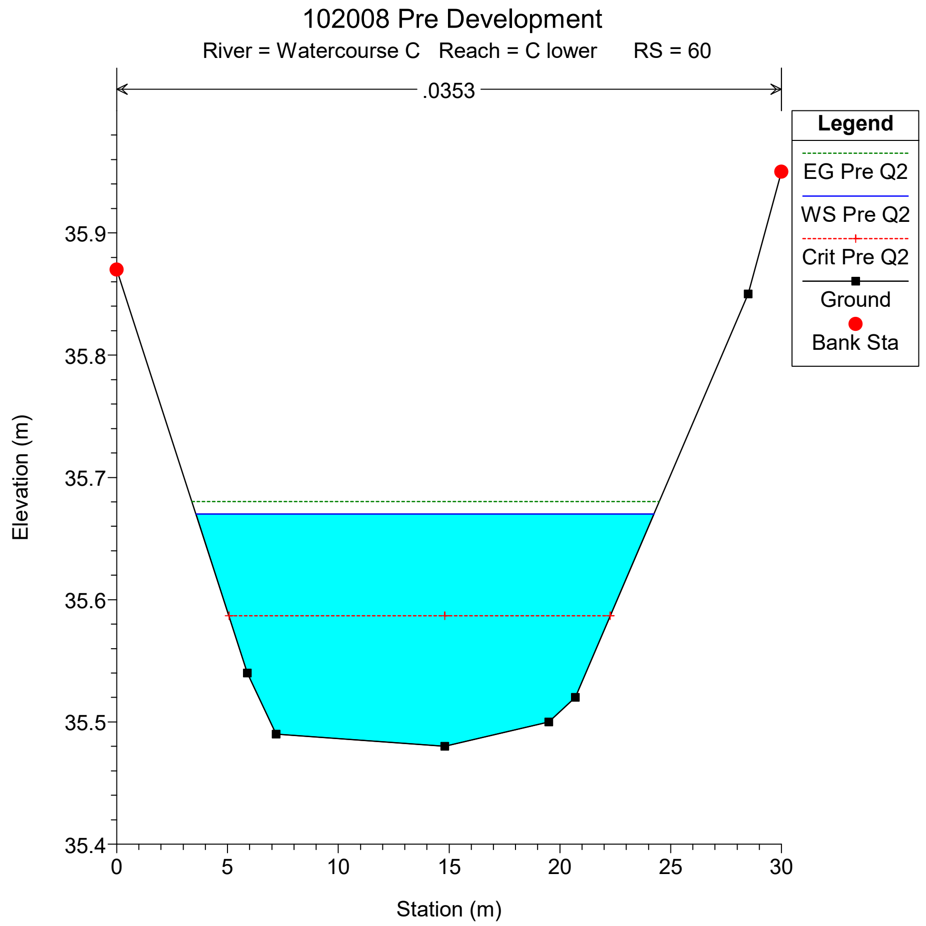

102008 Pre Development
River = Watercourse C Reach = C MIDDLE RS = 120
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
37.3
37.4
37.5
37.6
37.7
37.8
37.9
0
5
10
15
20
25
30

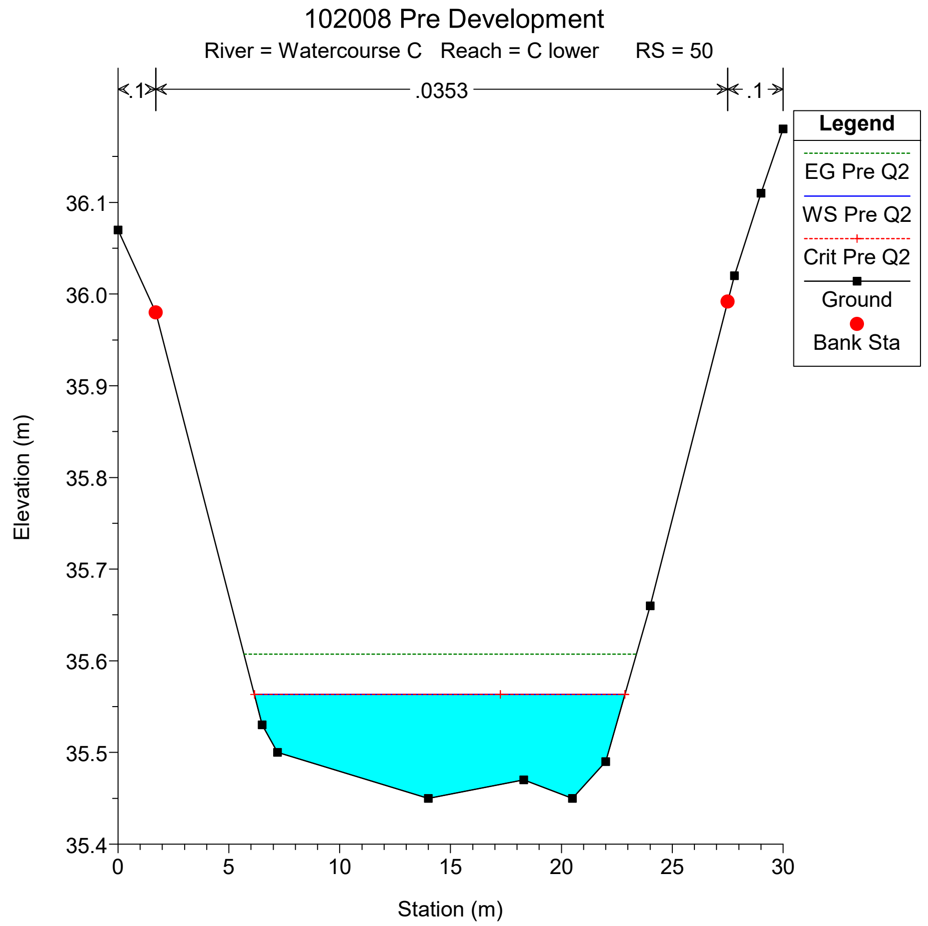

102008 Pre Development
River = Watercourse C Reach = C MIDDLE RS = 110
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
36.9
37.0
37.1
37.2
37.3
37.4
37.5
0
5
10
15
20
25
30

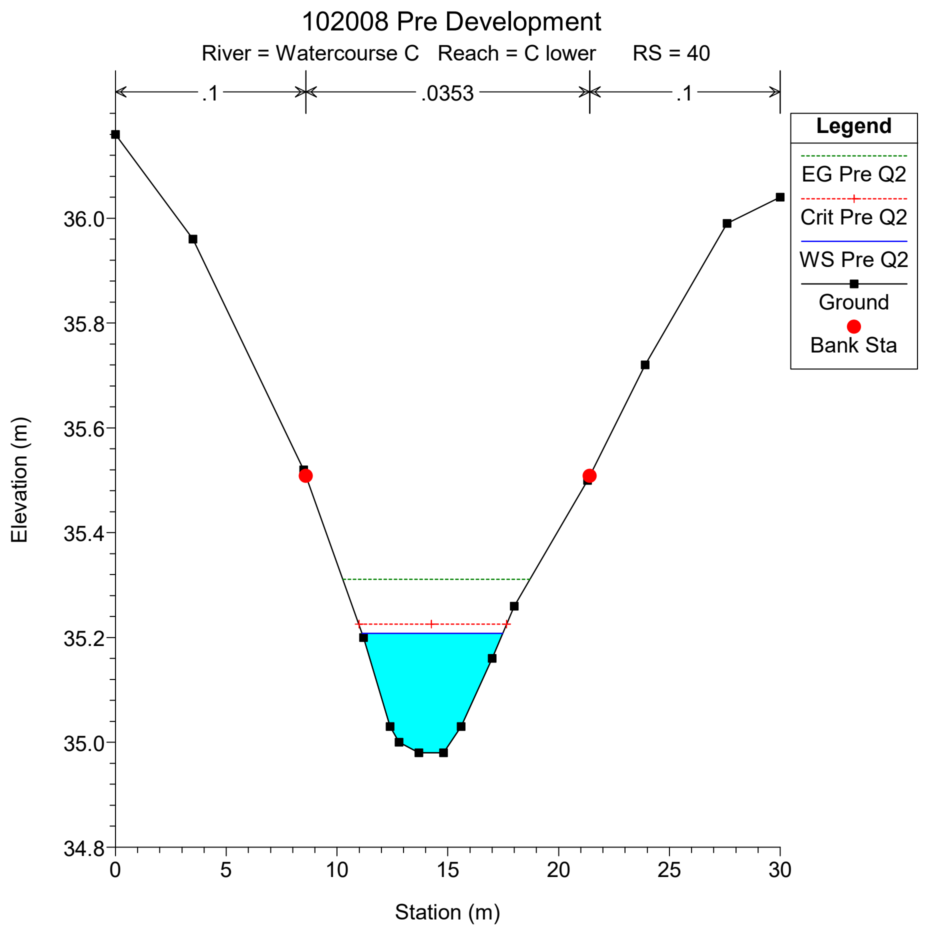

102008 Pre Development
River = Watercourse C Reach = C MIDDLE RS = 100
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
36.5
36.6
36.7
36.8
36.9
37.0
37.1
0
5
10
15
20
25
30

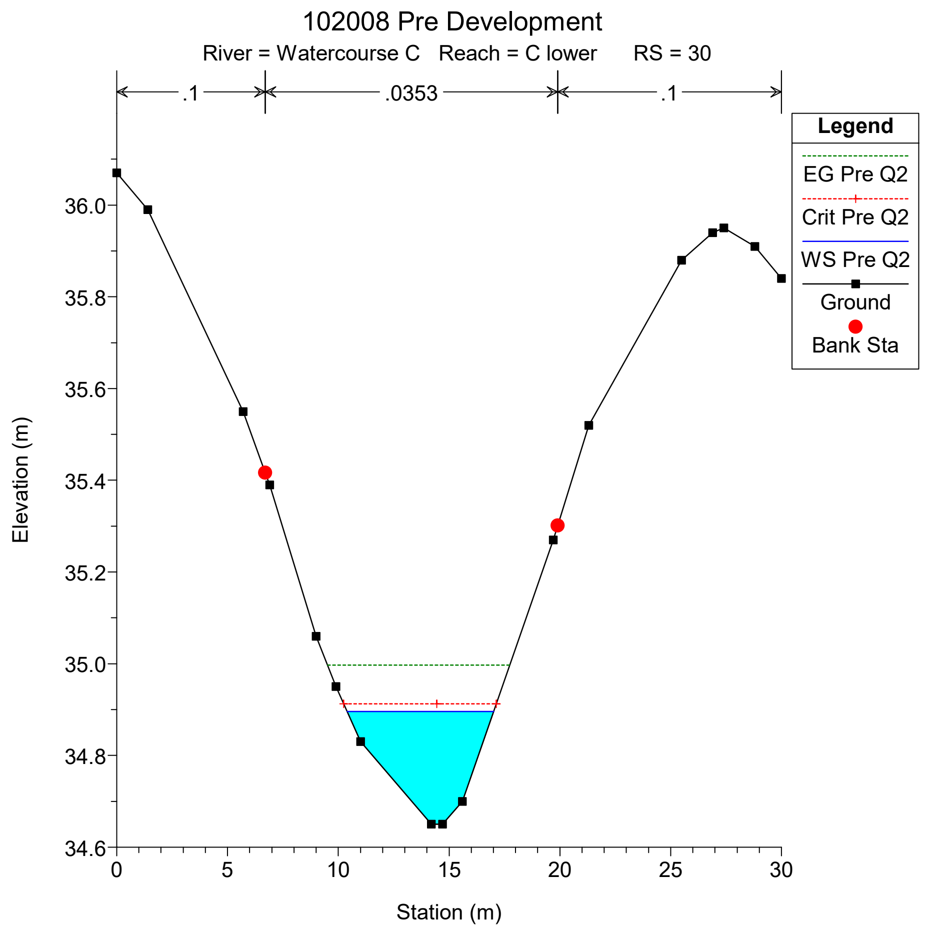

102008 Pre Development
River = Watercourse C Reach = C lower RS = 80
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
35.9
36.0
36.1
36.2
36.3
36.4
36.5
0
5
10
15
20
25
30

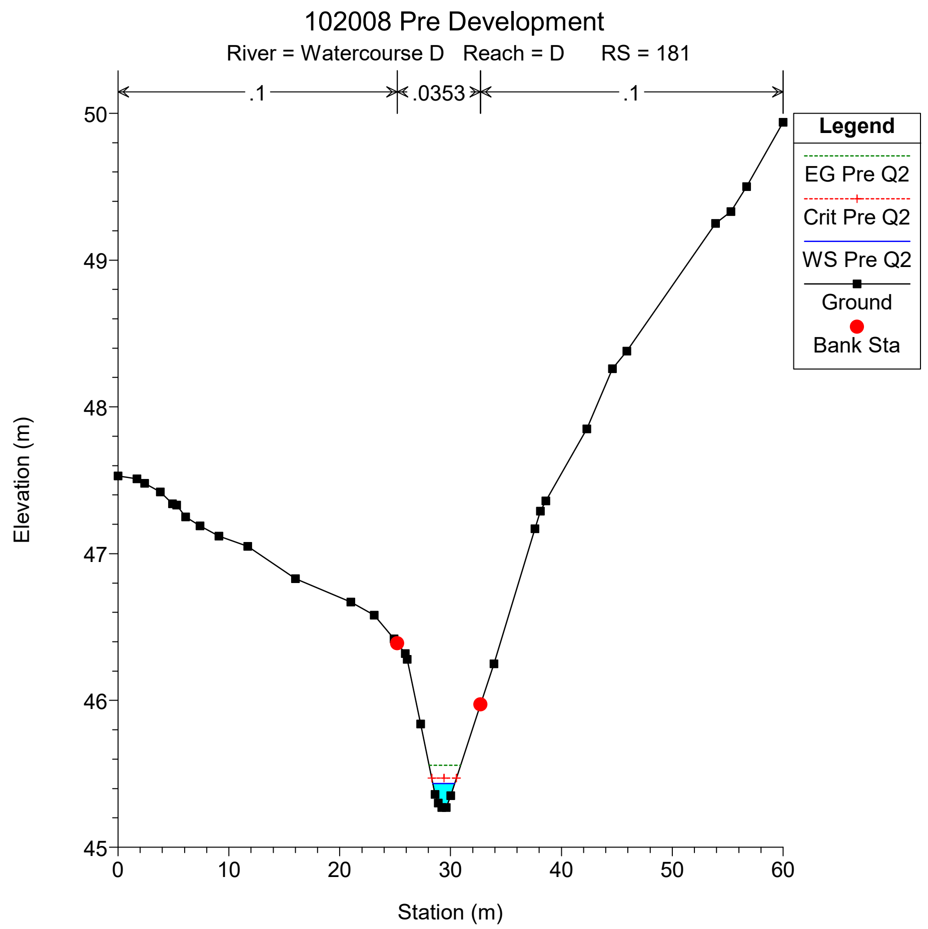

102008 Pre Development
River = Watercourse C Reach = C lower RS = 70
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

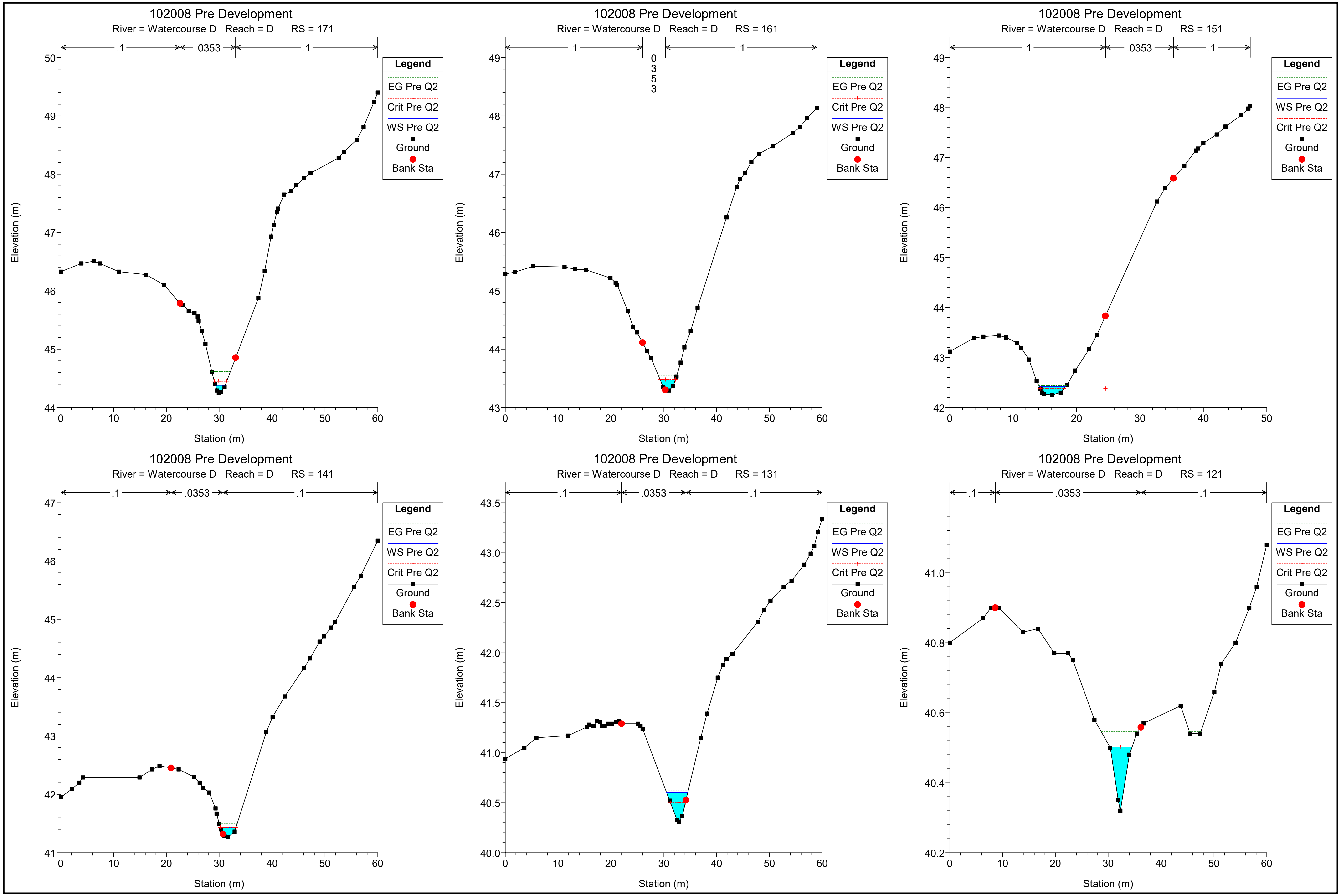

102008 Pre Development
River = Watercourse C Reach = C lower RS = 60
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

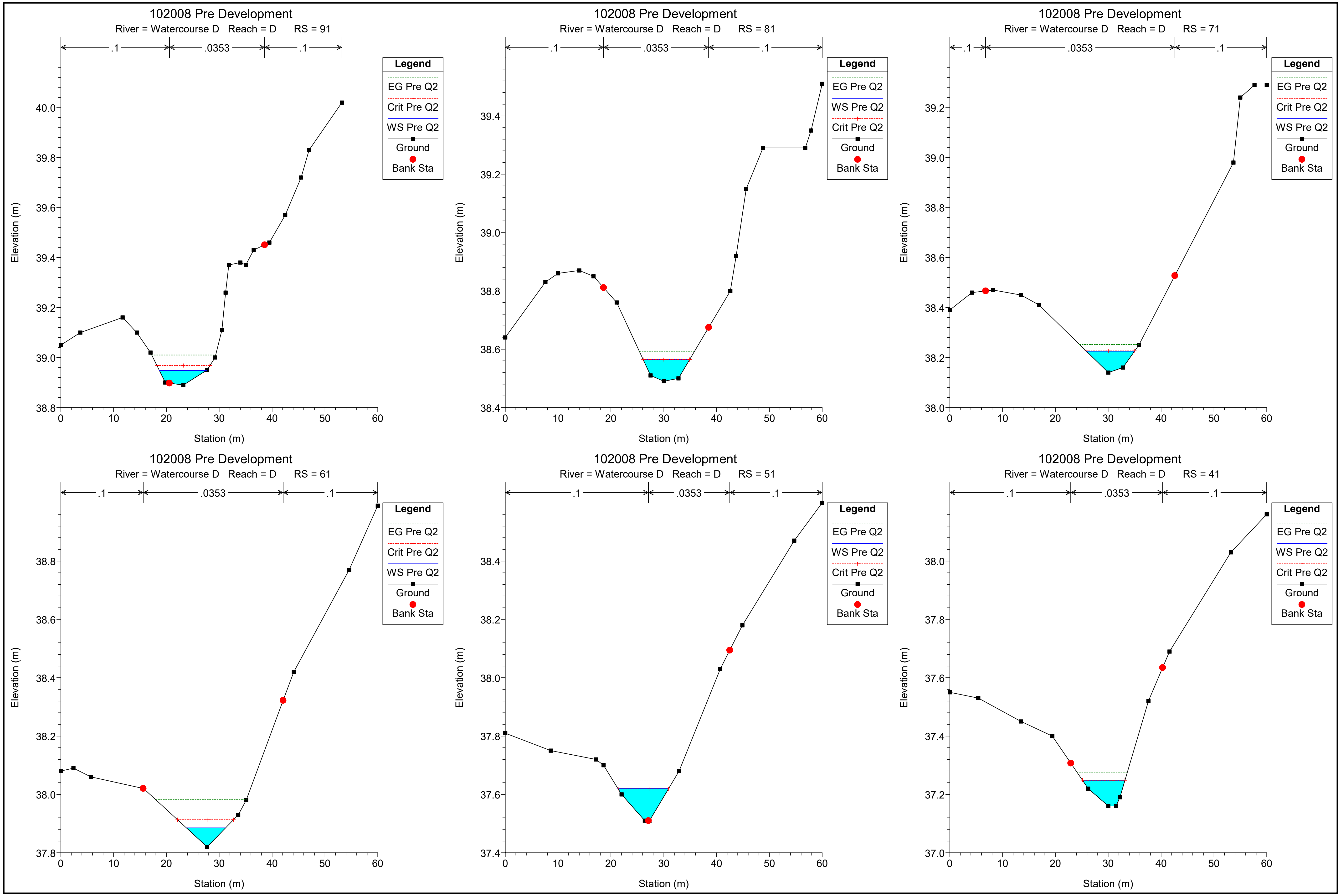

102008 Pre Development
River = Watercourse C Reach = C lower RS = 50
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

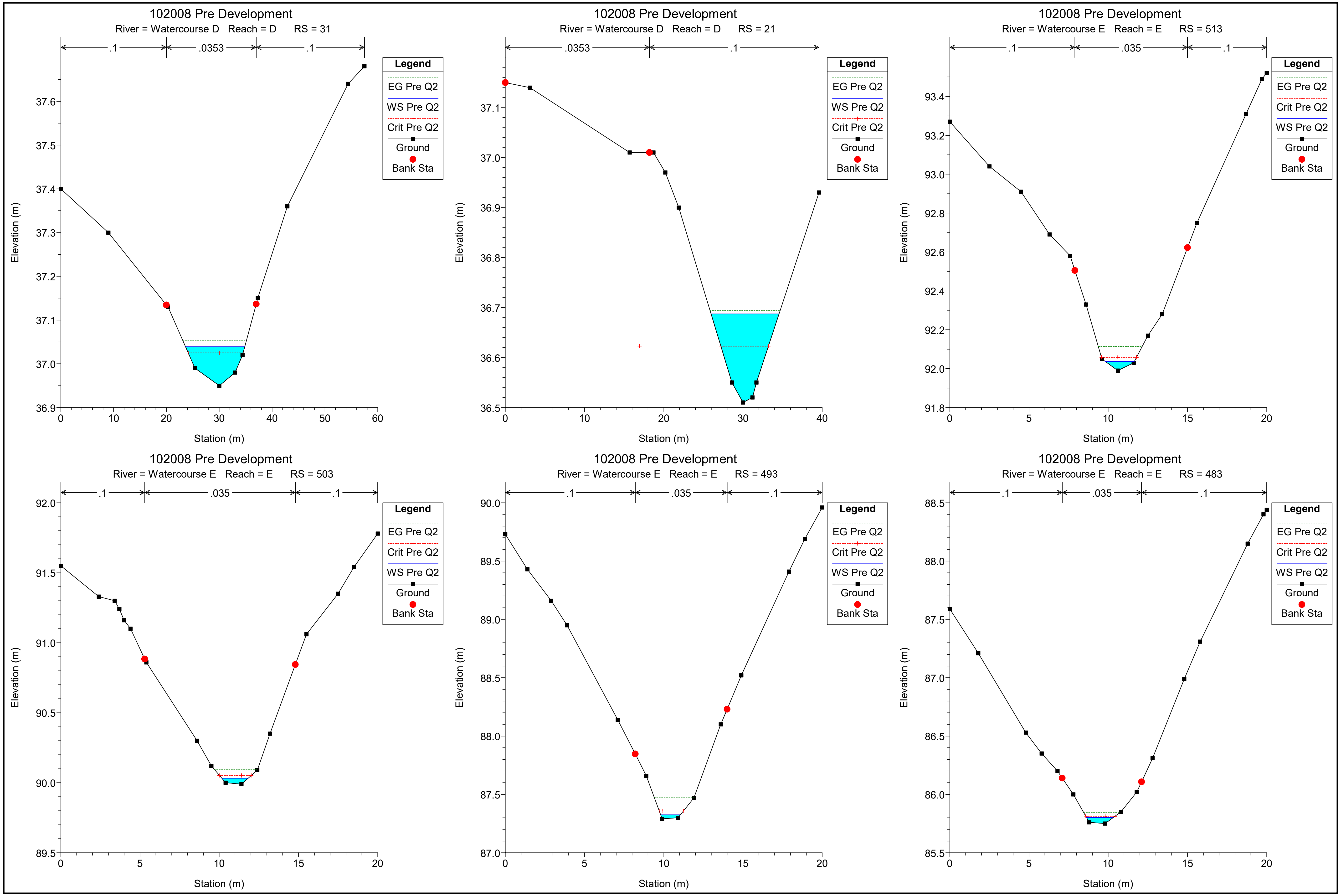

102008 Pre Development
River = Watercourse C Reach = C lower RS = 40
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

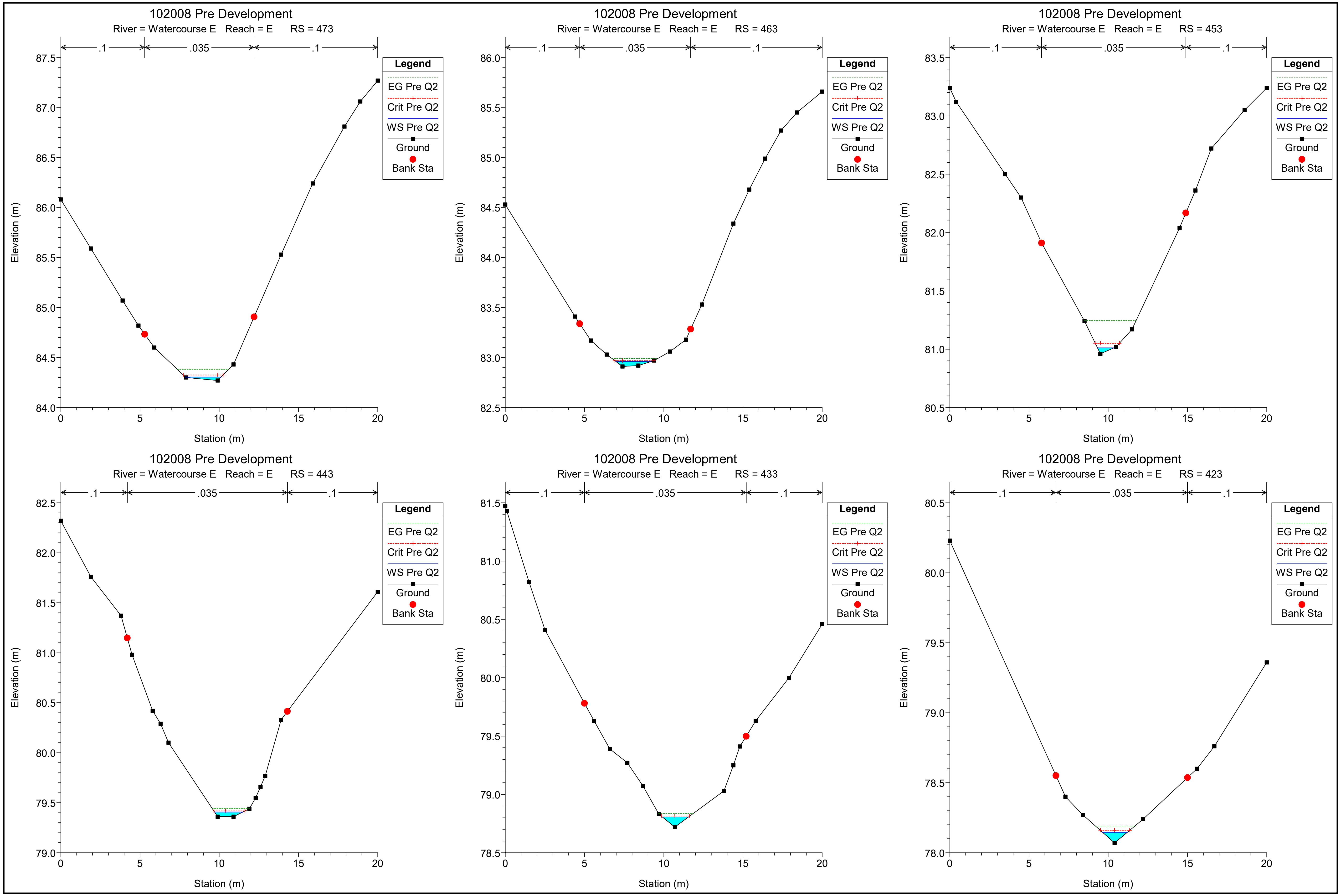

102008 Pre Development
River = Watercourse C Reach = C lower RS = 30
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

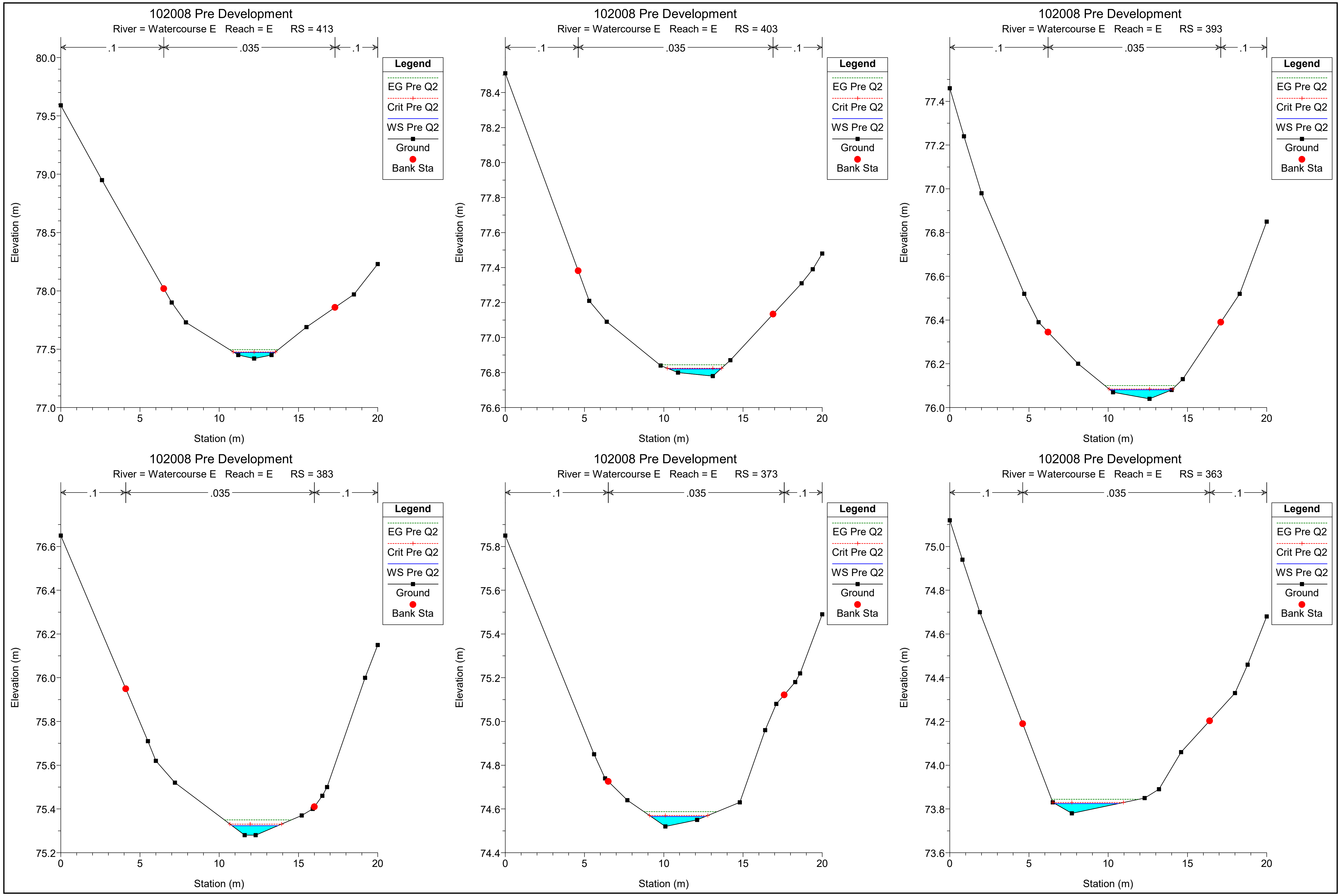

102008 Pre Development
River = Watercourse D Reach = D RS = 181
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)


102008 Pre Development
River = Watercourse D Reach = D RS = 171
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 161
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 151
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 141
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 131
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 121
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

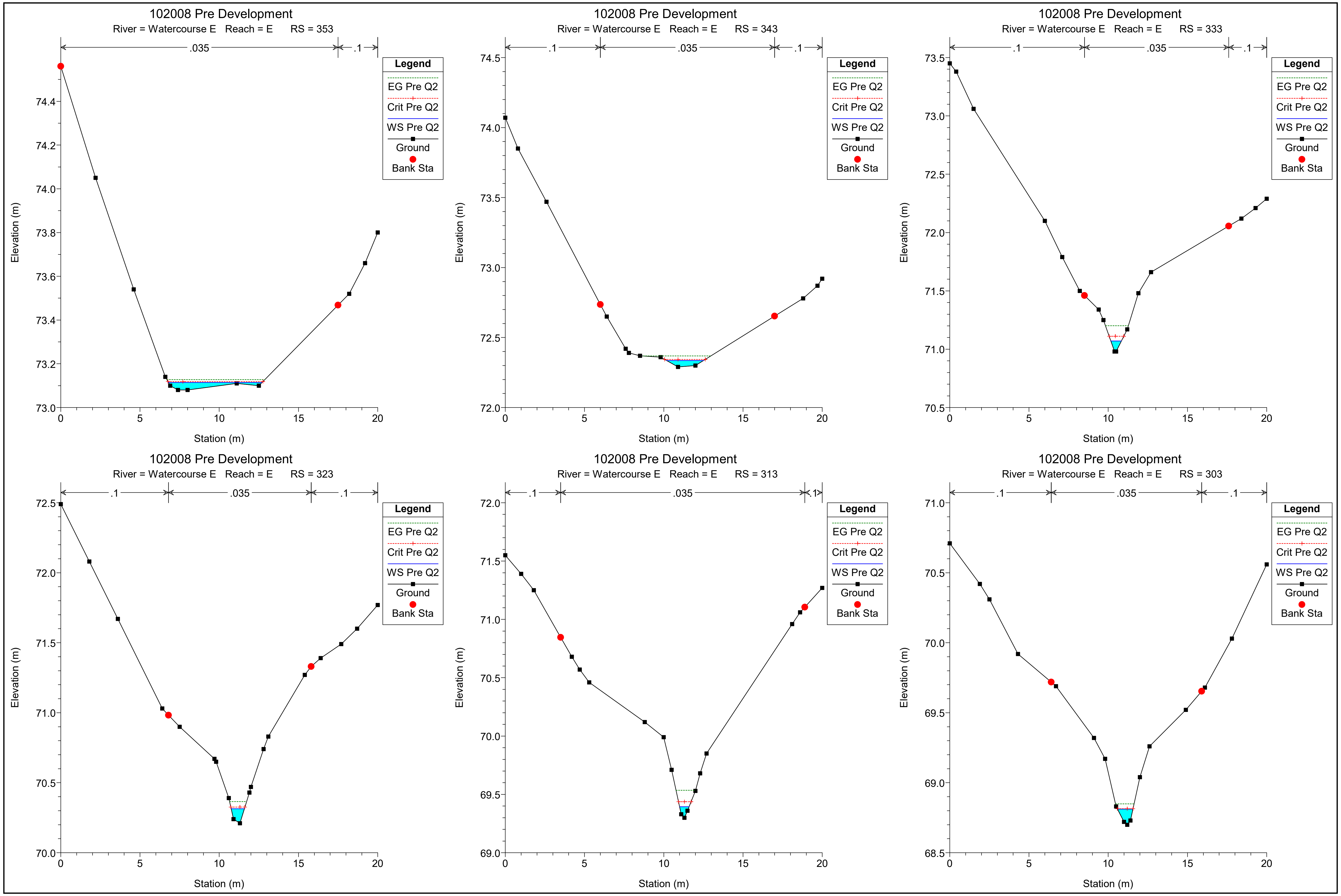

102008 Pre Development
River = Watercourse D Reach = D RS = 91
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 81
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 71
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 61
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 51
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 41
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

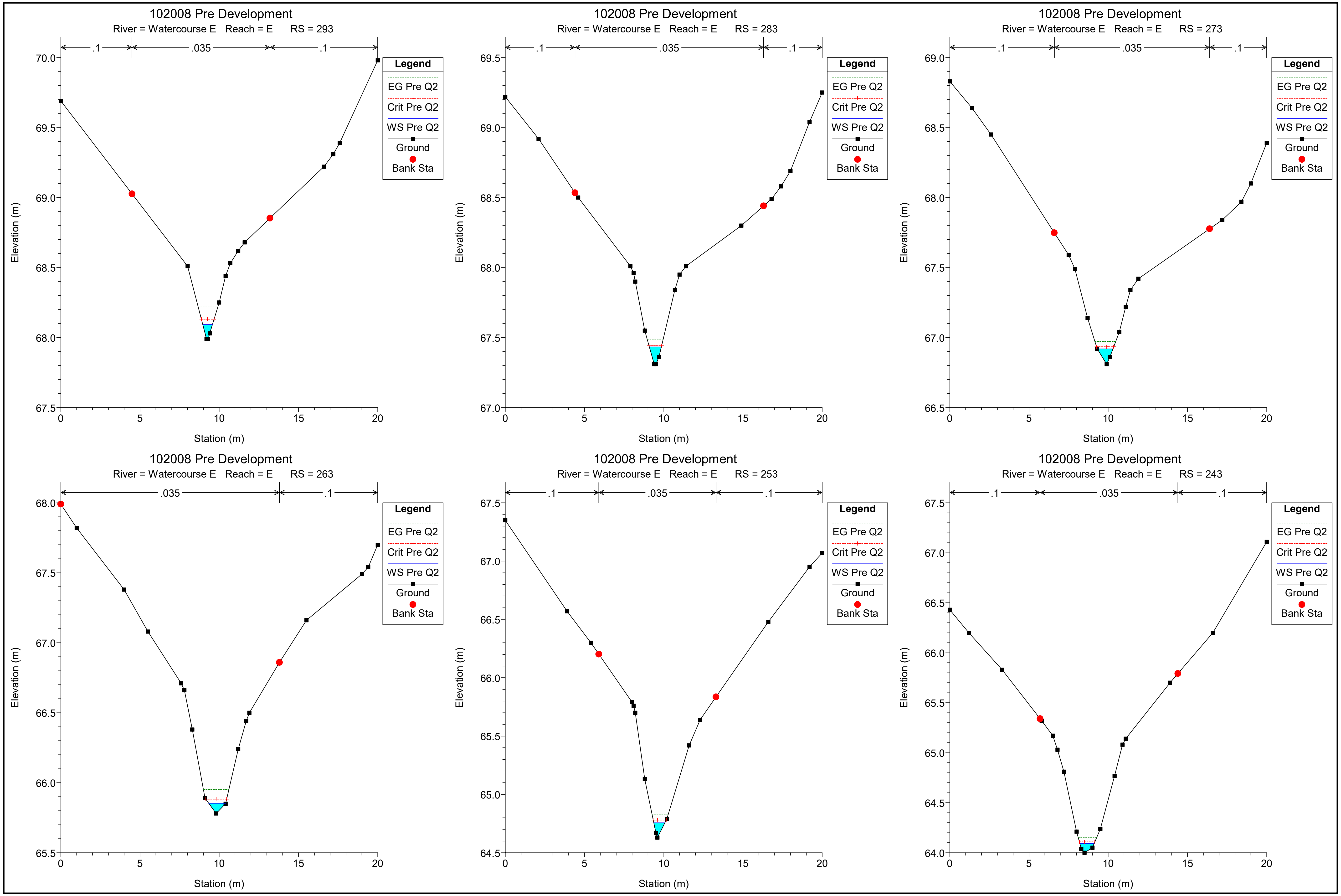

102008 Pre Development
River = Watercourse D Reach = D RS = 31
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse D Reach = D RS = 21
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 513
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 503
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 493
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 483
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

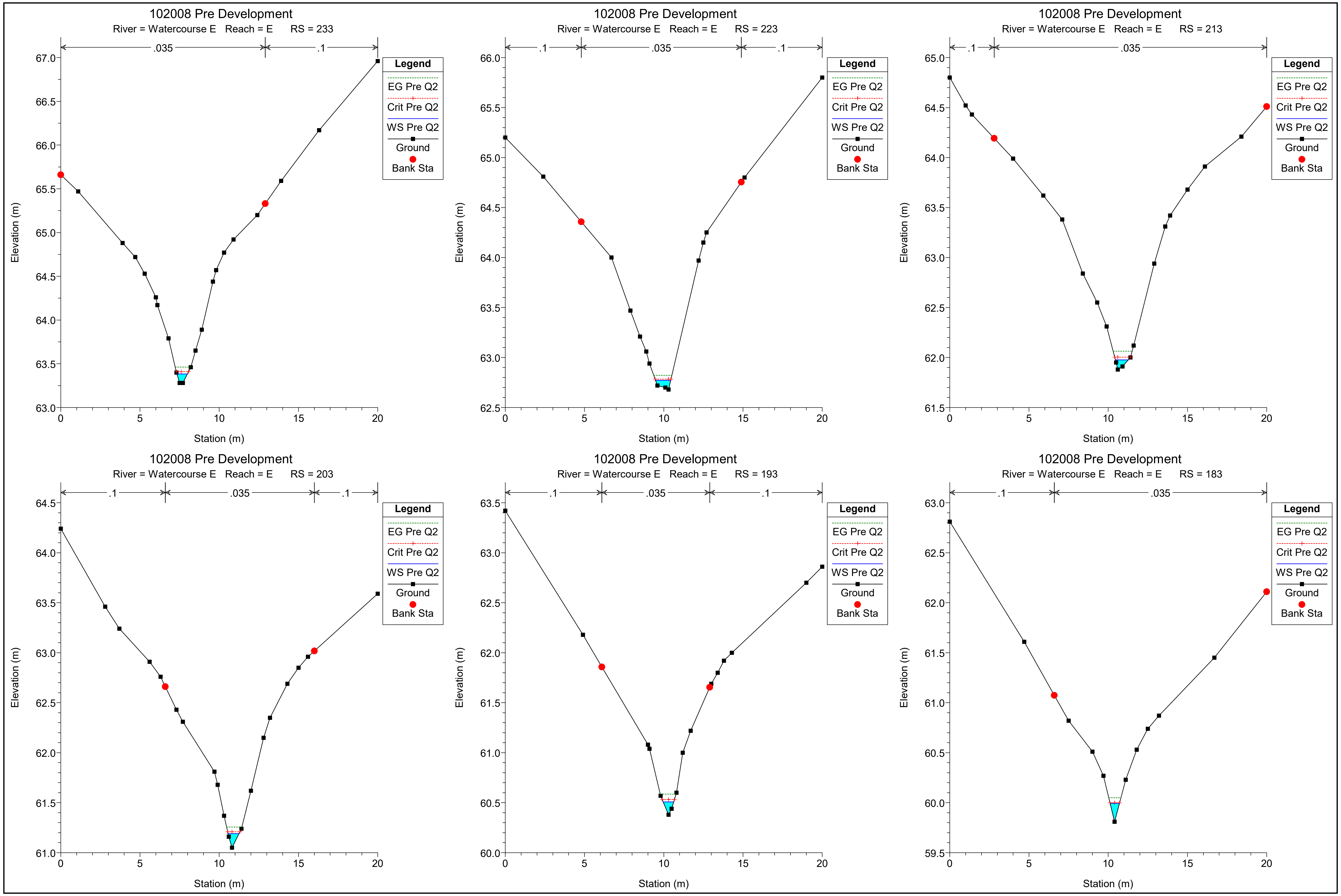

102008 Pre Development
River = Watercourse E Reach = E RS = 473
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 463
102008 Pre Development
River = Watercourse E Reach = E RS = 453
102008 Pre Development
River = Watercourse E Reach = E RS = 443
102008 Pre Development
River = Watercourse E Reach = E RS = 433
102008 Pre Development
River = Watercourse E Reach = E RS = 423

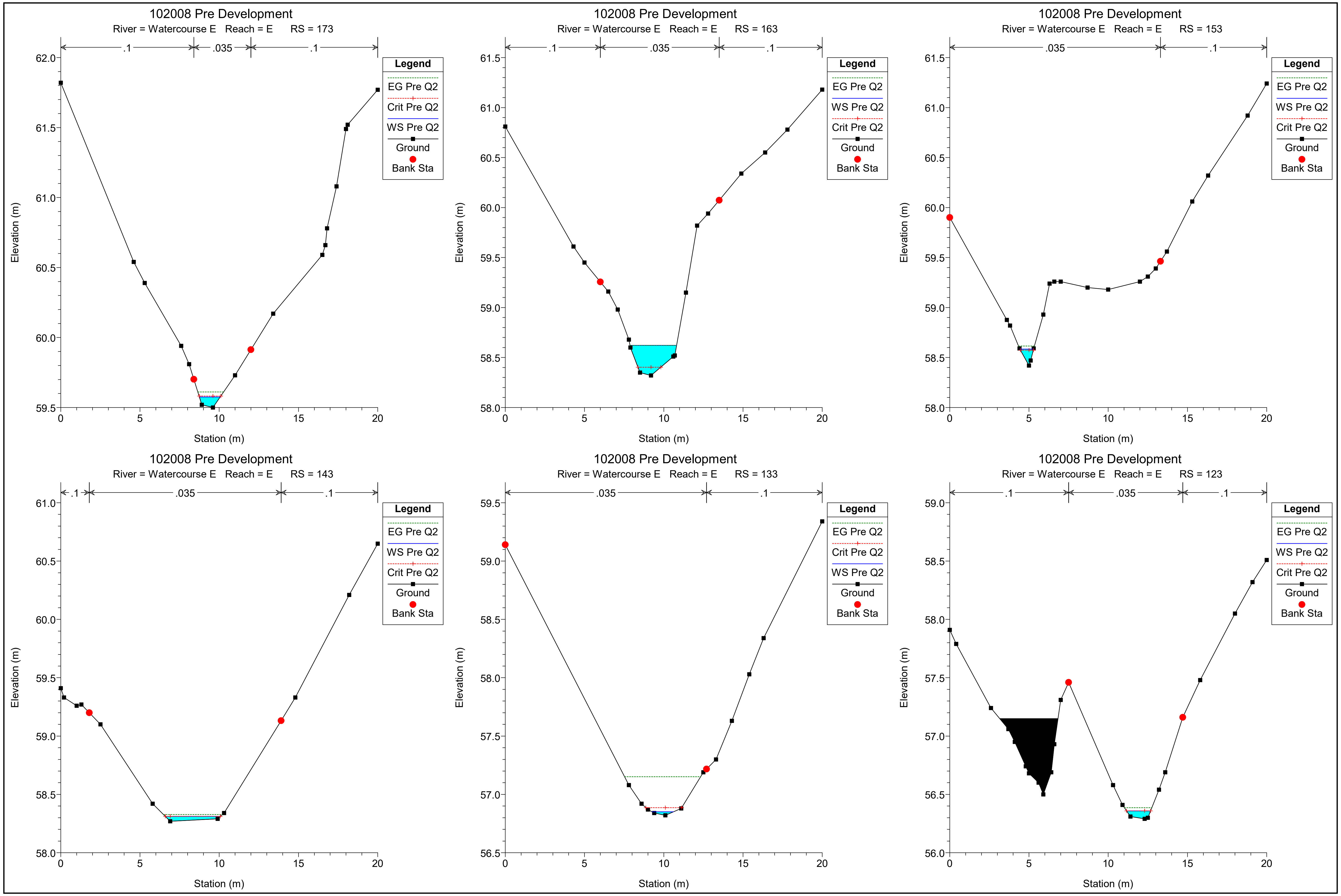


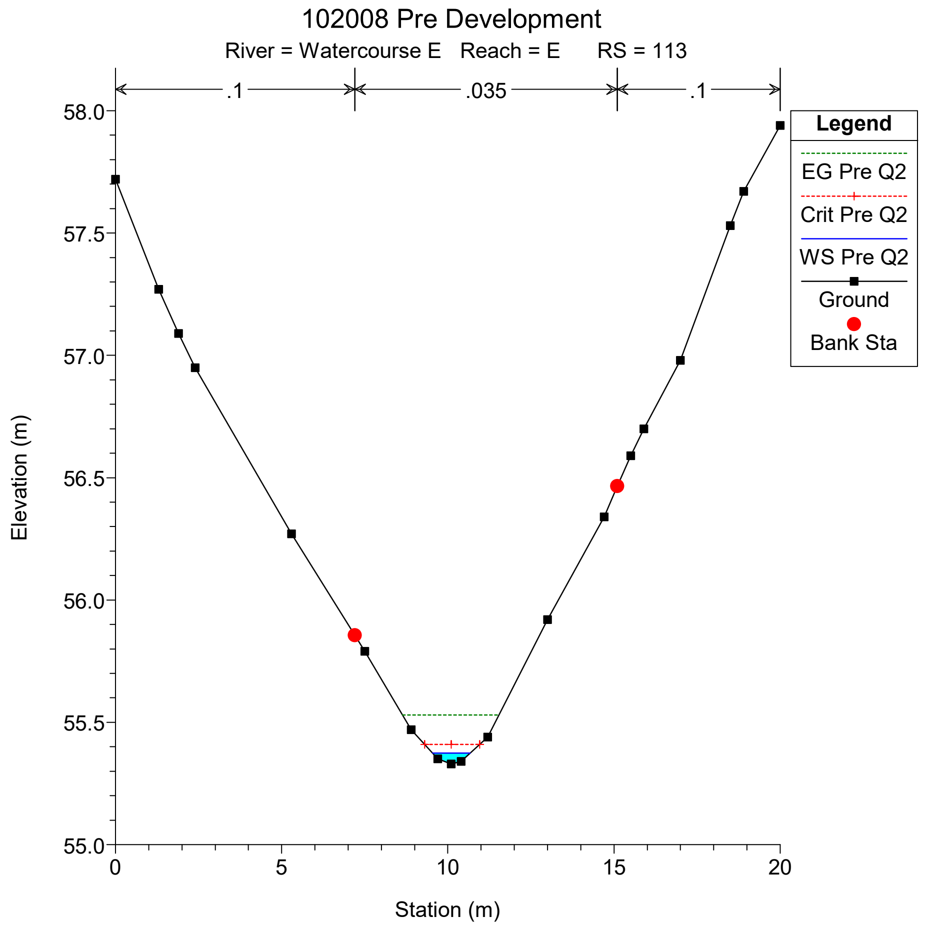
102008 Pre Development
River = Watercourse E Reach = E RS = 413
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 403
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 393
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 383
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 373
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 363
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

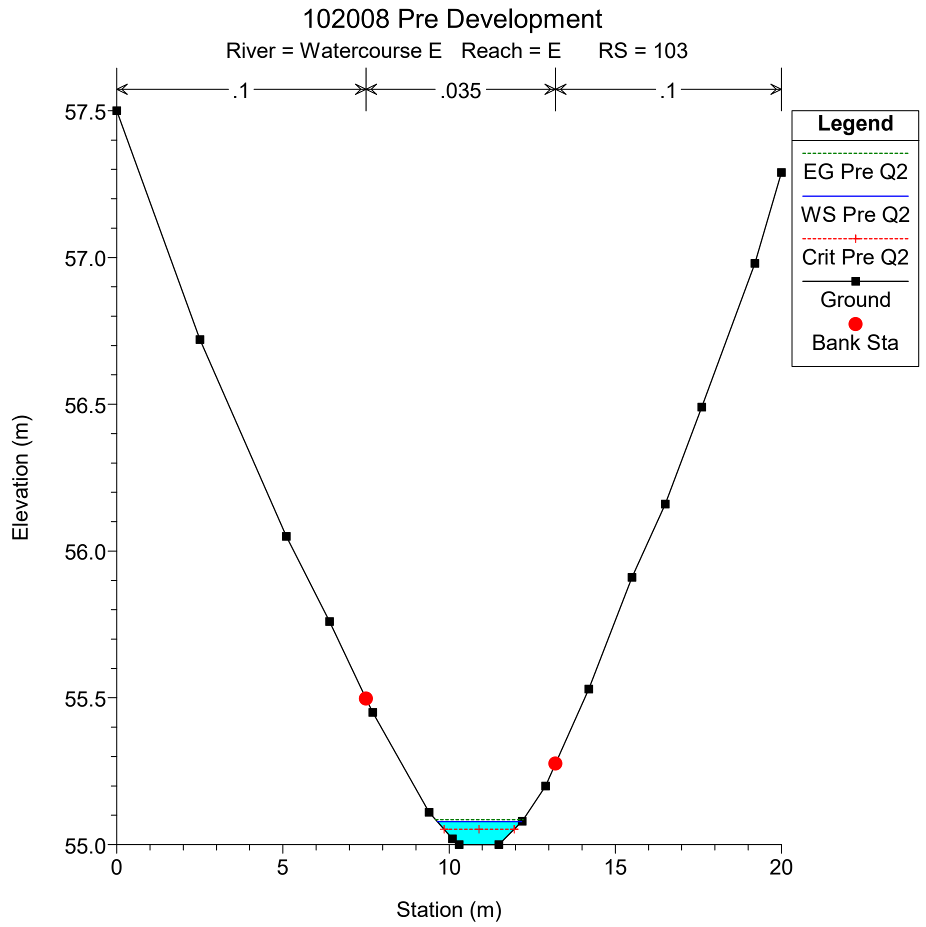

102008 Pre Development
River = Watercourse E Reach = E RS = 353
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 343
.1
.035
.1
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 333
.1
.035
.1
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 323
.1
.035
.1
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 313
.1
.035
.1
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 303
.1
.035
.1
Elevation (m)
Station (m)

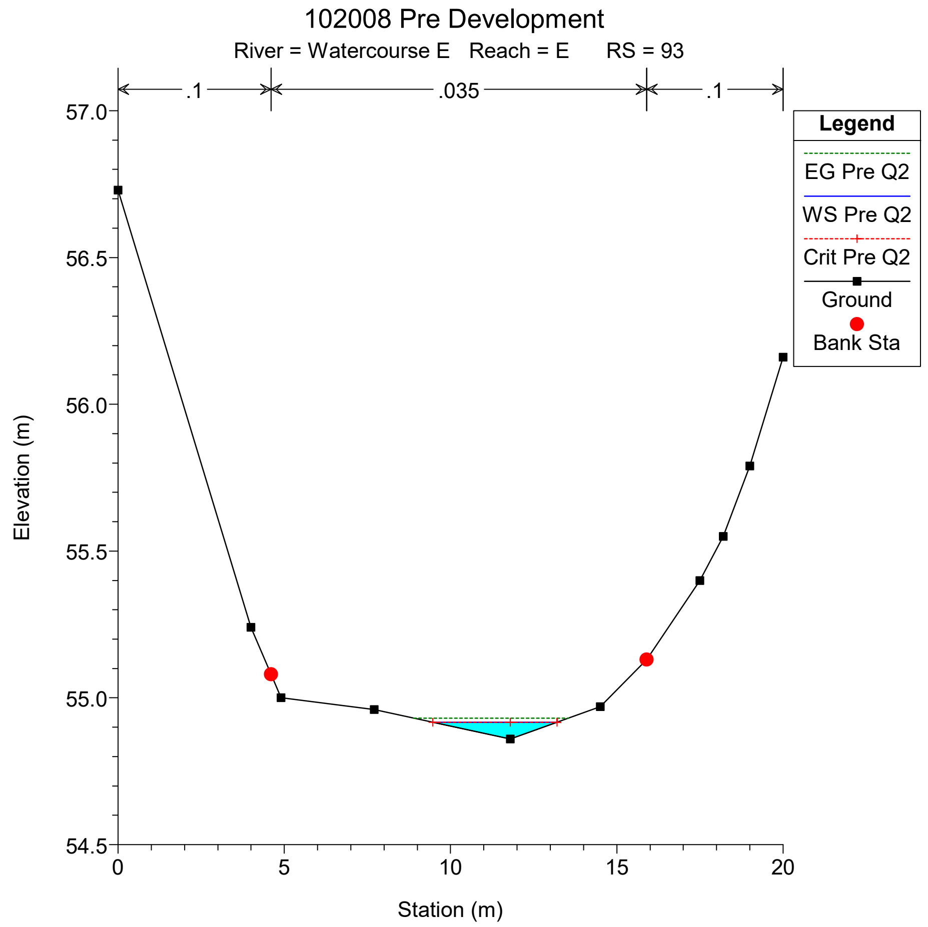

102008 Pre Development
River = Watercourse E Reach = E RS = 293
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 283
102008 Pre Development
River = Watercourse E Reach = E RS = 273
102008 Pre Development
River = Watercourse E Reach = E RS = 263
102008 Pre Development
River = Watercourse E Reach = E RS = 253
102008 Pre Development
River = Watercourse E Reach = E RS = 243

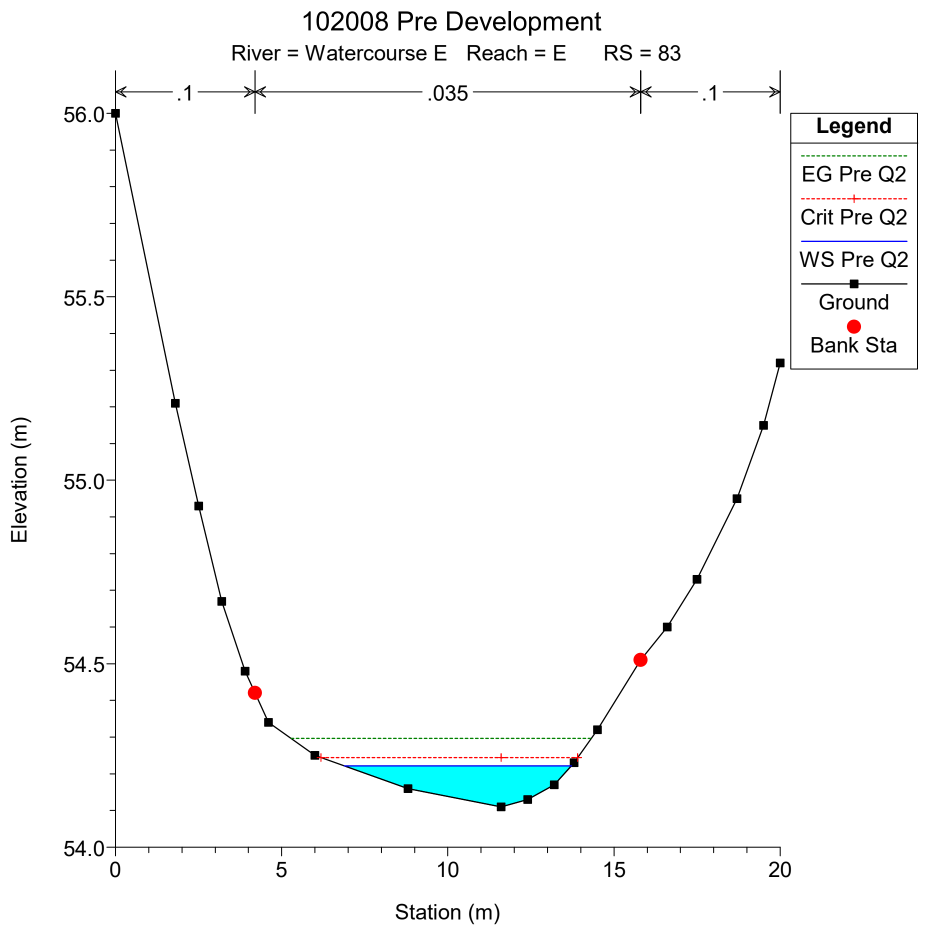

102008 Pre Development
River = Watercourse E Reach = E RS = 233
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 223
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 213
.1
.035
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 203
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 193
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 183
.1
.035
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

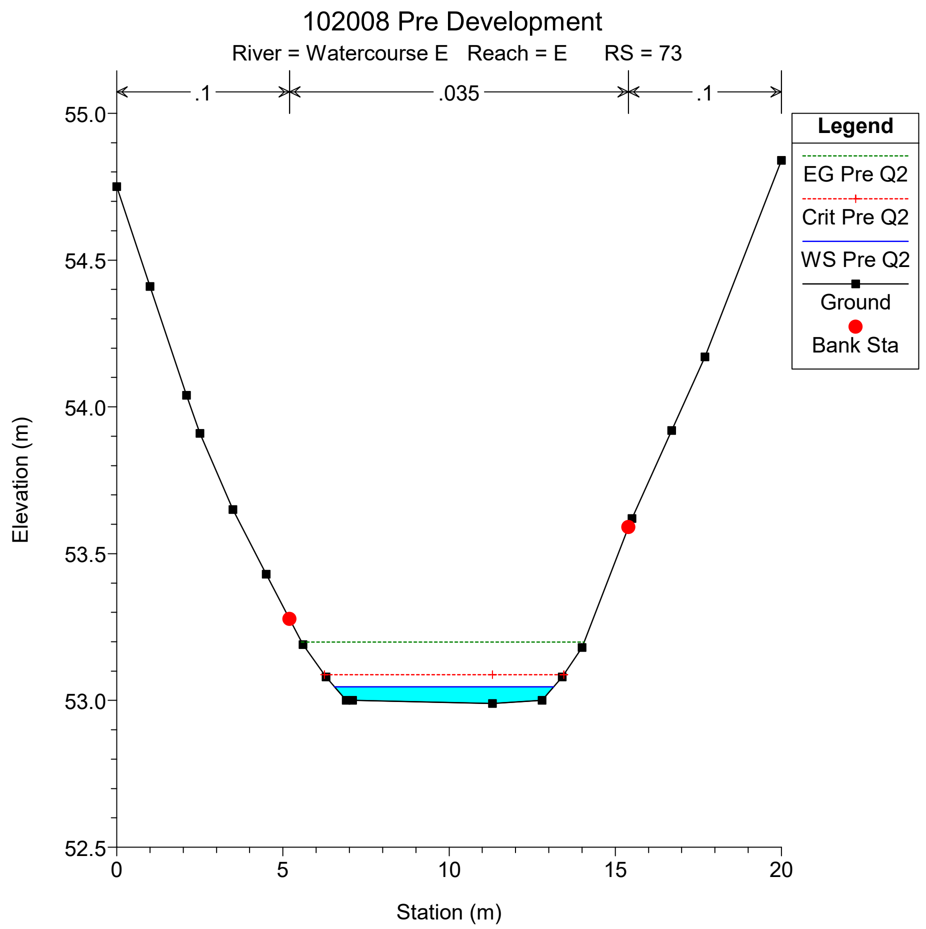

102008 Pre Development
River = Watercourse E Reach = E RS = 173
.1 .035 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 163
.1 .035 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 153
.035 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 143
.1 .035 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 133
.035 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 123
.1 .035 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

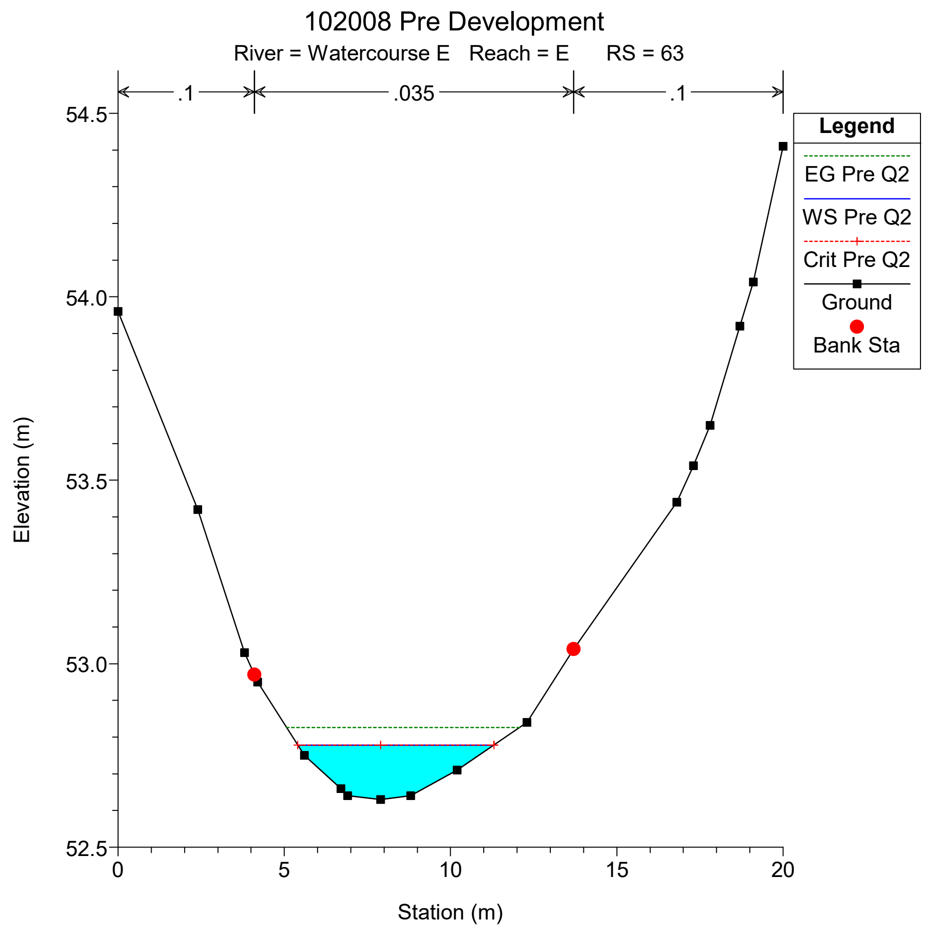

102008 Pre Development
River = Watercourse E Reach = E RS = 113
.1 .035 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

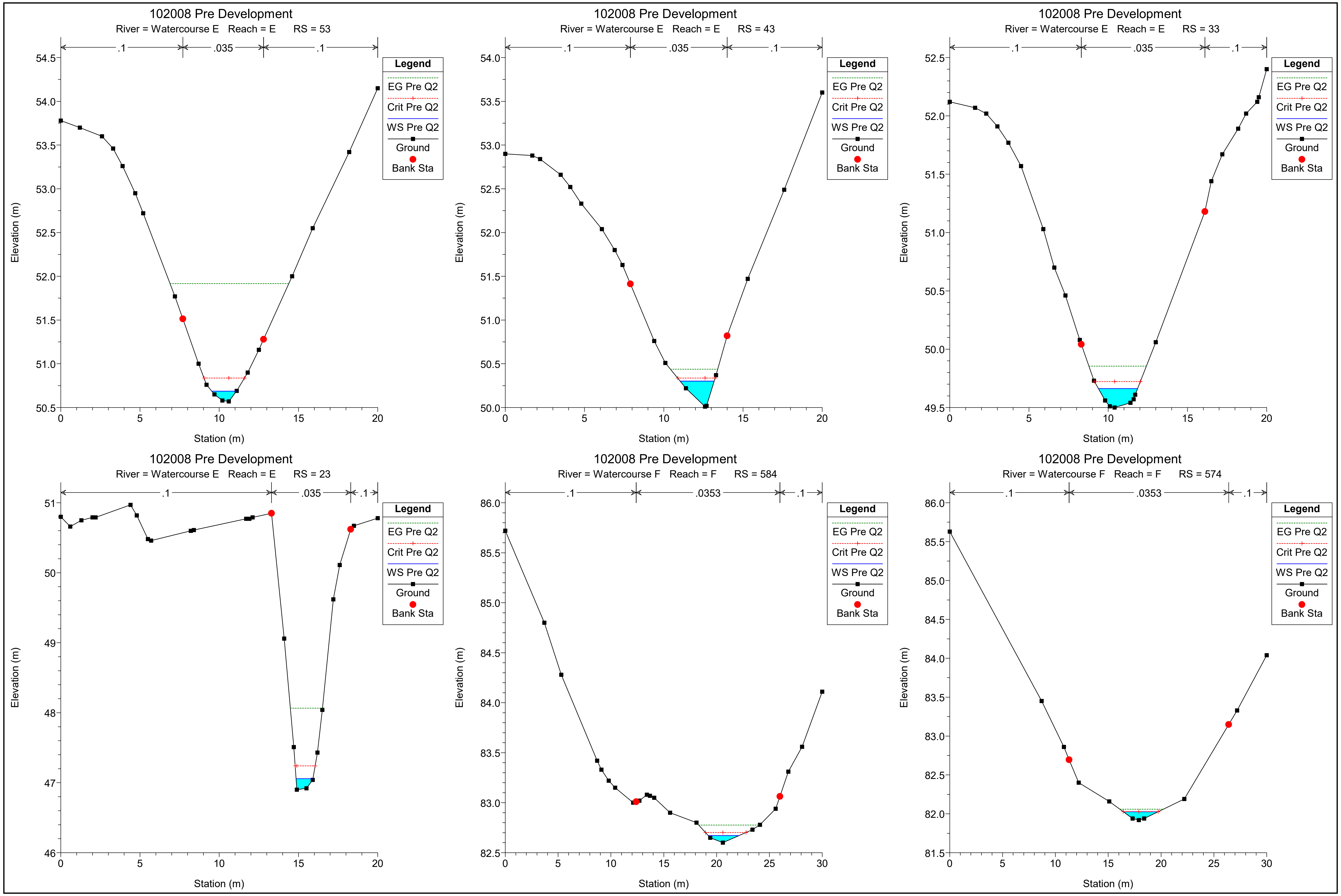

102008 Pre Development
River = Watercourse E Reach = E RS = 103
.1 .035 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta


102008 Pre Development
River = Watercourse E Reach = E RS = 93
.1 .035 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta

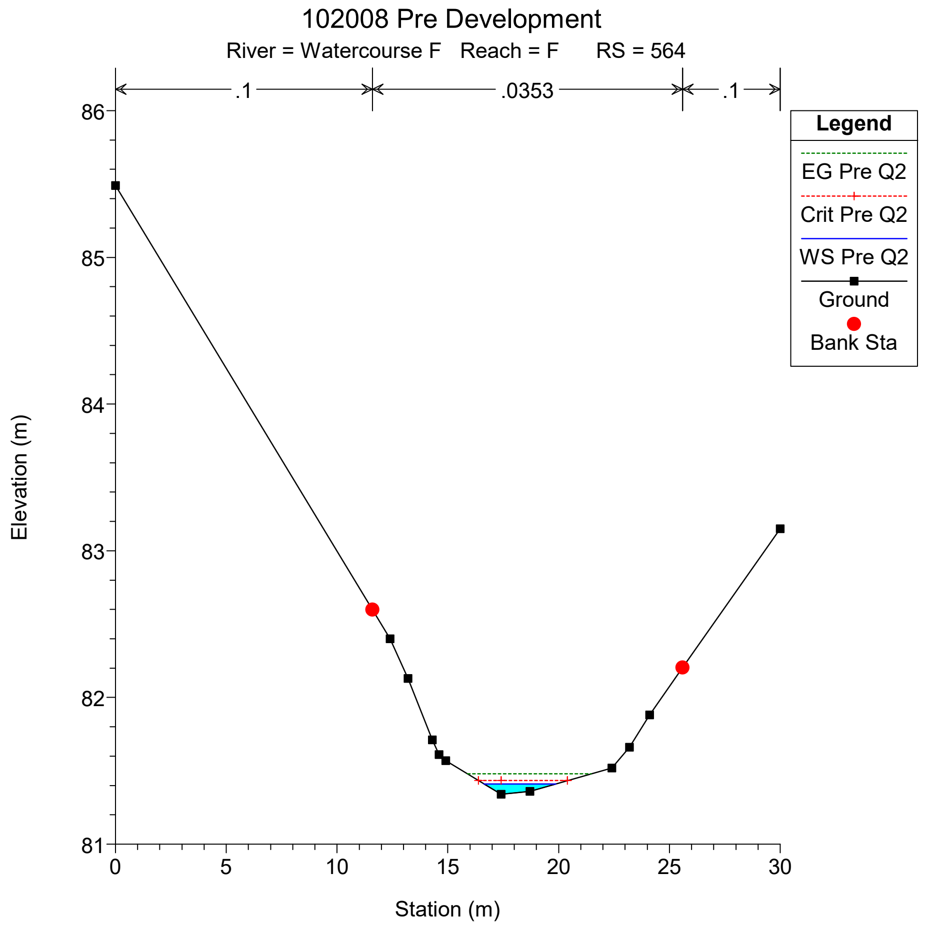

102008 Pre Development
River = Watercourse E Reach = E RS = 83
.1 .035 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

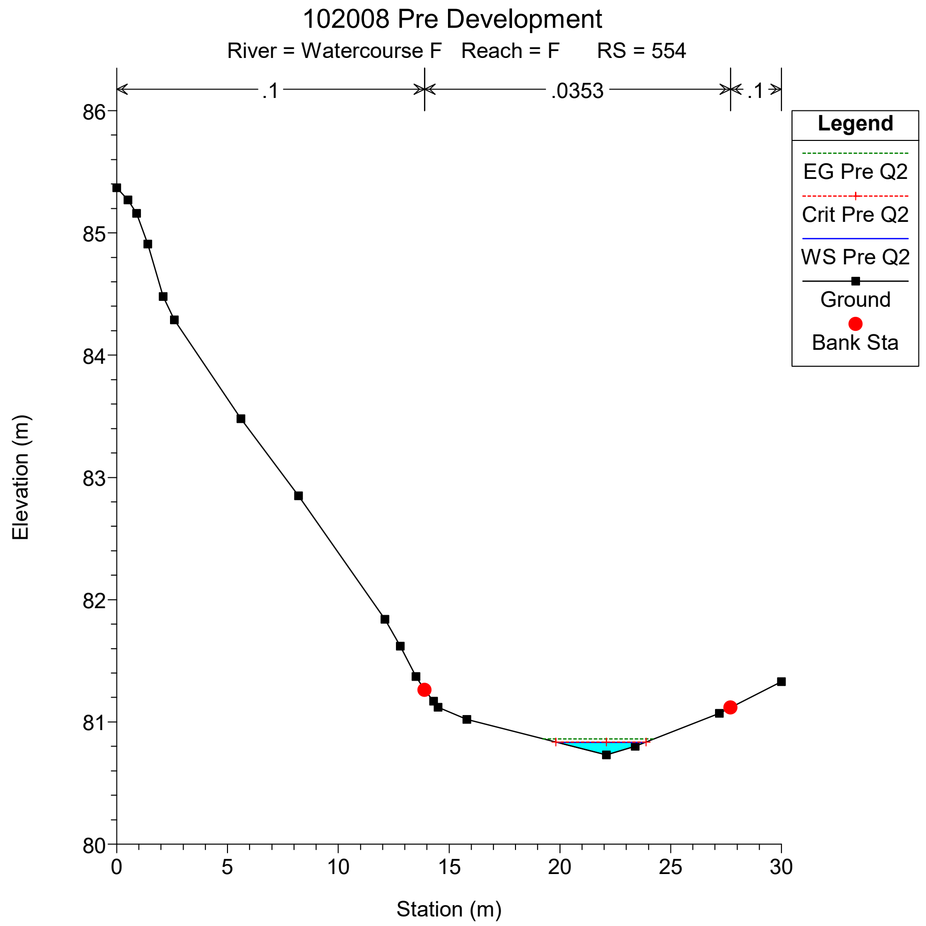

102008 Pre Development
River = Watercourse E Reach = E RS = 73
.1 .035 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

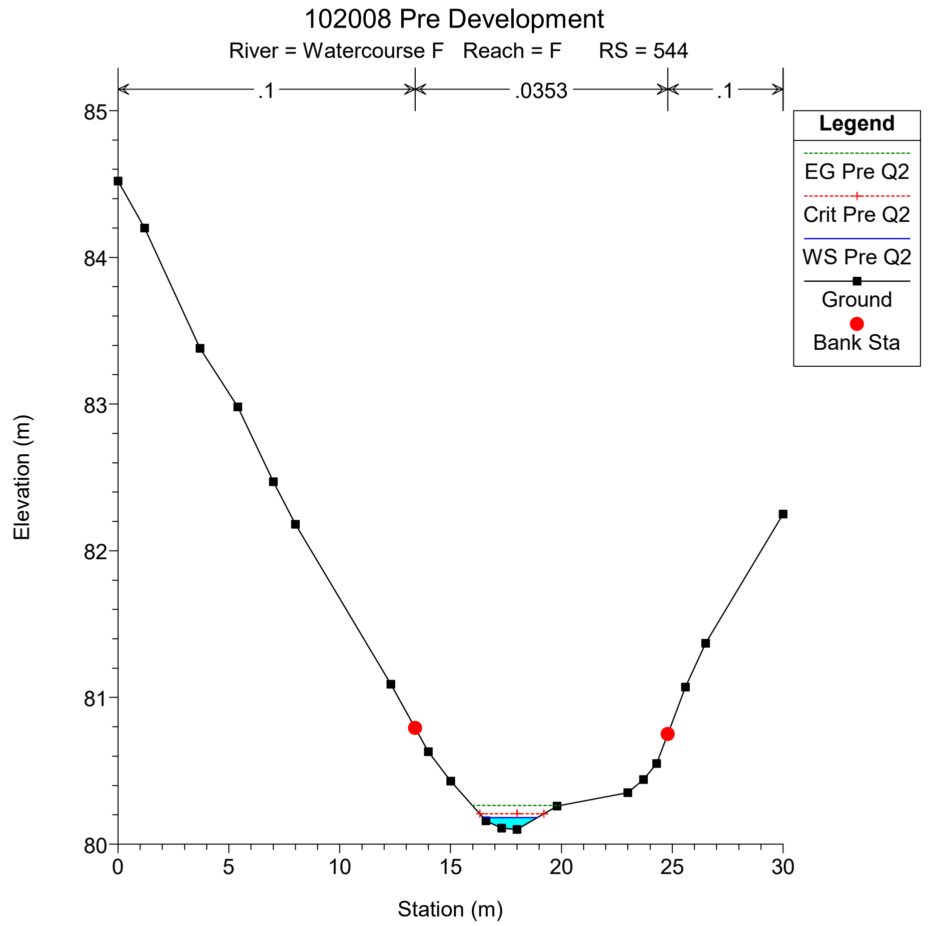

102008 Pre Development
River = Watercourse E Reach = E RS = 63
.1 .035 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta

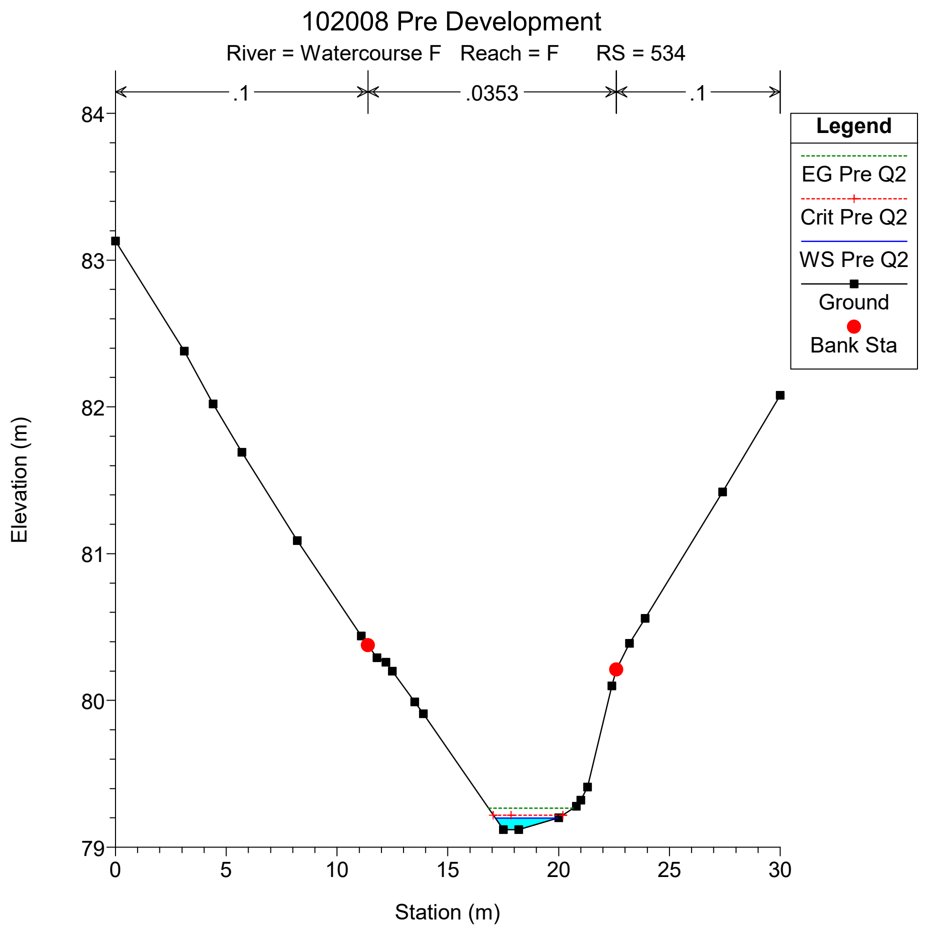


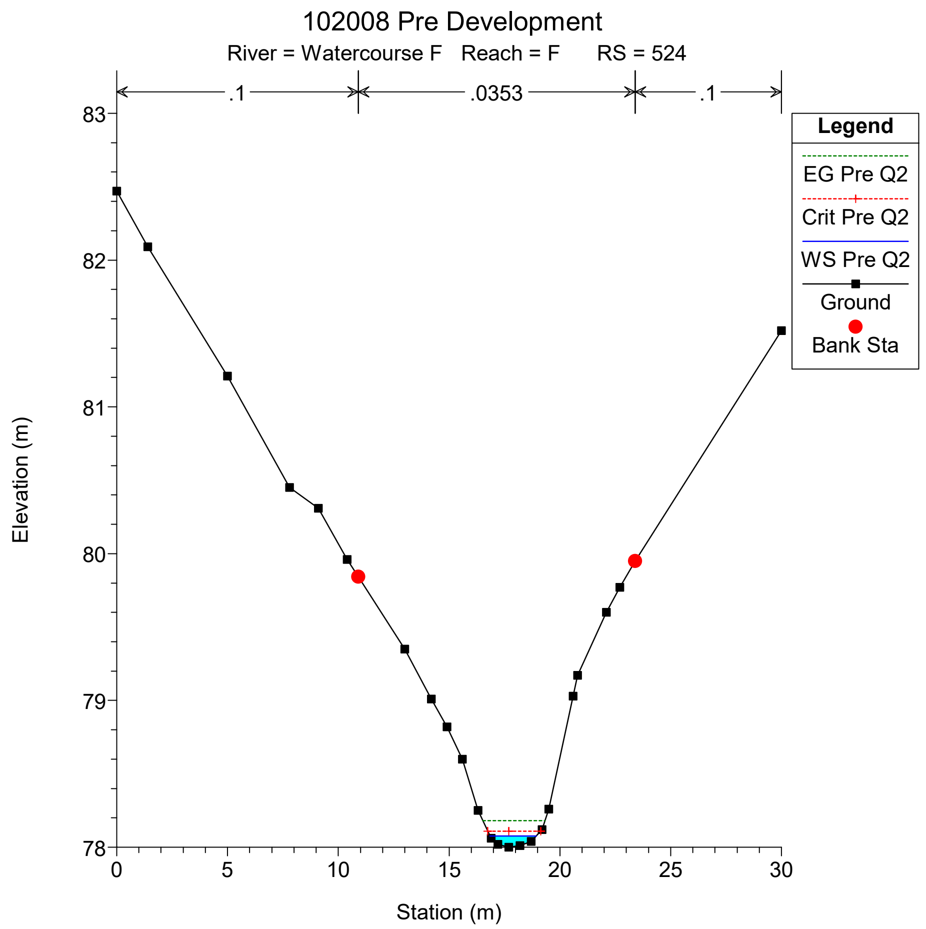
102008 Pre Development
River = Watercourse E Reach = E RS = 53
.1
.035
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse E Reach = E RS = 43
102008 Pre Development
River = Watercourse E Reach = E RS = 33
102008 Pre Development
River = Watercourse E Reach = E RS = 23
102008 Pre Development
River = Watercourse F Reach = F RS = 584
.0353
102008 Pre Development
River = Watercourse F Reach = F RS = 574

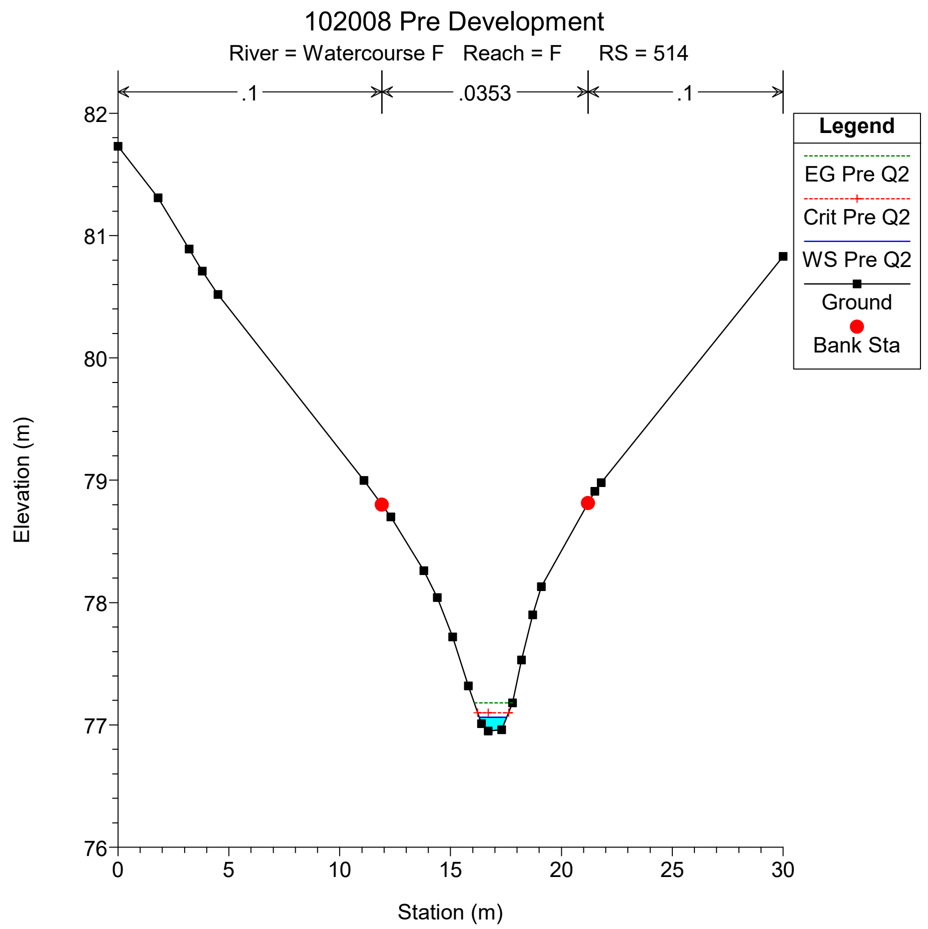

102008 Pre Development
River = Watercourse F Reach = F RS = 564
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
86
85
84
83
82
81
0
5
10
15
20
25
30

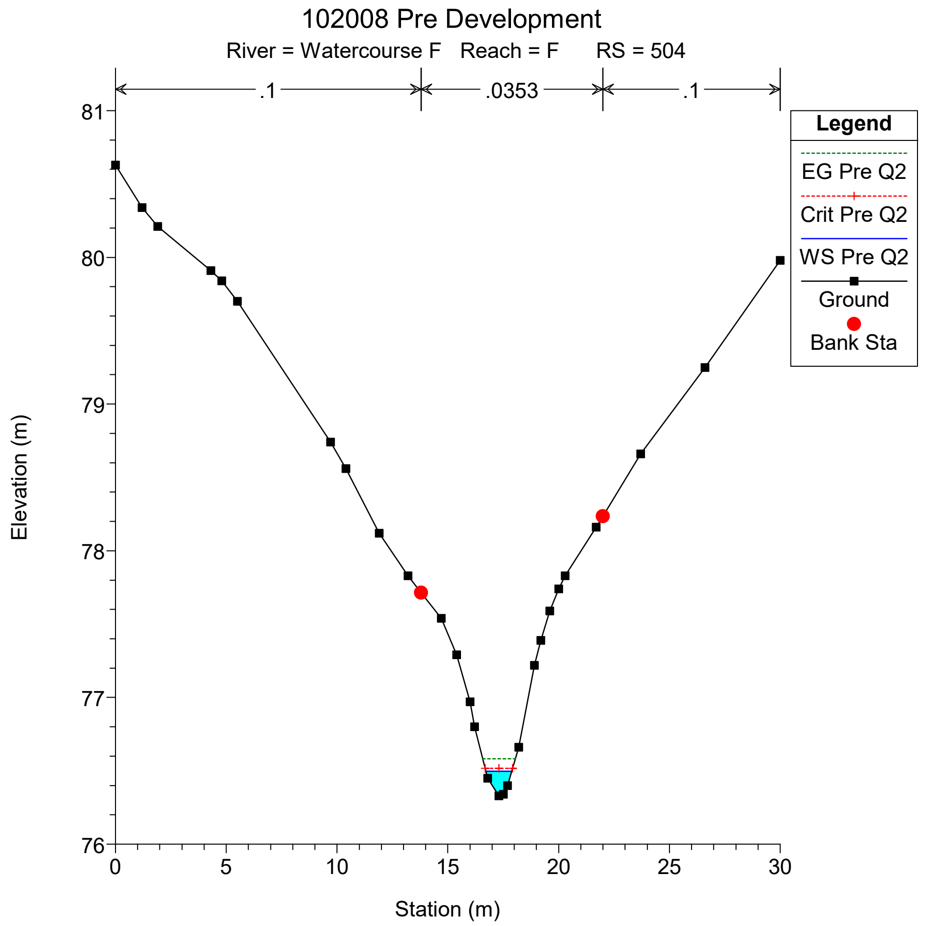

102008 Pre Development
River = Watercourse F Reach = F RS = 554
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
86
85
84
83
82
81
80
0
5
10
15
20
25
30

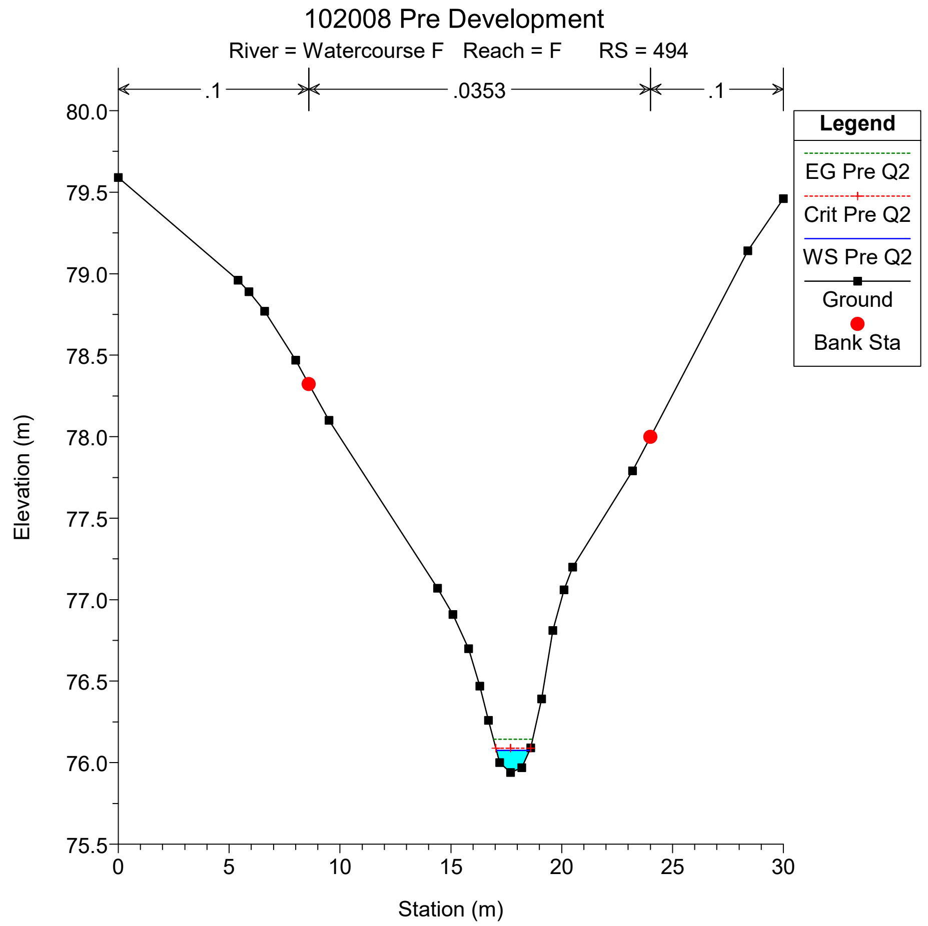

102008 Pre Development
River = Watercourse F Reach = F RS = 544
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
85
84
83
82
81
80
0
5
10
15
20
25
30

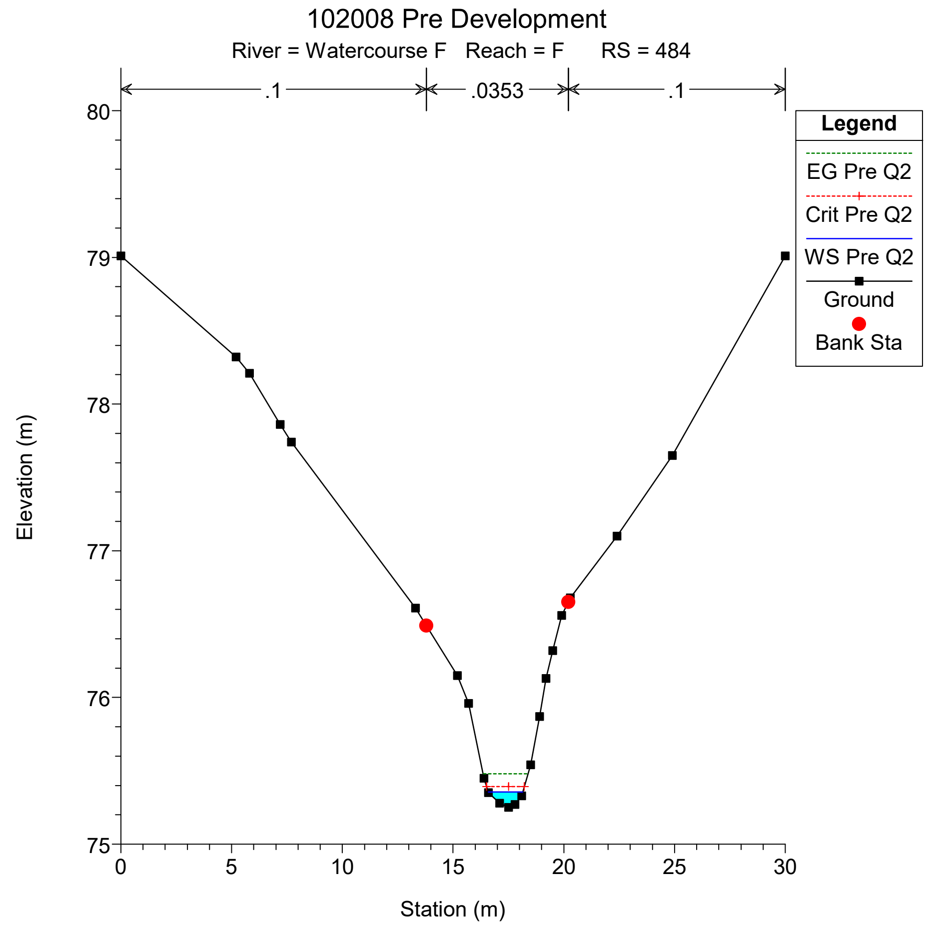

102008 Pre Development
River = Watercourse F Reach = F RS = 534
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
84
83
82
81
80
79
0
5
10
15
20
25
30

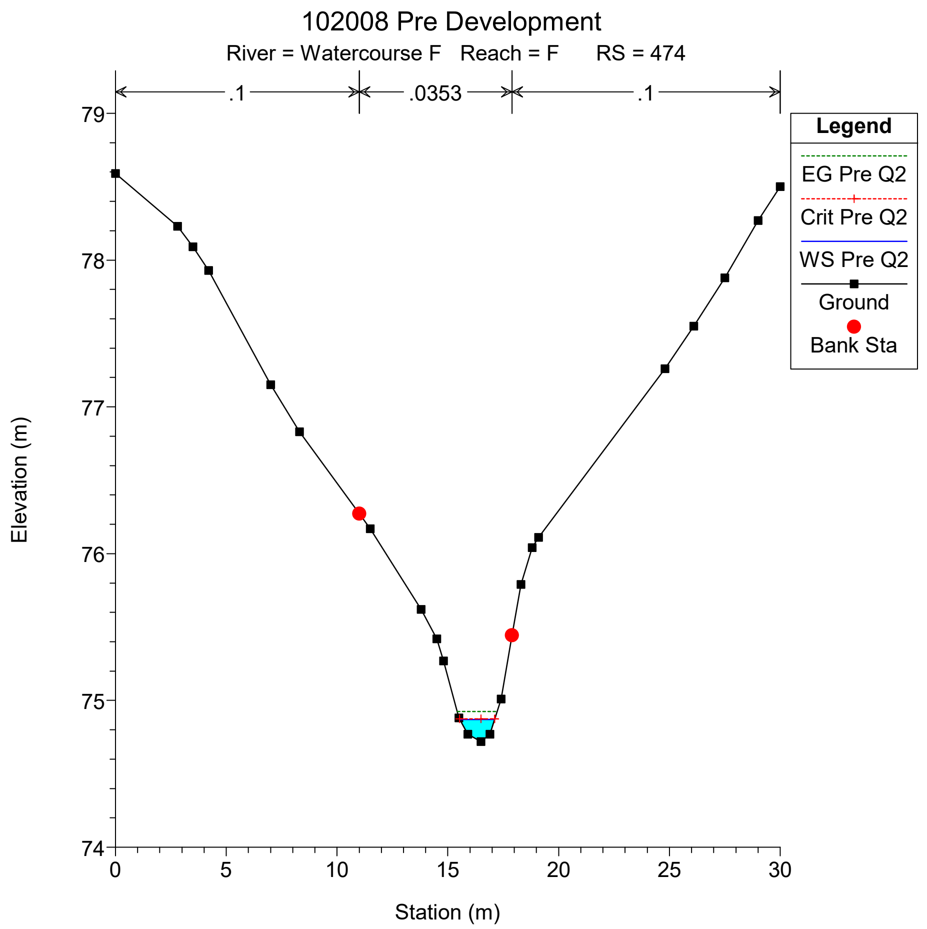

102008 Pre Development
River = Watercourse F Reach = F RS = 524
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
83
82
81
80
79
78
0
5
10
15
20
25
30

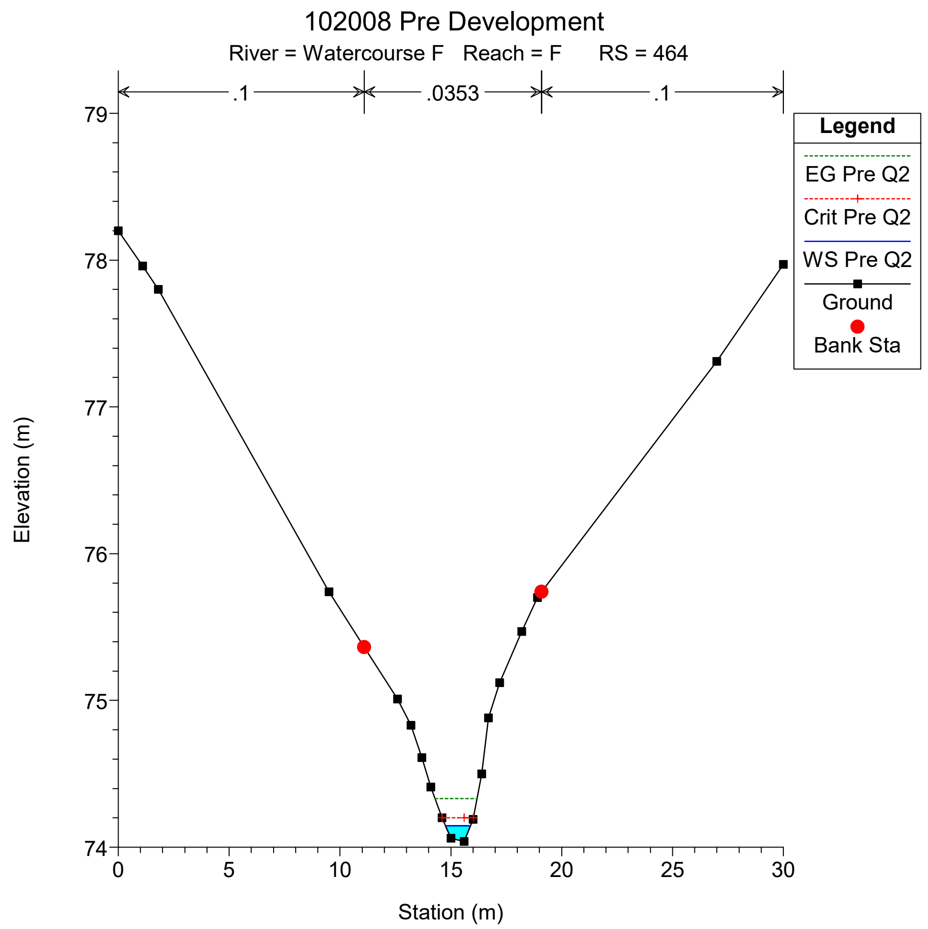

102008 Pre Development
River = Watercourse F Reach = F RS = 514
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
82
81
80
79
78
77
76
0
5
10
15
20
25
30

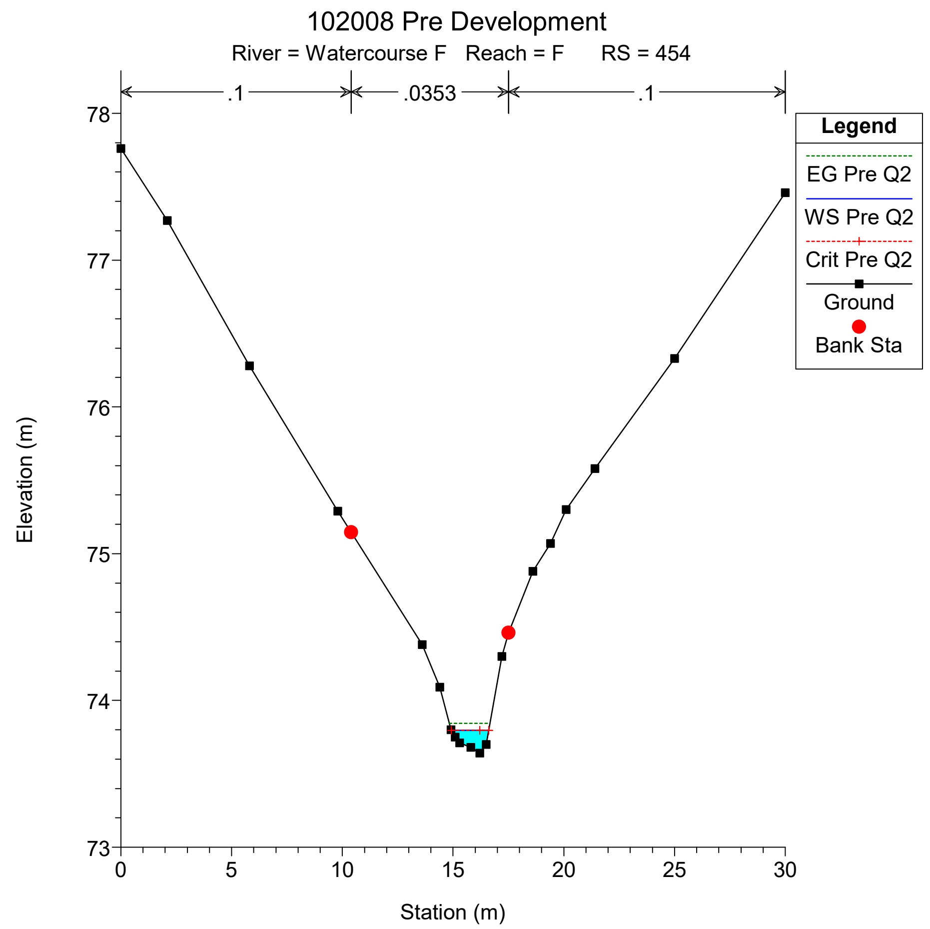

102008 Pre Development
River = Watercourse F Reach = F RS = 504
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

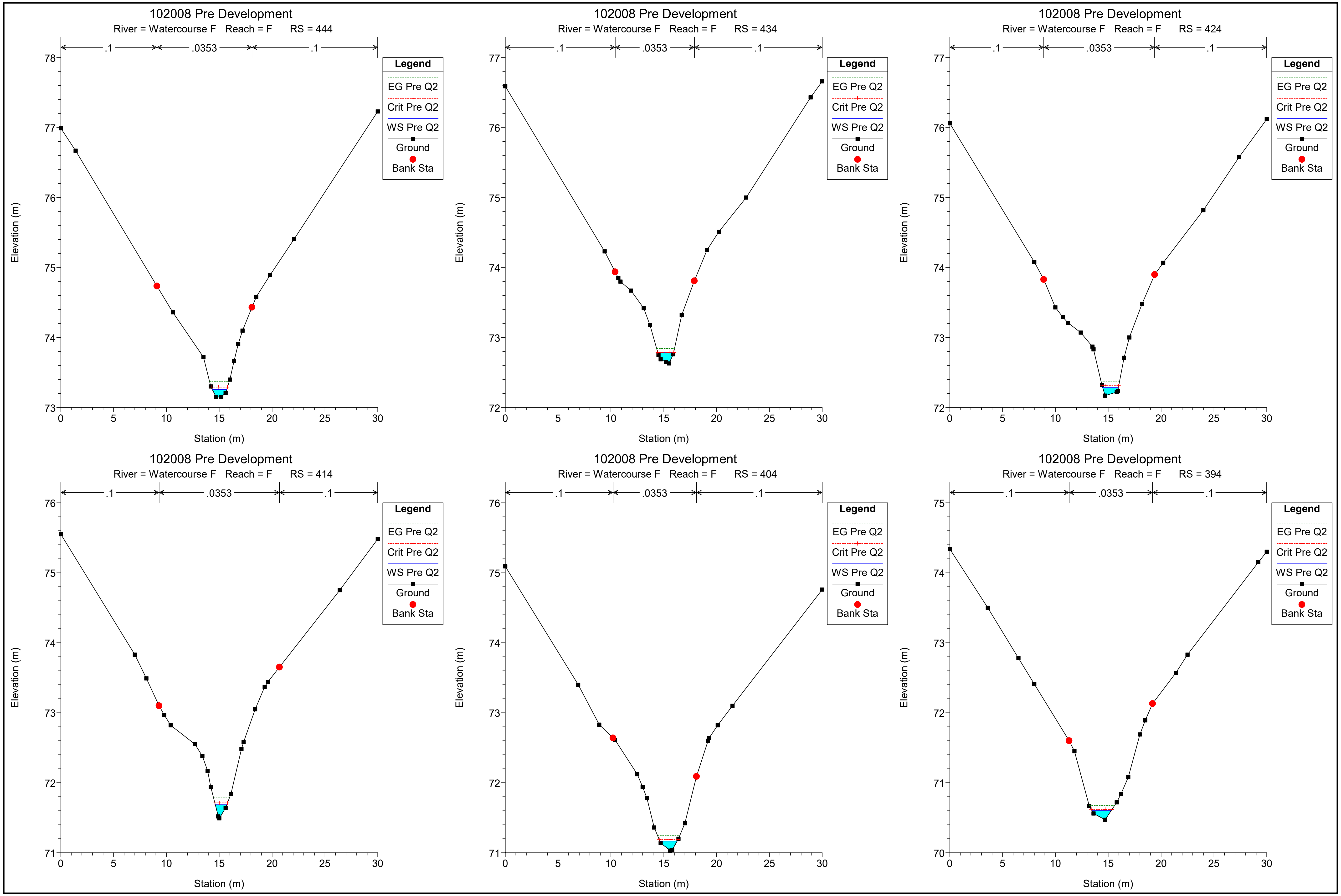

102008 Pre Development
River = Watercourse F Reach = F RS = 494
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)


102008 Pre Development
River = Watercourse F Reach = F RS = 484
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

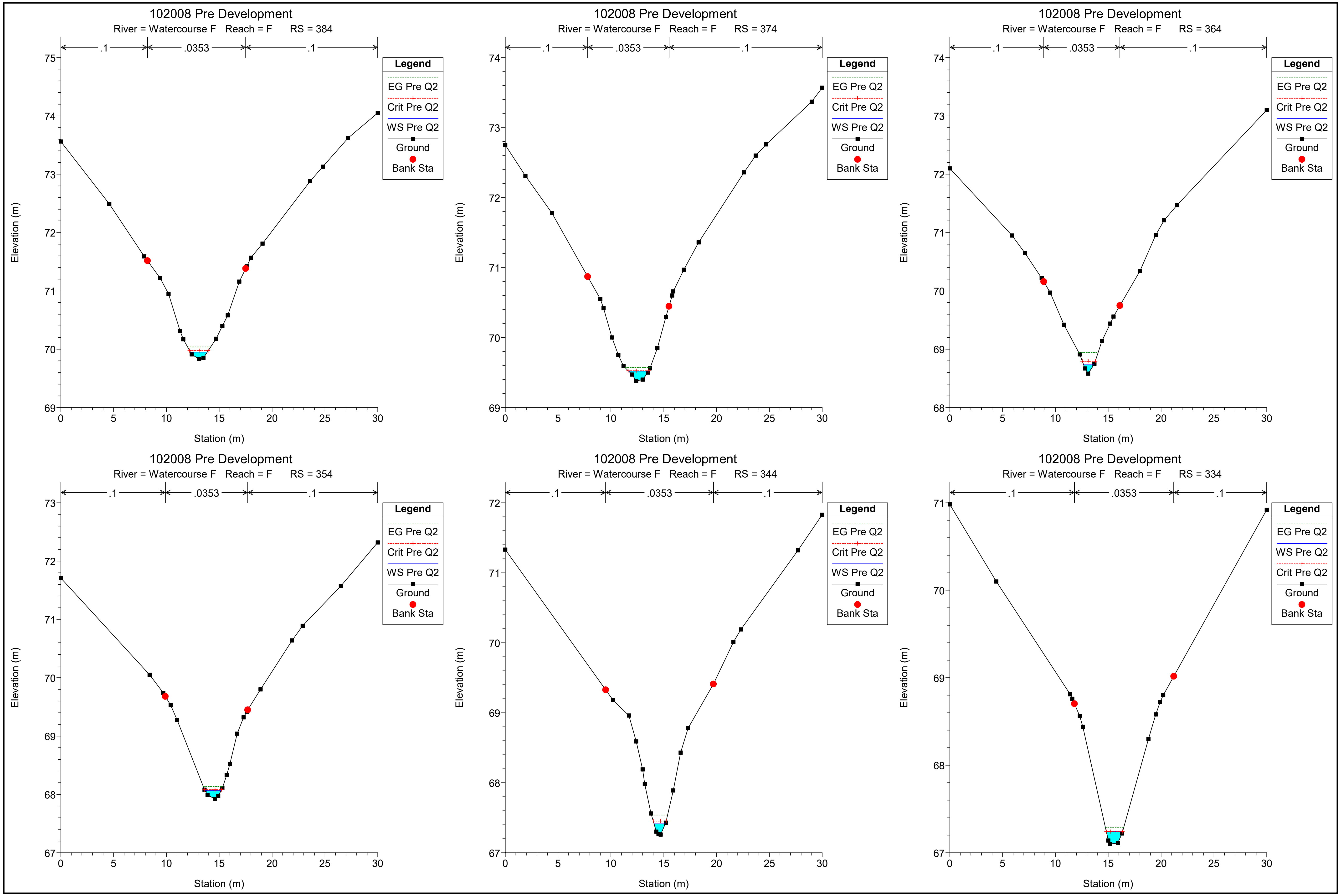

102008 Pre Development
River = Watercourse F Reach = F RS = 474
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

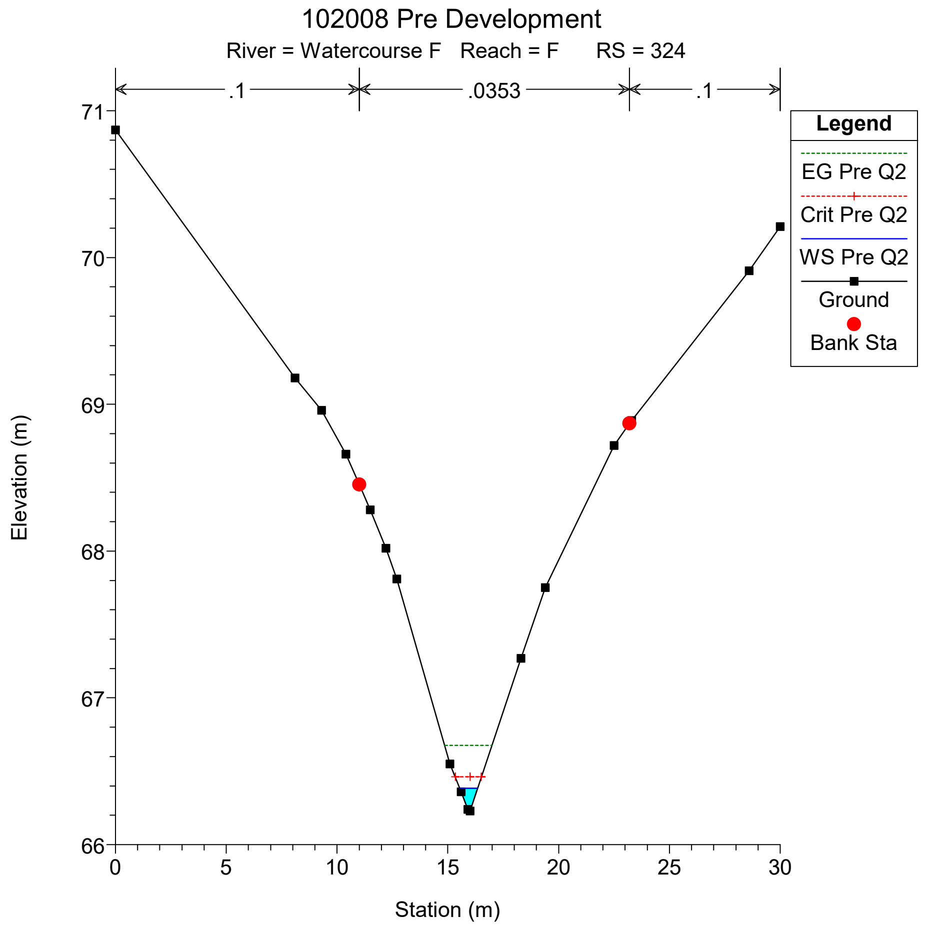

102008 Pre Development
River = Watercourse F Reach = F RS = 464
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

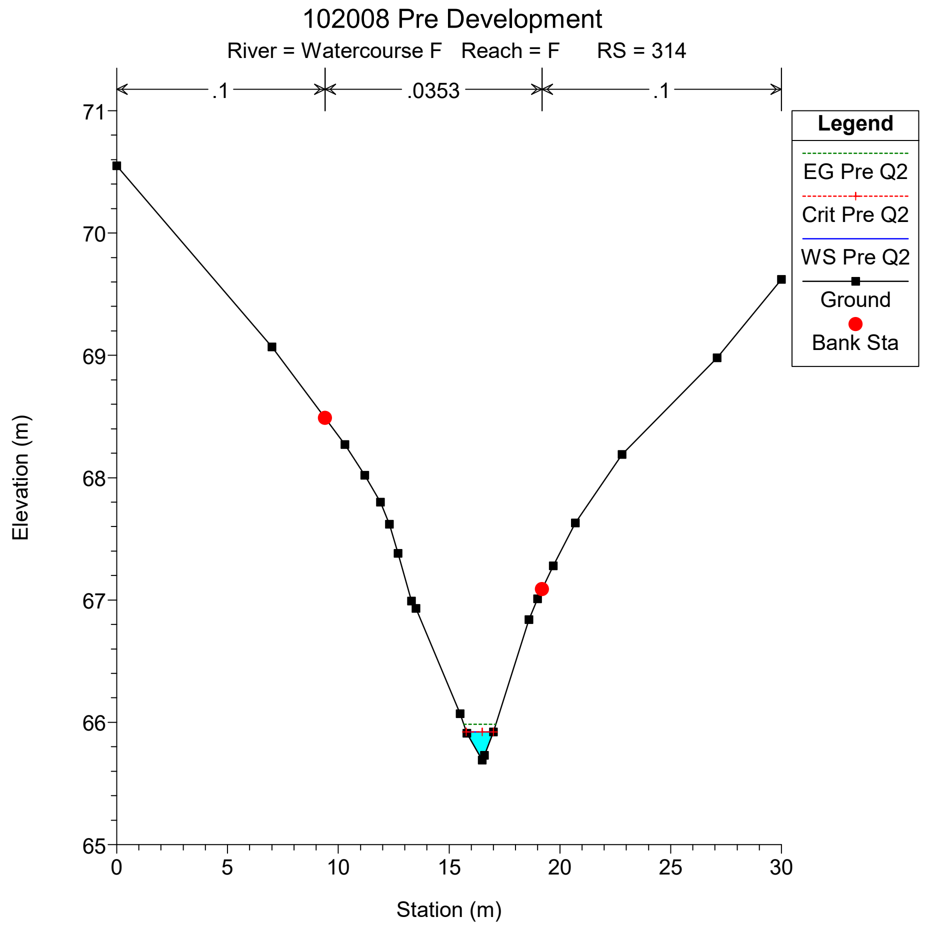

102008 Pre Development
River = Watercourse F Reach = F RS = 454
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

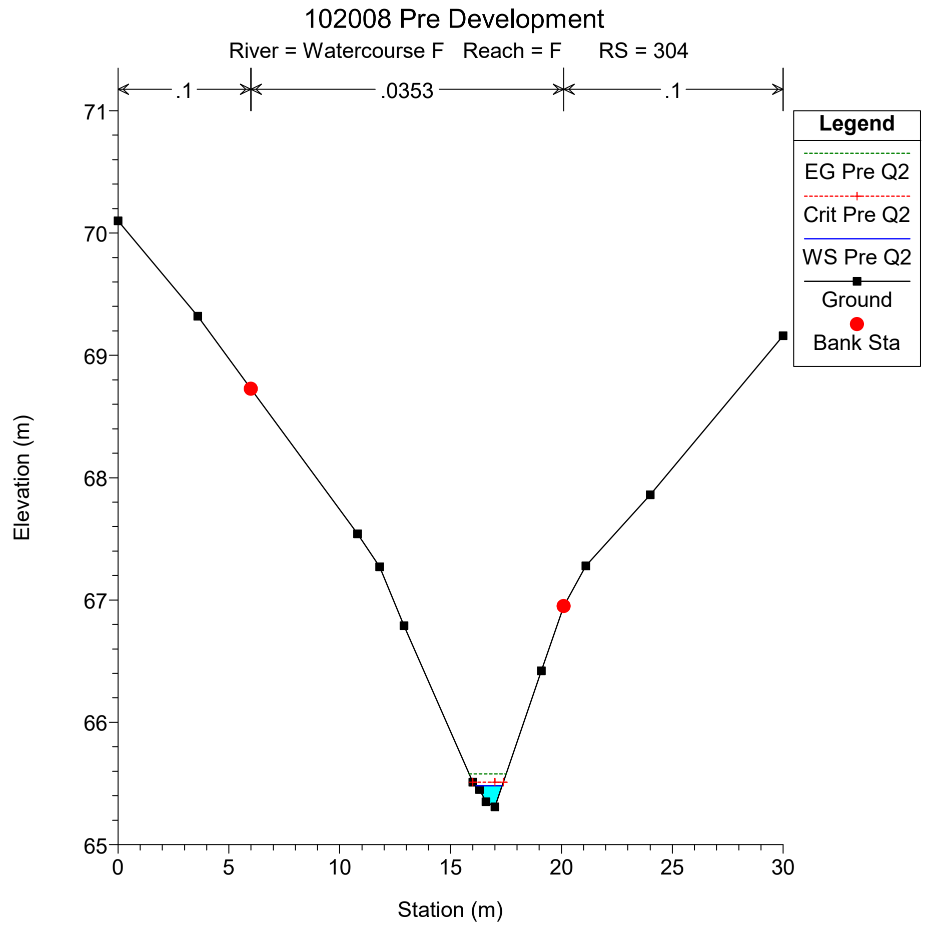


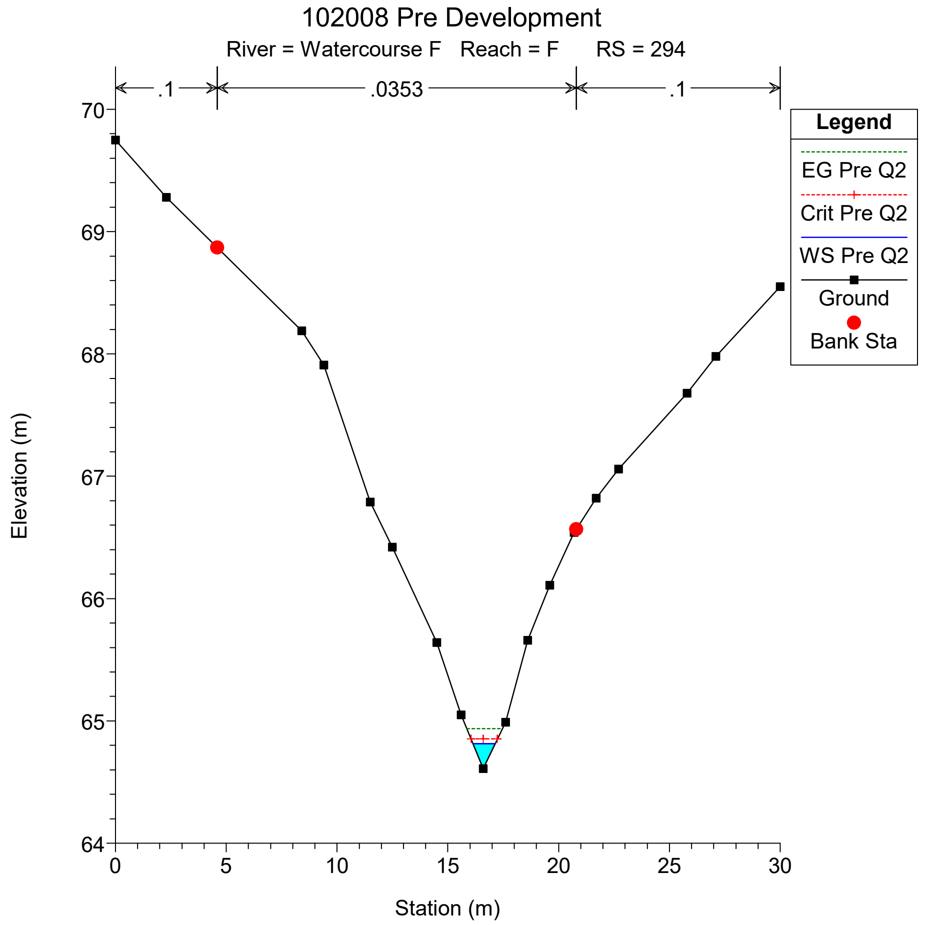
102008 Pre Development
River = Watercourse F Reach = F RS = 444
102008 Pre Development
River = Watercourse F Reach = F RS = 434
102008 Pre Development
River = Watercourse F Reach = F RS = 424
102008 Pre Development
River = Watercourse F Reach = F RS = 414
102008 Pre Development
River = Watercourse F Reach = F RS = 404
102008 Pre Development
River = Watercourse F Reach = F RS = 394
.1
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

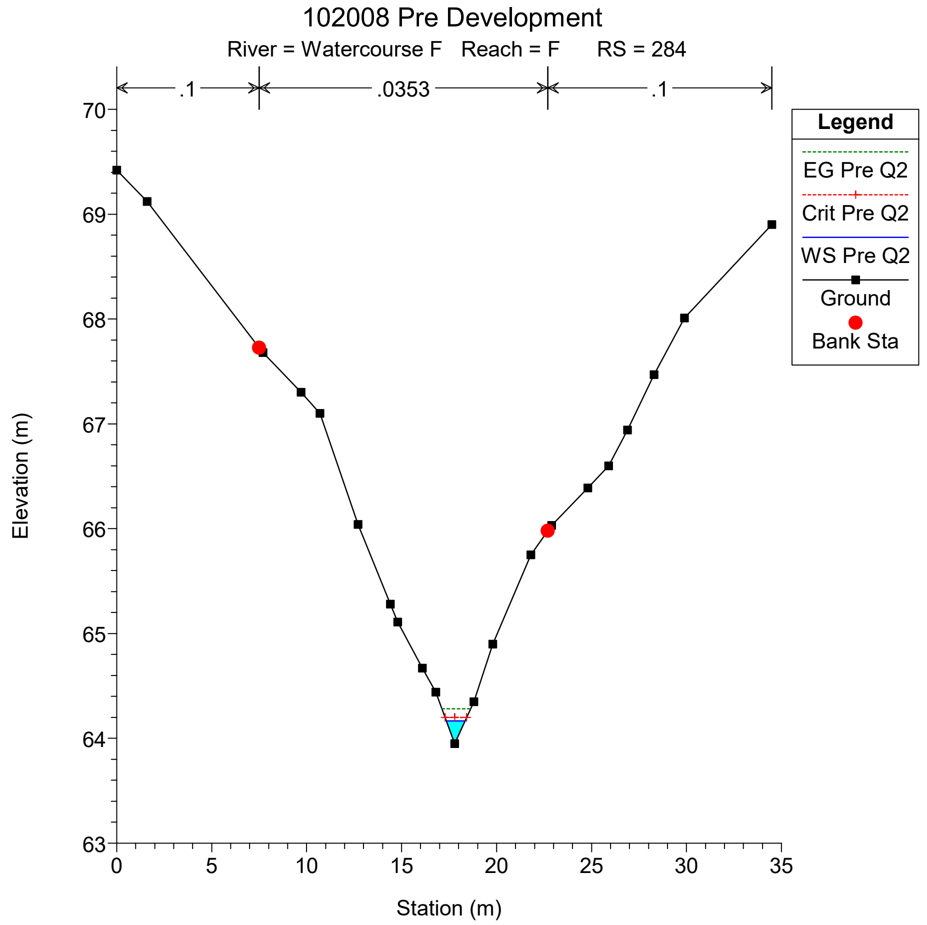

102008 Pre Development
River = Watercourse F Reach = F RS = 384
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse F Reach = F RS = 374
102008 Pre Development
River = Watercourse F Reach = F RS = 364
102008 Pre Development
River = Watercourse F Reach = F RS = 354
102008 Pre Development
River = Watercourse F Reach = F RS = 344
102008 Pre Development
River = Watercourse F Reach = F RS = 334

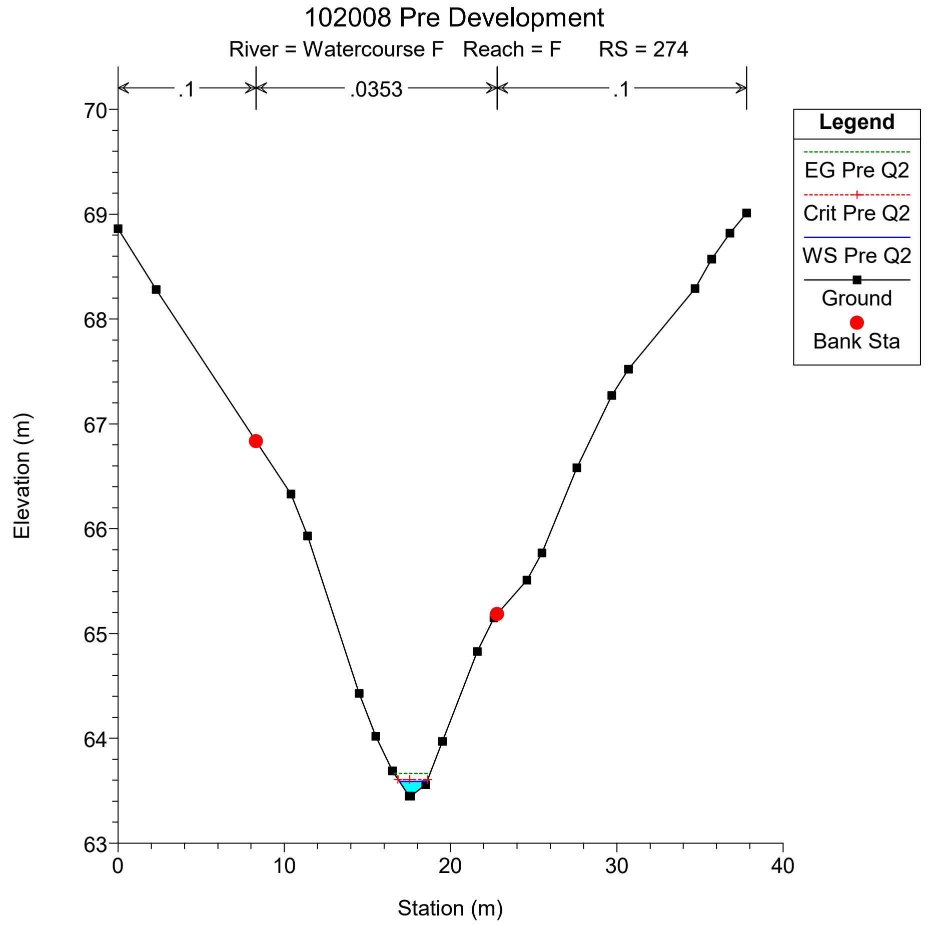

102008 Pre Development
River = Watercourse F Reach = F RS = 324
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

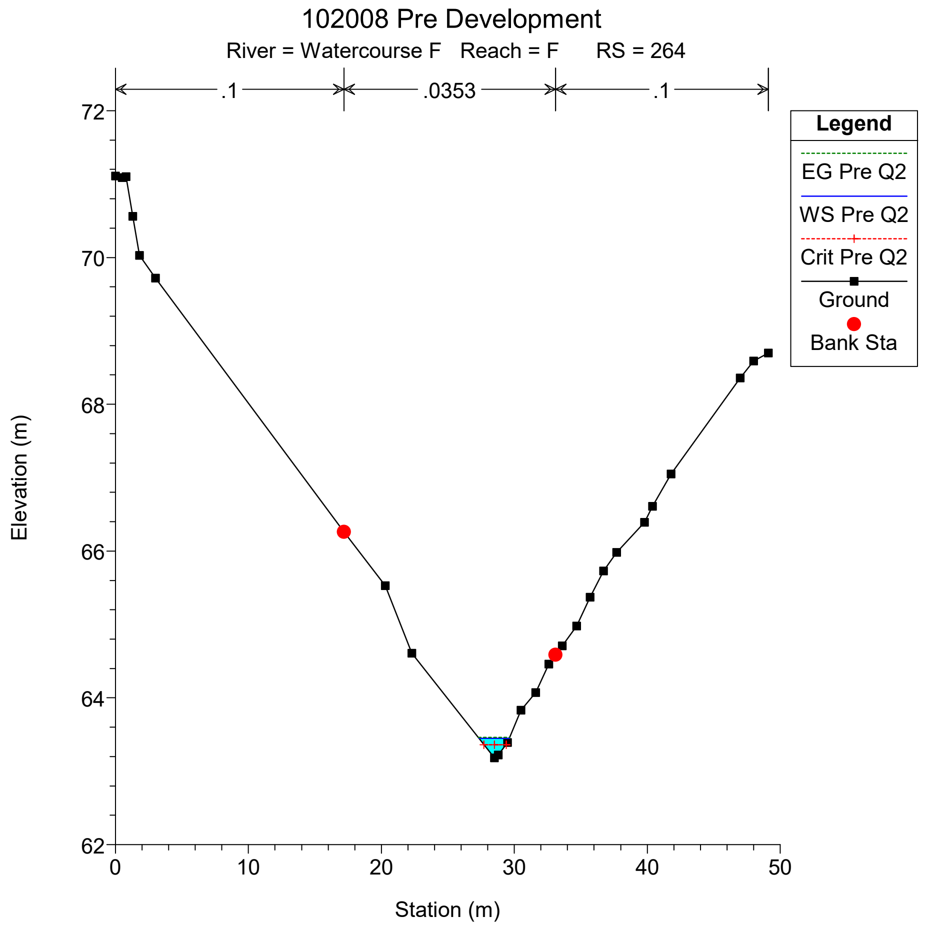

102008 Pre Development
River = Watercourse F Reach = F RS = 314
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

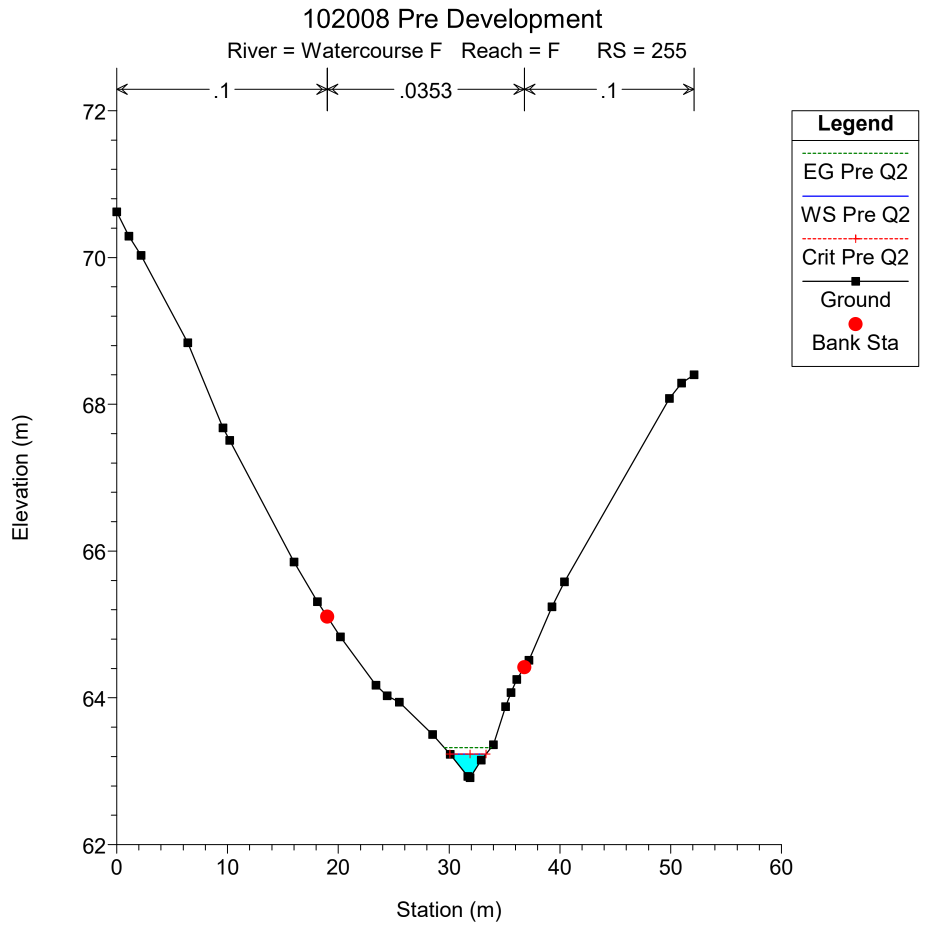

102008 Pre Development
River = Watercourse F Reach = F RS = 304
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

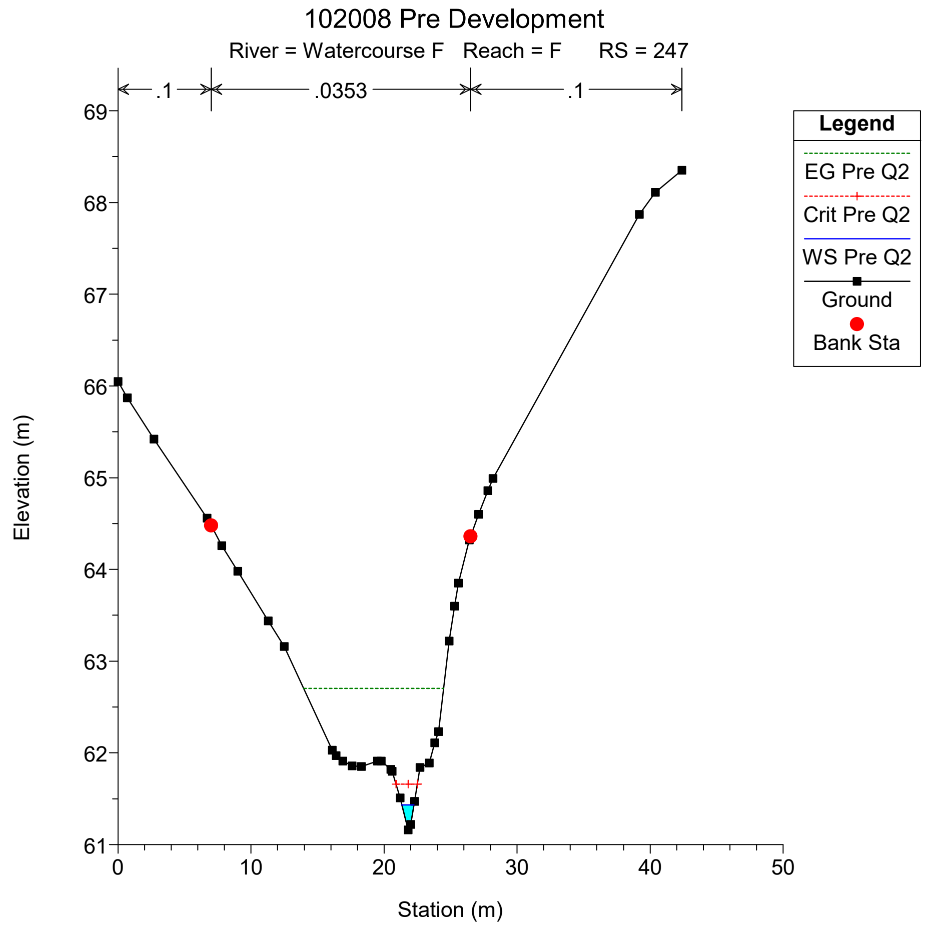

102008 Pre Development
River = Watercourse F Reach = F RS = 294
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

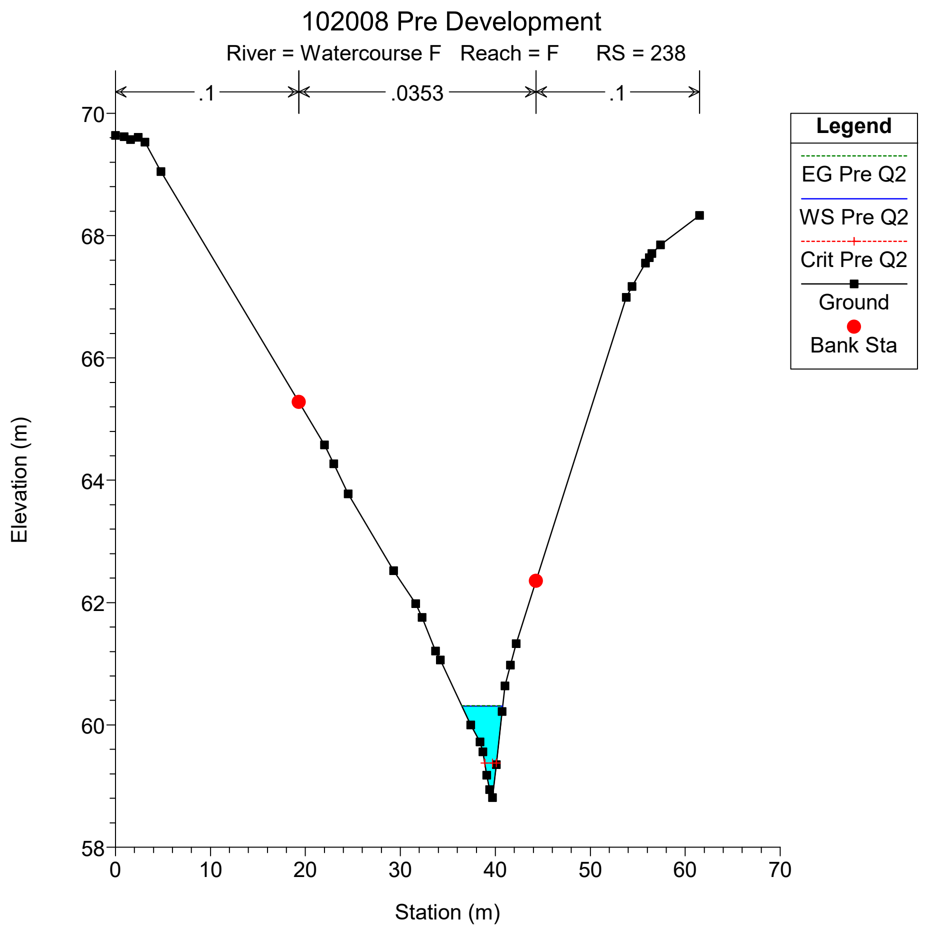

102008 Pre Development
River = Watercourse F Reach = F RS = 284
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

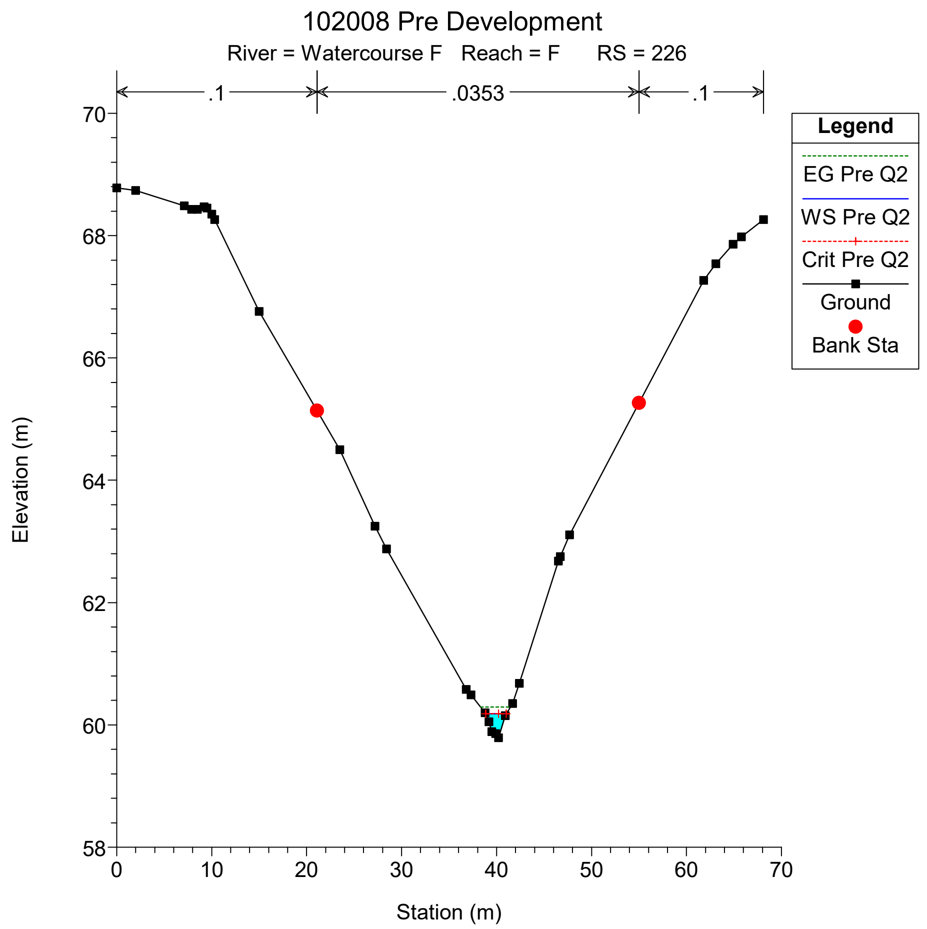

102008 Pre Development
River = Watercourse F Reach = F RS = 274
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

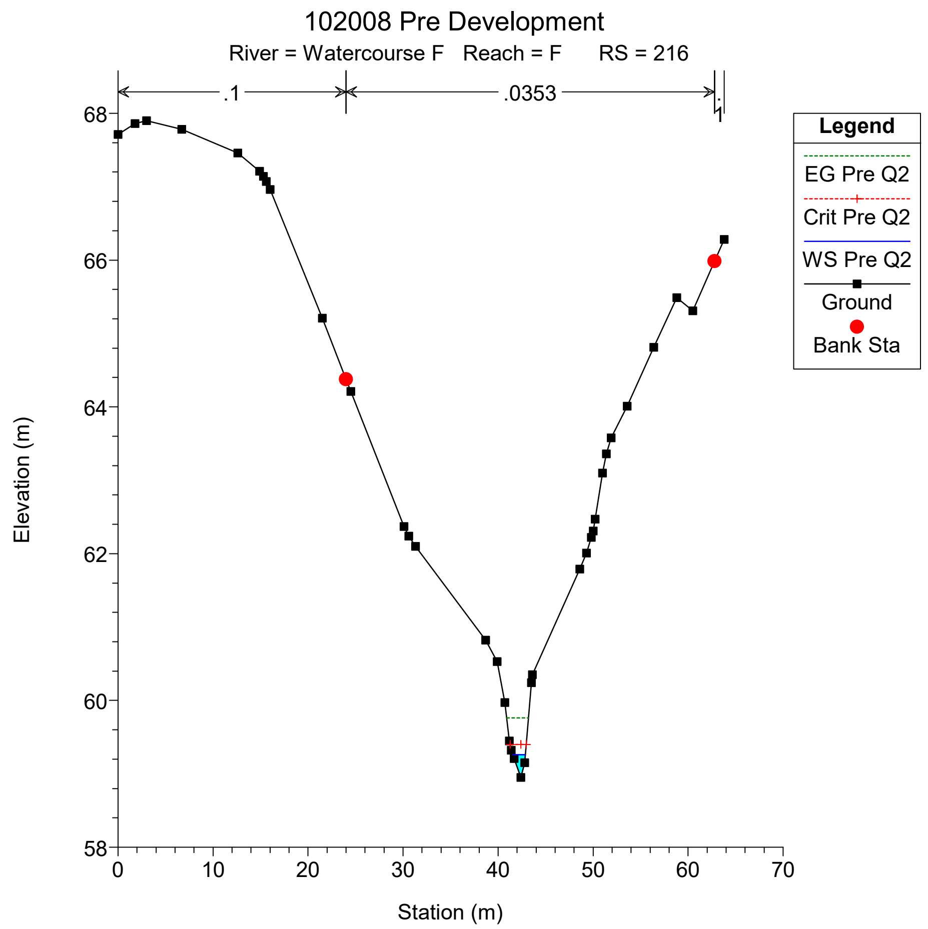

102008 Pre Development
River = Watercourse F Reach = F RS = 264
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
62
64
66
68
70
72
0
10
20
30
40
50

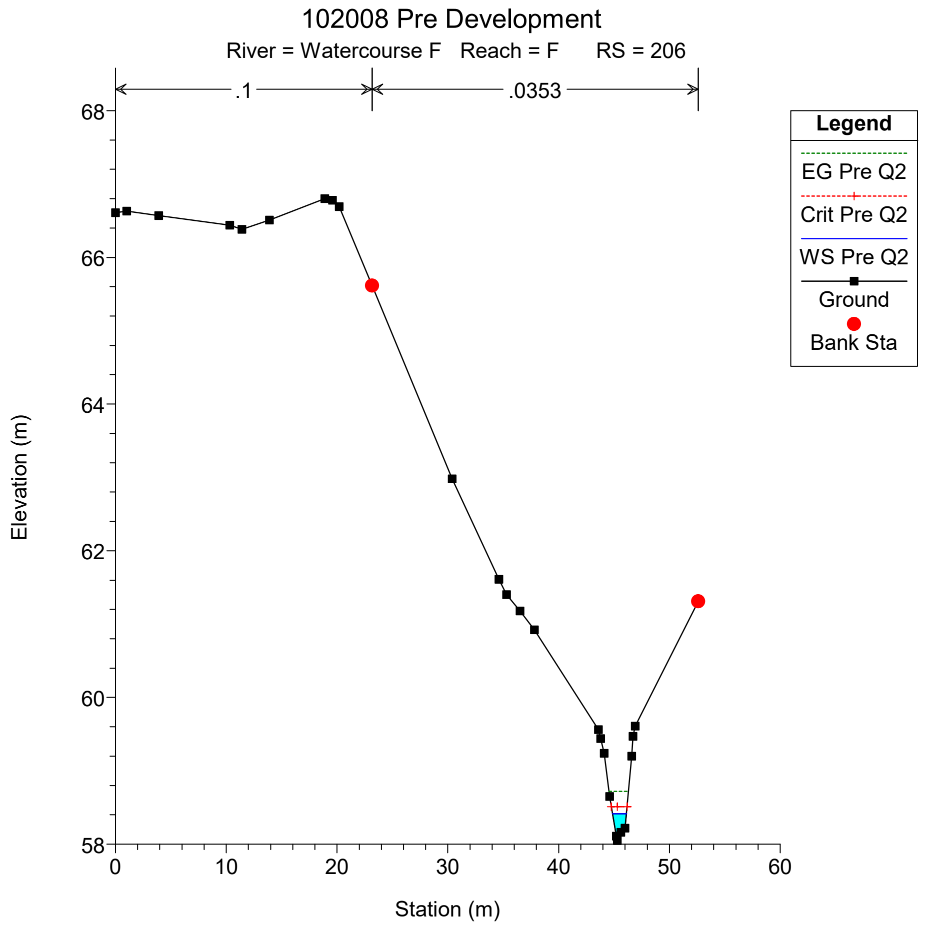

102008 Pre Development
River = Watercourse F Reach = F RS = 255
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
62
64
66
68
70
72
0
10
20
30
40
50
60

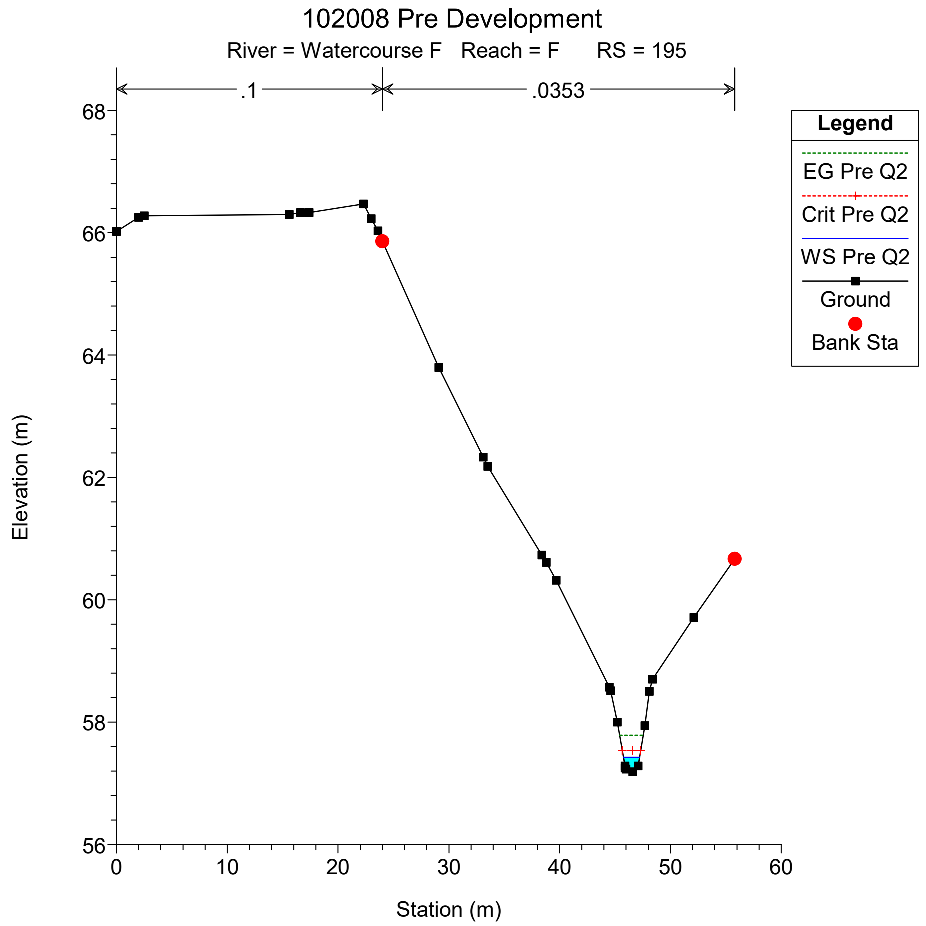

102008 Pre Development
River = Watercourse F Reach = F RS = 247
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
61
62
63
64
65
66
67
68
69
0
10
20
30
40
50

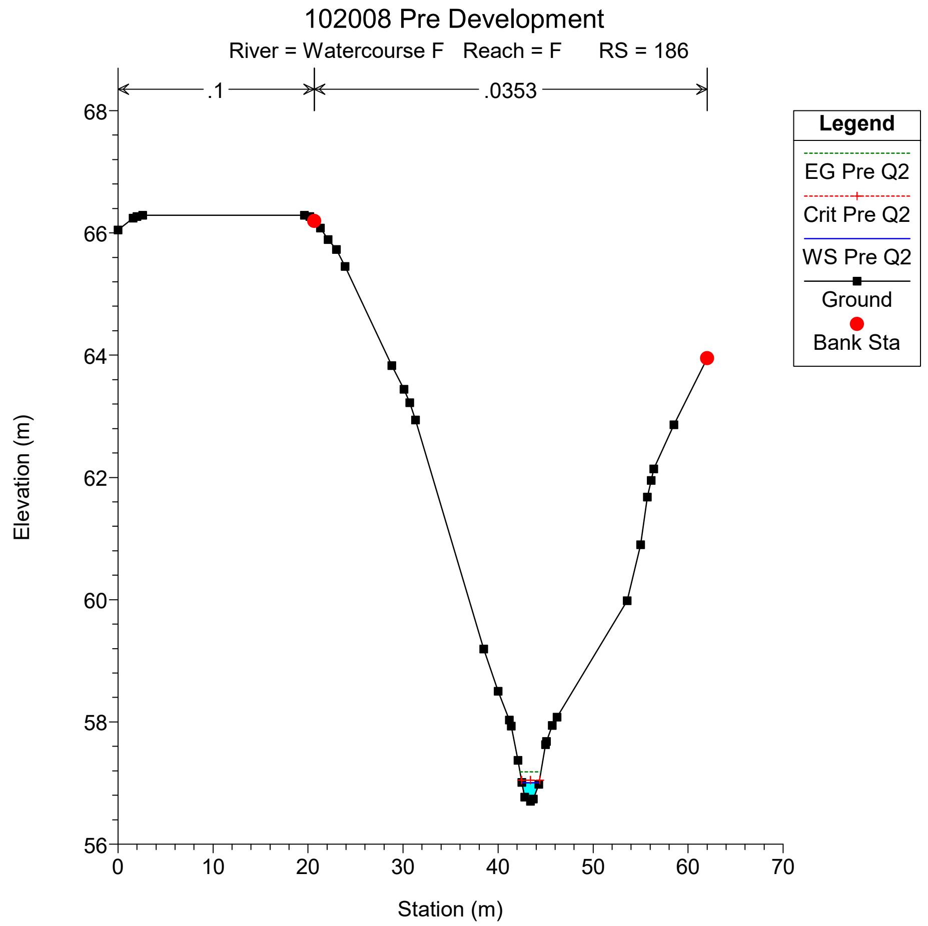

102008 Pre Development
River = Watercourse F Reach = F RS = 238
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
58
60
62
64
66
68
70
0
10
20
30
40
50
60
70

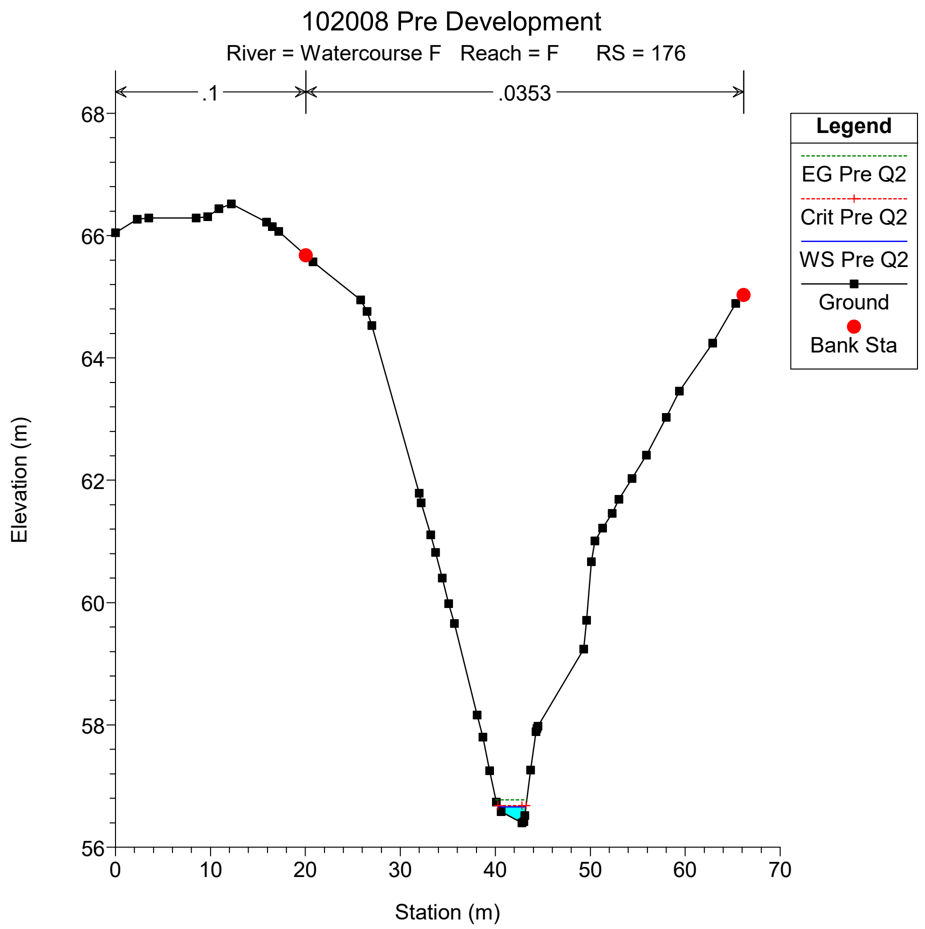

102008 Pre Development
River = Watercourse F Reach = F RS = 226
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
58
60
62
64
66
68
70
0
10
20
30
40
50
60
70

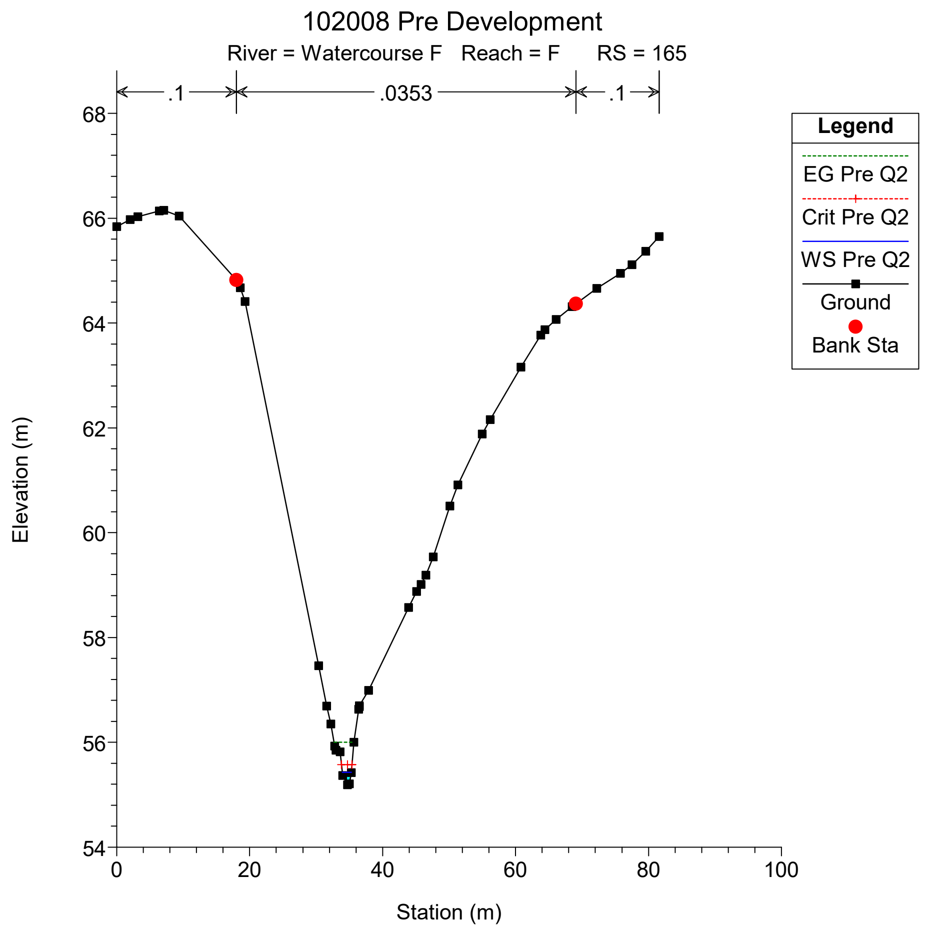

102008 Pre Development
River = Watercourse F Reach = F RS = 216
.1
.0353
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
58
60
62
64
66
68
0
10
20
30
40
50
60
70

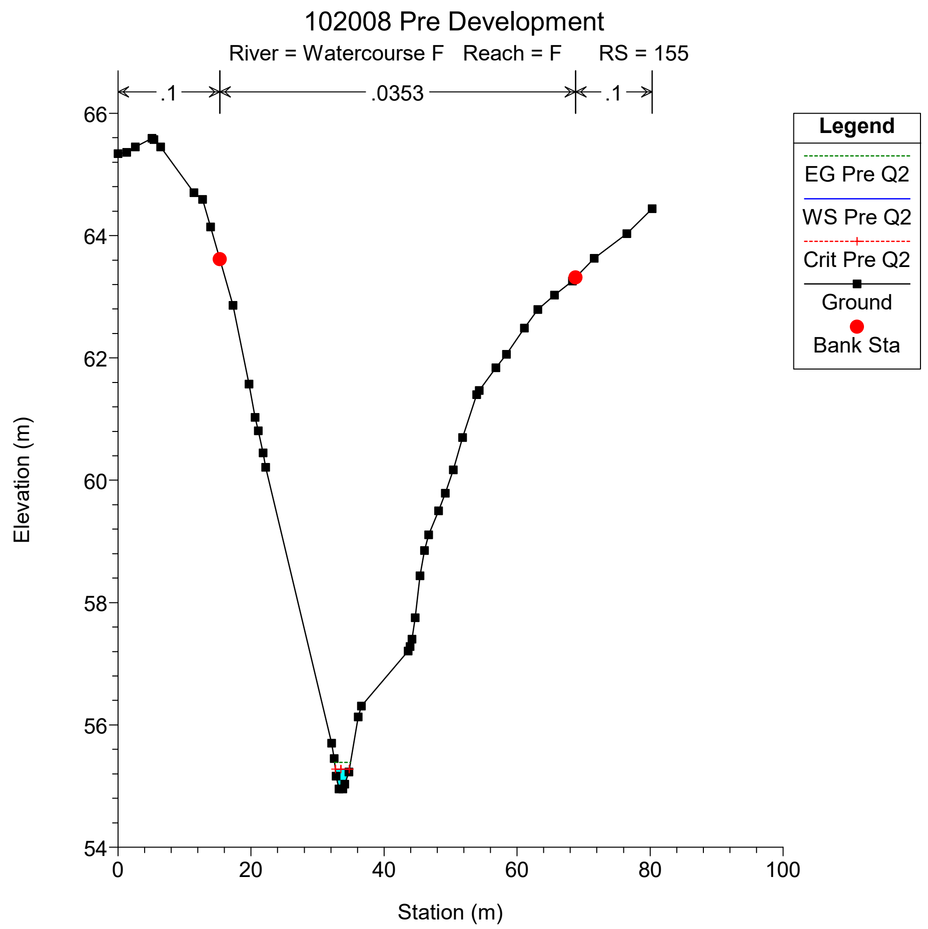

102008 Pre Development
River = Watercourse F Reach = F RS = 206
.1
.0353
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

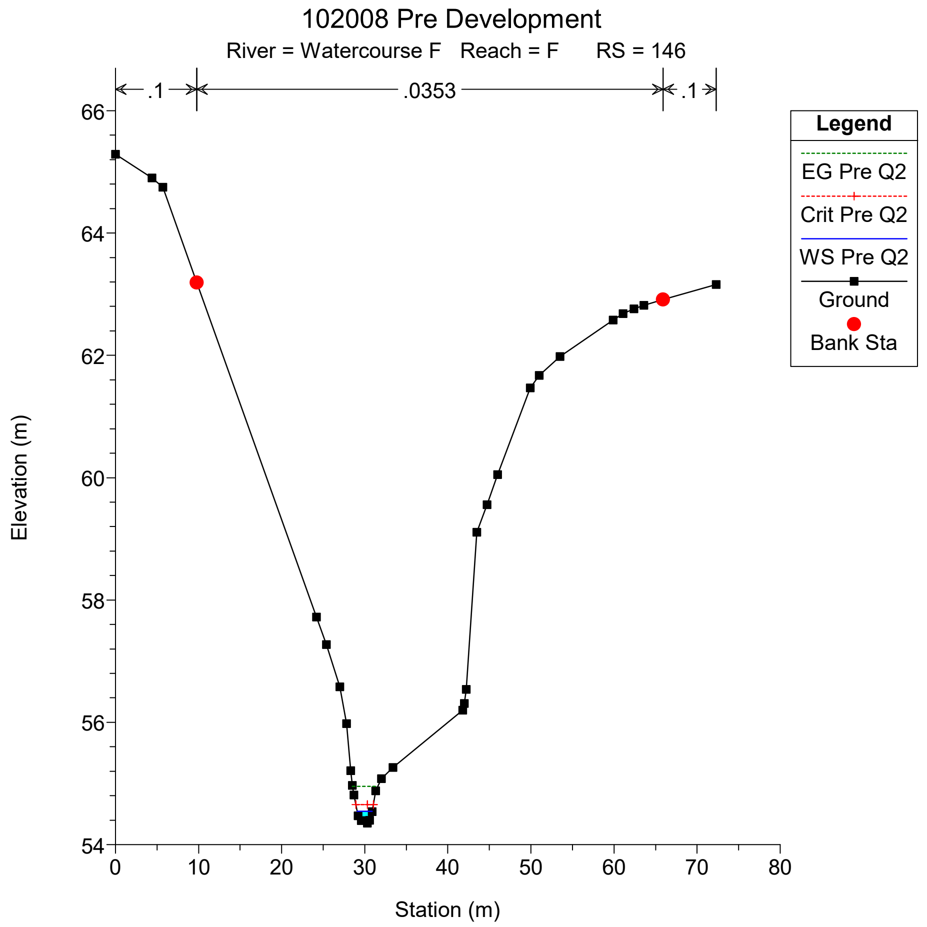

102008 Pre Development
River = Watercourse F Reach = F RS = 195
.1
.0353
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

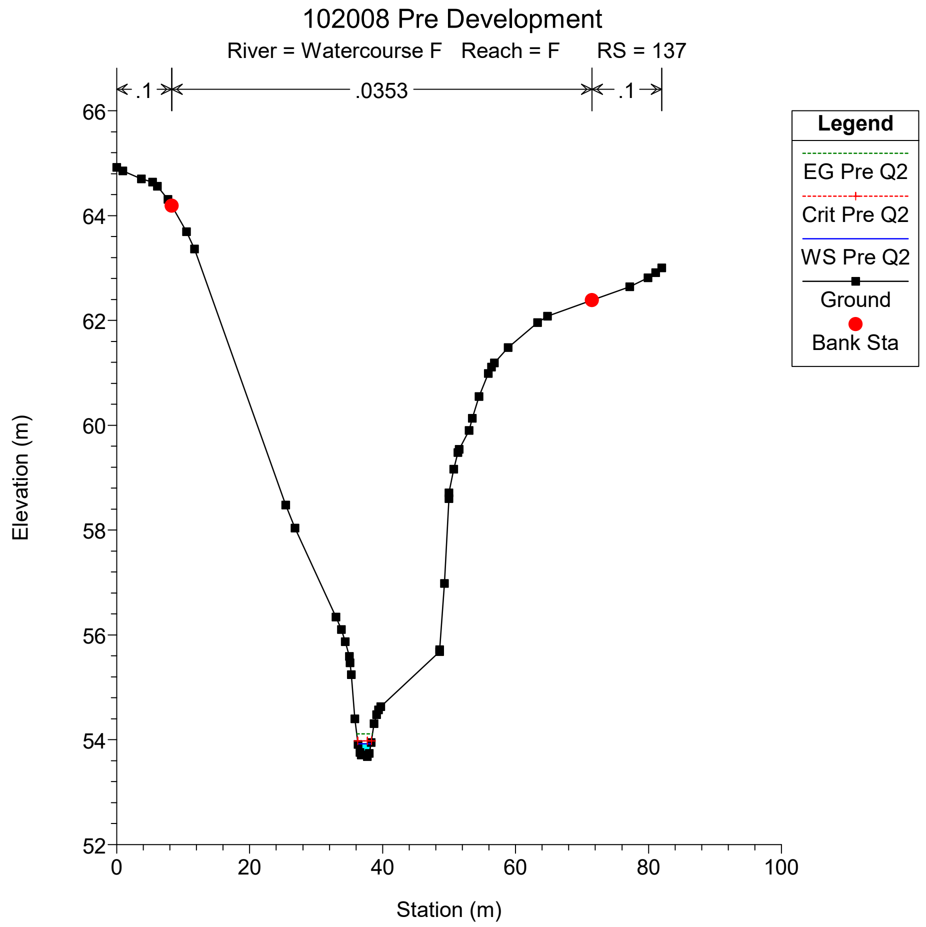

102008 Pre Development
River = Watercourse F Reach = F RS = 186
.1
.0353
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

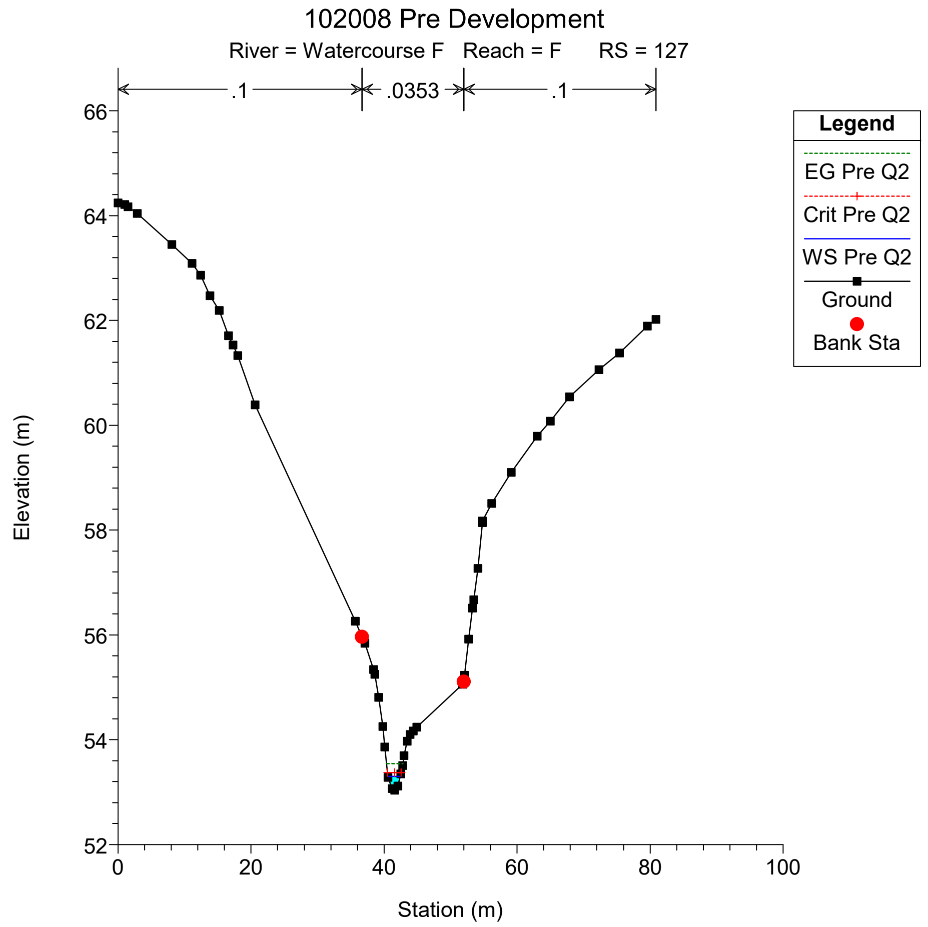

102008 Pre Development
River = Watercourse F Reach = F RS = 176
.1
.0353
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

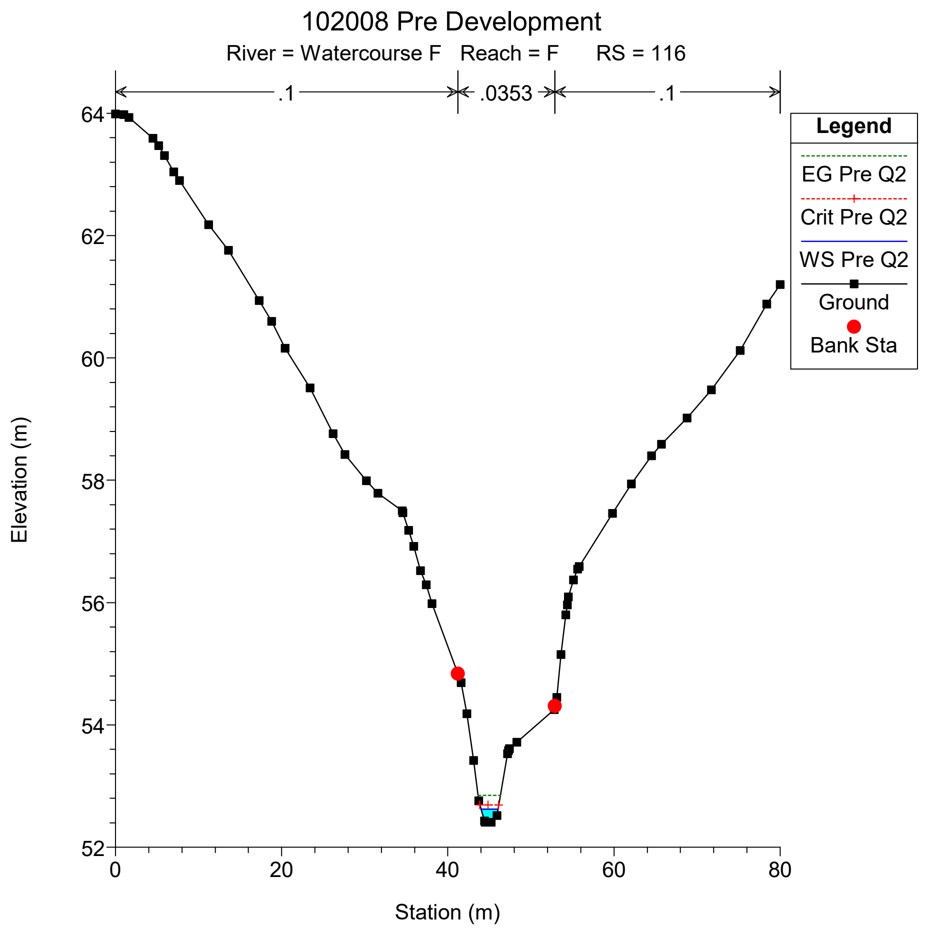

102008 Pre Development
River = Watercourse F Reach = F RS = 165
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

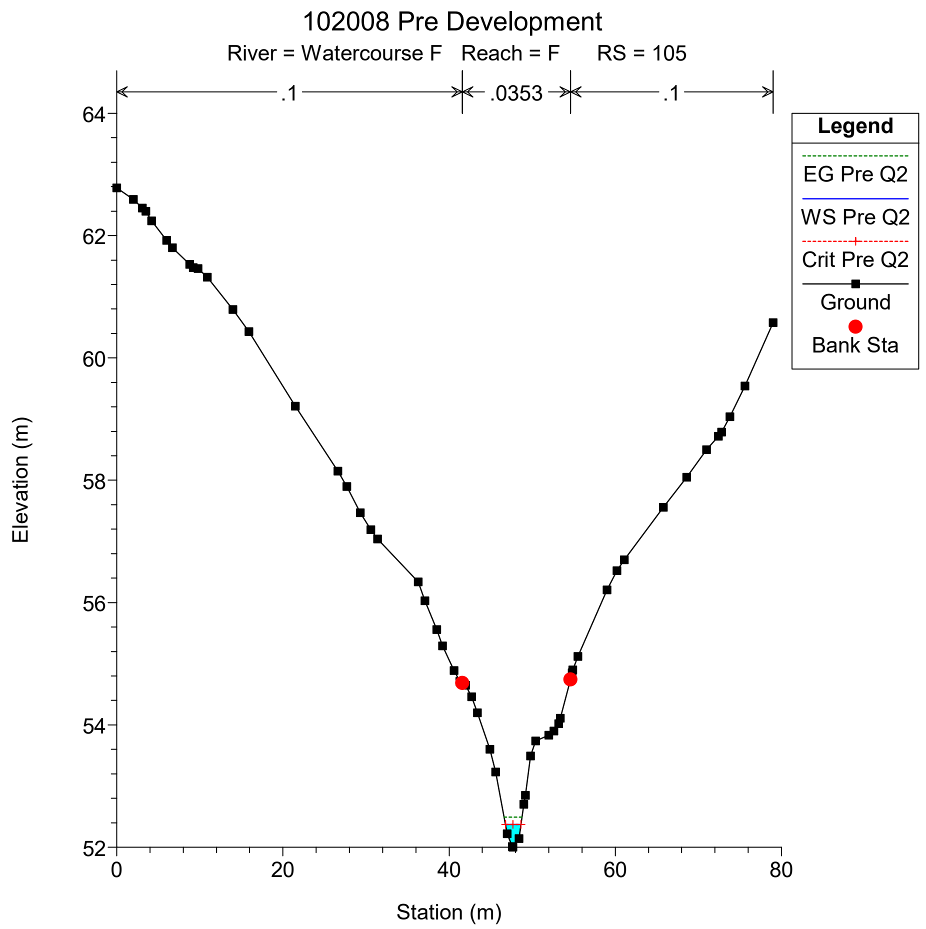

102008 Pre Development
River = Watercourse F Reach = F RS = 155
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta

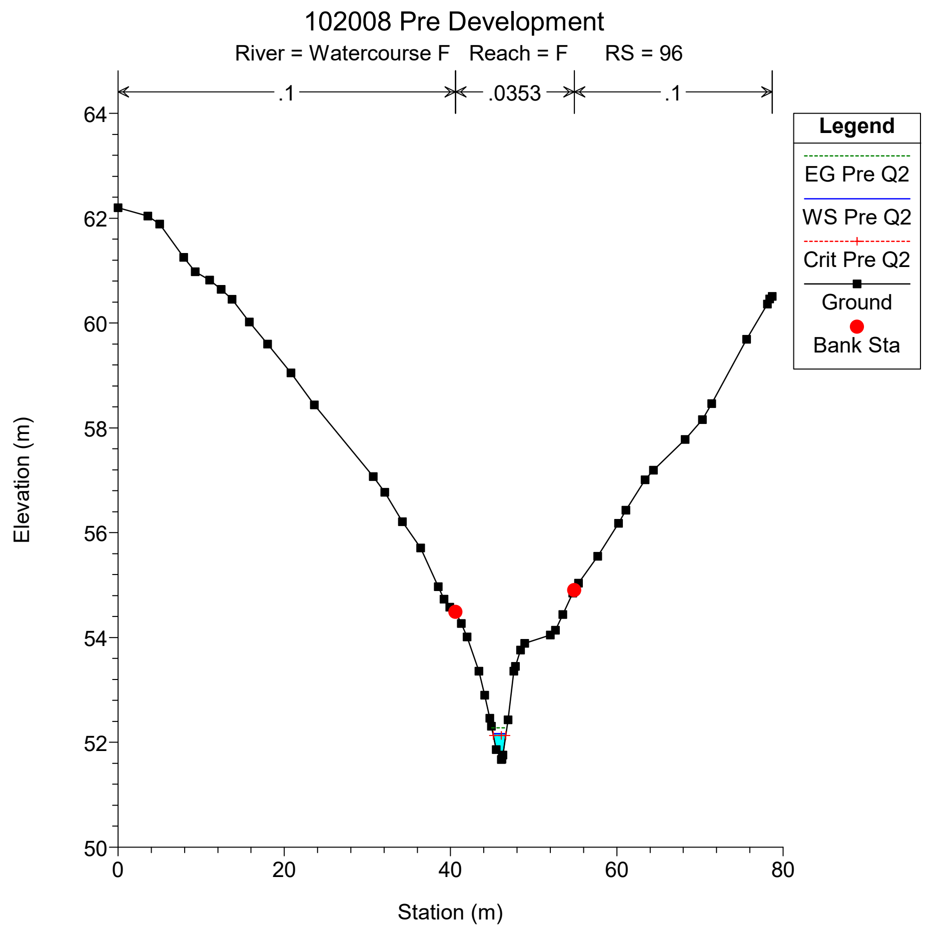

102008 Pre Development
River = Watercourse F Reach = F RS = 146
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

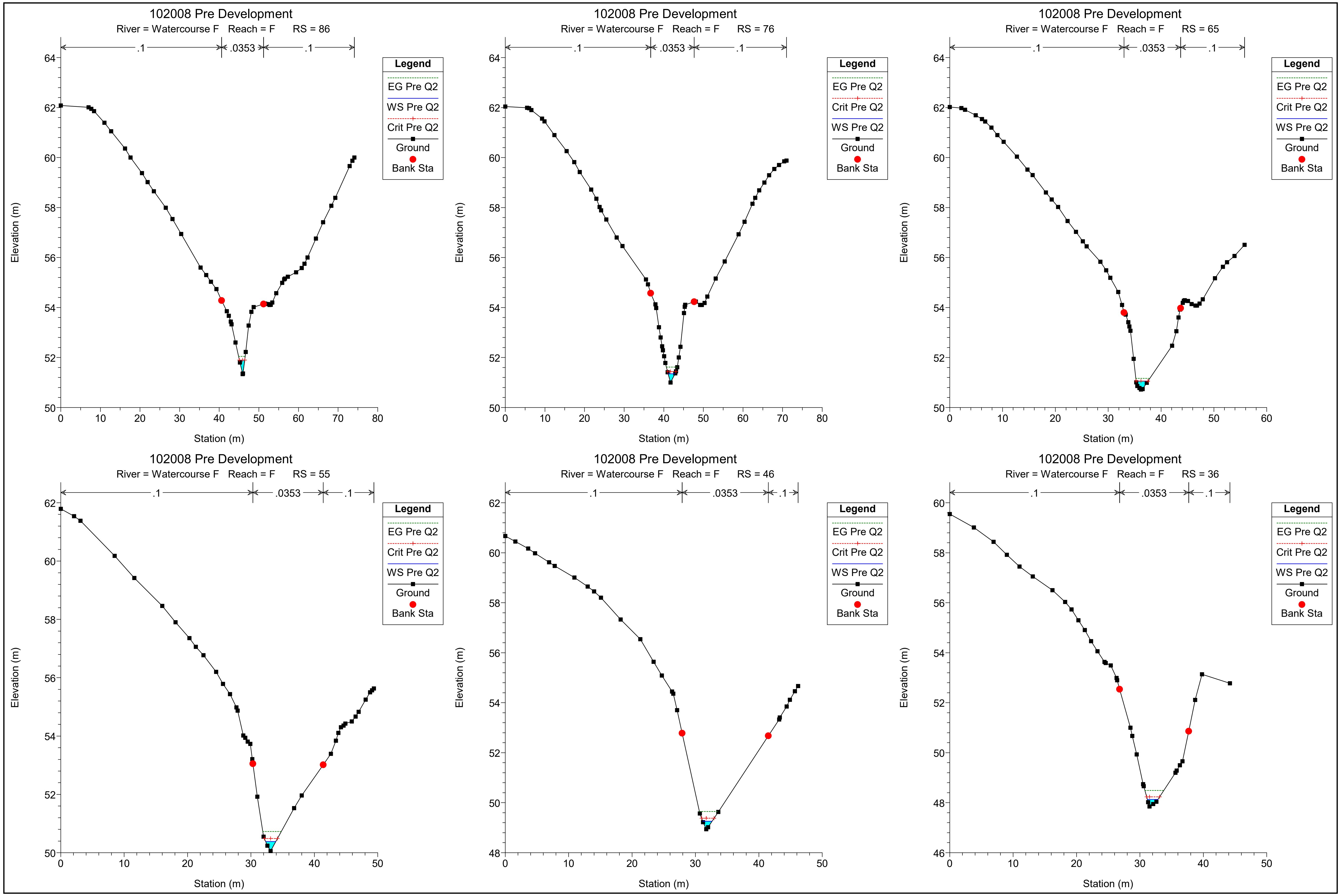

102008 Pre Development
River = Watercourse F Reach = F RS = 137
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

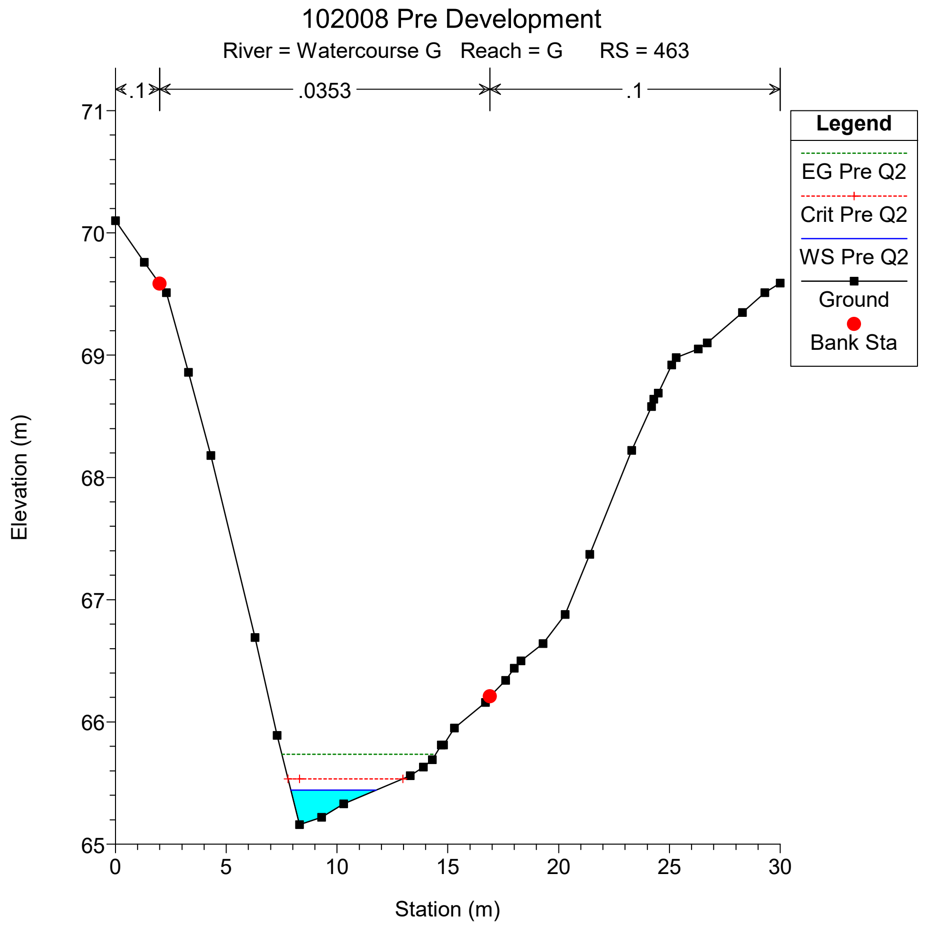

102008 Pre Development
River = Watercourse F Reach = F RS = 127
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

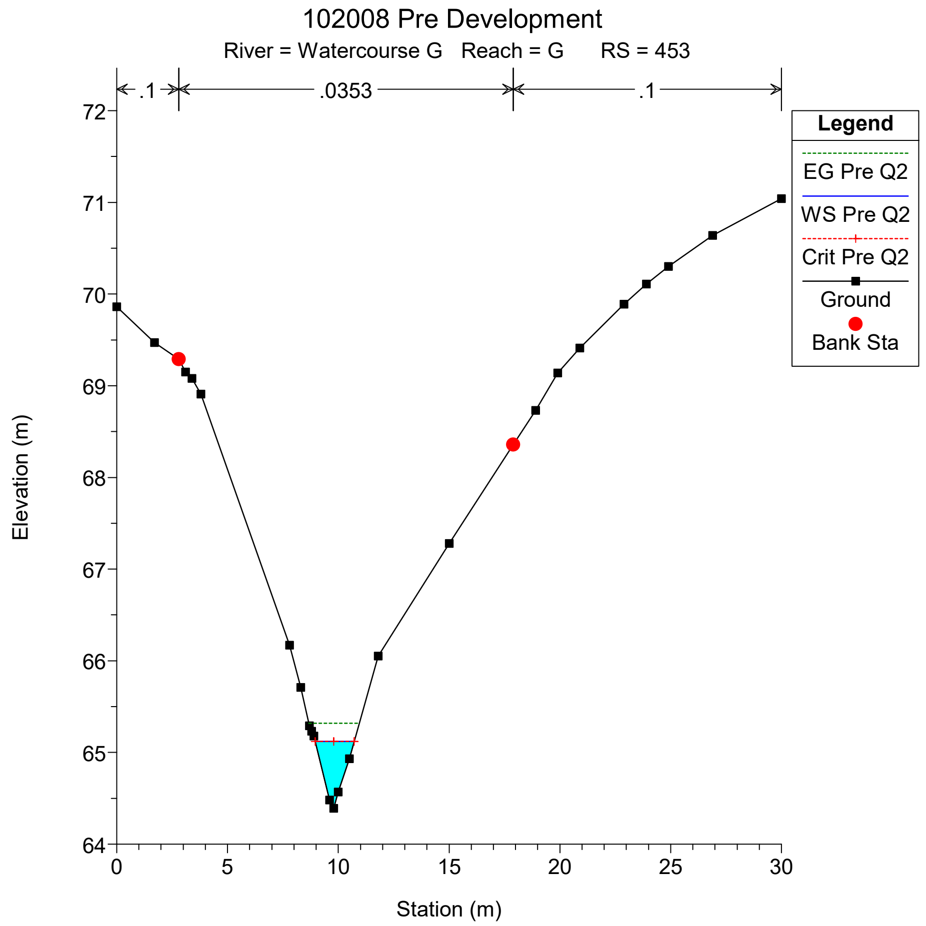

102008 Pre Development
River = Watercourse F Reach = F RS = 116
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

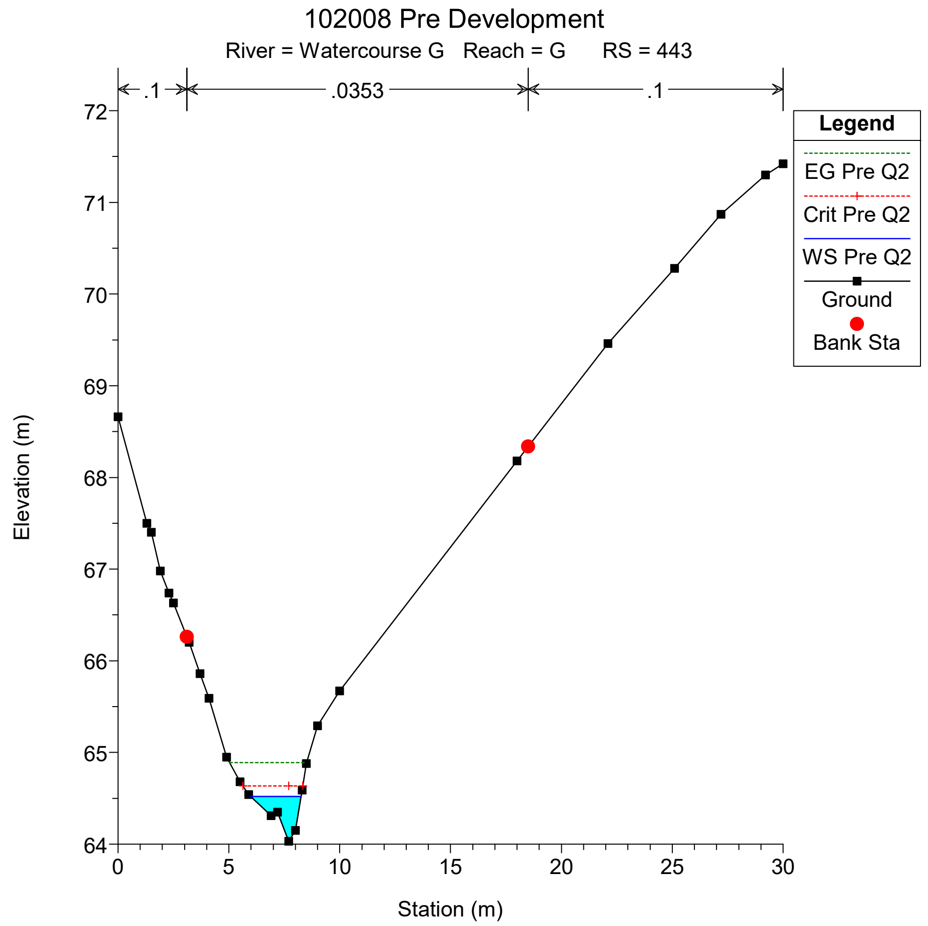

102008 Pre Development
River = Watercourse F Reach = F RS = 105
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

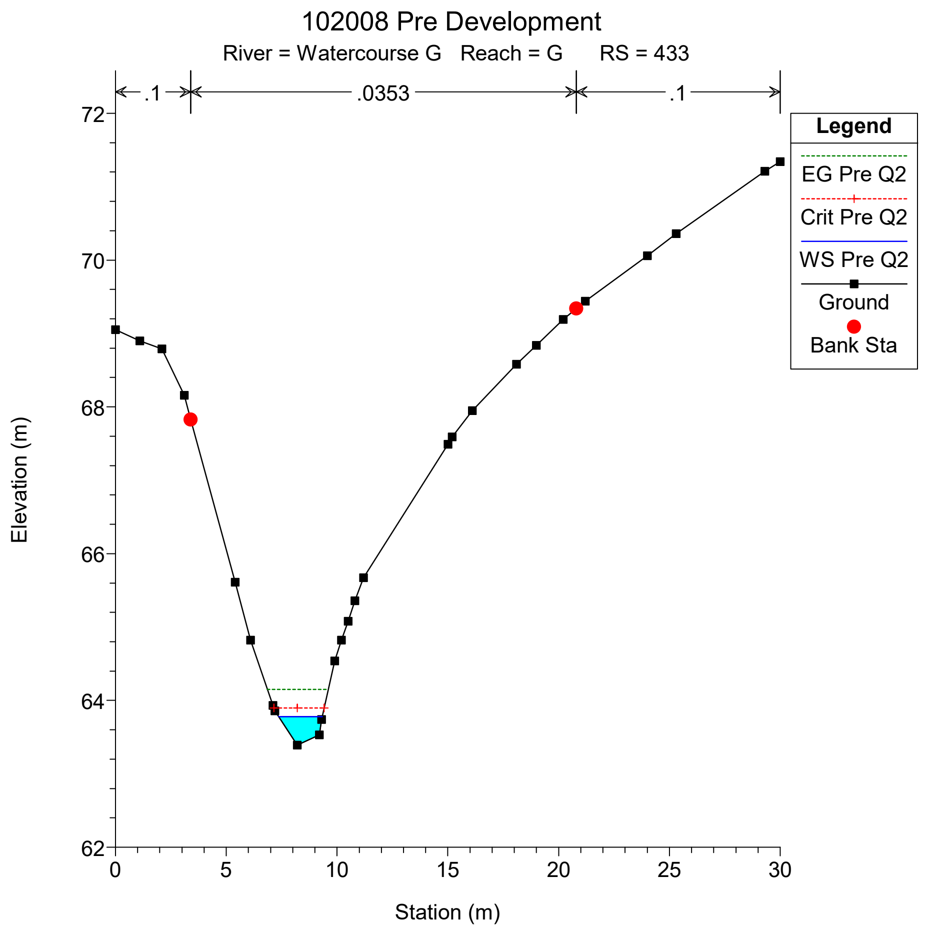

102008 Pre Development
River = Watercourse F Reach = F RS = 96
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

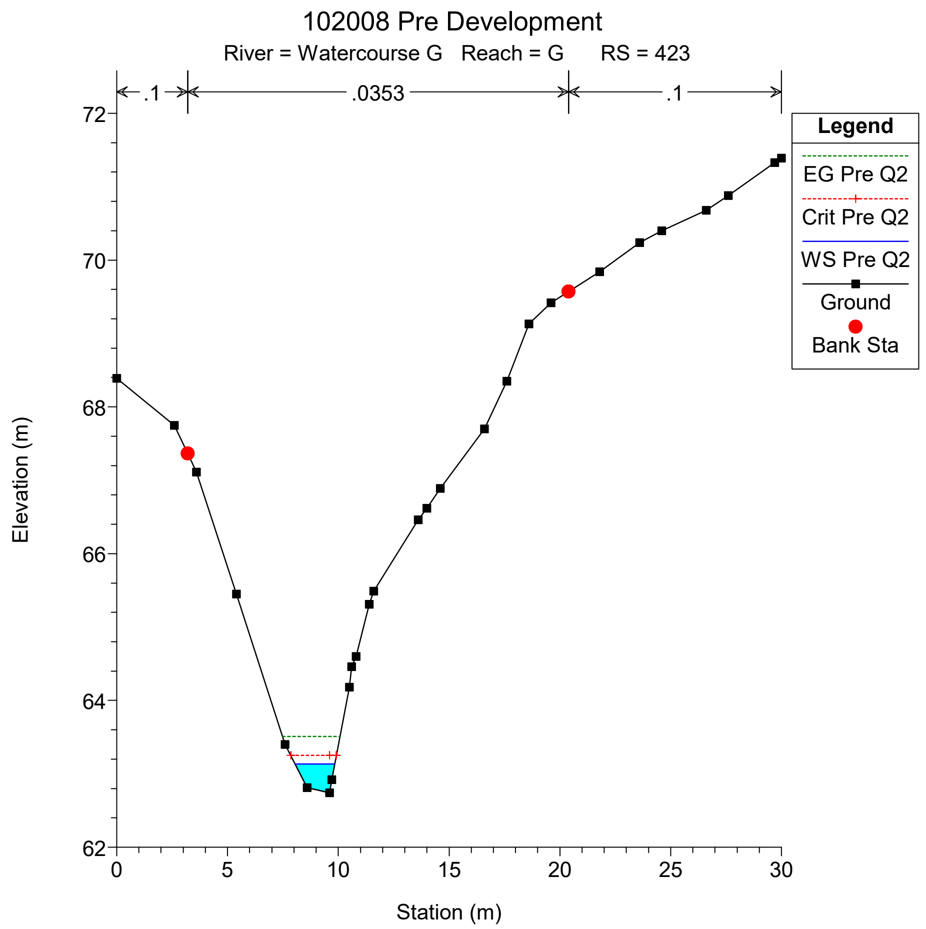

102008 Pre Development
River = Watercourse F Reach = F RS = 86
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse F Reach = F RS = 76
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse F Reach = F RS = 65
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse F Reach = F RS = 55
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse F Reach = F RS = 46
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse F Reach = F RS = 36
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

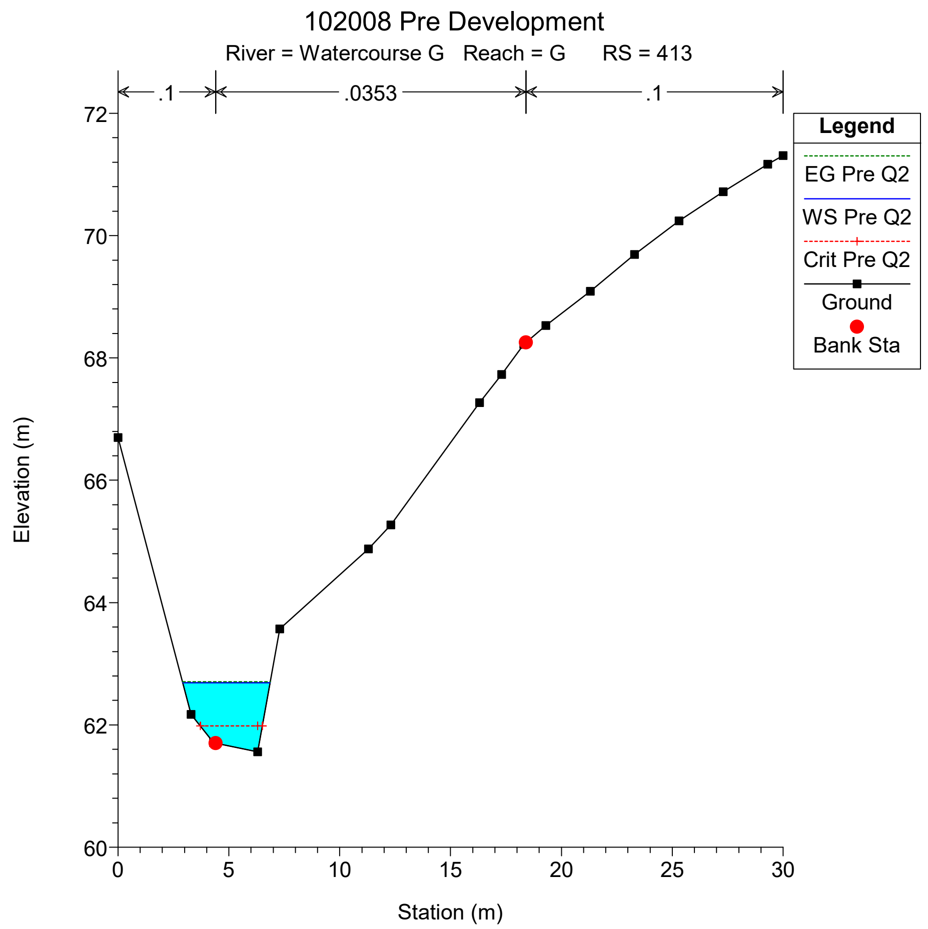

102008 Pre Development
River = Watercourse G Reach = G RS = 463
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

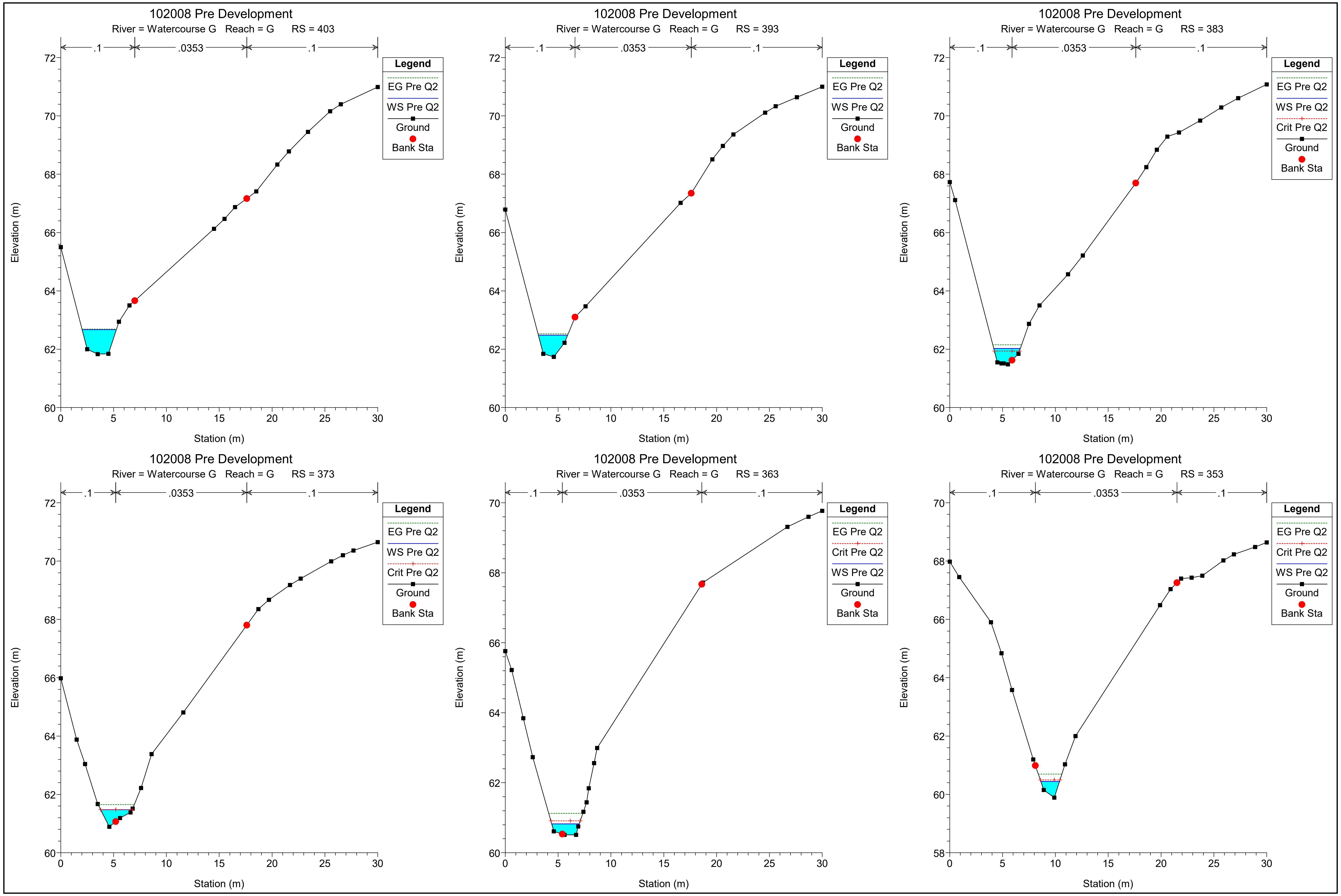

102008 Pre Development
River = Watercourse G Reach = G RS = 453
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)


102008 Pre Development
River = Watercourse G Reach = G RS = 443
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

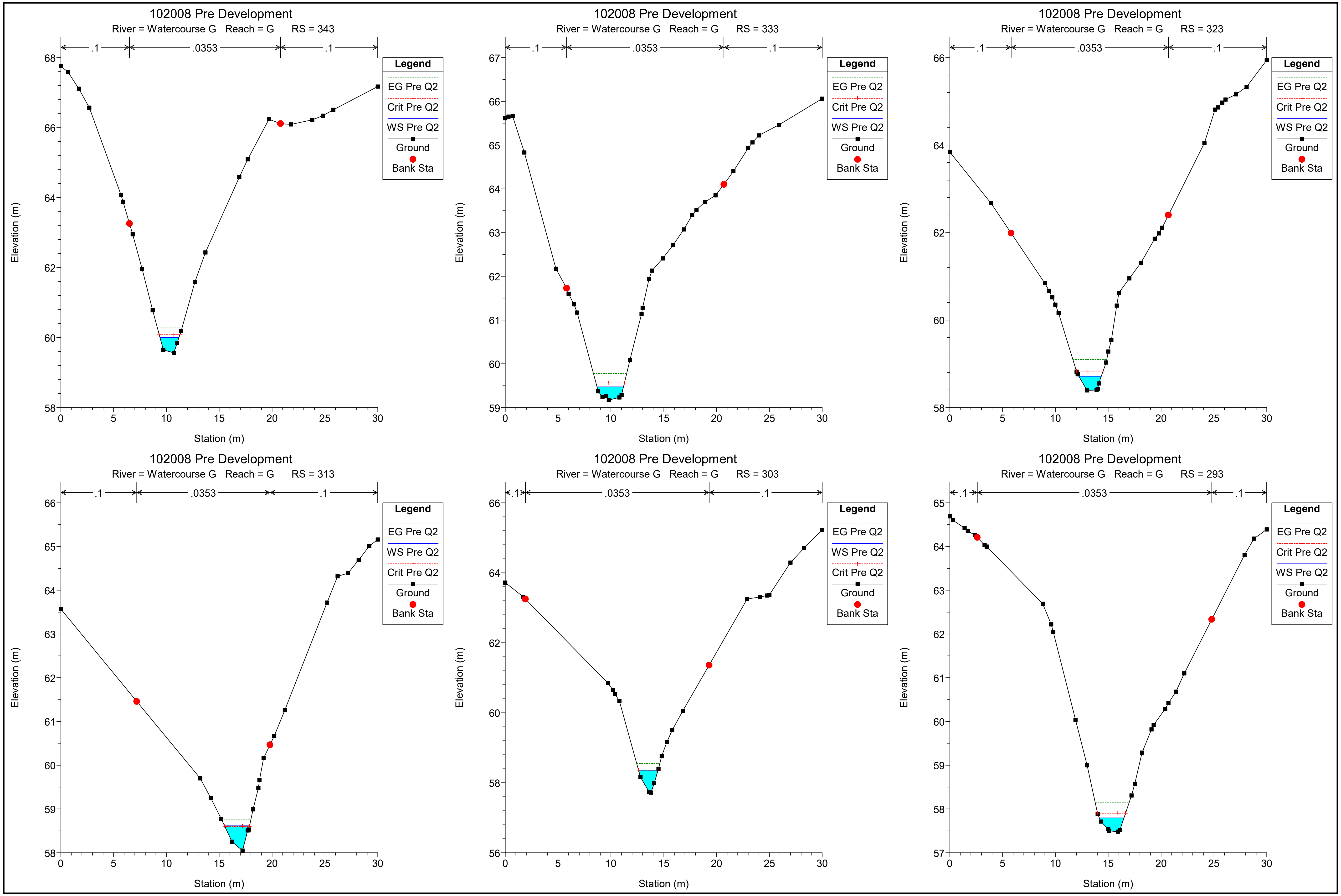

102008 Pre Development
River = Watercourse G Reach = G RS = 433
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)


102008 Pre Development
River = Watercourse G Reach = G RS = 423
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

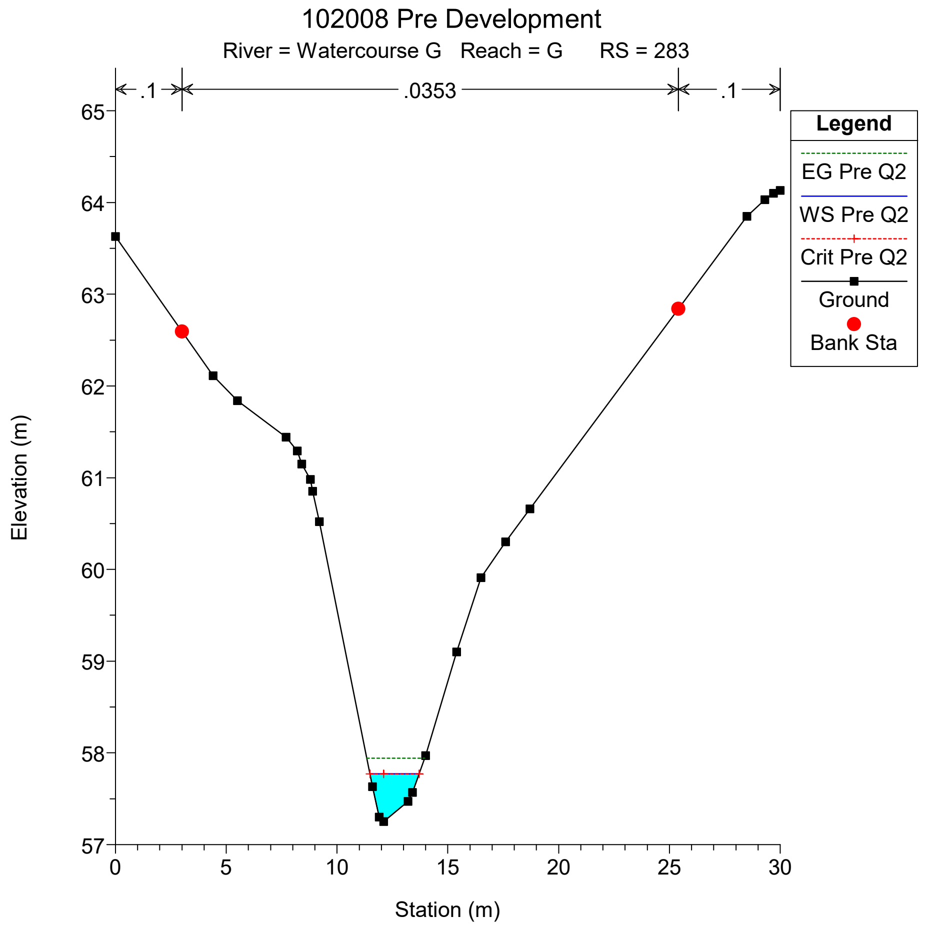

102008 Pre Development
River = Watercourse G Reach = G RS = 413
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

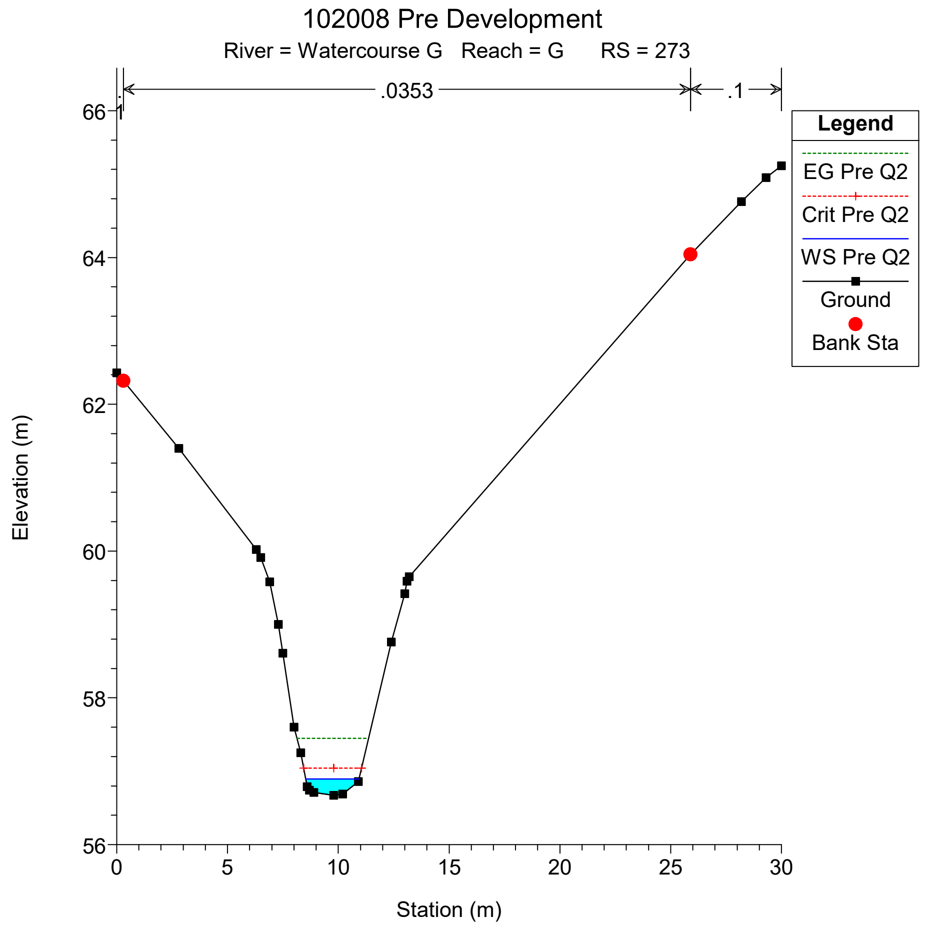

102008 Pre Development
River = Watercourse G Reach = G RS = 403
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 393
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 383
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 373
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 363
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 353
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

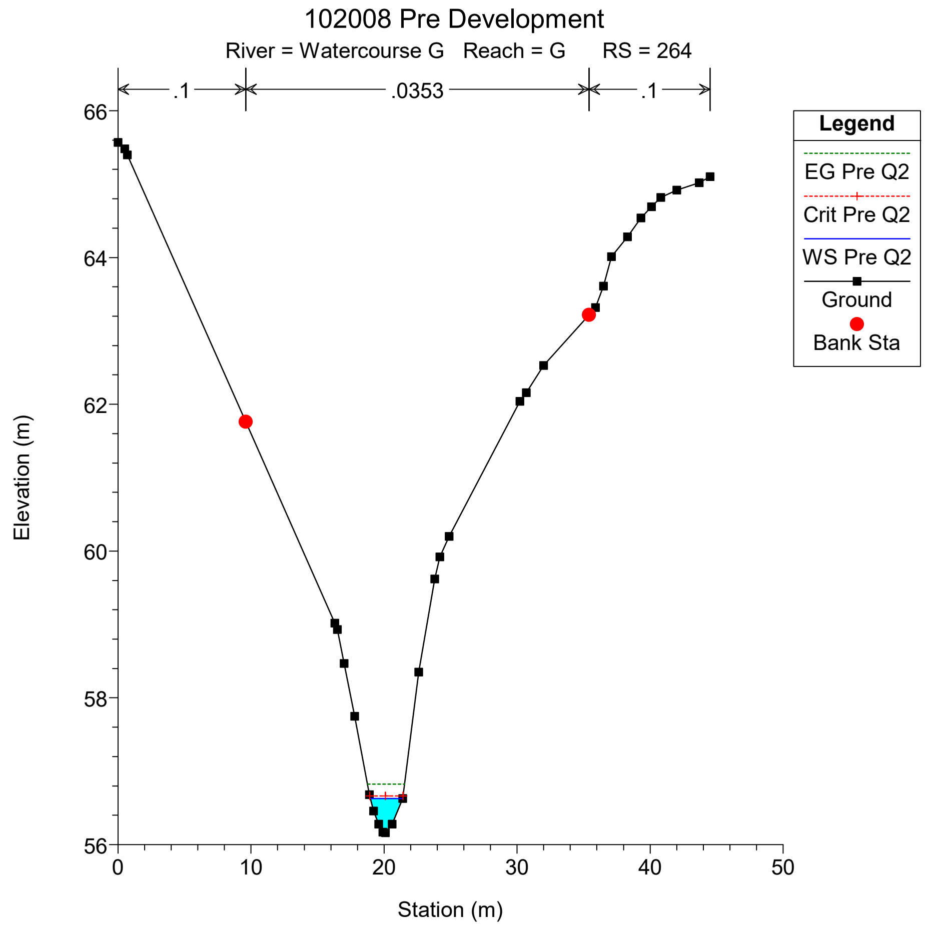
30

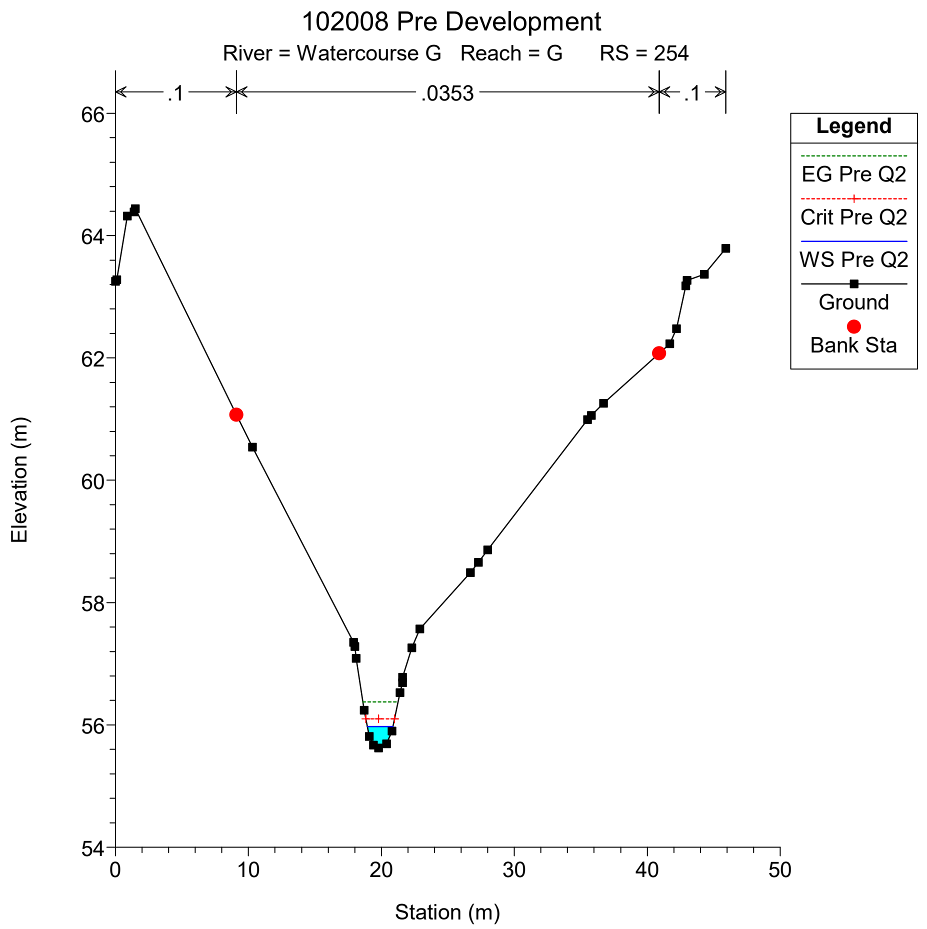


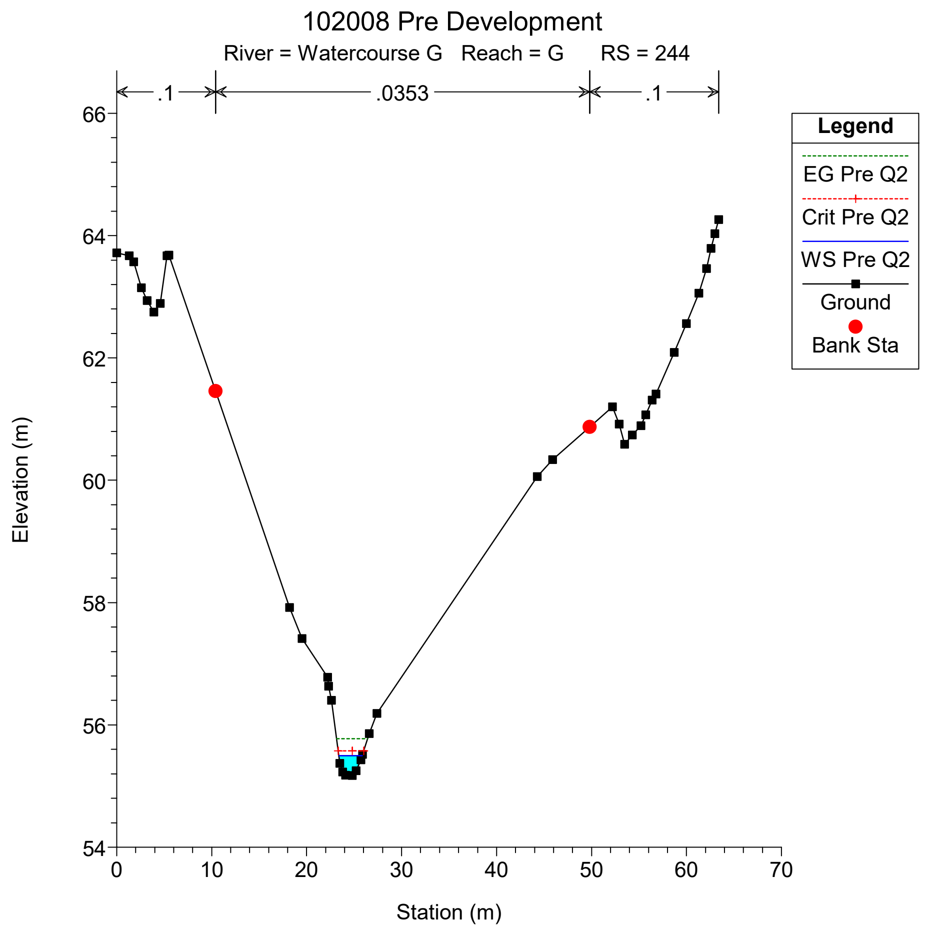
102008 Pre Development
River = Watercourse G Reach = G RS = 343
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 333
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 323
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 313
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 303
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 293
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

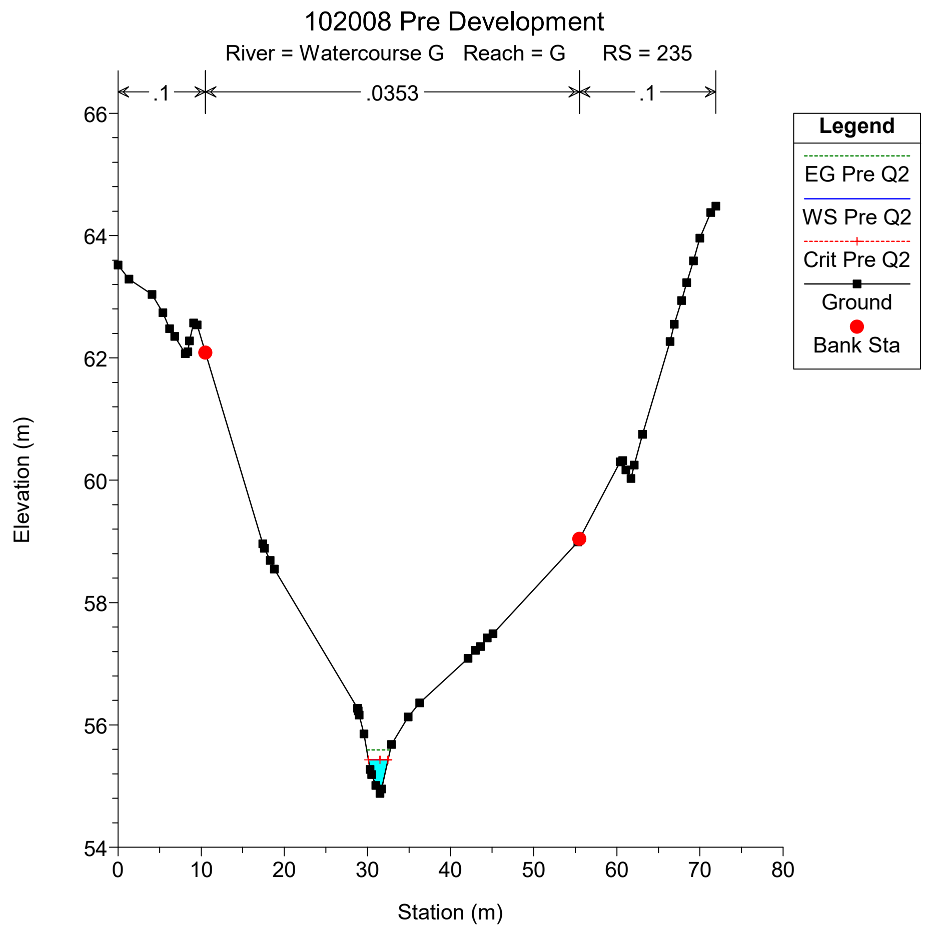

102008 Pre Development
River = Watercourse G Reach = G RS = 283
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

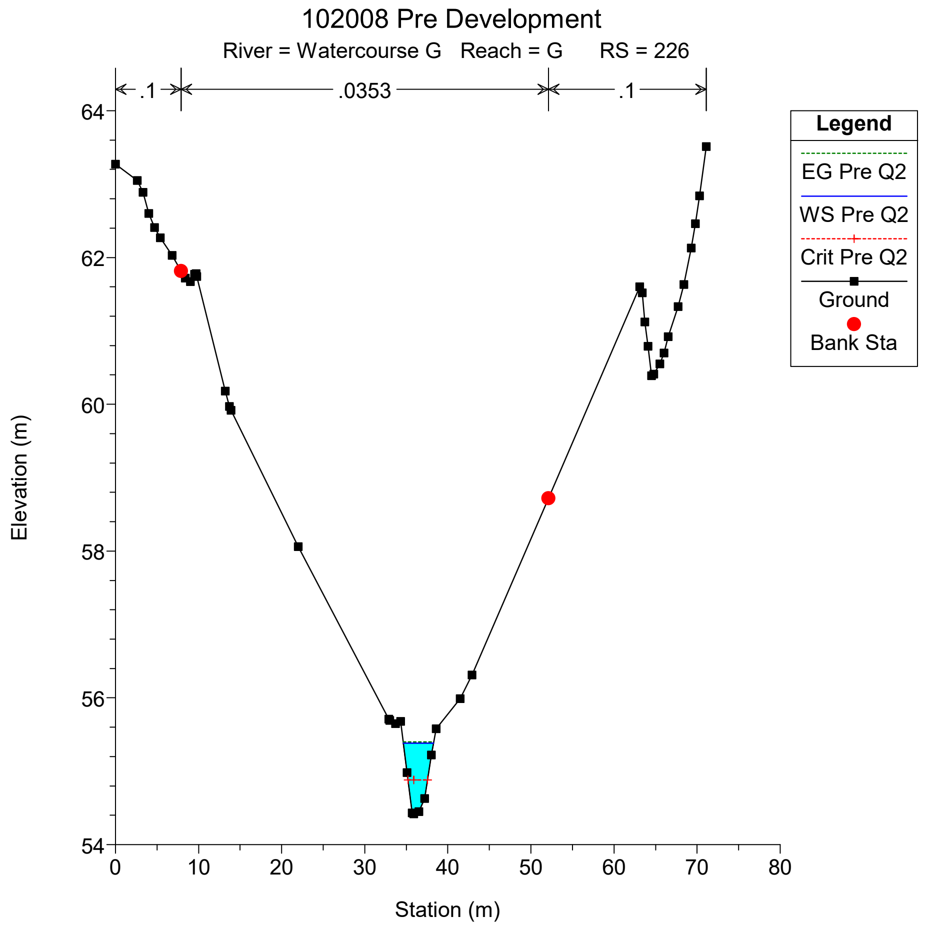

102008 Pre Development
River = Watercourse G Reach = G RS = 273
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

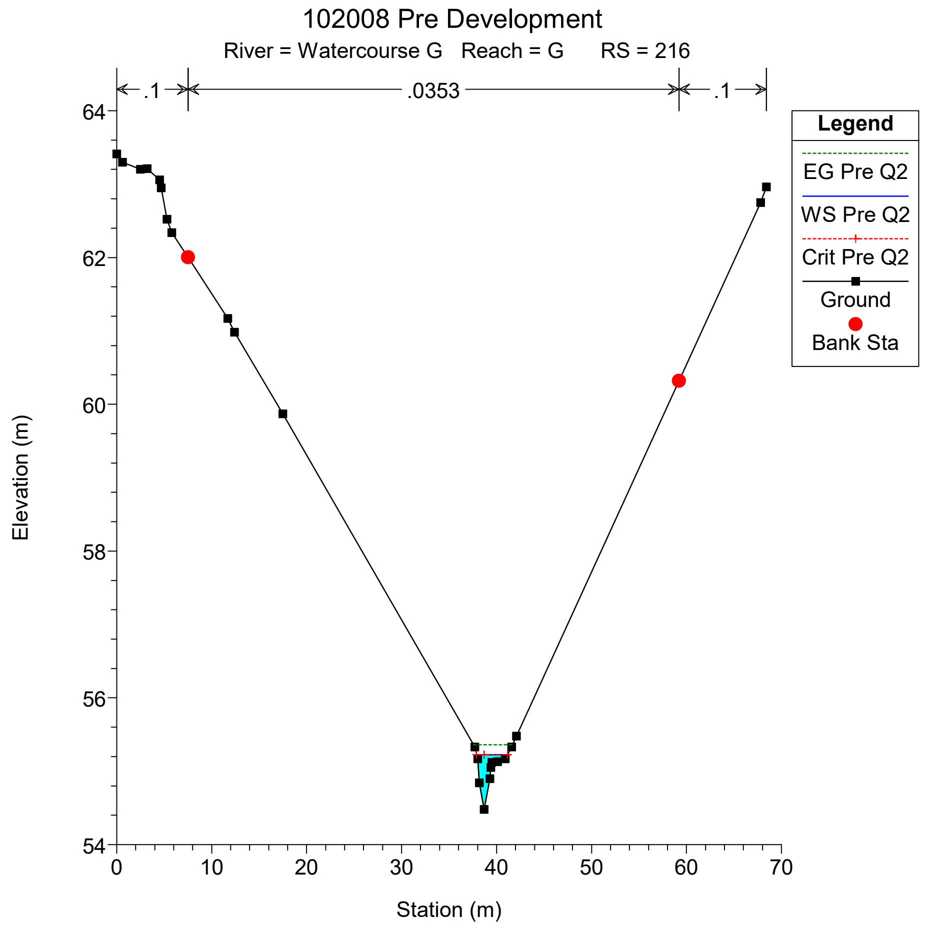

102008 Pre Development
River = Watercourse G Reach = G RS = 264
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

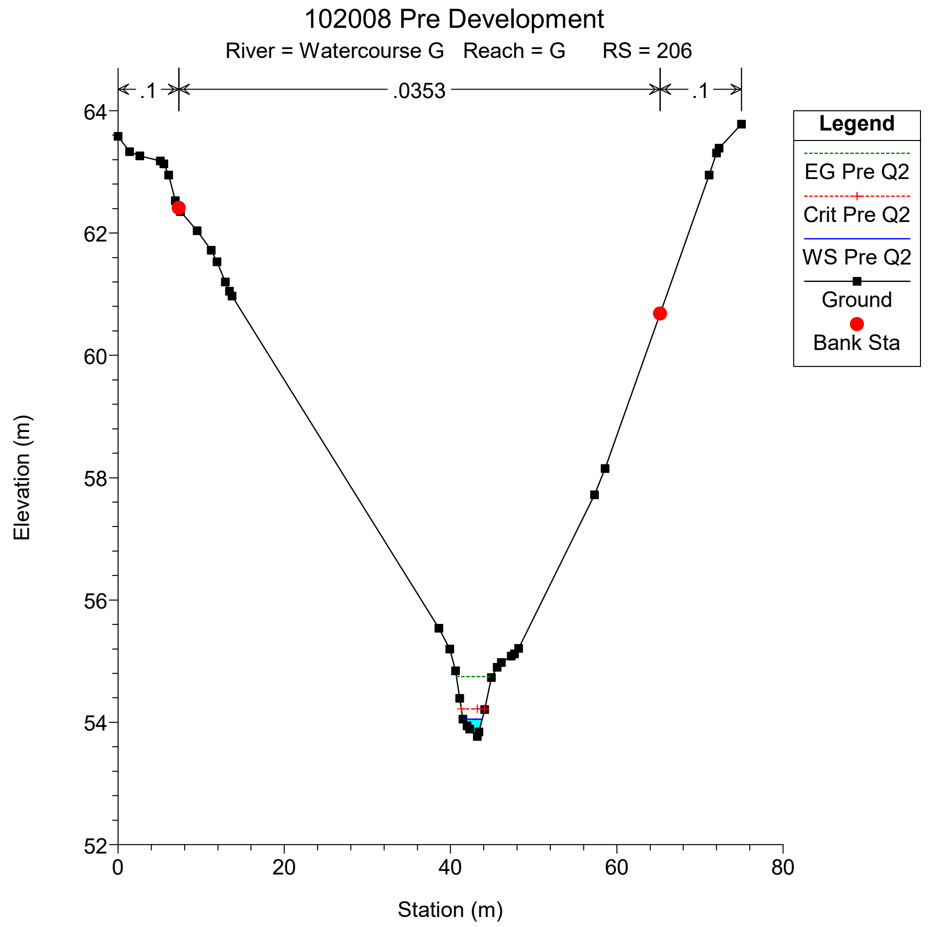

102008 Pre Development
River = Watercourse G Reach = G RS = 254
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

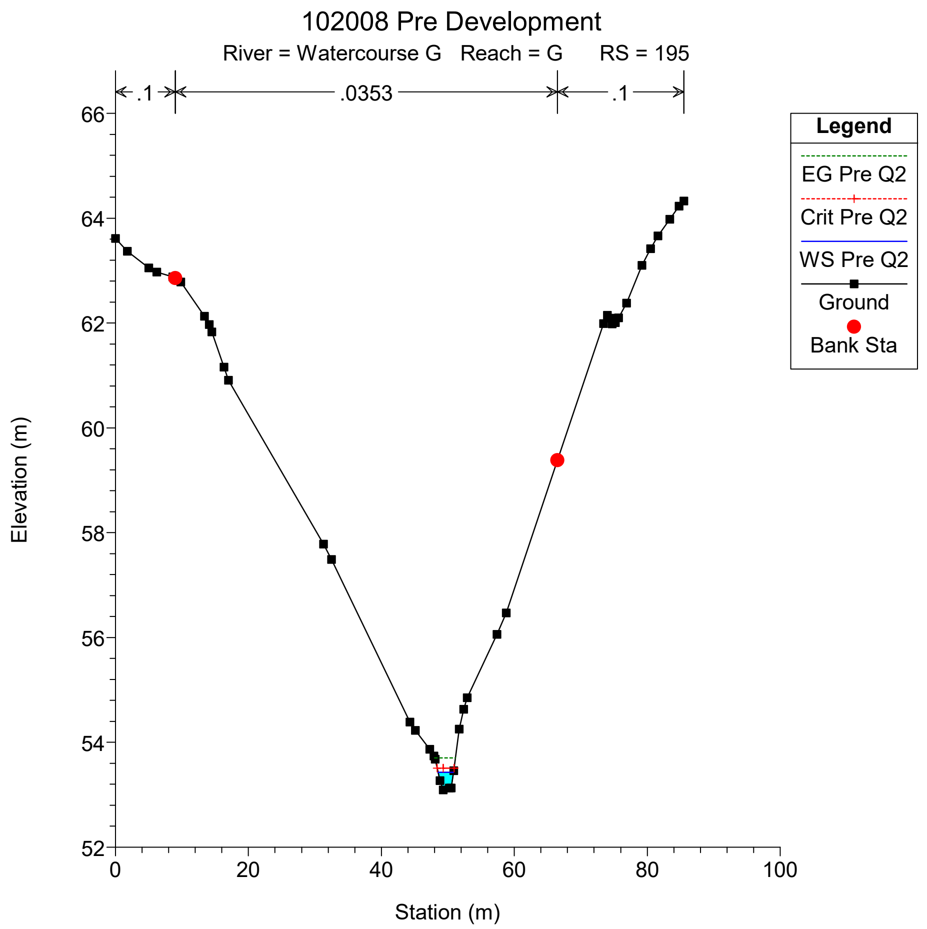

102008 Pre Development
River = Watercourse G Reach = G RS = 244
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

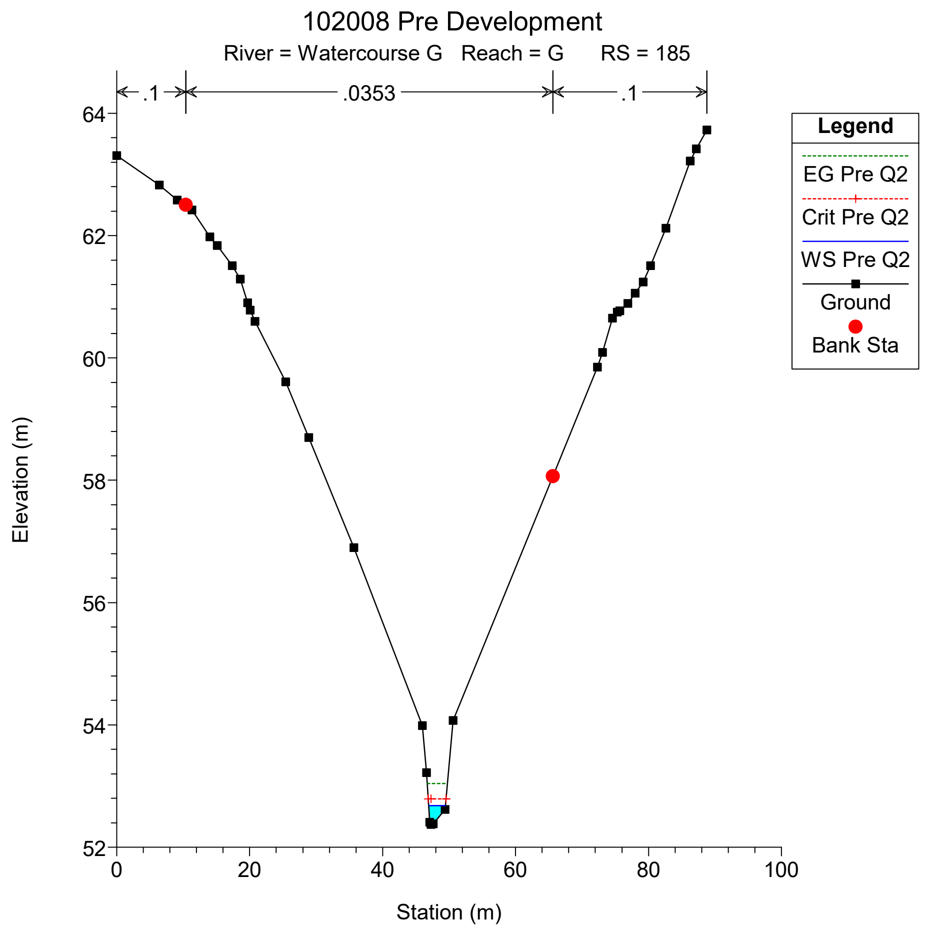

102008 Pre Development
River = Watercourse G Reach = G RS = 235
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

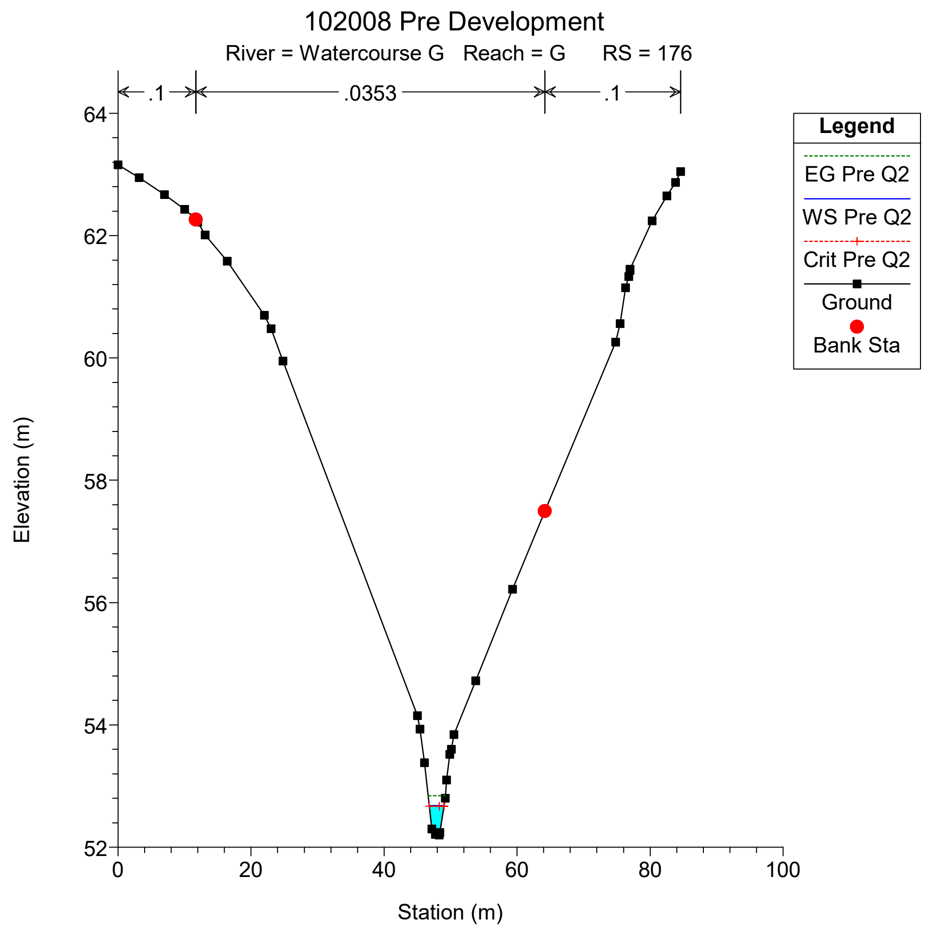

102008 Pre Development
River = Watercourse G Reach = G RS = 226
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

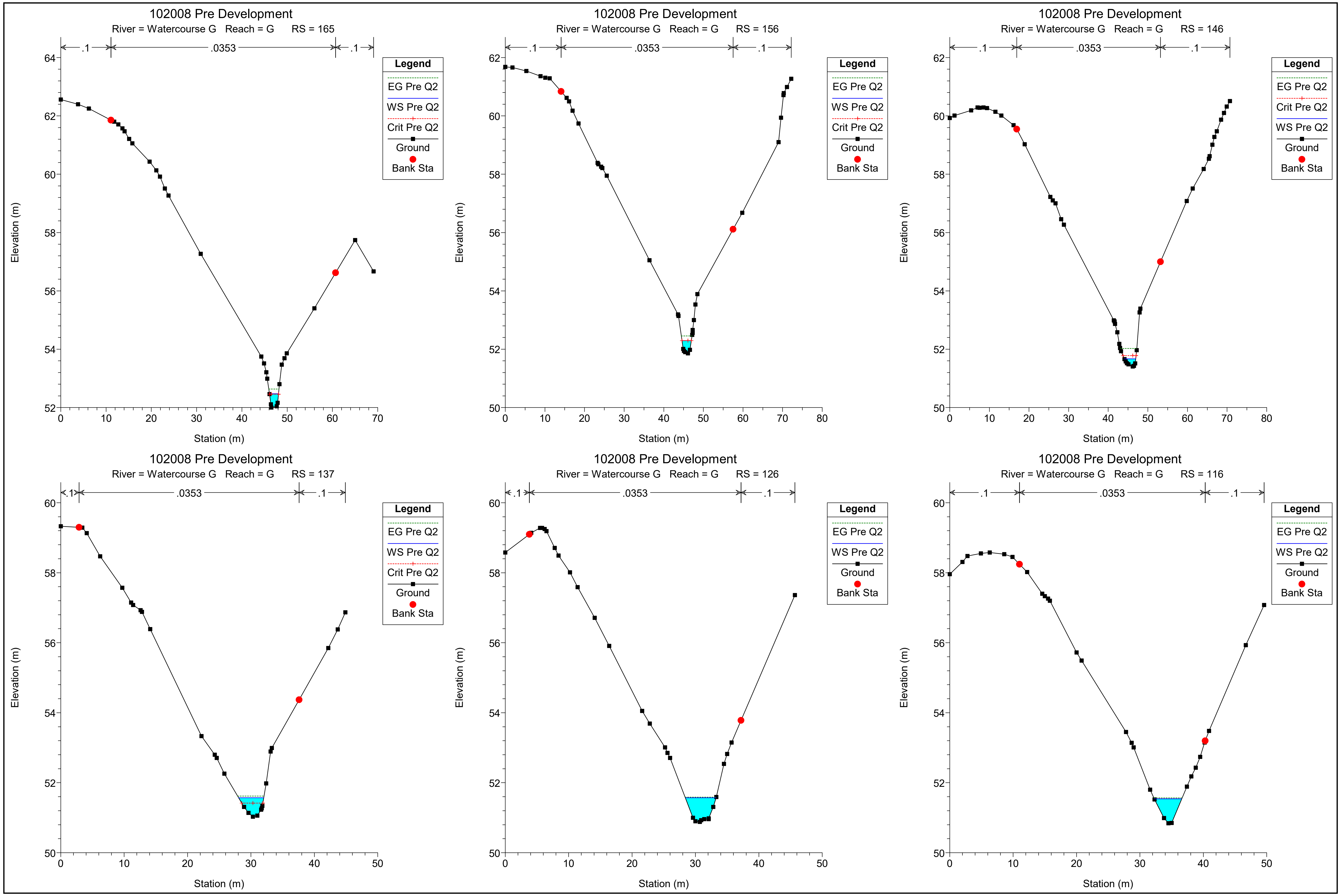

102008 Pre Development
River = Watercourse G Reach = G RS = 216
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

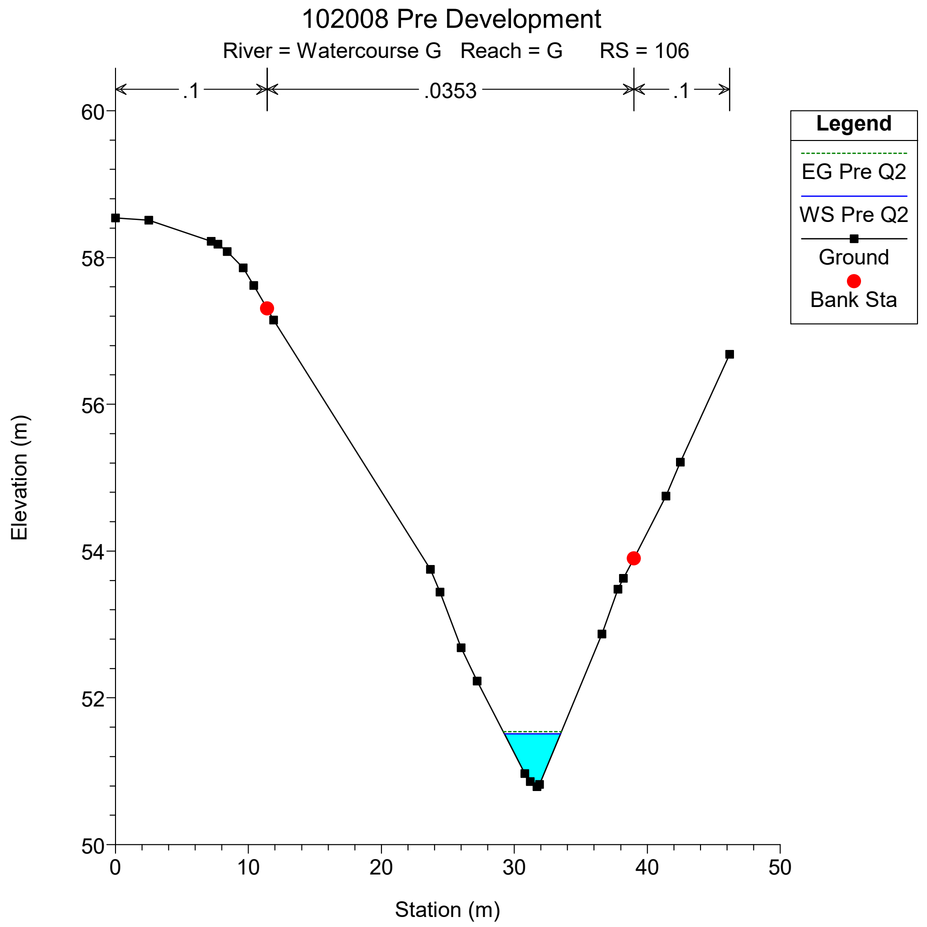

102008 Pre Development
River = Watercourse G Reach = G RS = 206
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

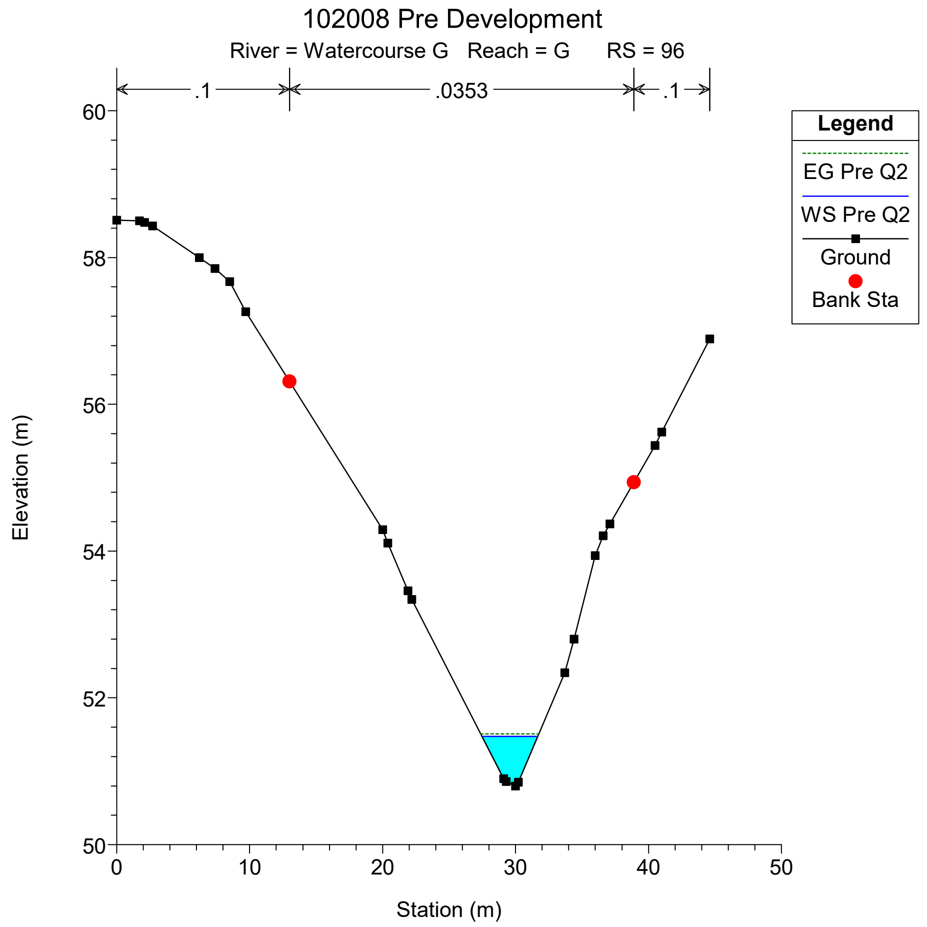

102008 Pre Development
River = Watercourse G Reach = G RS = 195
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

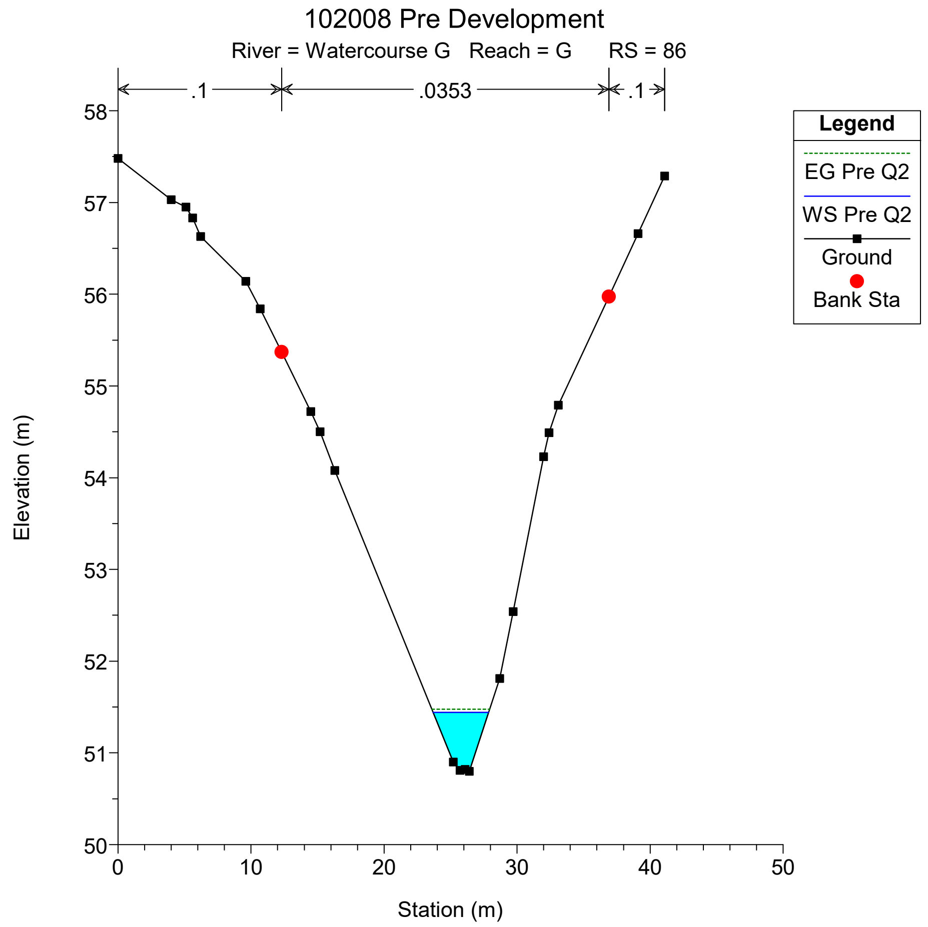

102008 Pre Development
River = Watercourse G Reach = G RS = 185
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

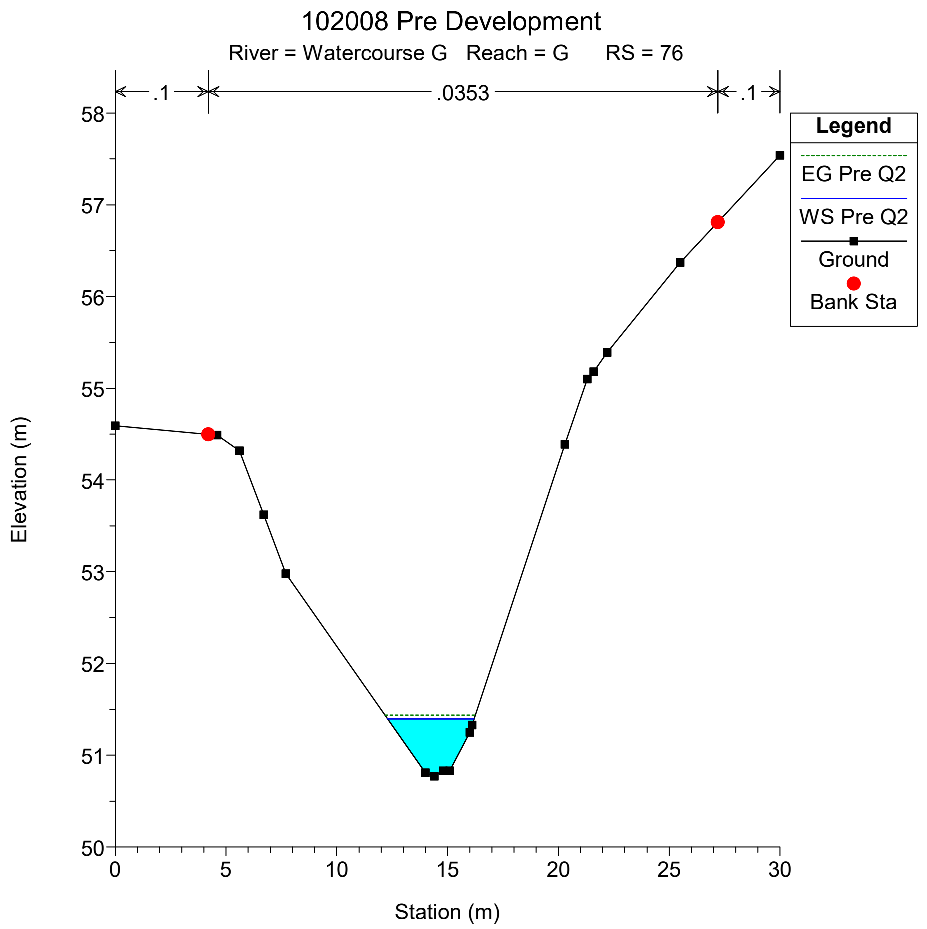

102008 Pre Development
River = Watercourse G Reach = G RS = 176
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

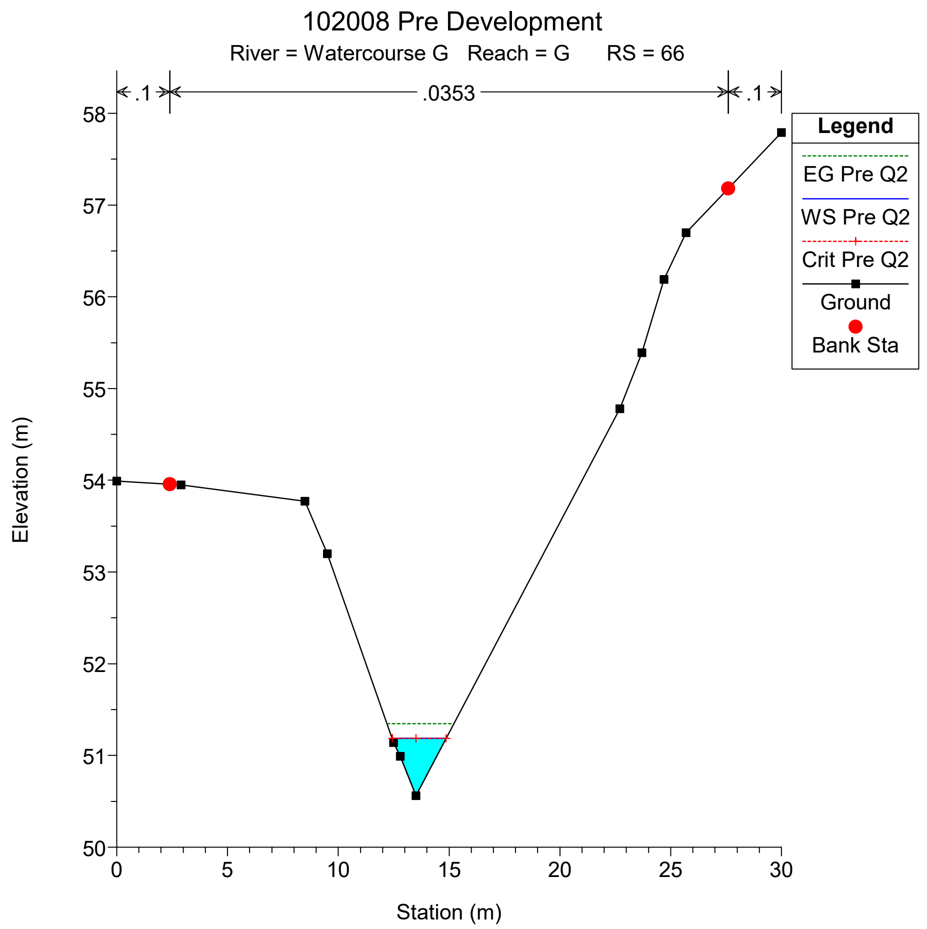

102008 Pre Development
River = Watercourse G Reach = G RS = 165
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 156
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 146
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 137
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 126
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse G Reach = G RS = 116
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

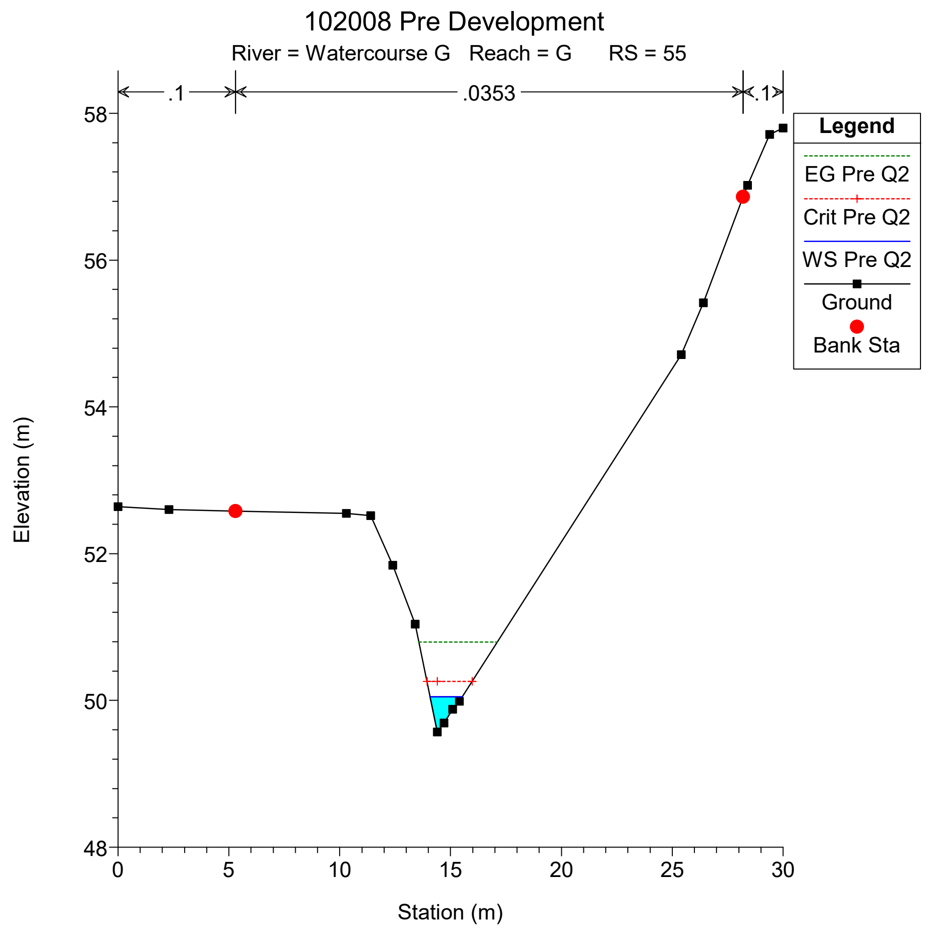

102008 Pre Development
River = Watercourse G Reach = G RS = 106
.1 .0353 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta

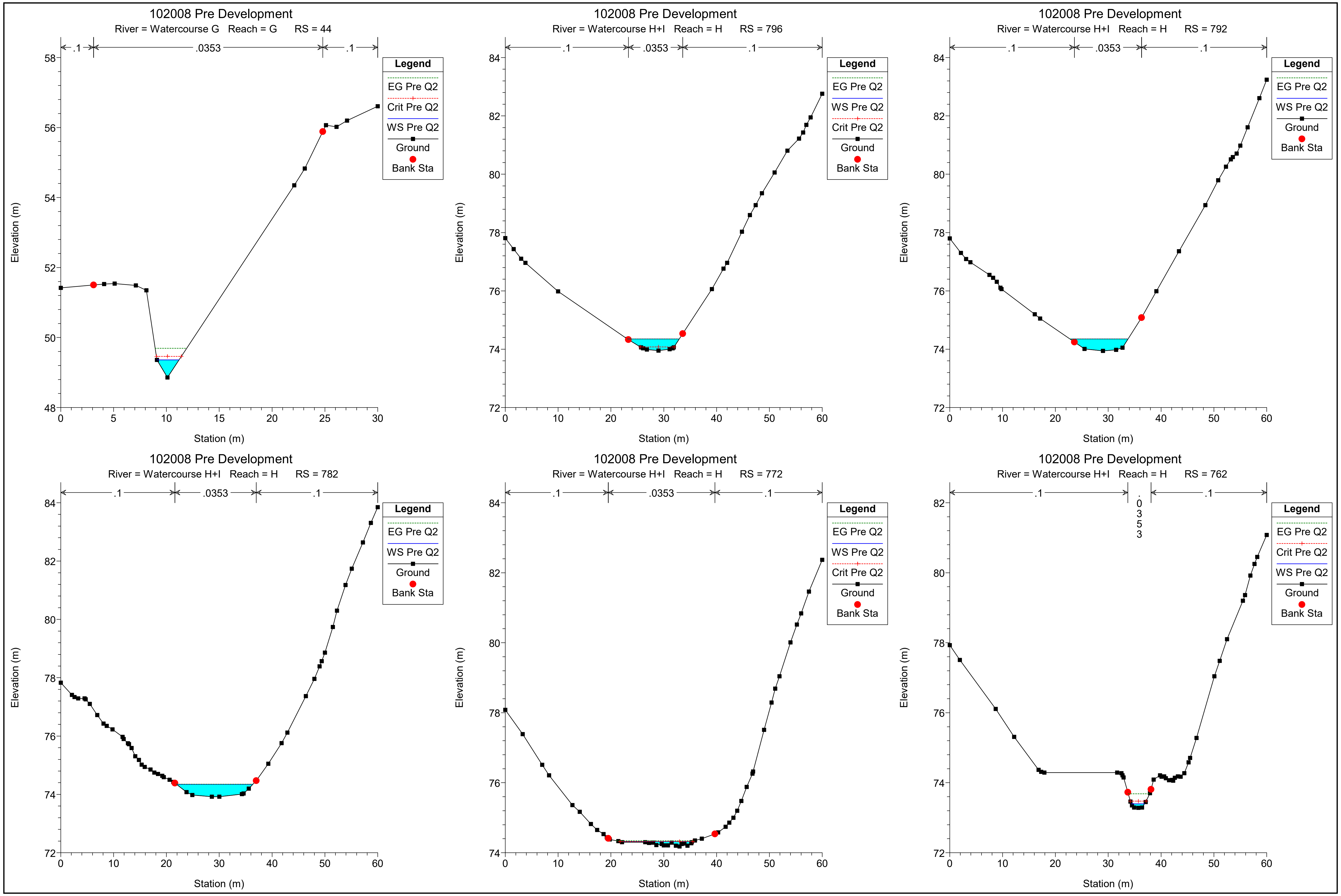

102008 Pre Development
River = Watercourse G Reach = G RS = 96
.1 .0353 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta

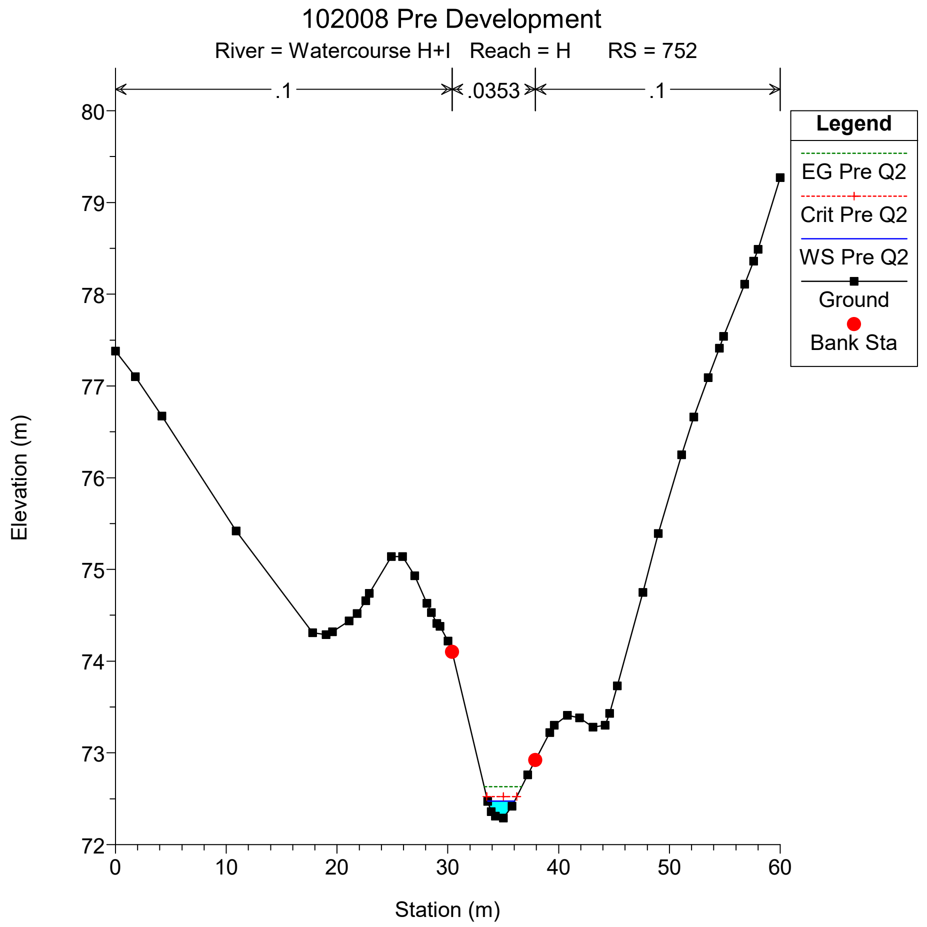

102008 Pre Development
River = Watercourse G Reach = G RS = 86
.1 .0353 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta

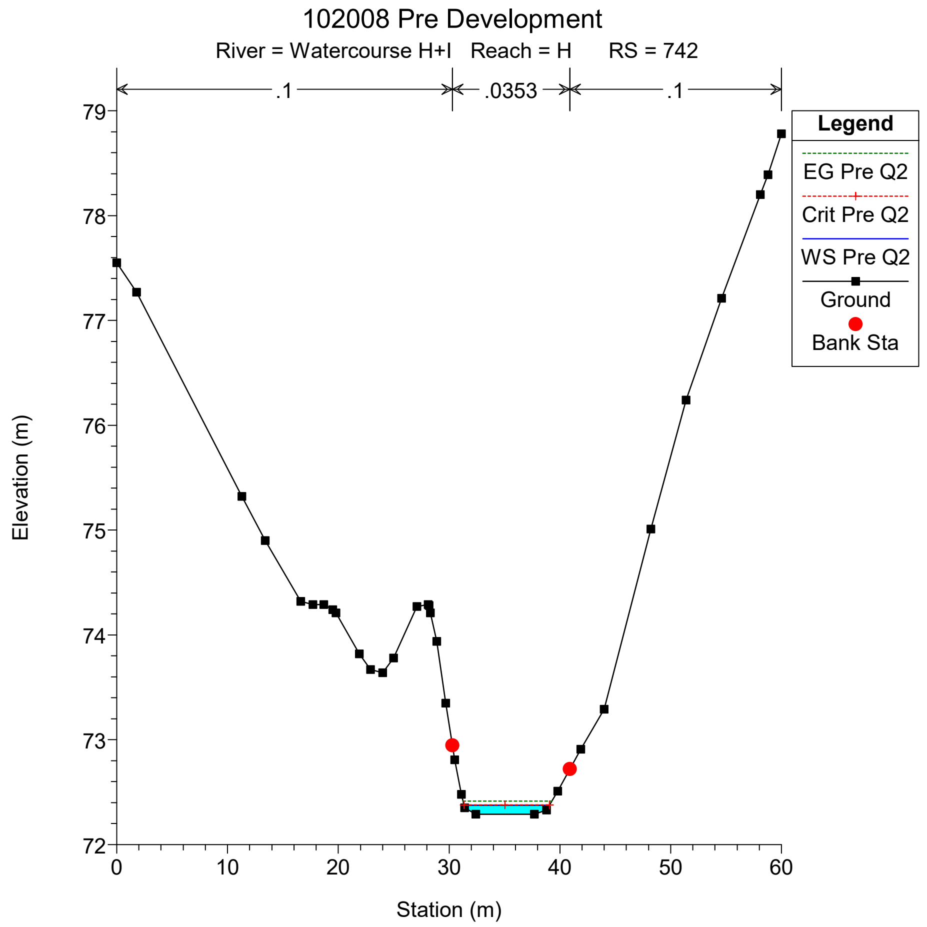

102008 Pre Development
River = Watercourse G Reach = G RS = 76
.1 .0353 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta

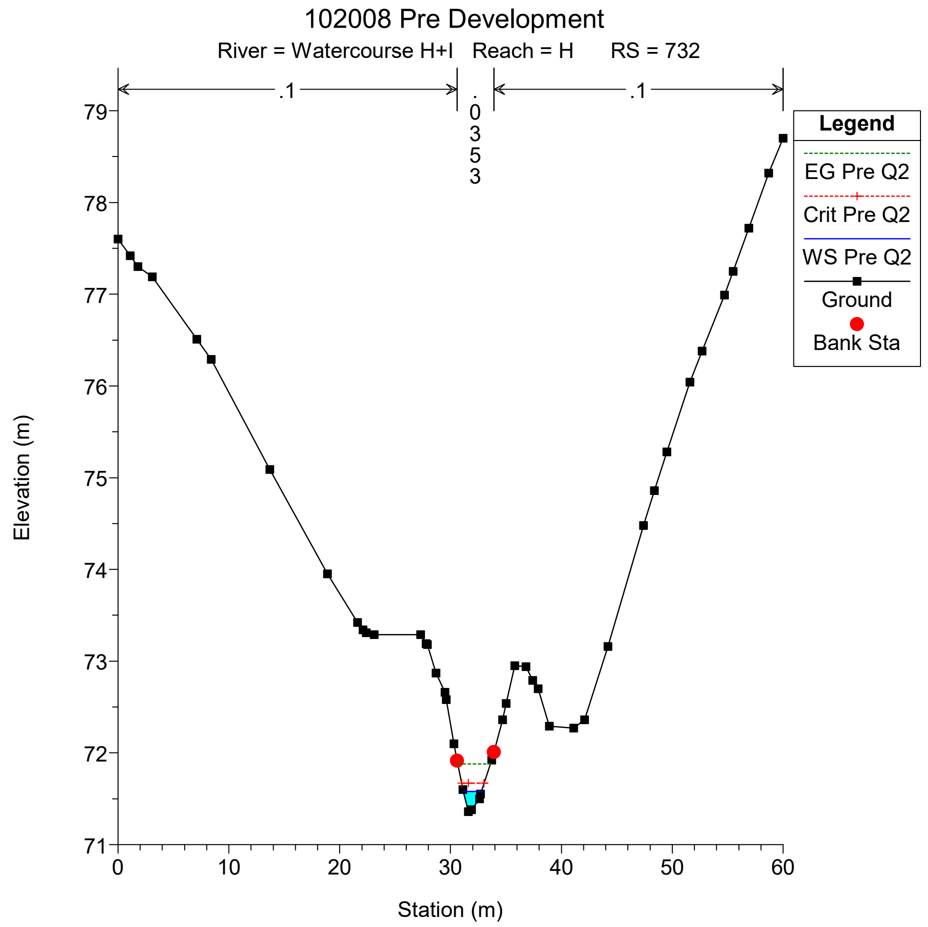

102008 Pre Development
River = Watercourse G Reach = G RS = 66
.1 .0353 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta

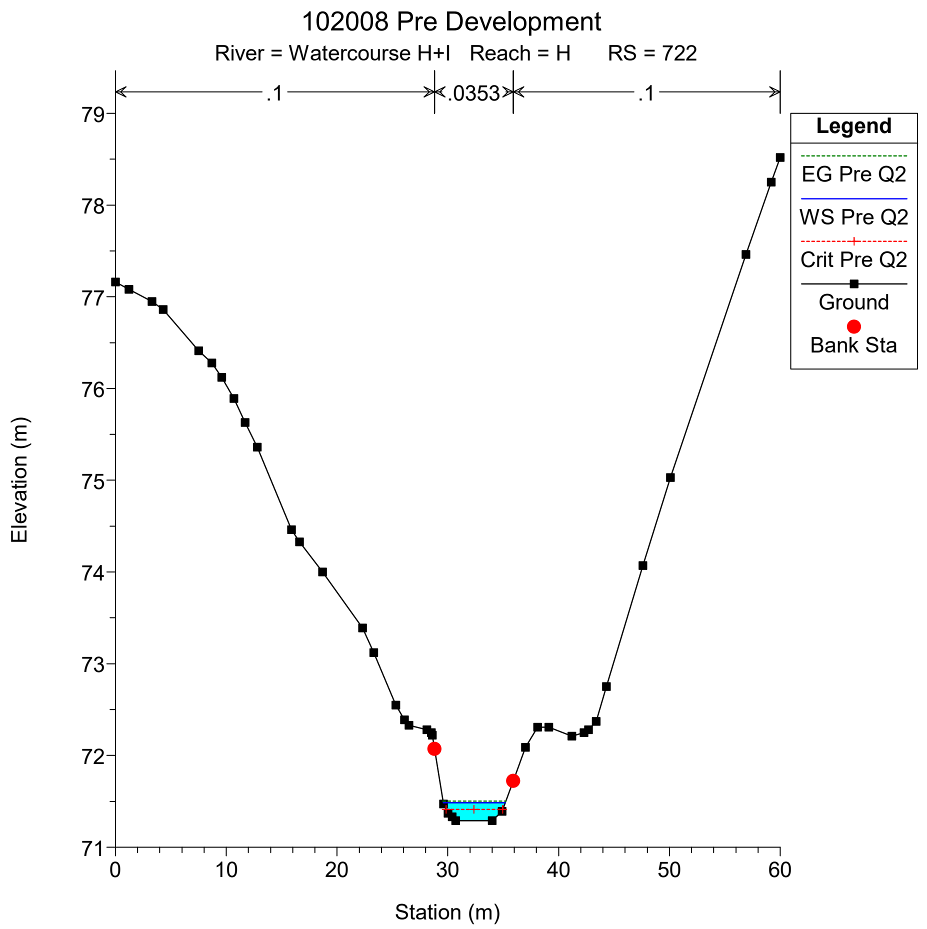

102008 Pre Development
River = Watercourse G Reach = G RS = 55
.1 .0353 .1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

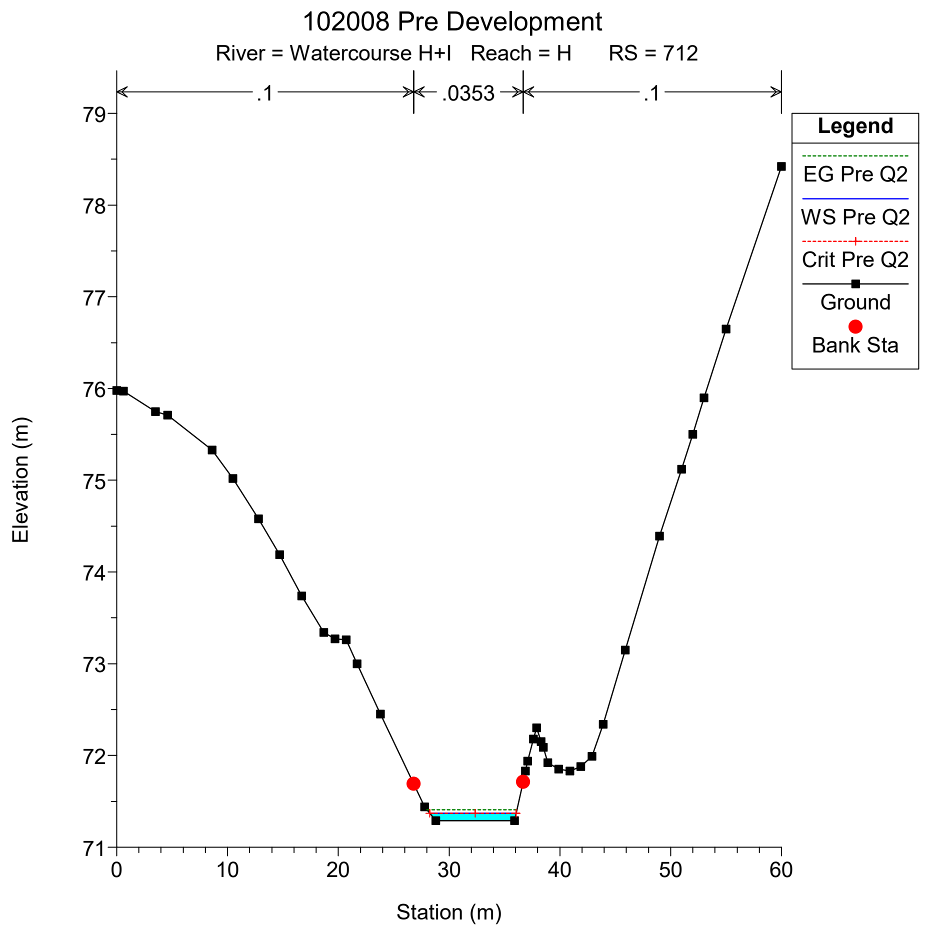

102008 Pre Development
River = Watercourse G Reach = G RS = 44
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 796
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 792
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 782
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 772
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 762
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

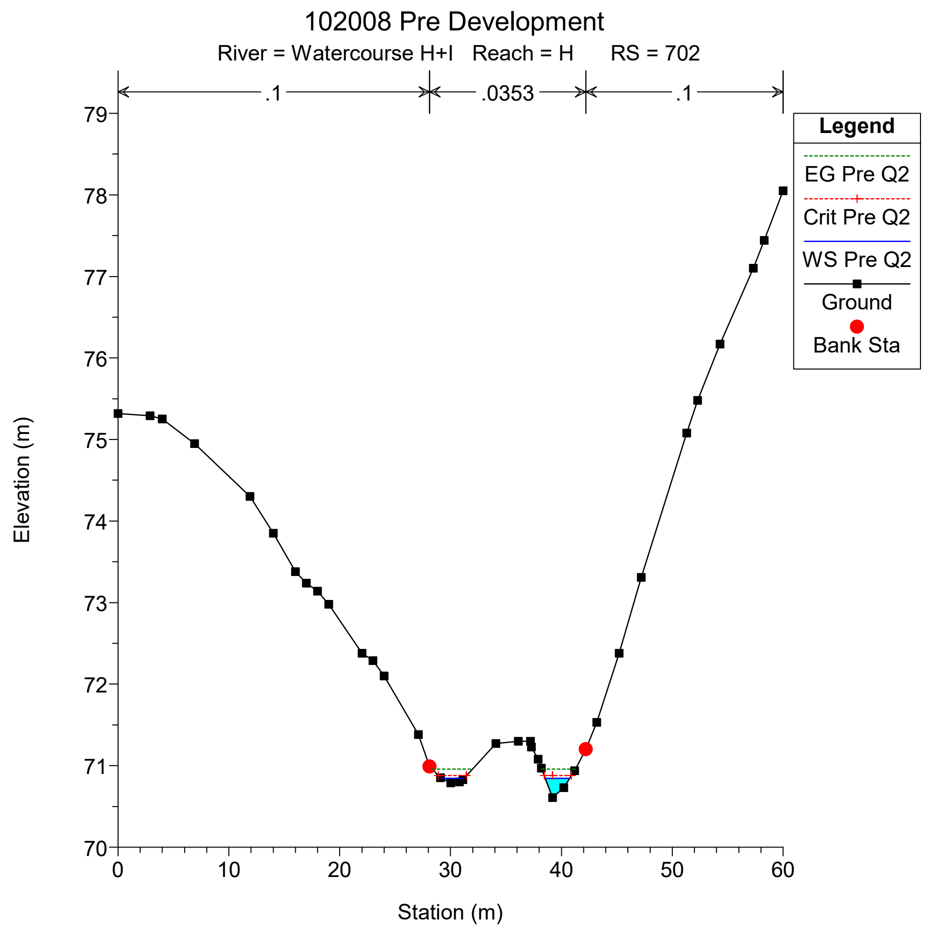

102008 Pre Development
River = Watercourse H+I Reach = H RS = 752
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

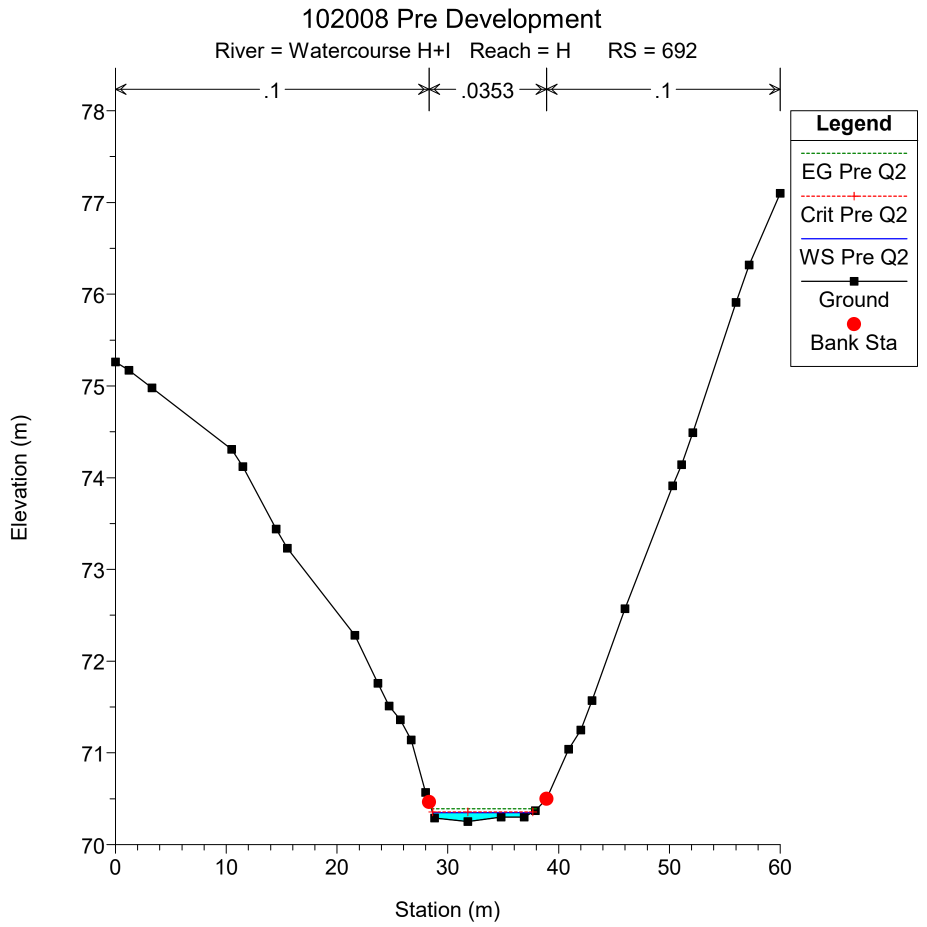

102008 Pre Development
River = Watercourse H+I Reach = H RS = 742
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

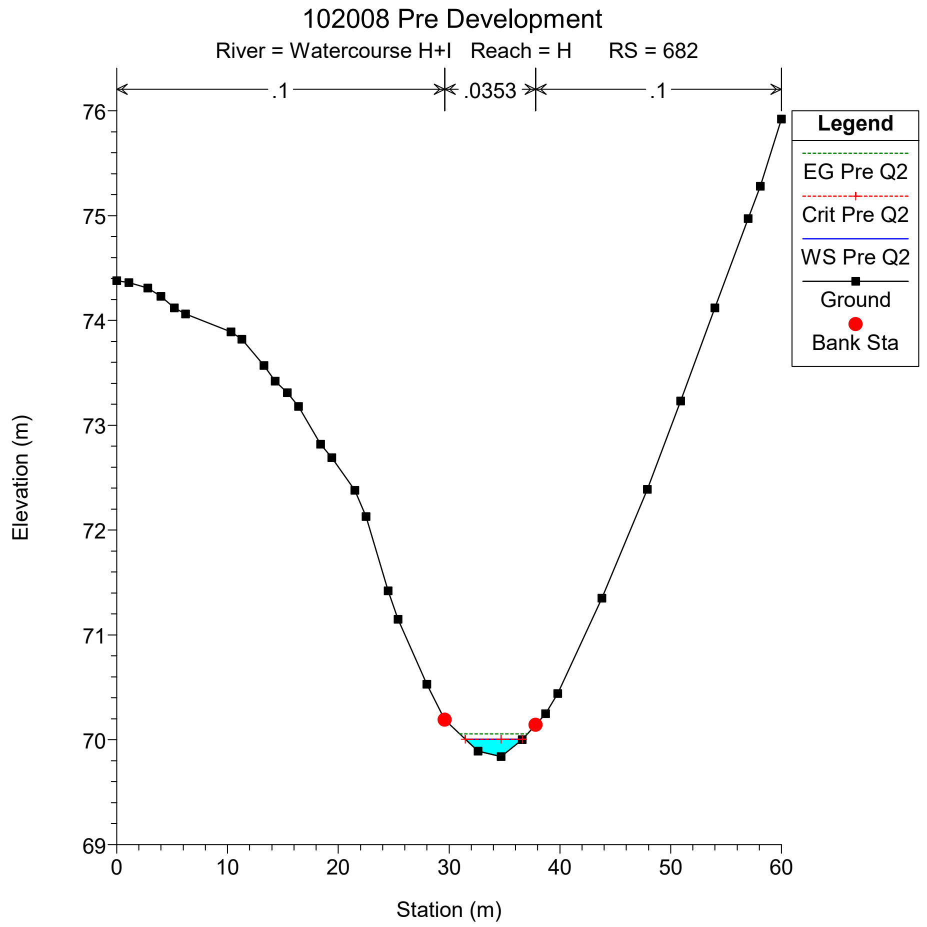

102008 Pre Development
River = Watercourse H+I Reach = H RS = 732
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

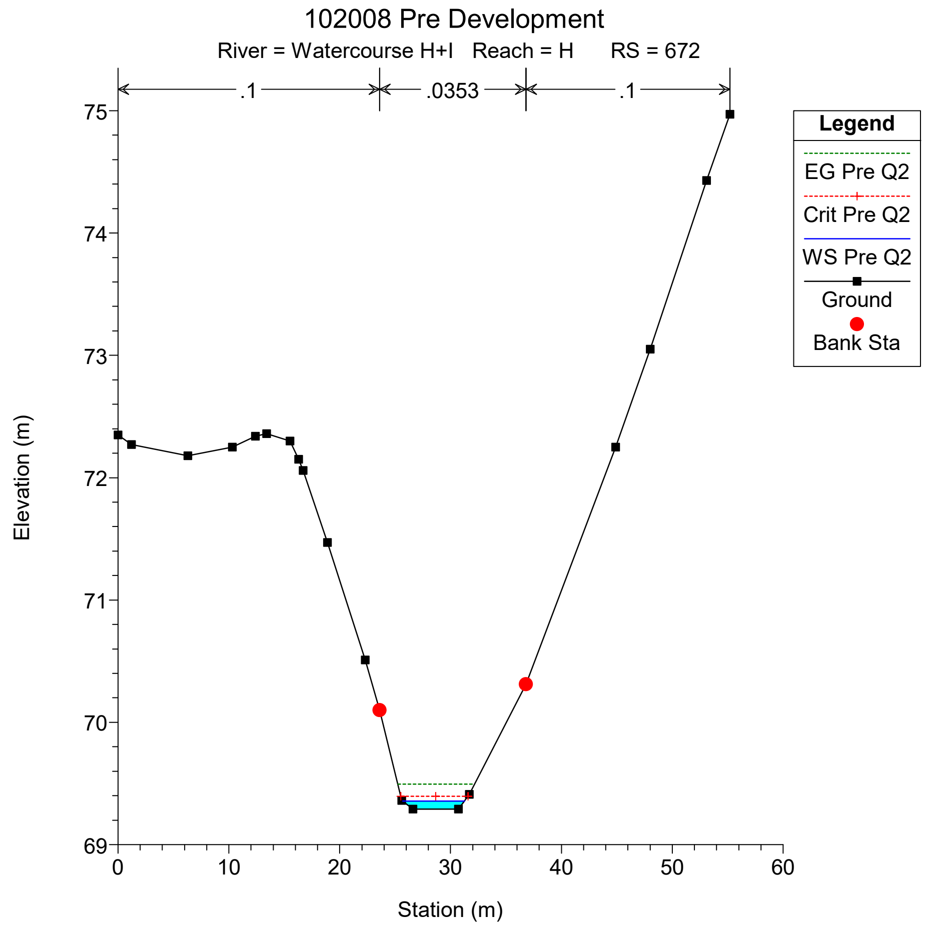

102008 Pre Development
River = Watercourse H+I Reach = H RS = 722
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

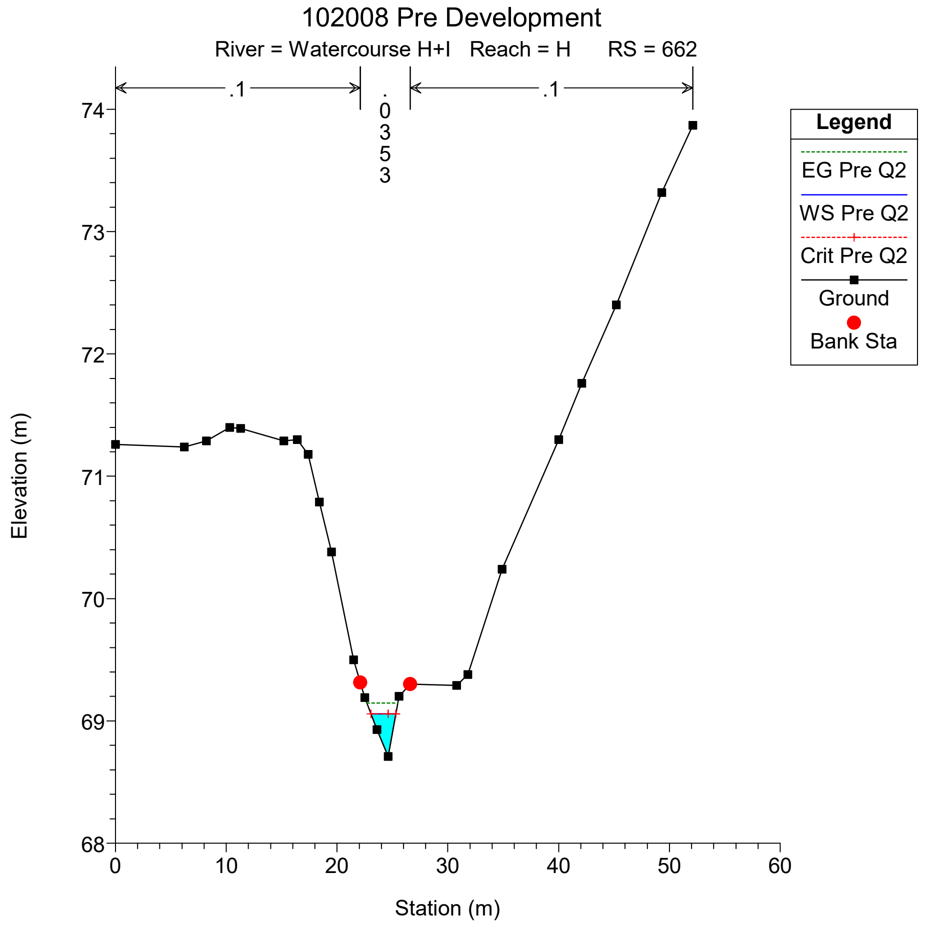

102008 Pre Development
River = Watercourse H+I Reach = H RS = 712
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

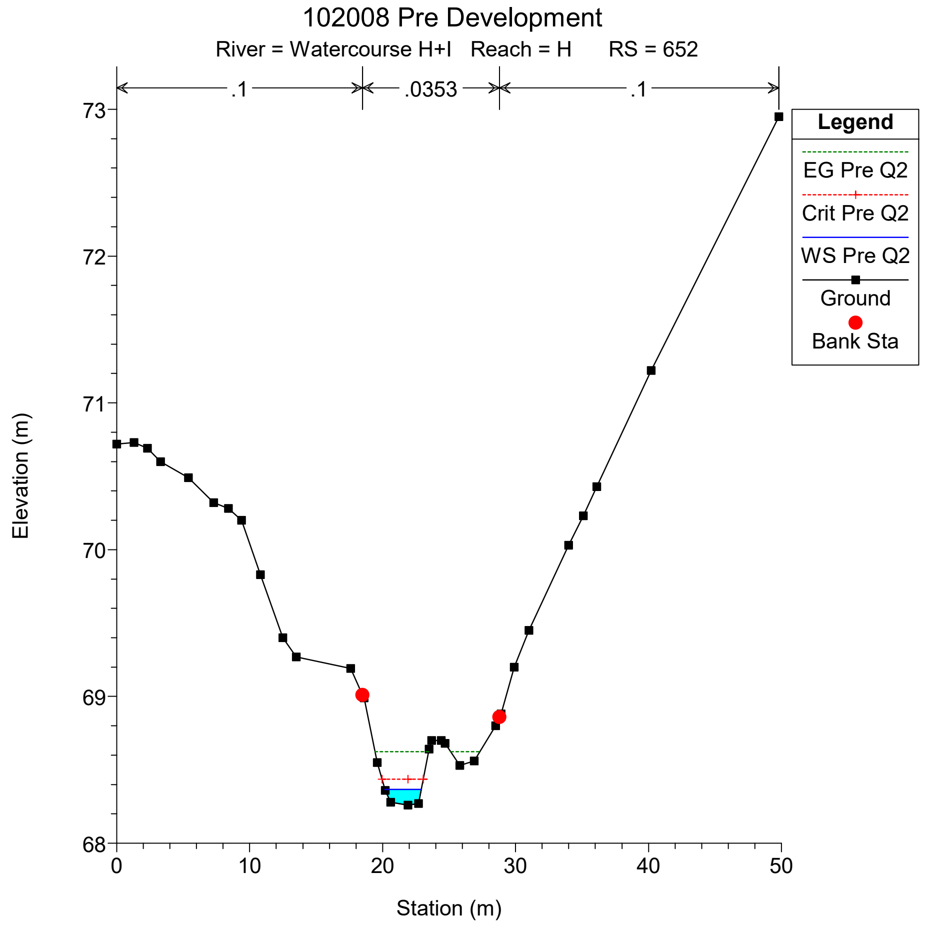

102008 Pre Development
River = Watercourse H+I Reach = H RS = 702
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

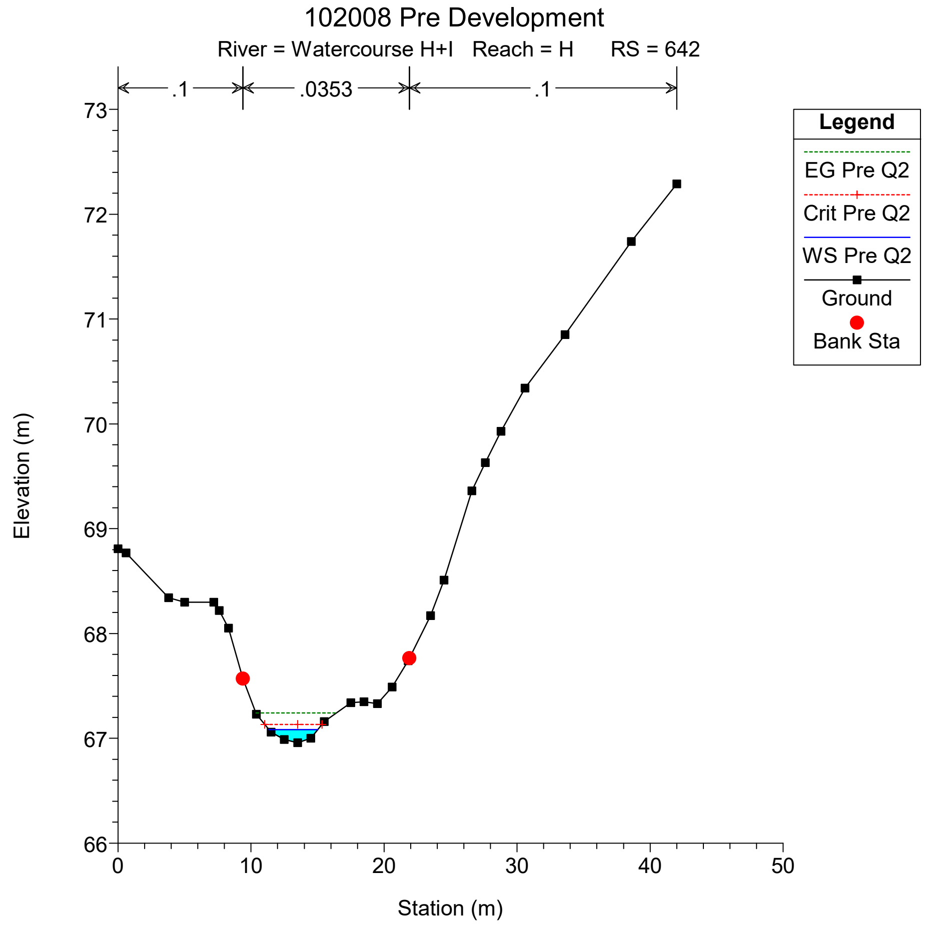

102008 Pre Development
River = Watercourse H+I Reach = H RS = 692
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

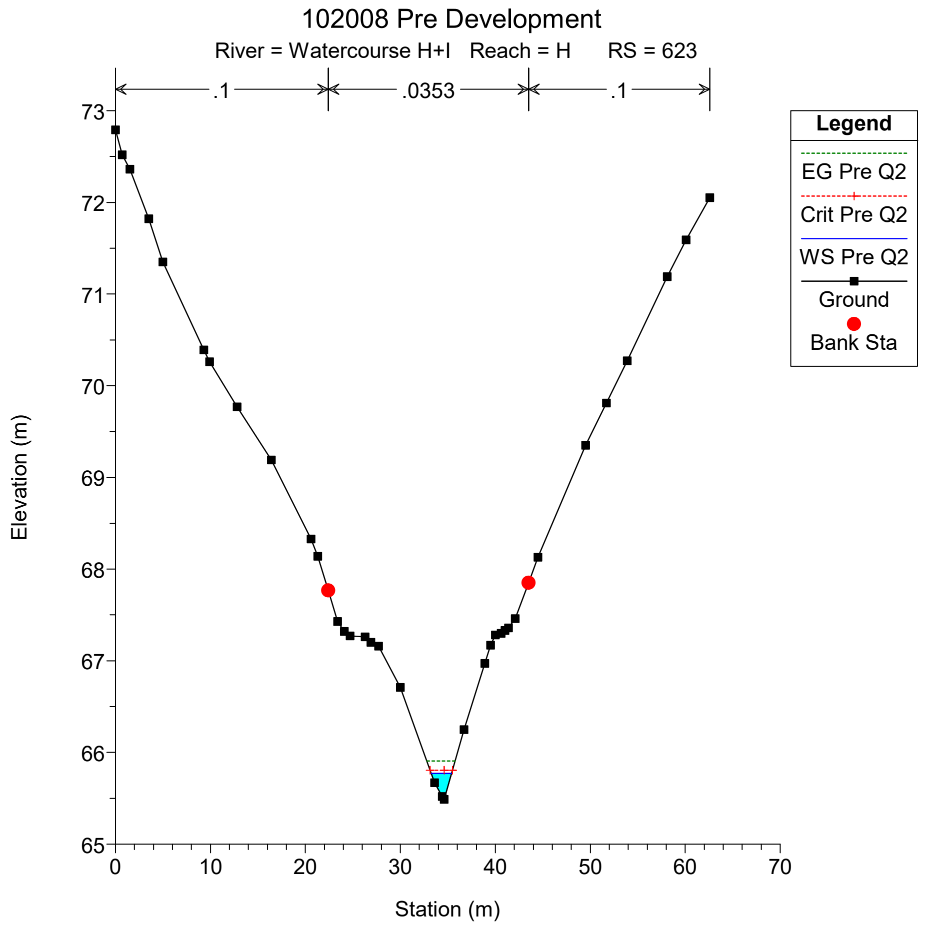

102008 Pre Development
River = Watercourse H+I Reach = H RS = 682
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

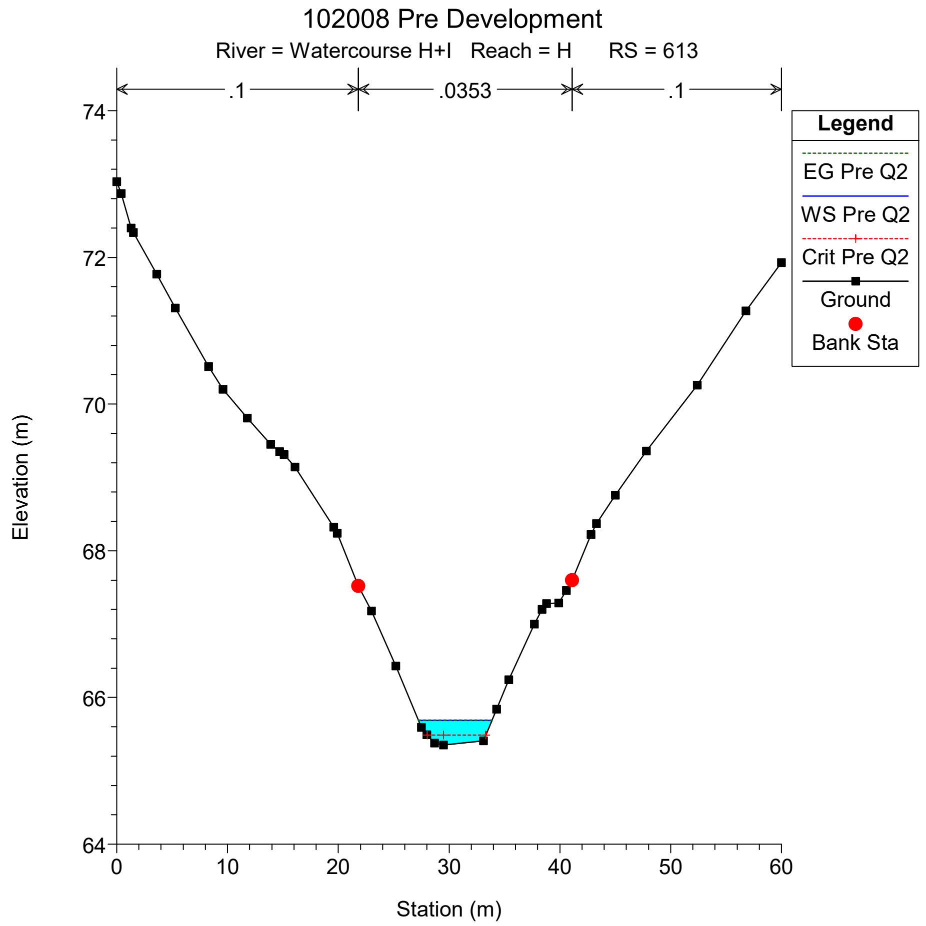

102008 Pre Development
River = Watercourse H+I Reach = H RS = 672
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

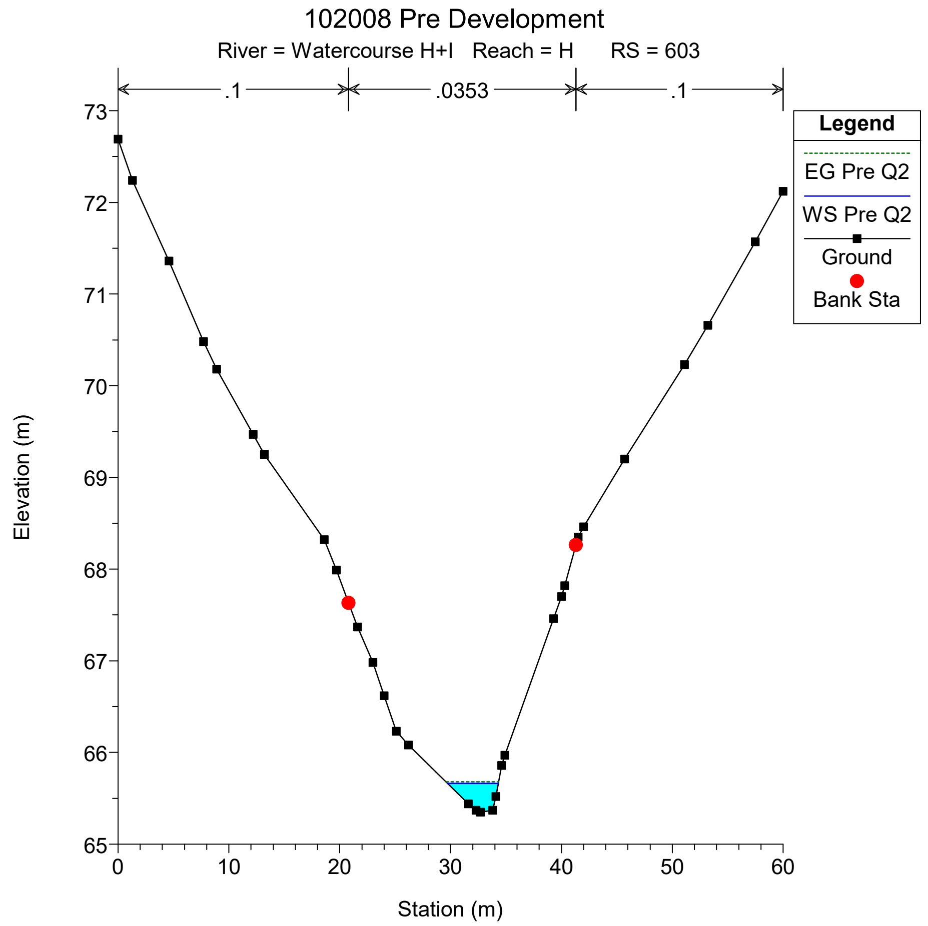

102008 Pre Development
River = Watercourse H+I Reach = H RS = 662
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

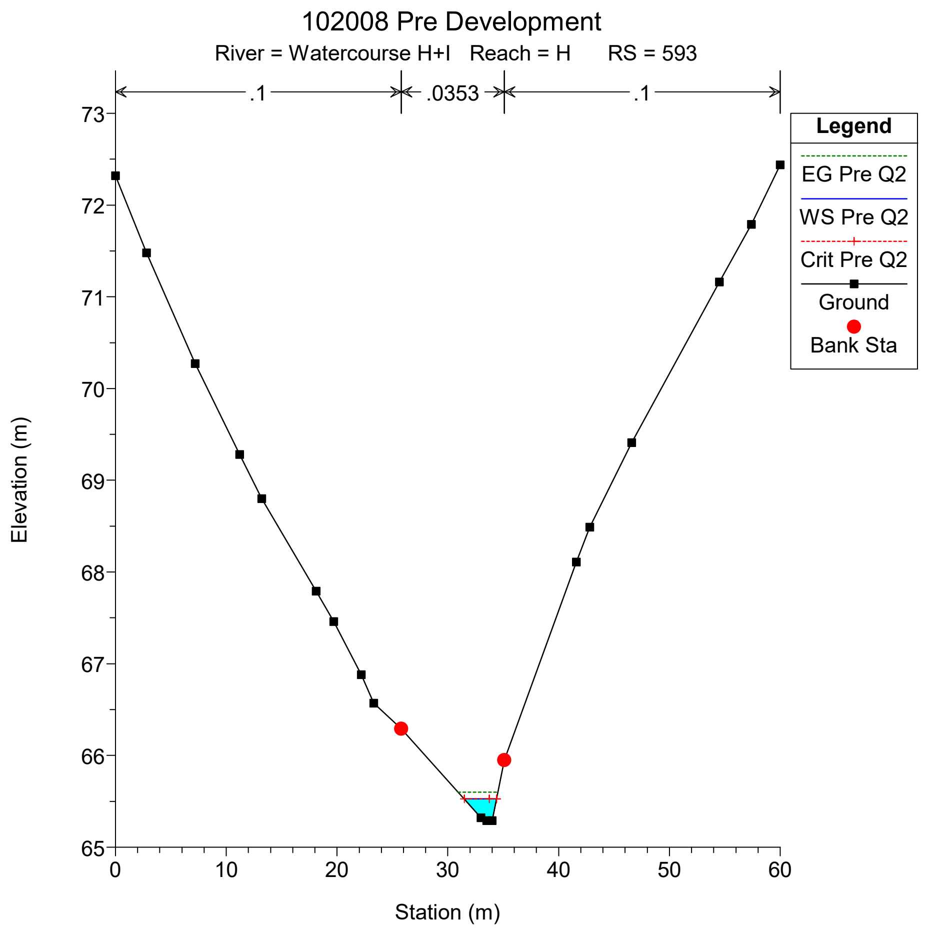

102008 Pre Development
River = Watercourse H+I Reach = H RS = 652
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

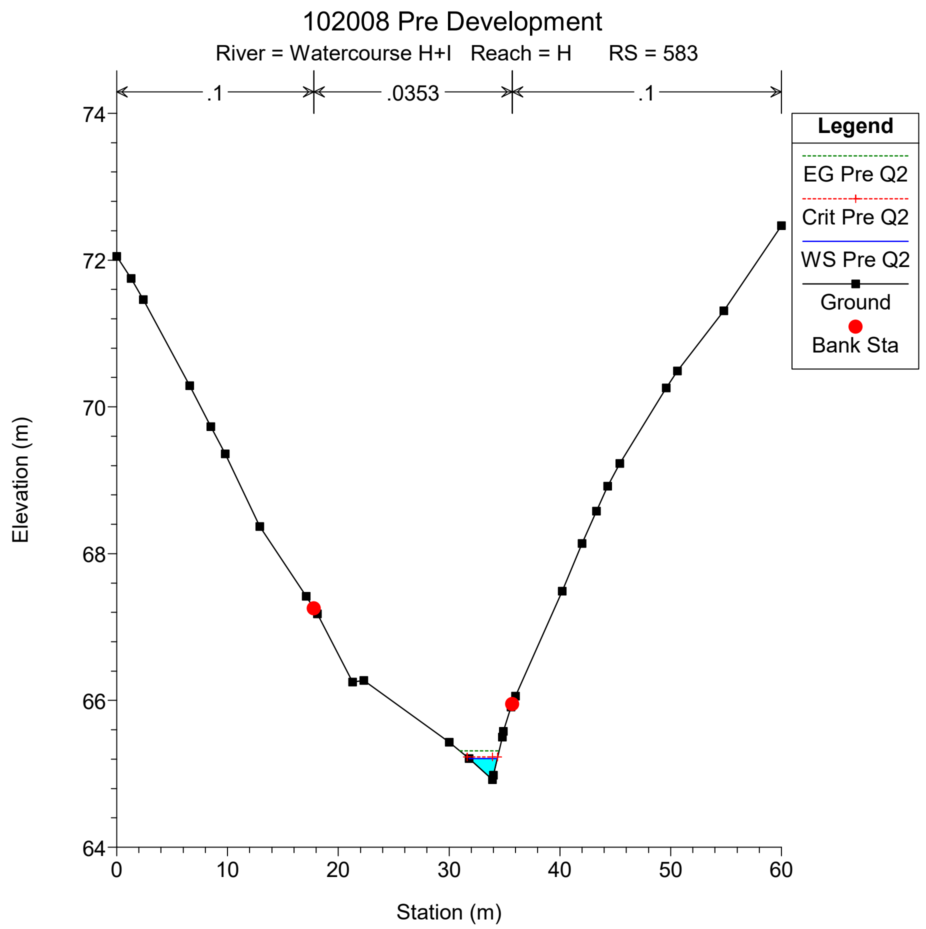

102008 Pre Development
River = Watercourse H+I Reach = H RS = 642
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

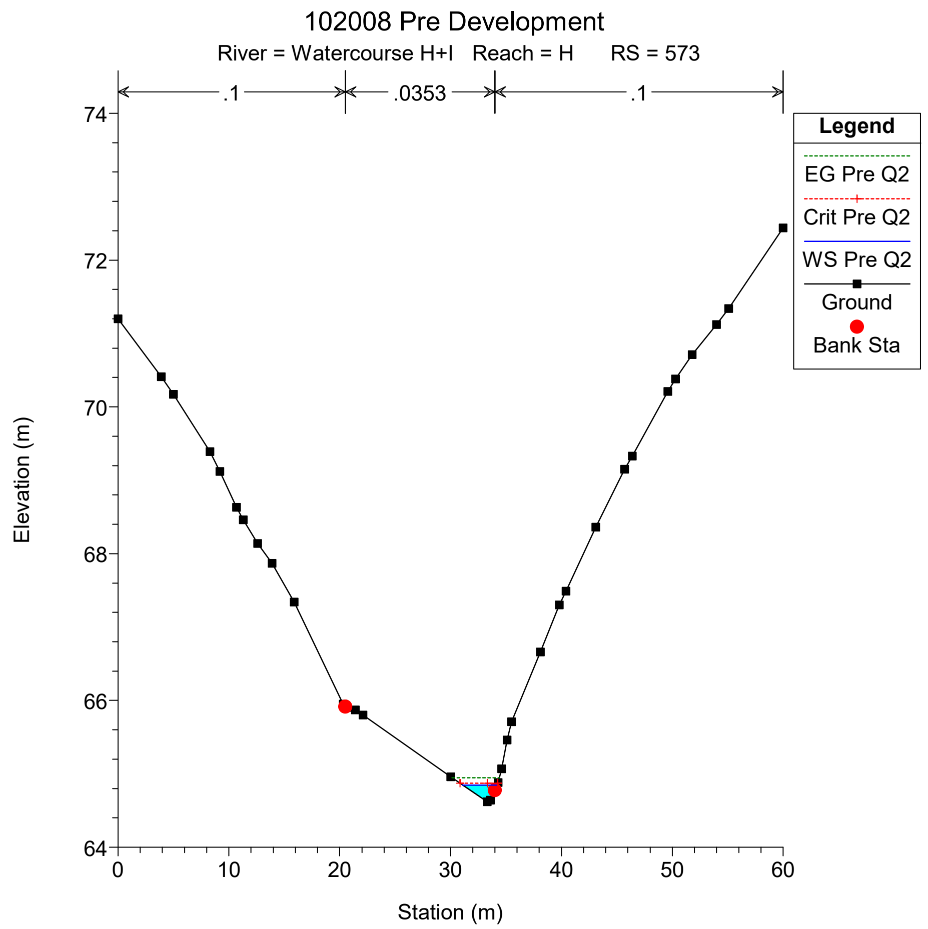

102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 623
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

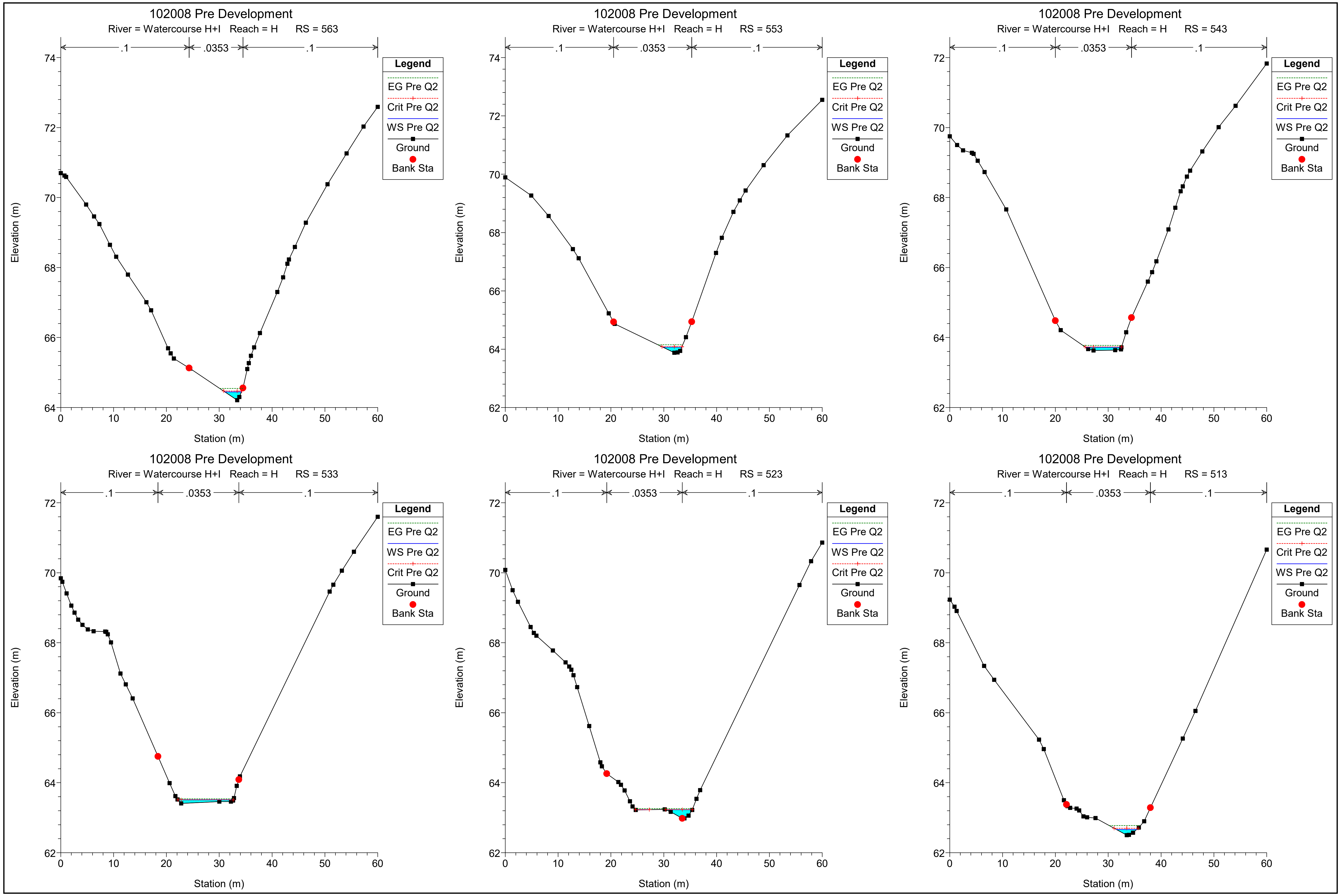

102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 613
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

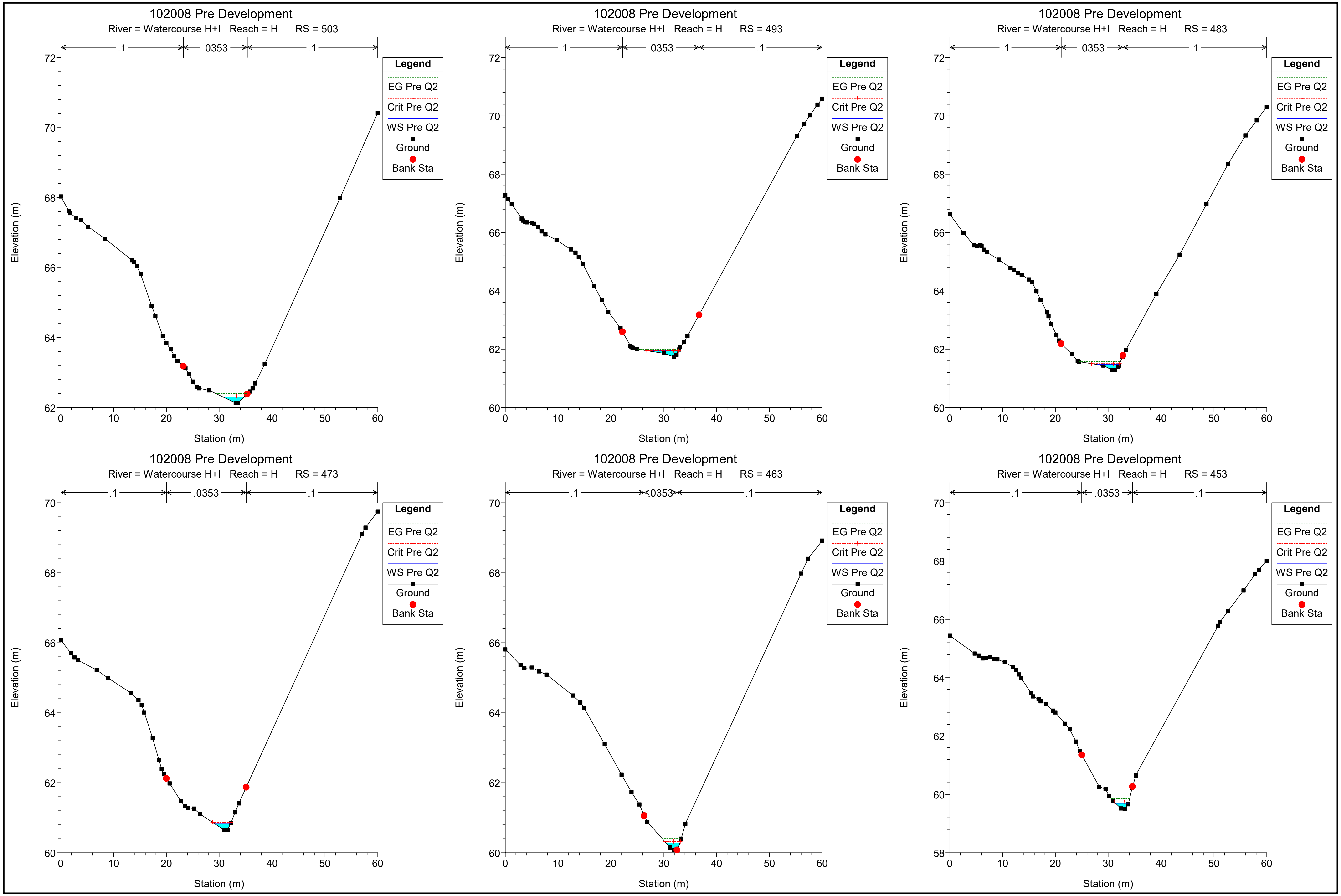

102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 603
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

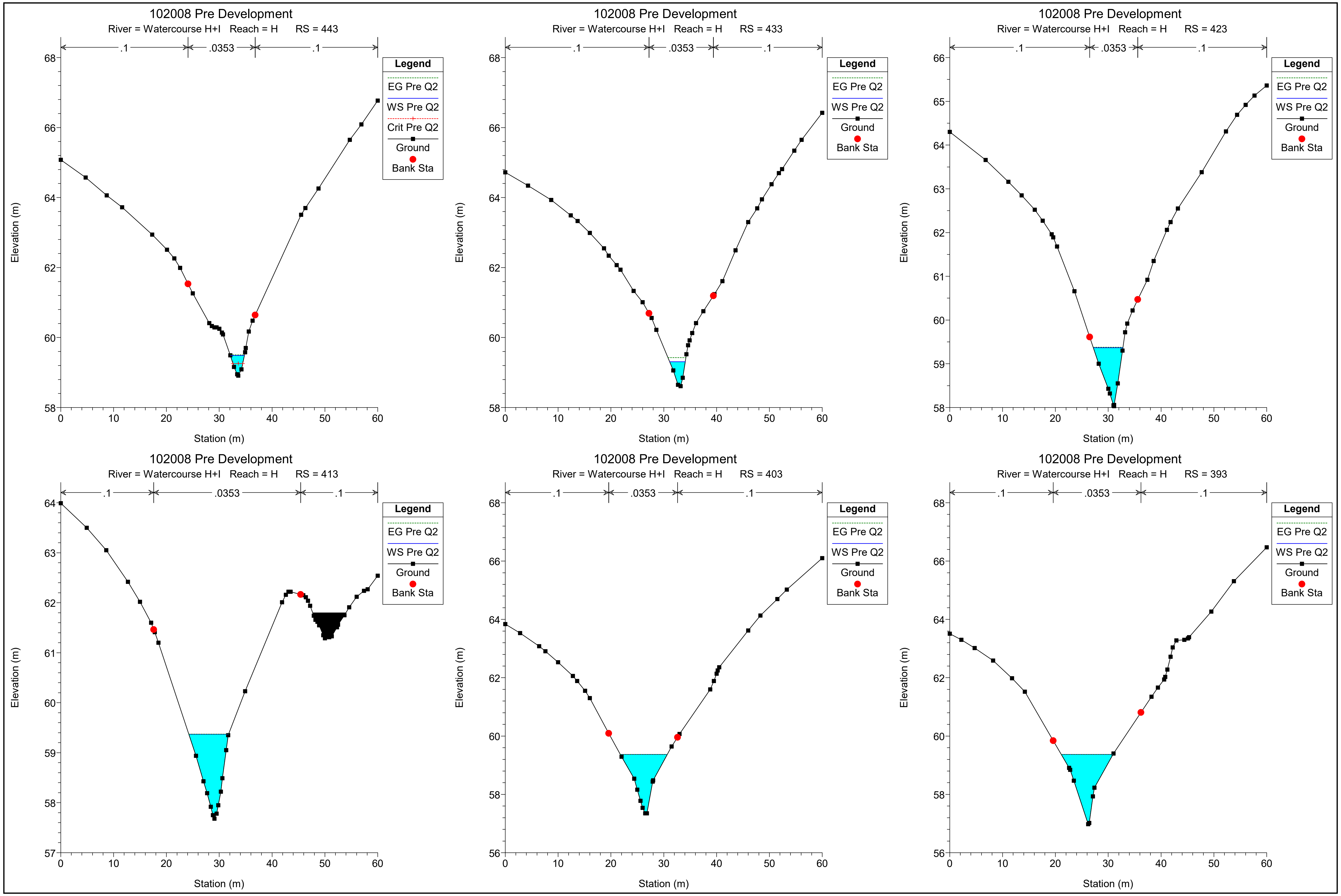

102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 593
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

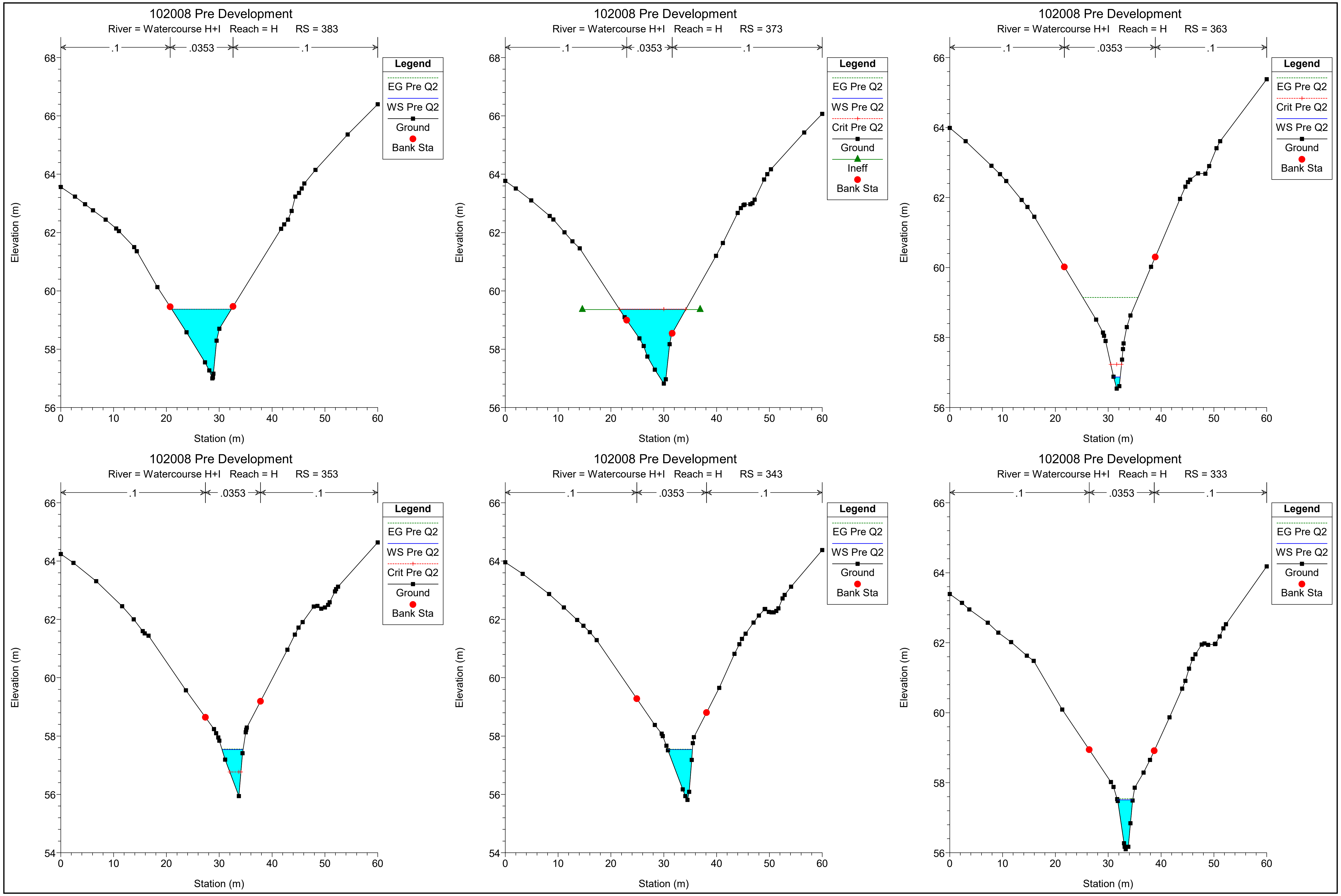

102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 583
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

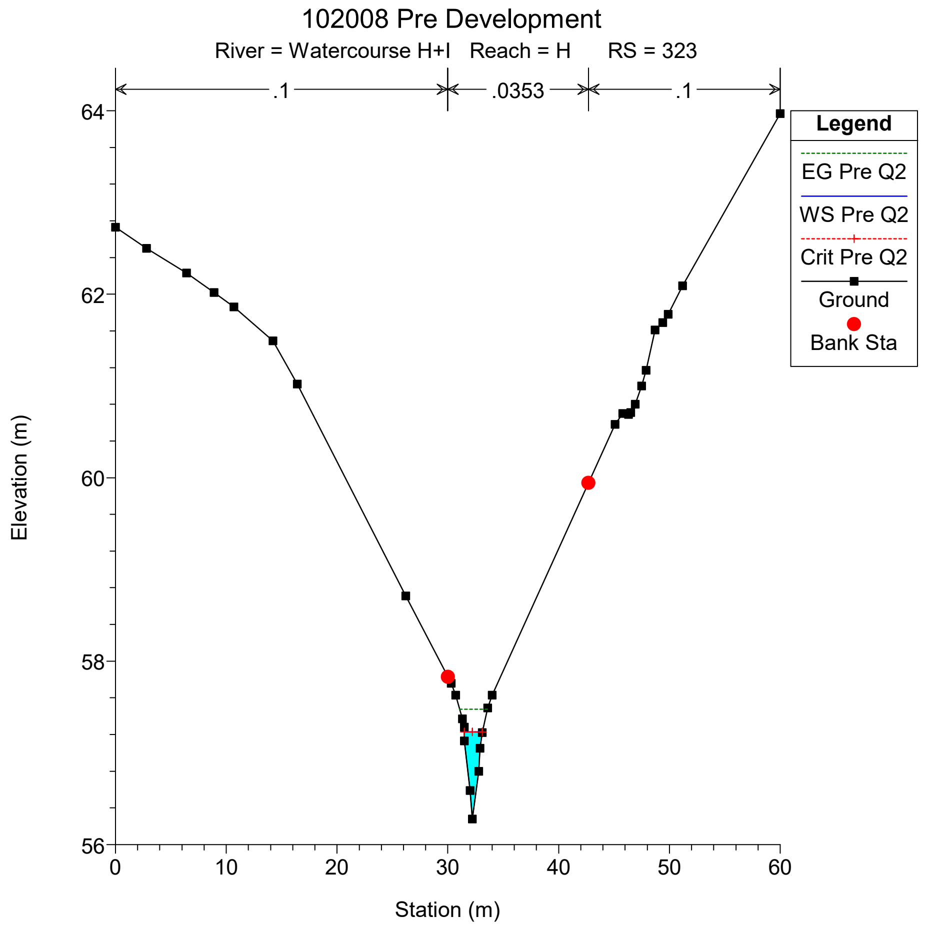

102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 573
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

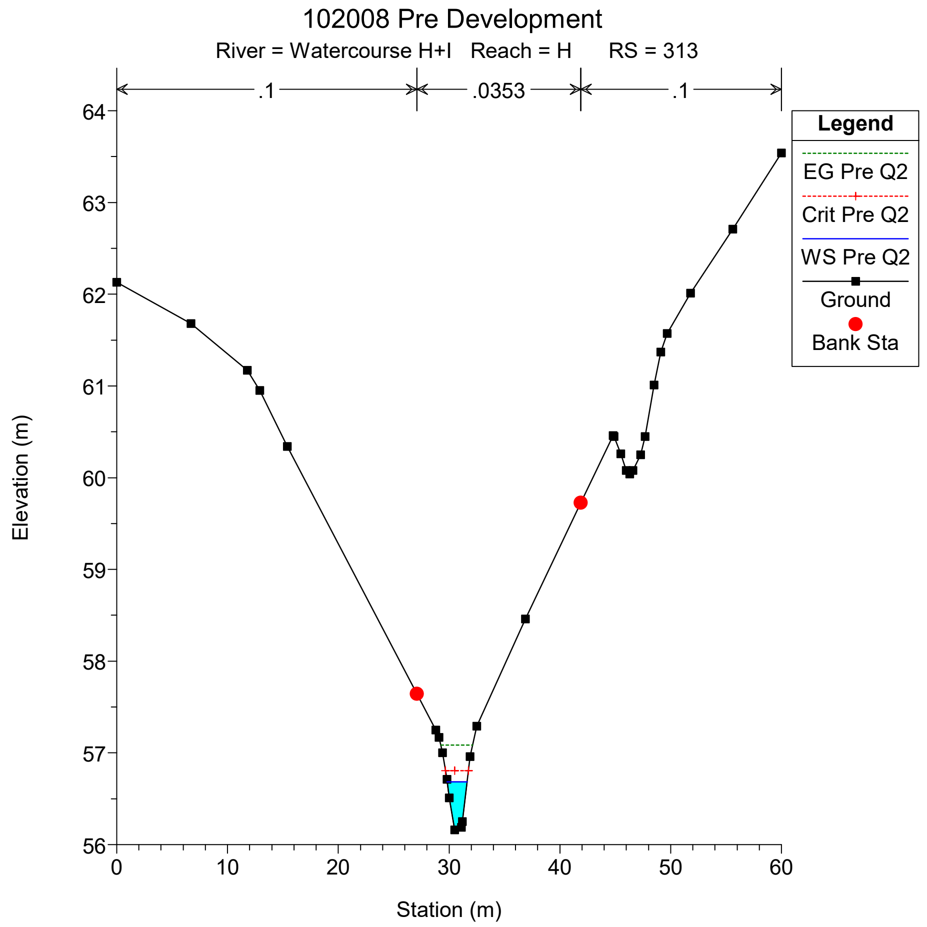

102008 Pre Development
River = Watercourse H+I Reach = H RS = 563
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 553
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 543
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 533
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 523
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 513
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

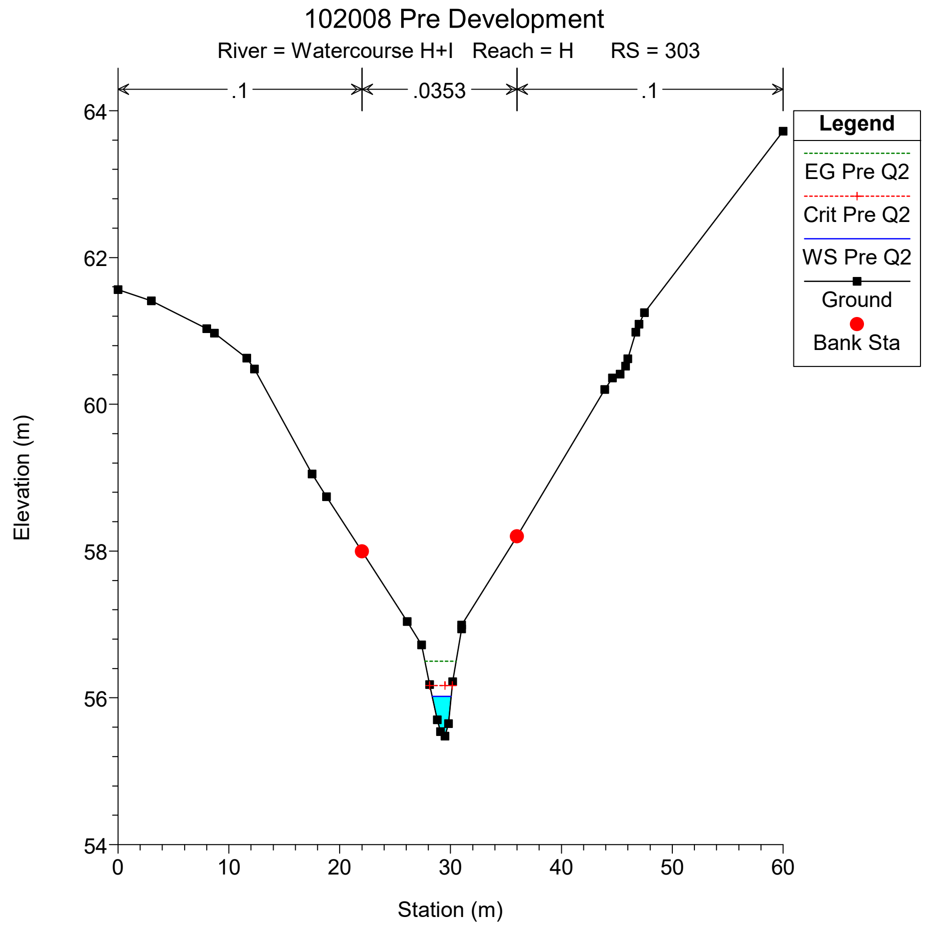

102008 Pre Development
River = Watercourse H+I Reach = H RS = 503
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 493
102008 Pre Development
River = Watercourse H+I Reach = H RS = 483
102008 Pre Development
River = Watercourse H+I Reach = H RS = 473
102008 Pre Development
River = Watercourse H+I Reach = H RS = 463
102008 Pre Development
River = Watercourse H+I Reach = H RS = 453

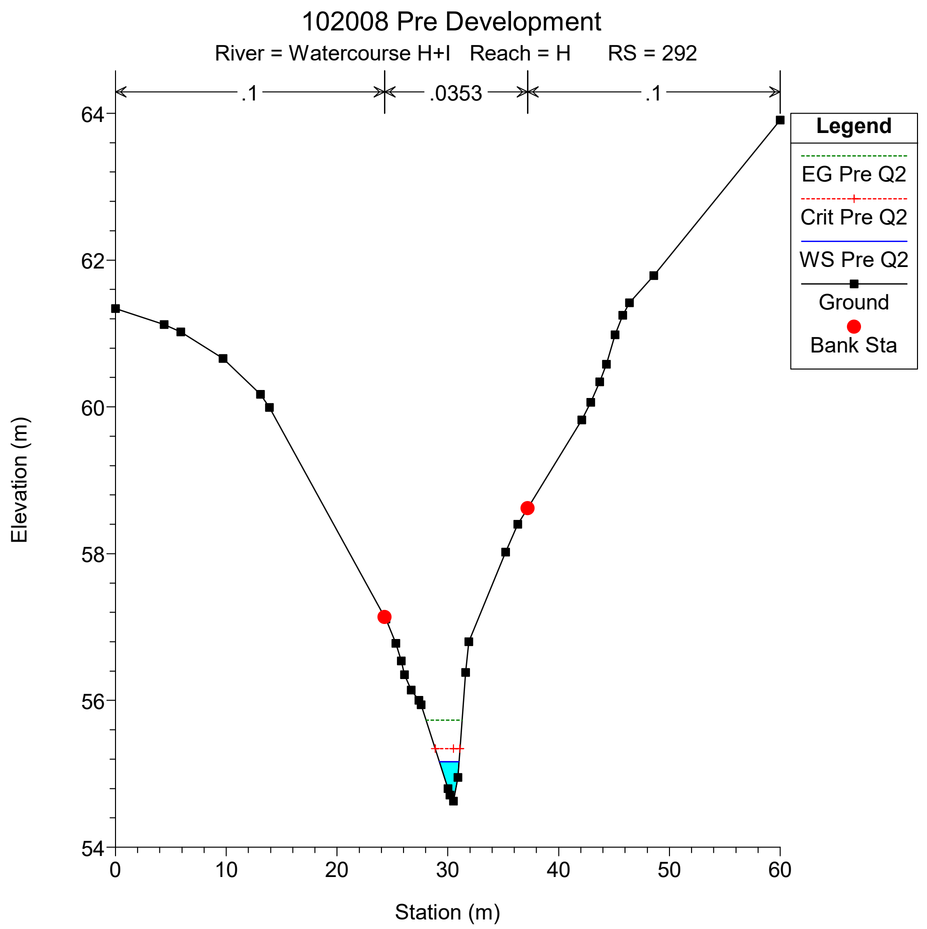

102008 Pre Development
River = Watercourse H+I Reach = H RS = 443
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 433
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 423
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 413
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 403
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 393
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

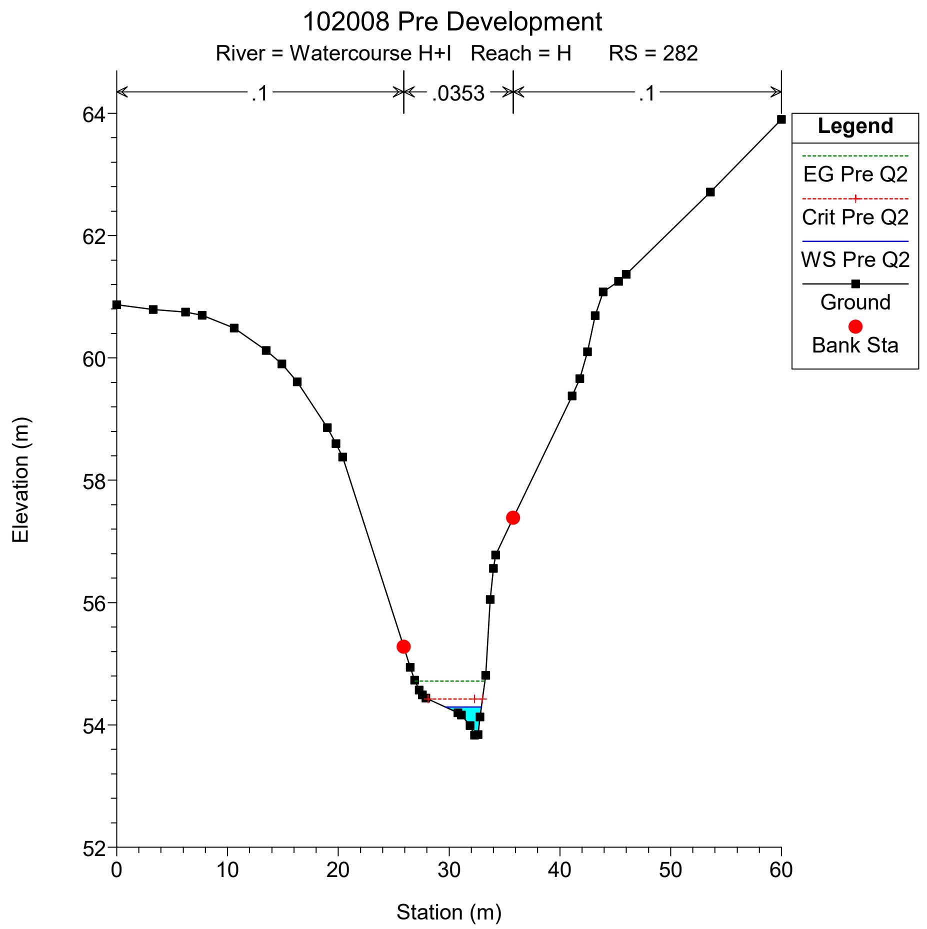

102008 Pre Development
River = Watercourse H+I Reach = H RS = 383
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 373
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 363
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 353
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 343
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 333
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

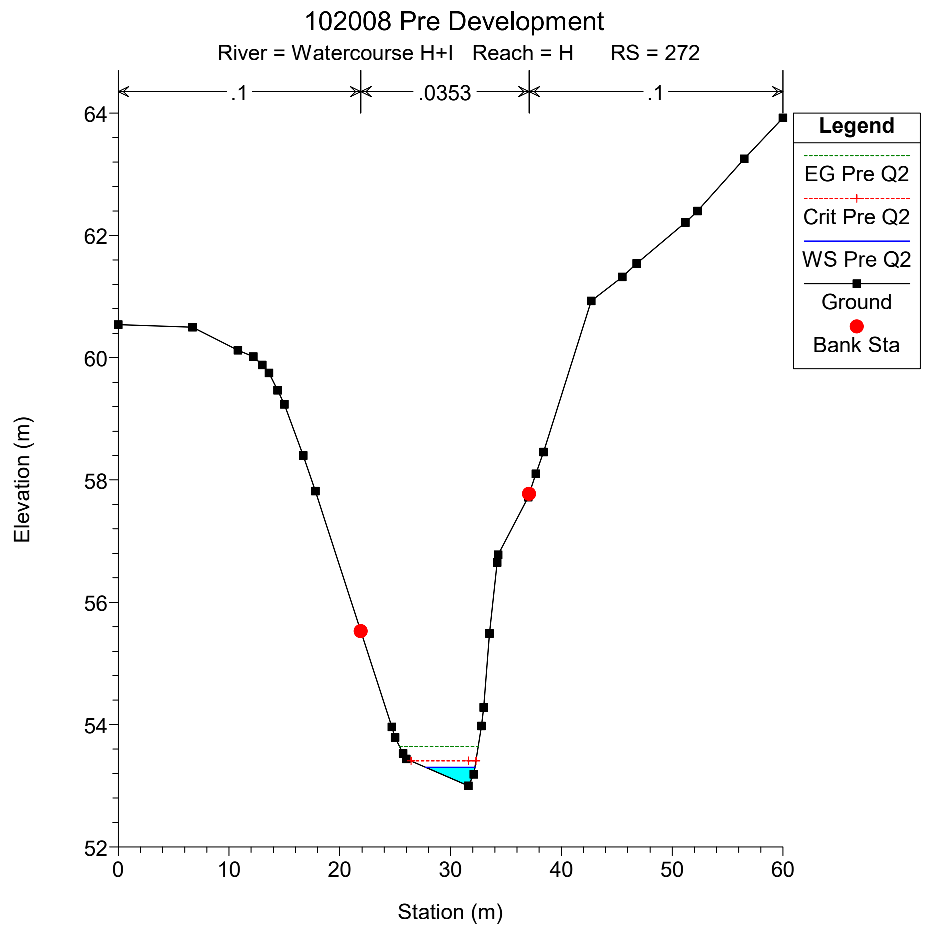

102008 Pre Development
River = Watercourse H+I Reach = H RS = 323
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

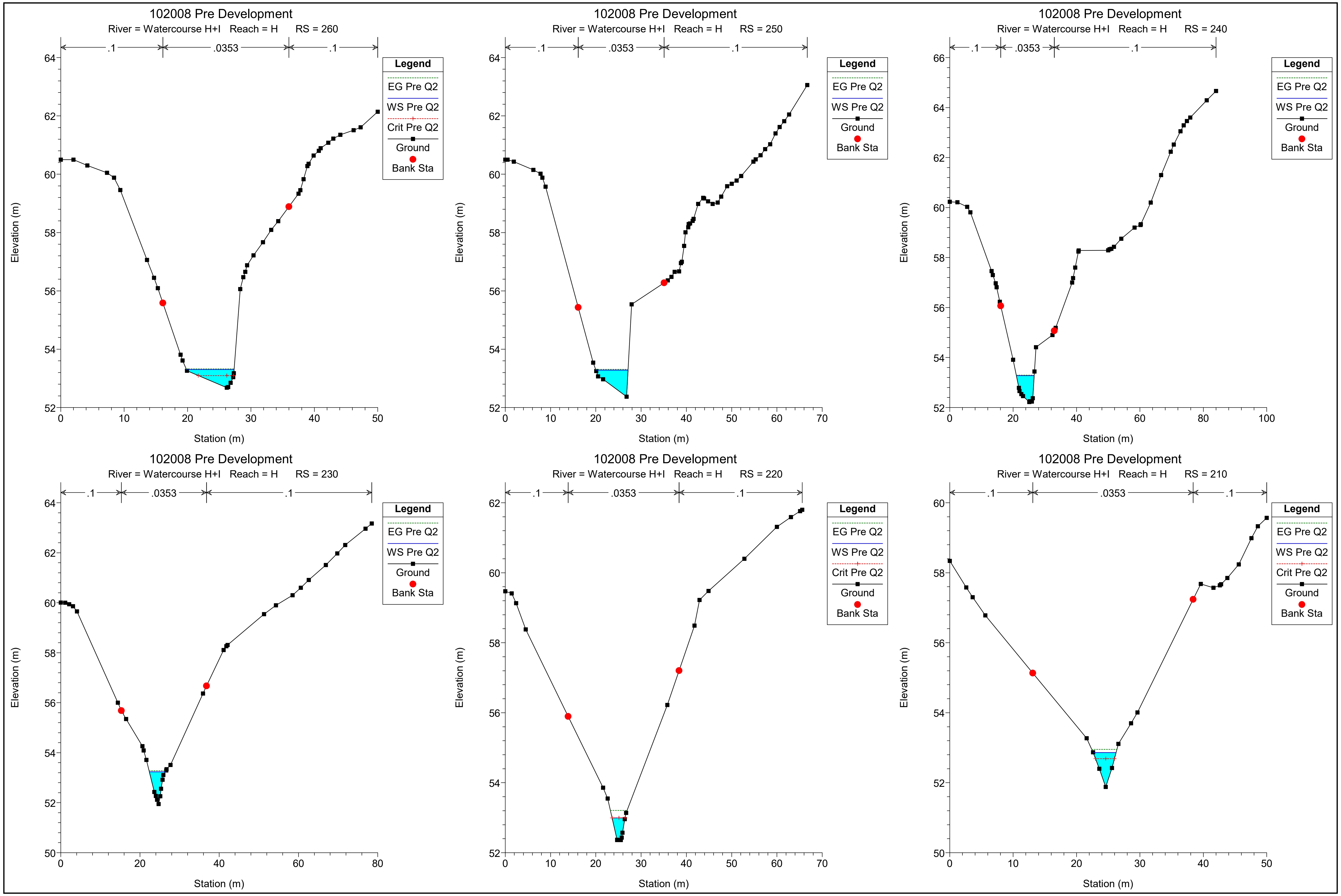

102008 Pre Development
River = Watercourse H+I Reach = H RS = 313
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)


102008 Pre Development
River = Watercourse H+I Reach = H RS = 303
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

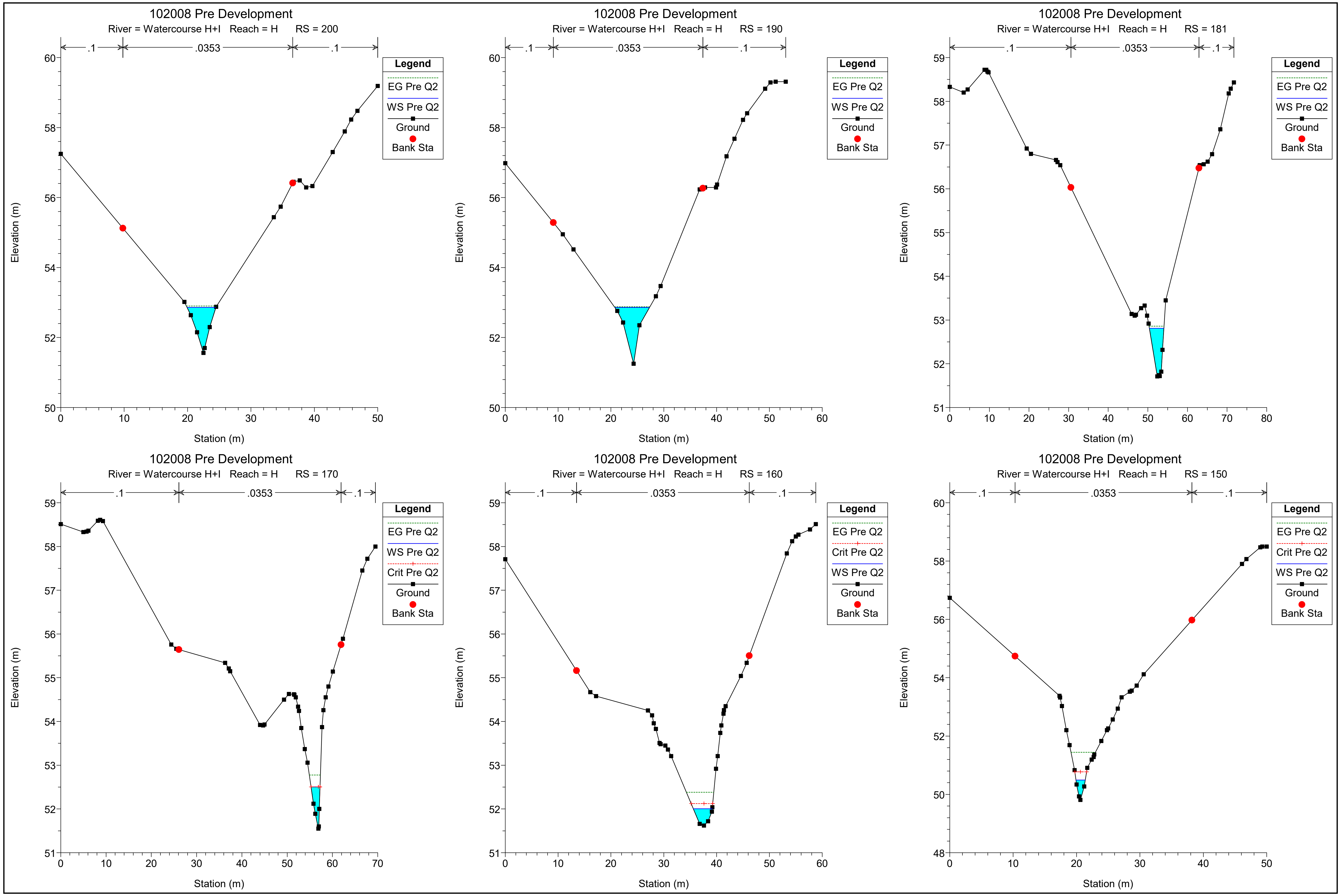

102008 Pre Development
River = Watercourse H+I Reach = H RS = 292
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

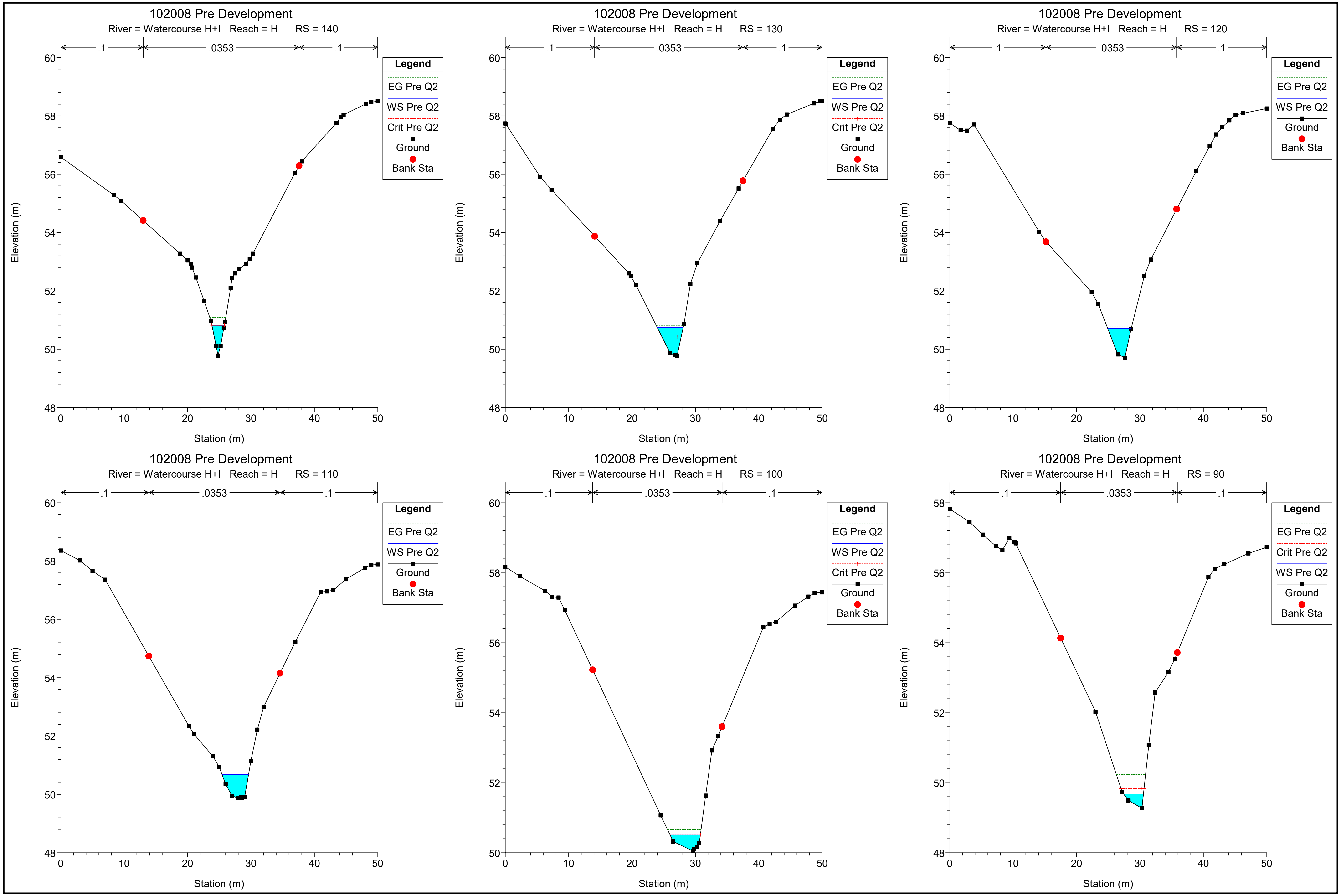

102008 Pre Development
River = Watercourse H+I Reach = H RS = 282
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

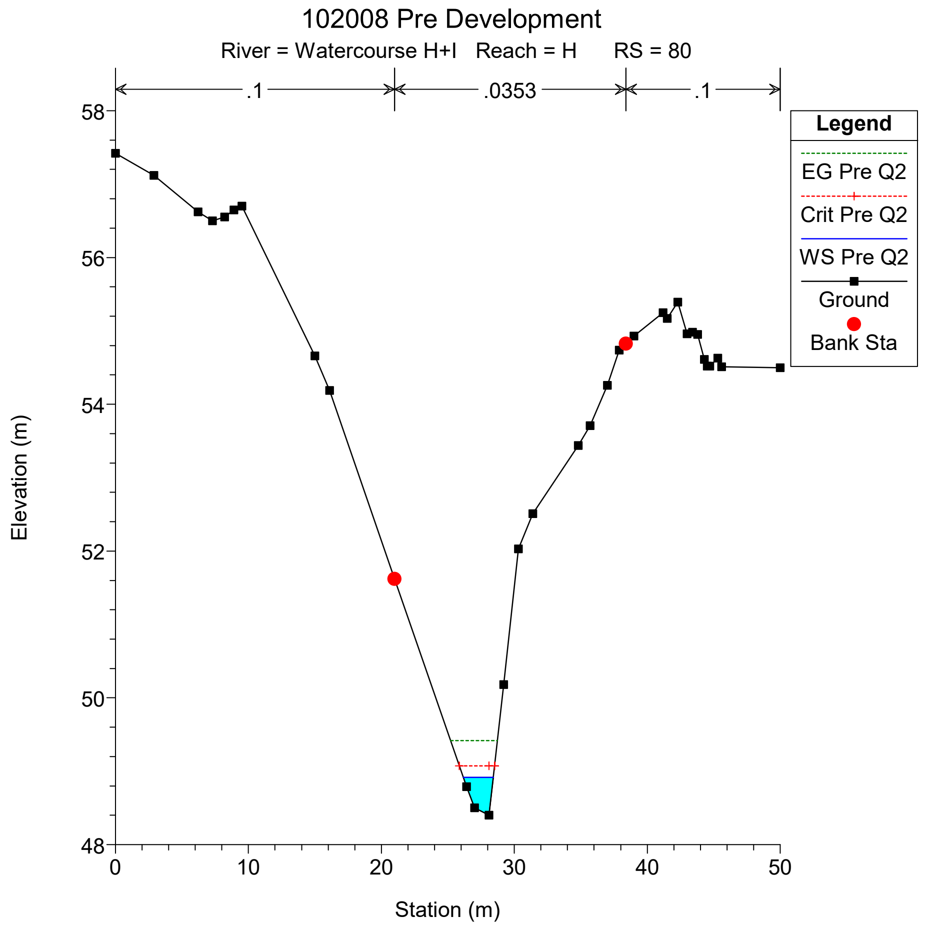

102008 Pre Development
River = Watercourse H+I Reach = H RS = 272
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

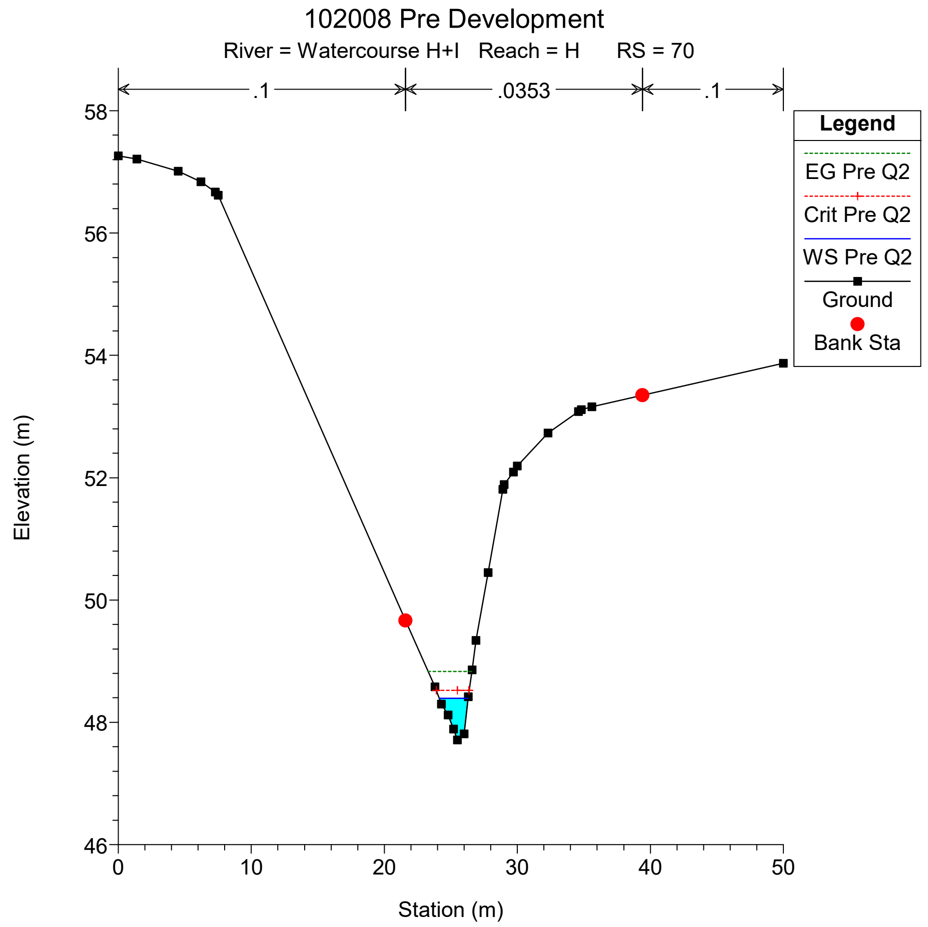


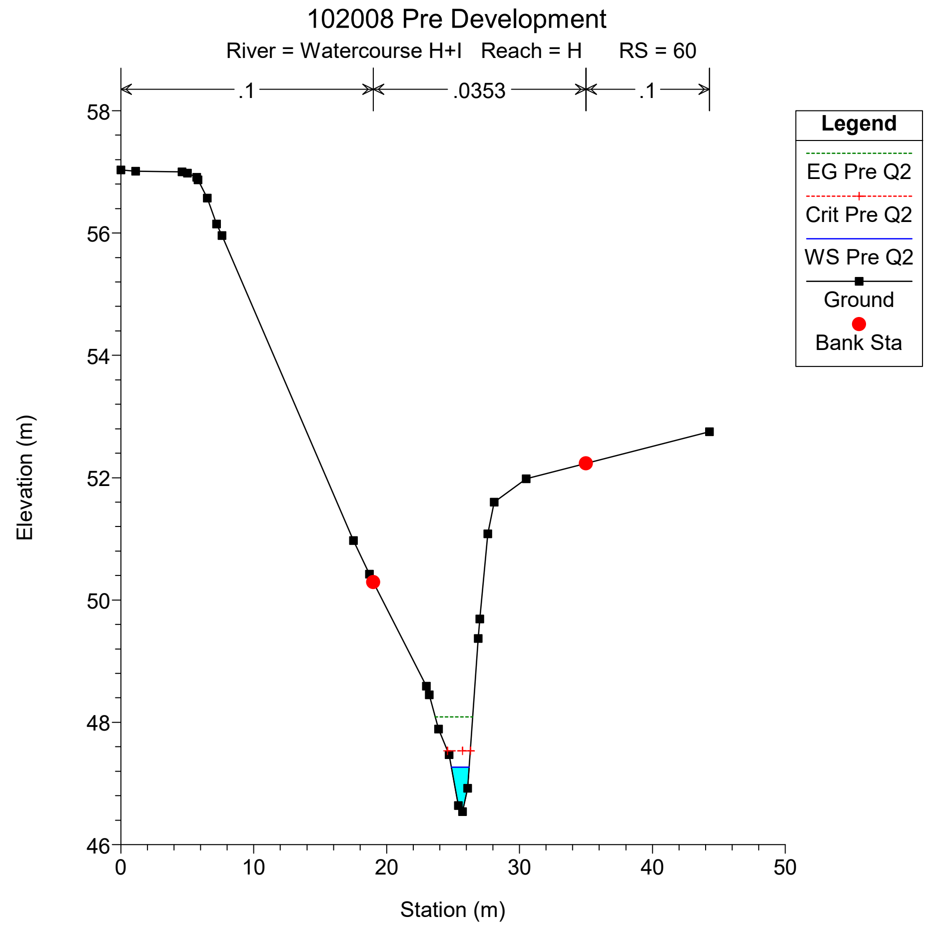
102008 Pre Development
River = Watercourse H+I Reach = H RS = 260
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 250
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 240
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 230
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 220
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 210
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

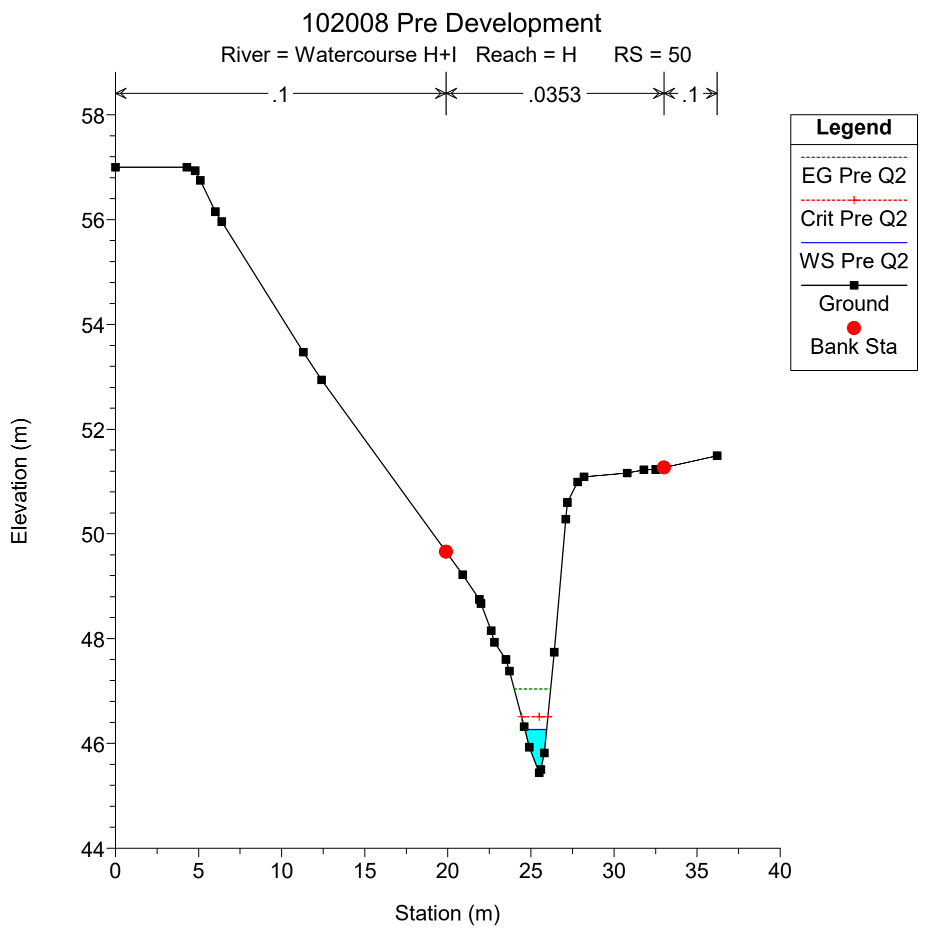

102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 200
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 190
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 181
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 170
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 160
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I   Reach = H   RS = 150
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

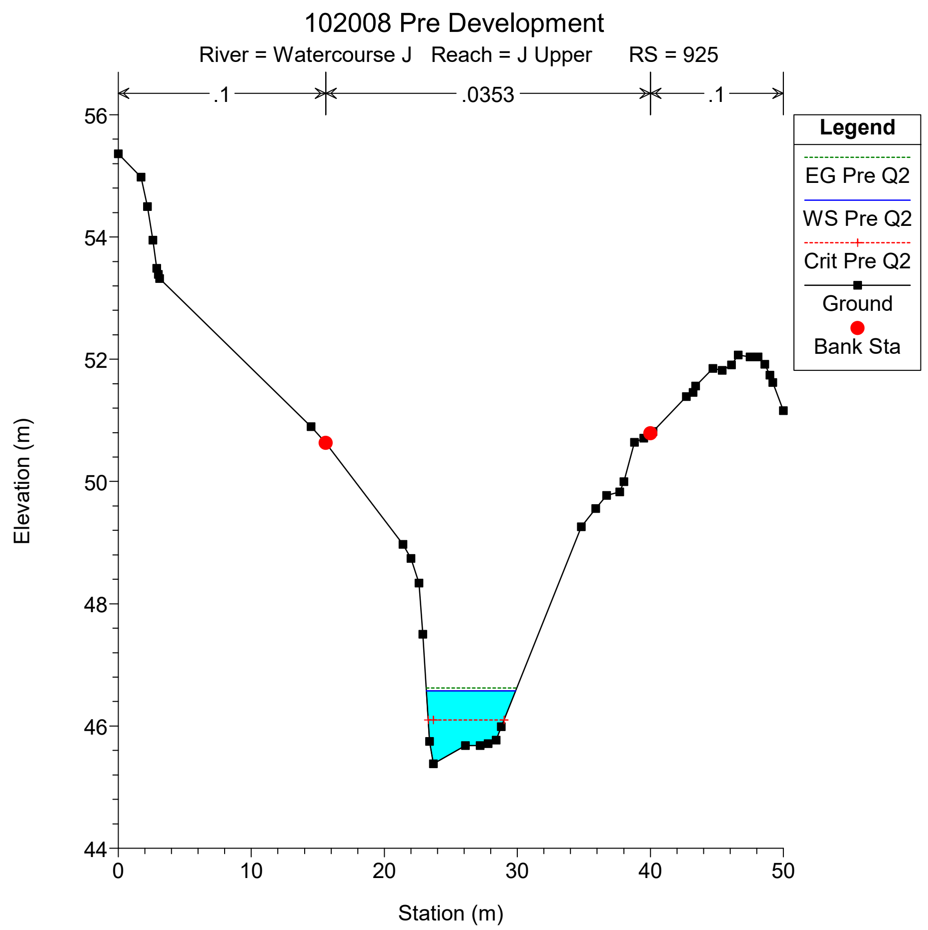

102008 Pre Development
River = Watercourse H+I Reach = H RS = 140
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse H+I Reach = H RS = 130
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 120
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 110
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 100
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse H+I Reach = H RS = 90
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

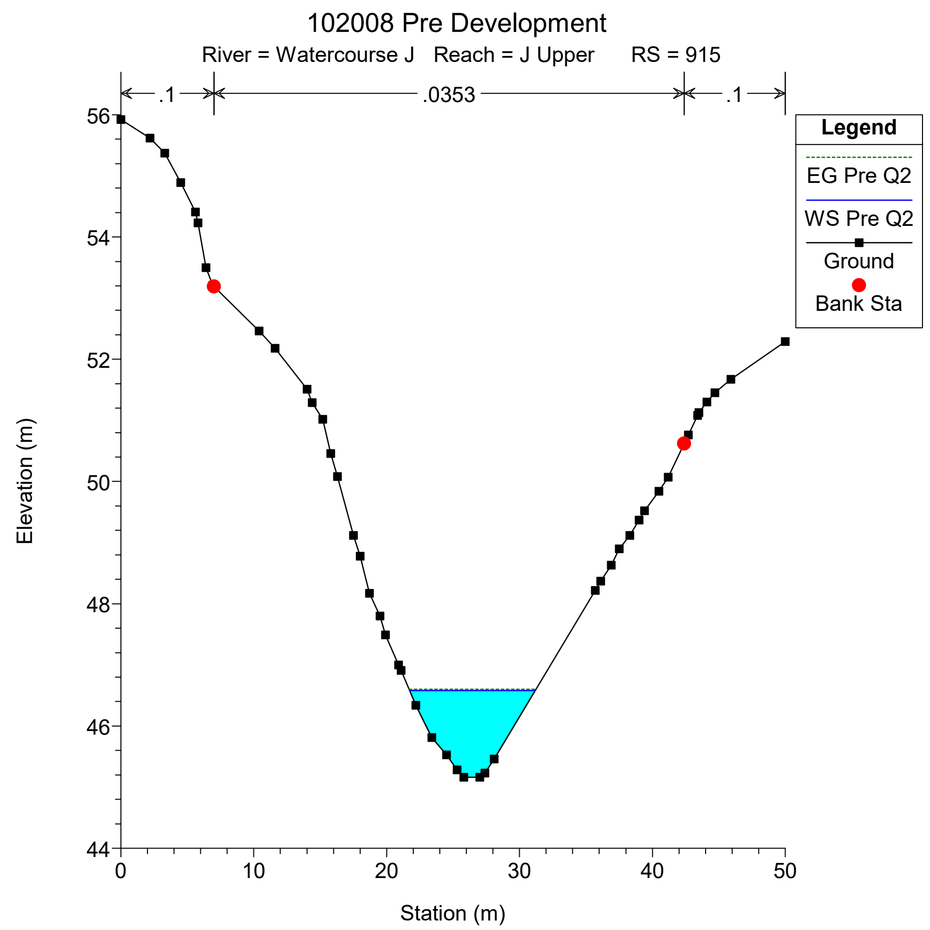

102008 Pre Development
River = Watercourse H+I Reach = H RS = 80
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

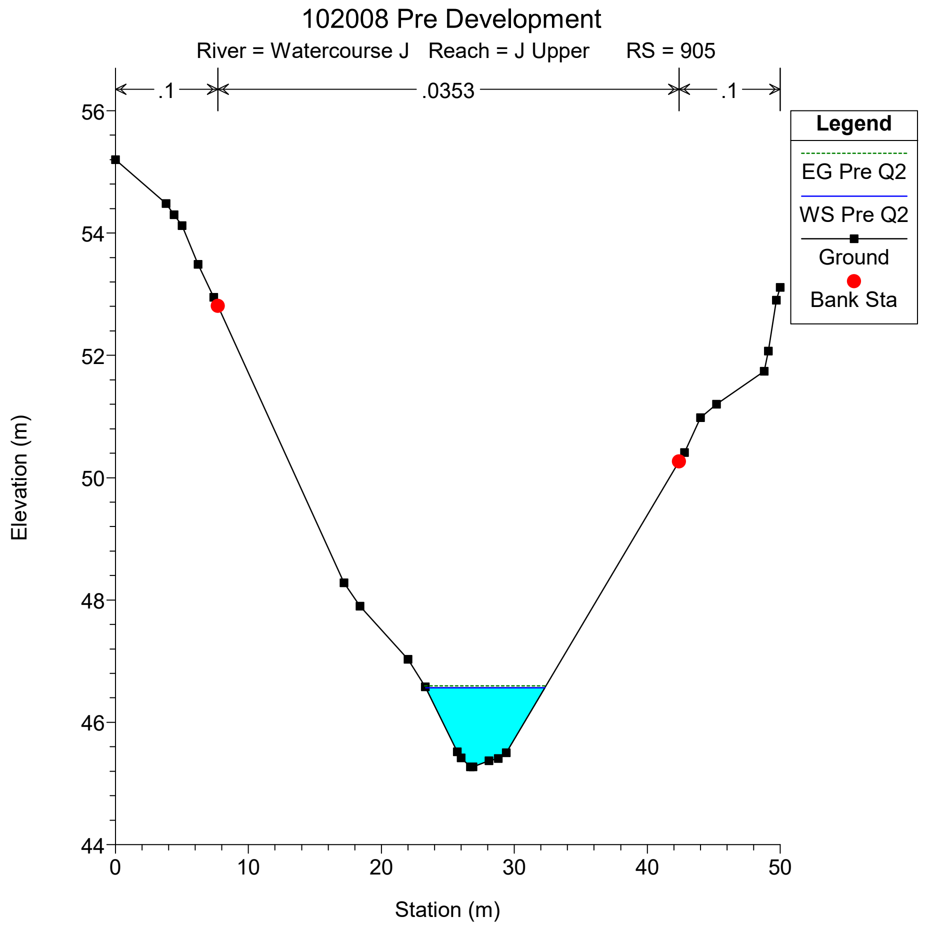

102008 Pre Development
River = Watercourse H+I Reach = H RS = 70
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

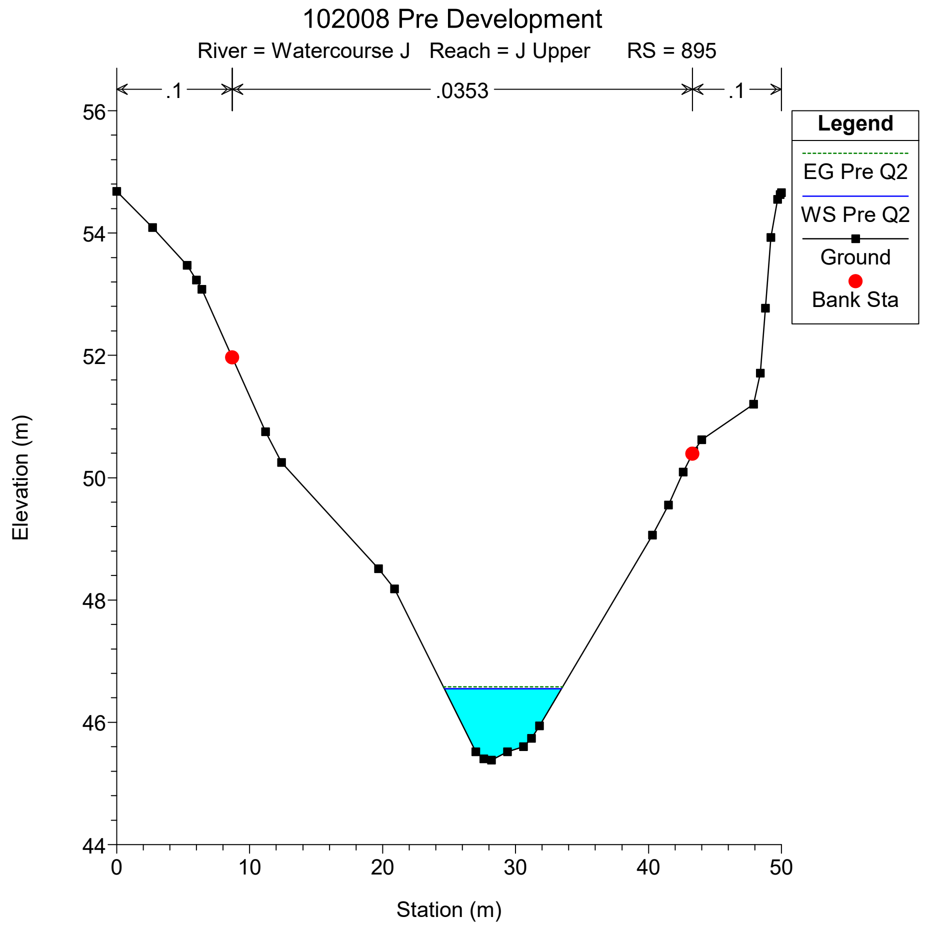

102008 Pre Development
River = Watercourse H+I Reach = H RS = 60
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

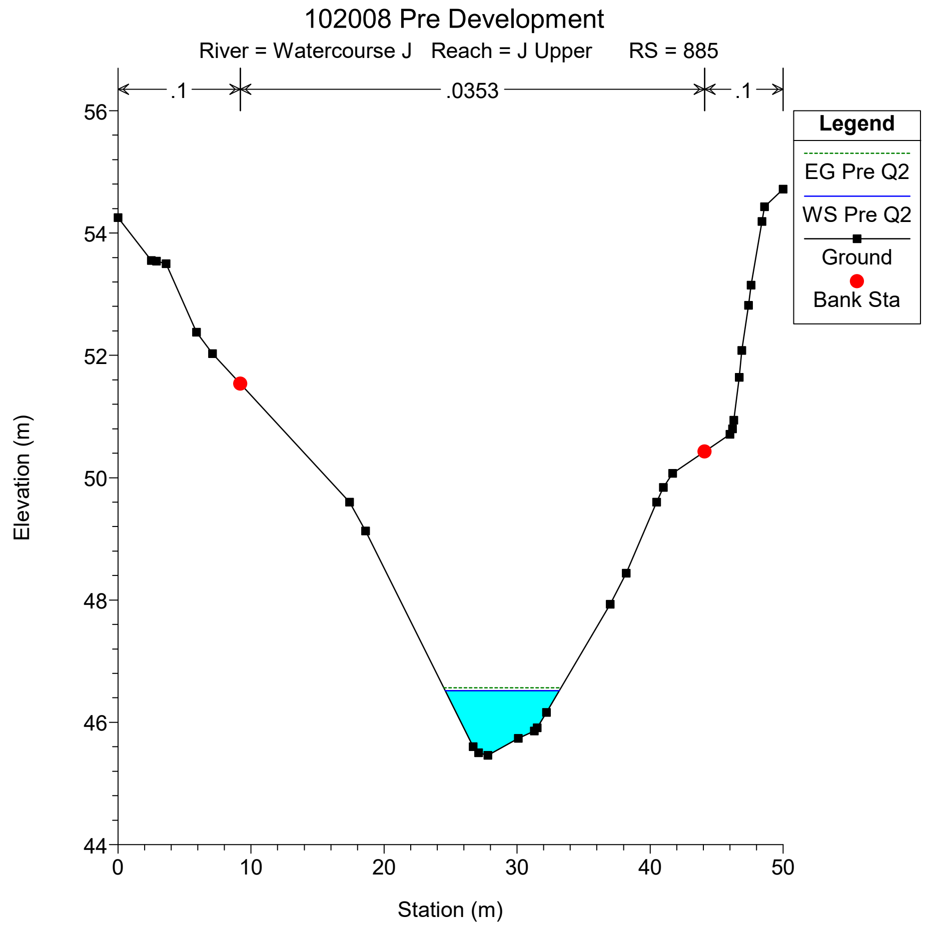

102008 Pre Development
River = Watercourse H+I Reach = H RS = 50
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

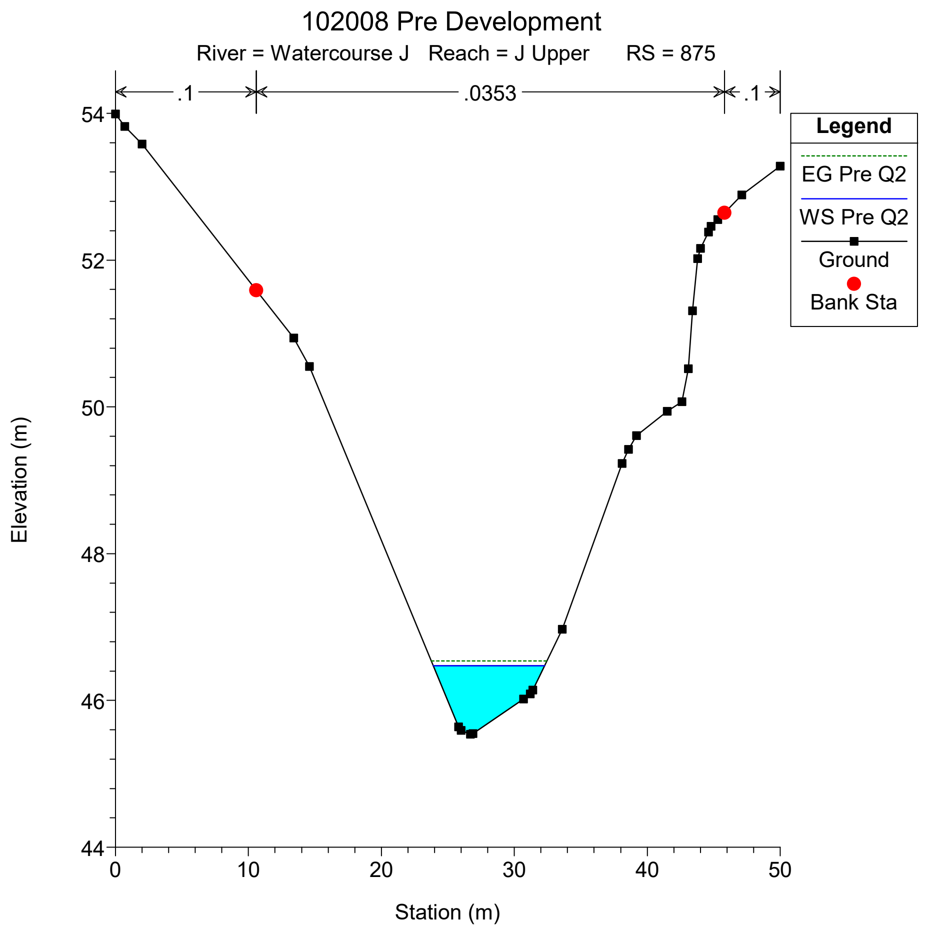

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 925
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

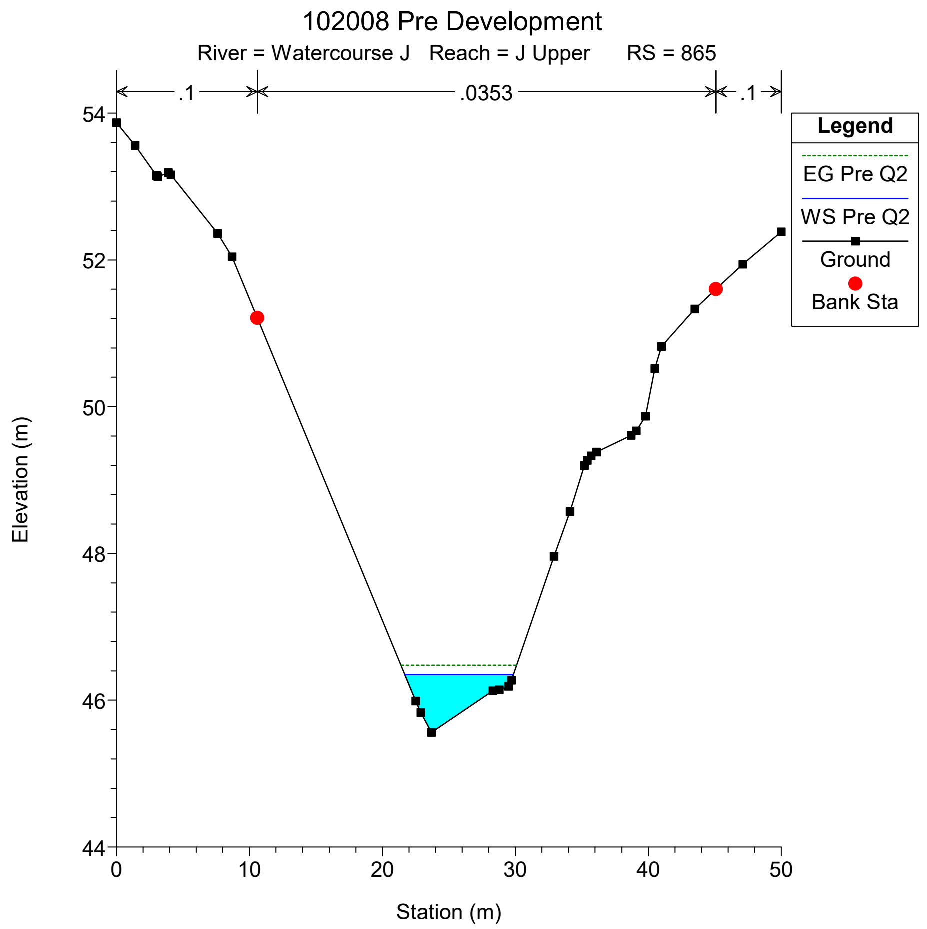

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 915
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

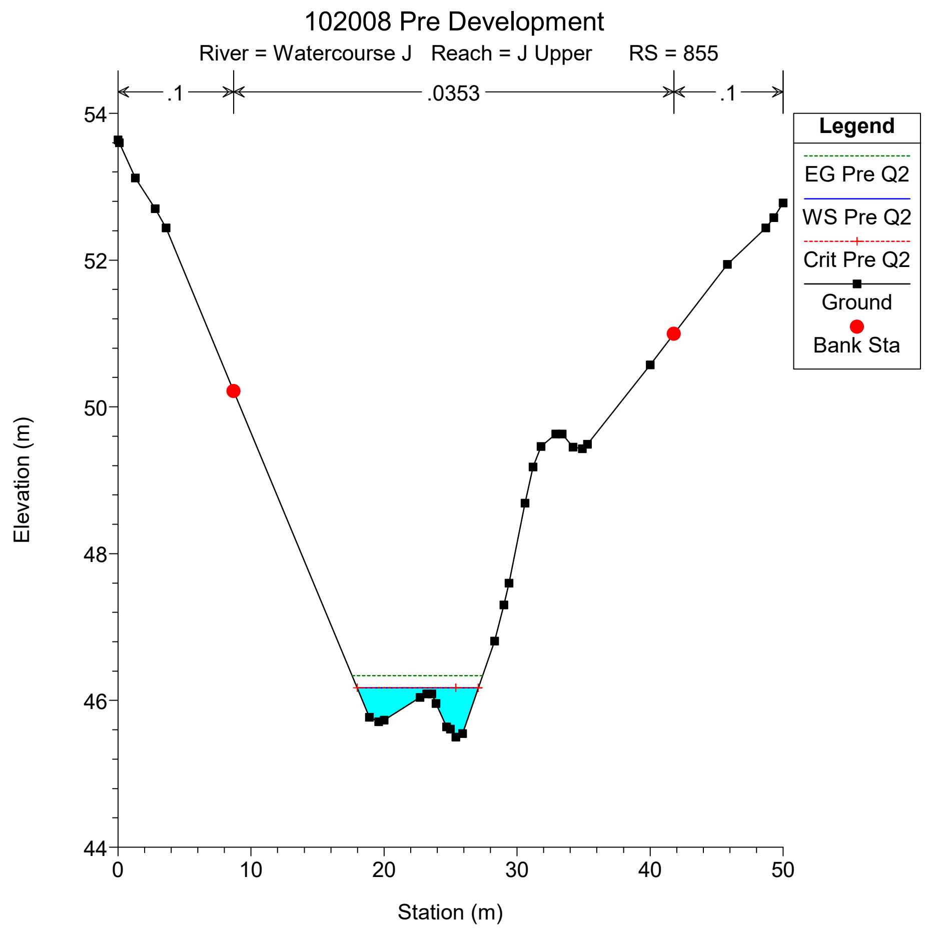

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 905
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

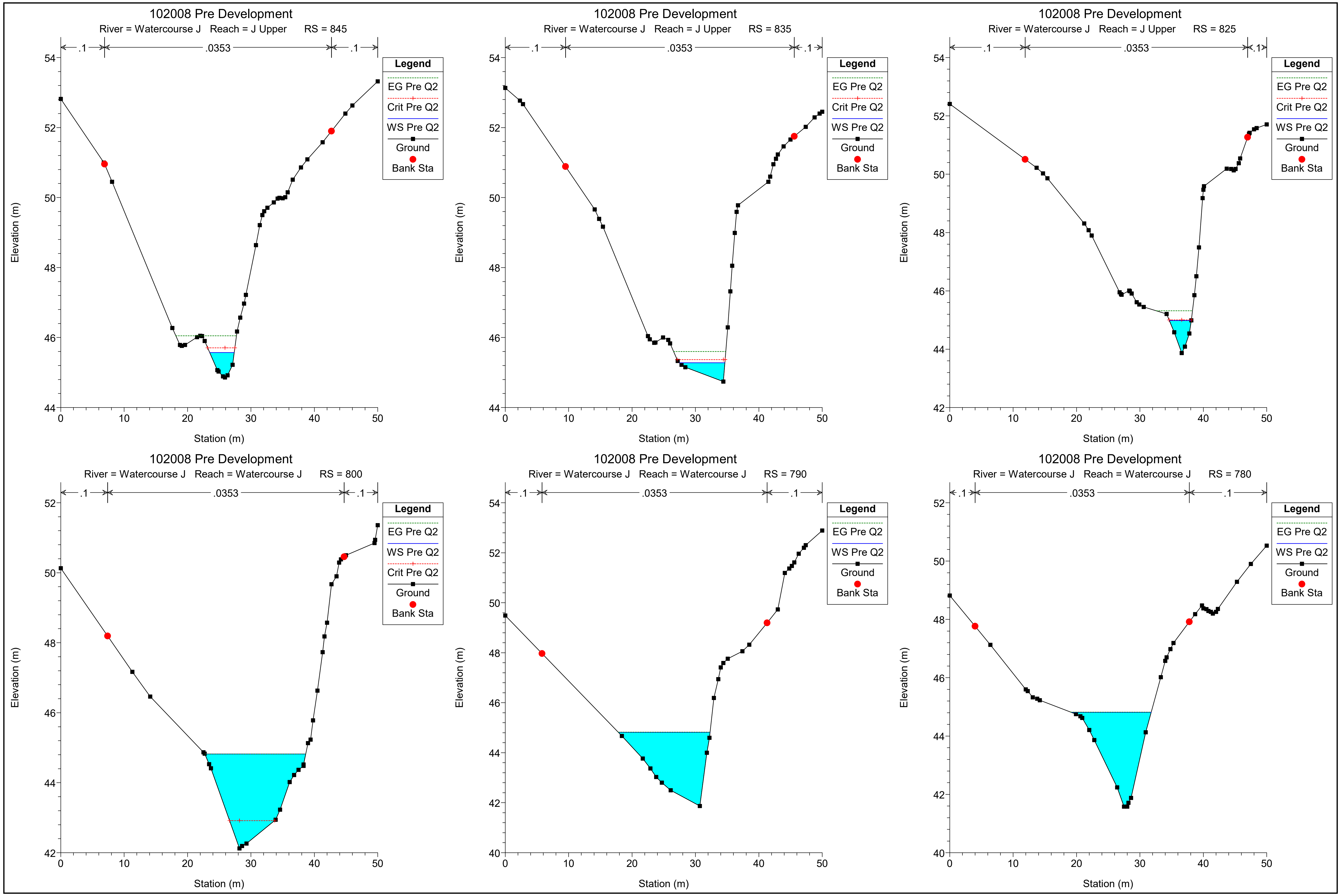

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 895
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

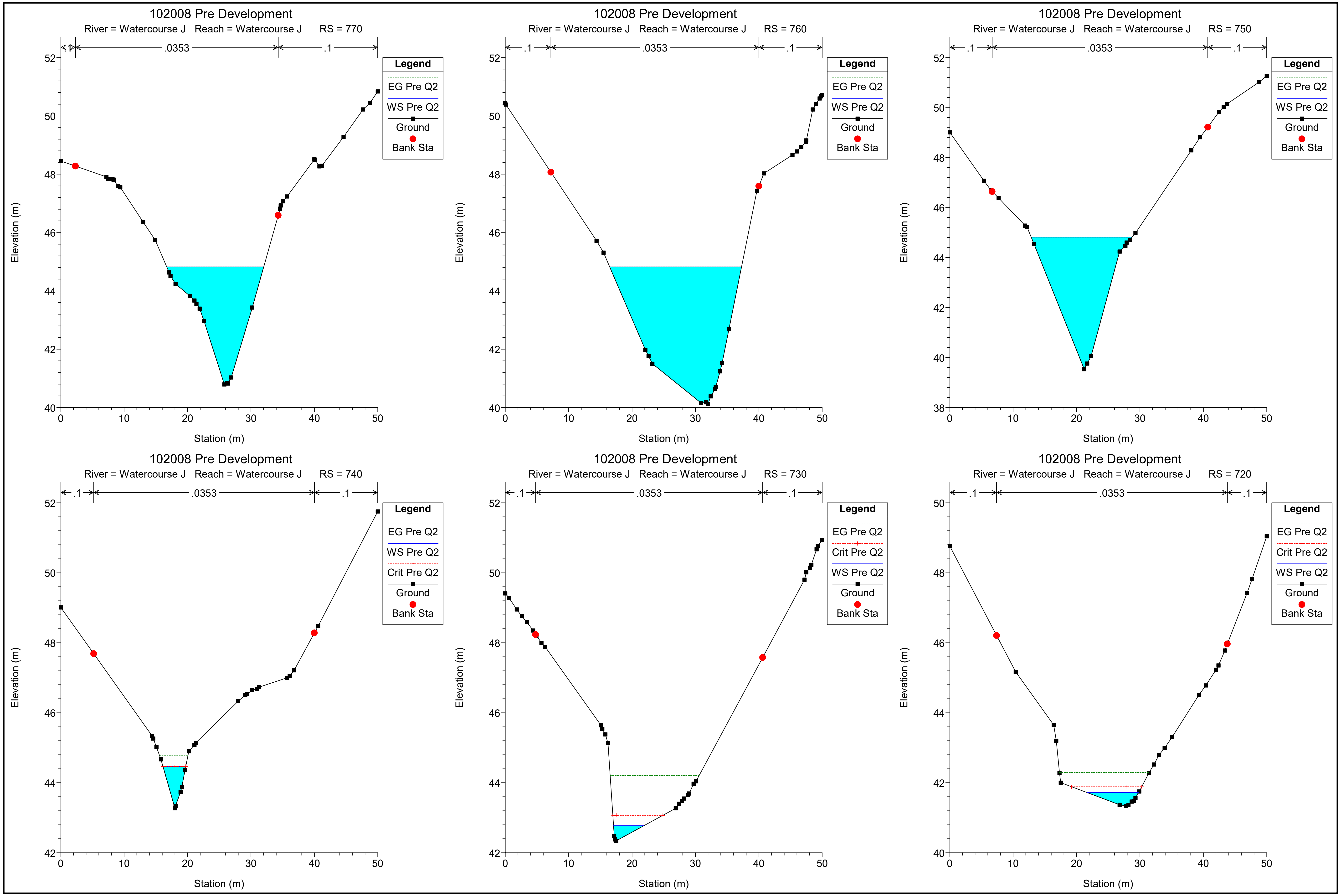

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 885
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

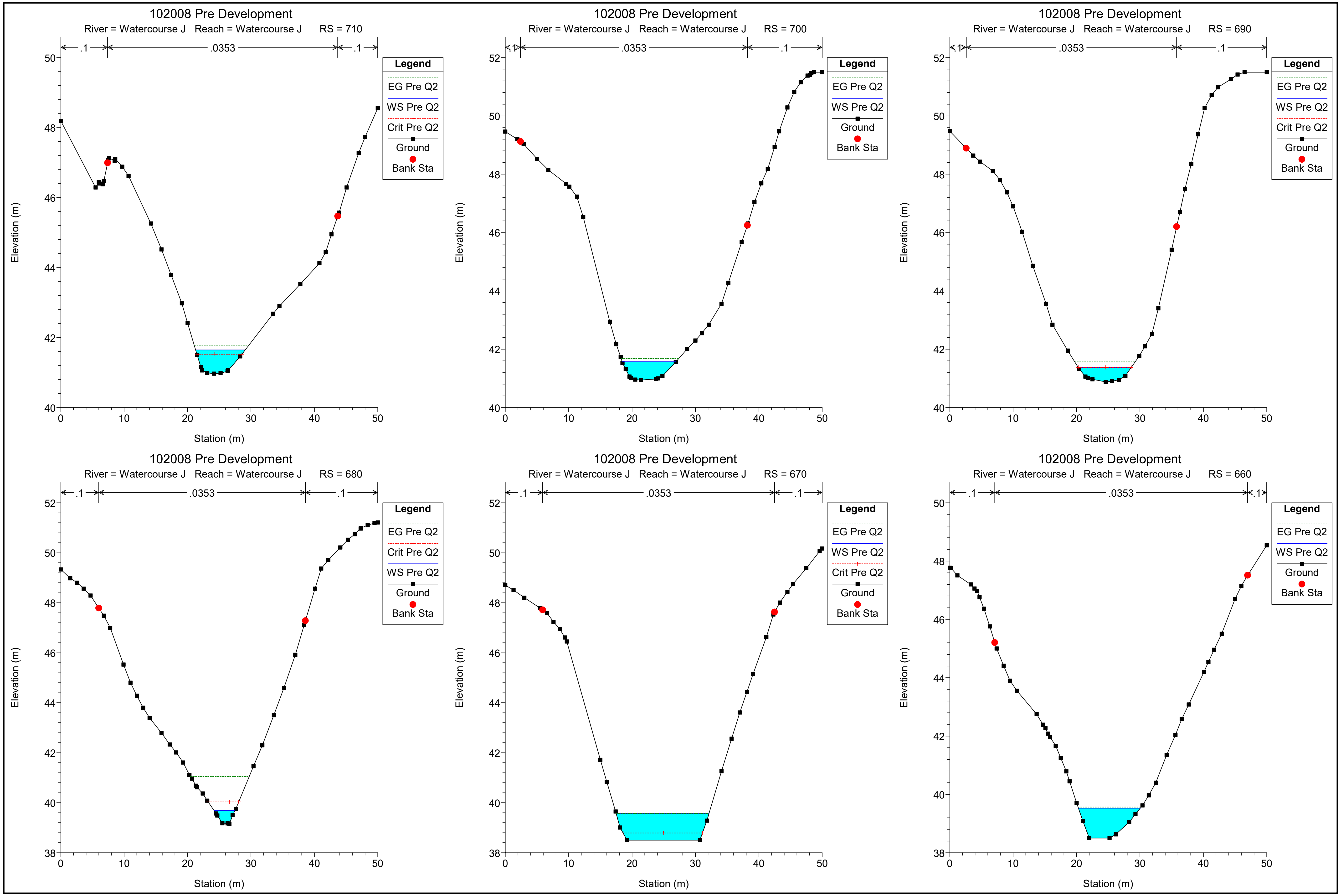

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 875
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

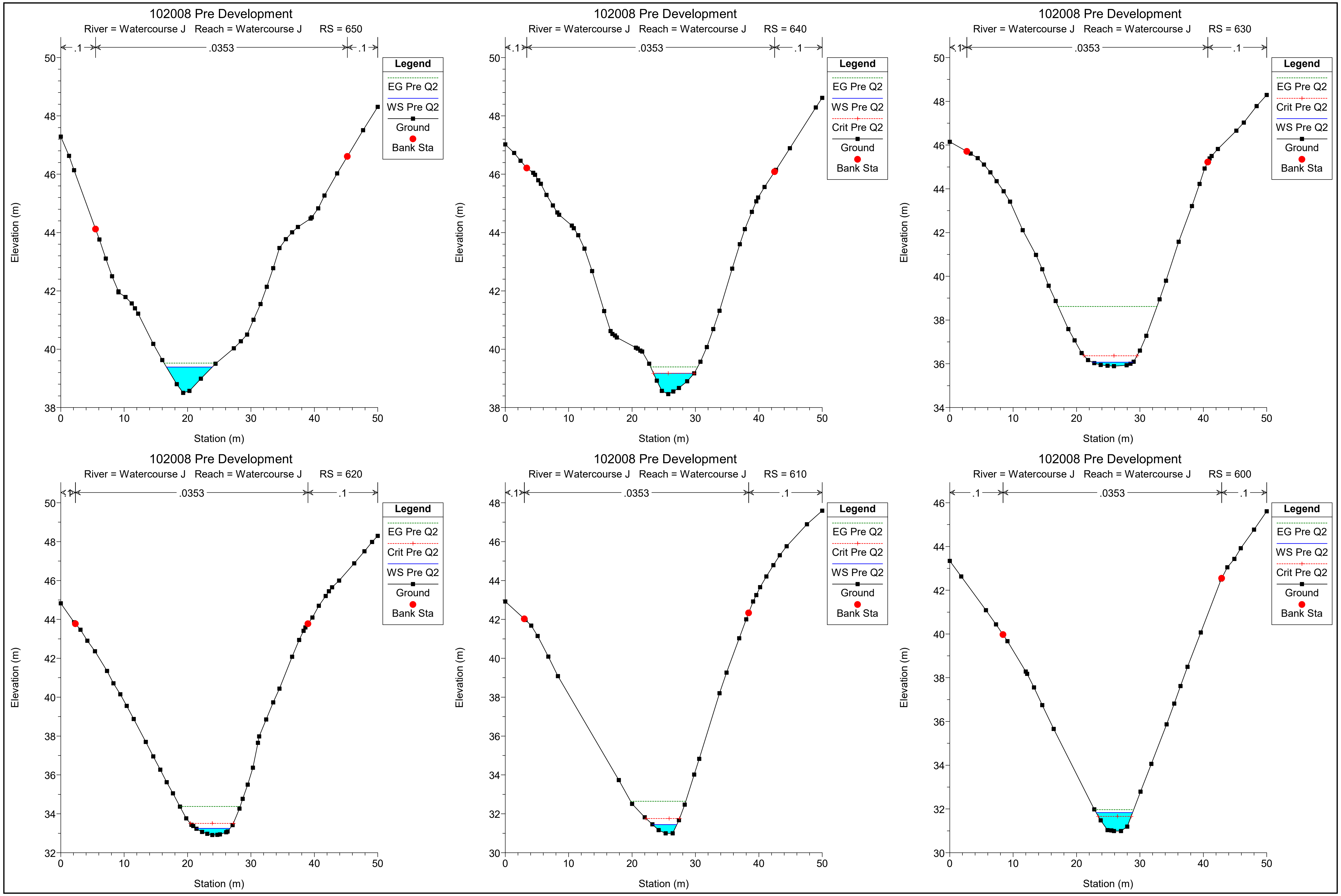

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 865
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

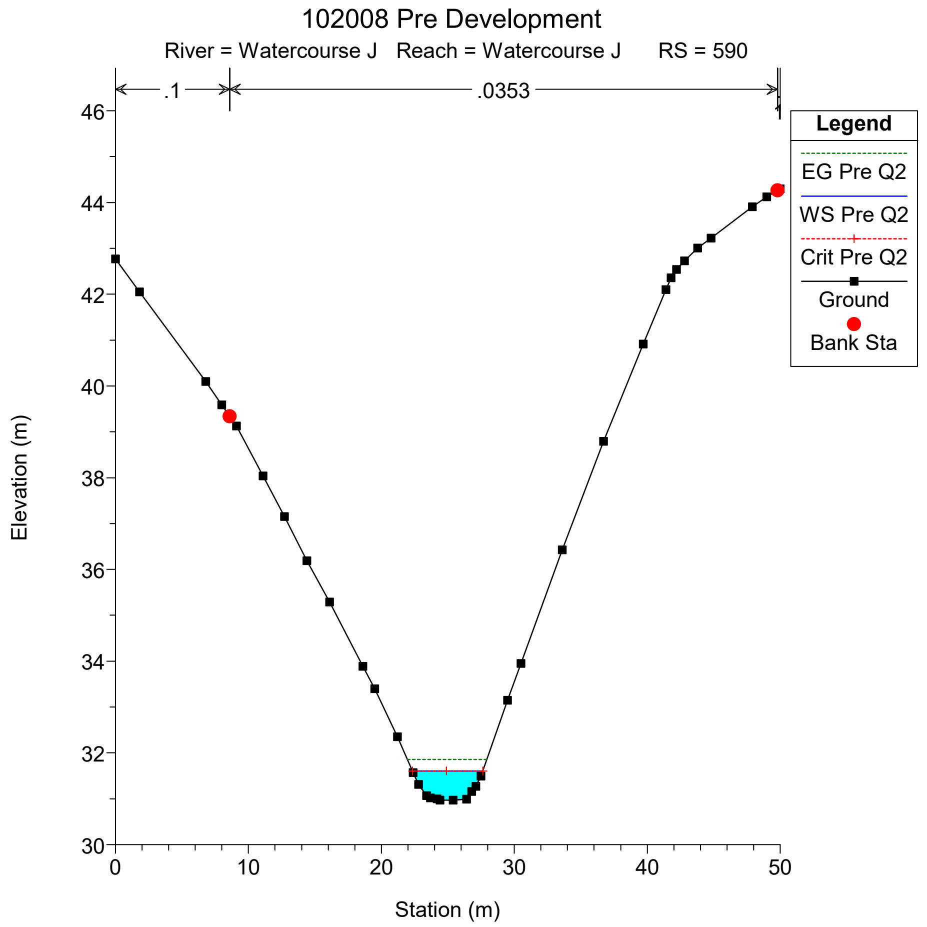

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 855
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

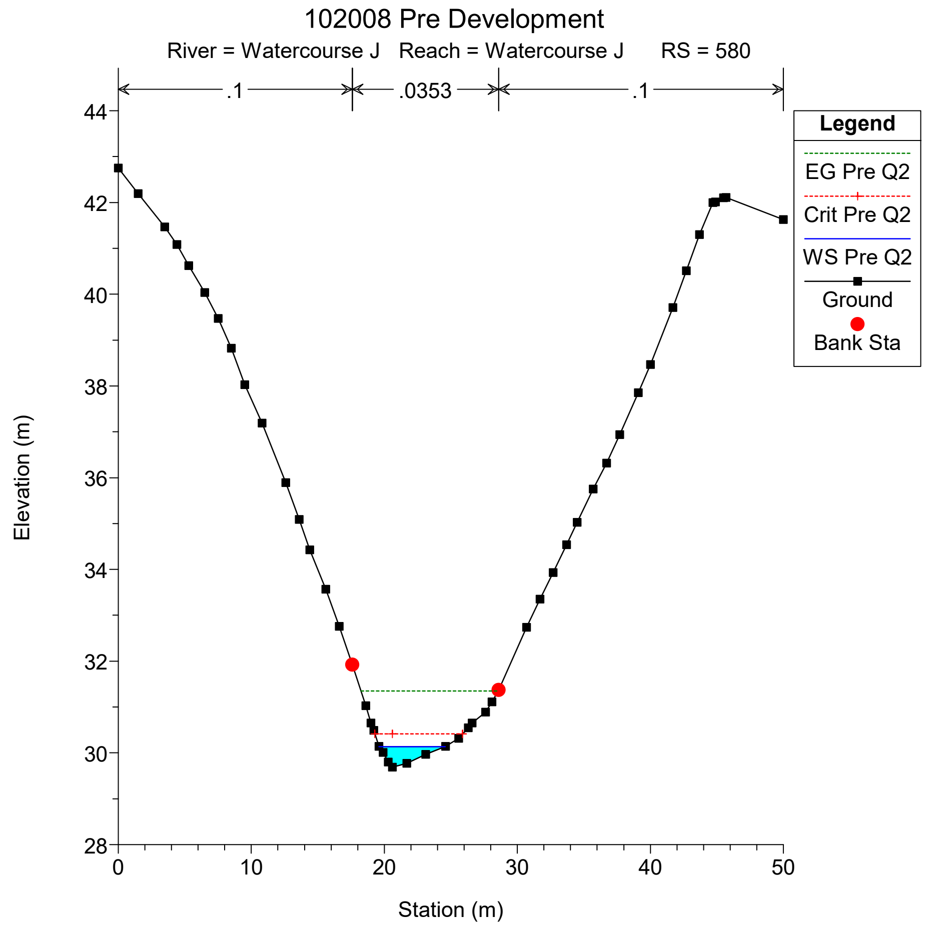

102008 Pre Development
River = Watercourse J Reach = J Upper RS = 845
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = J Upper RS = 835
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = J Upper RS = 825
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 800
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 790
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 780
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

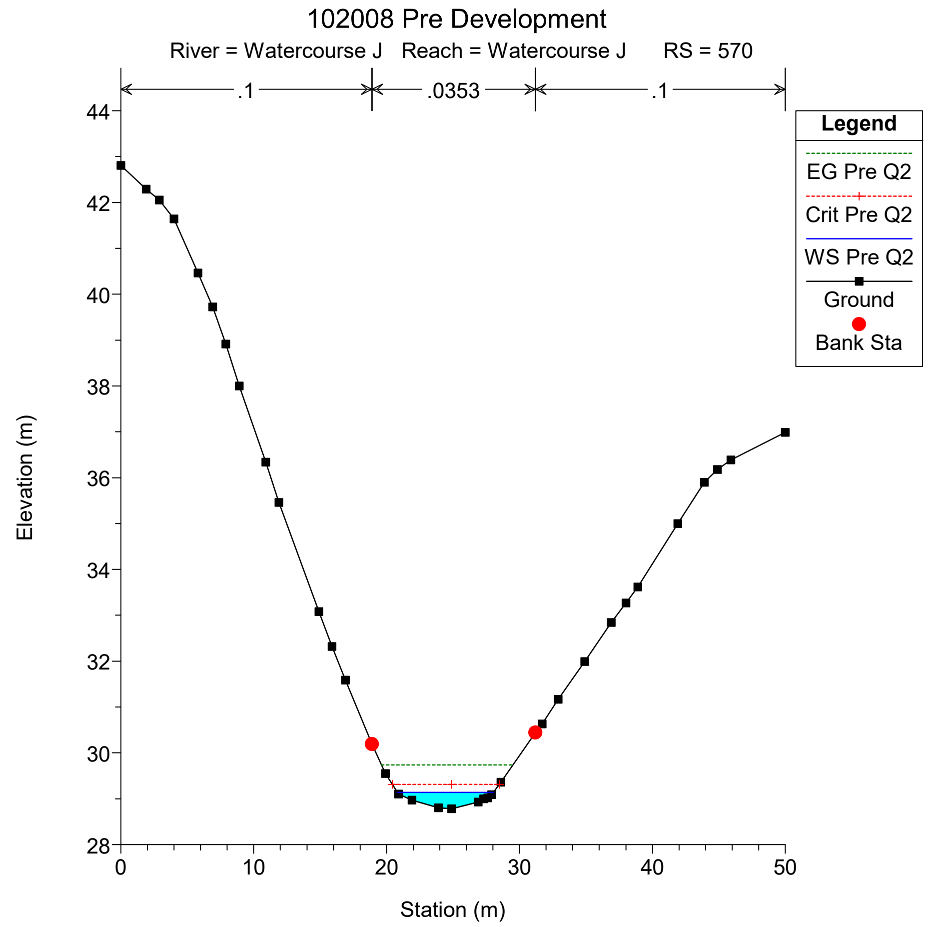

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 770
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 760
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 750
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 740
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 730
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 720
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

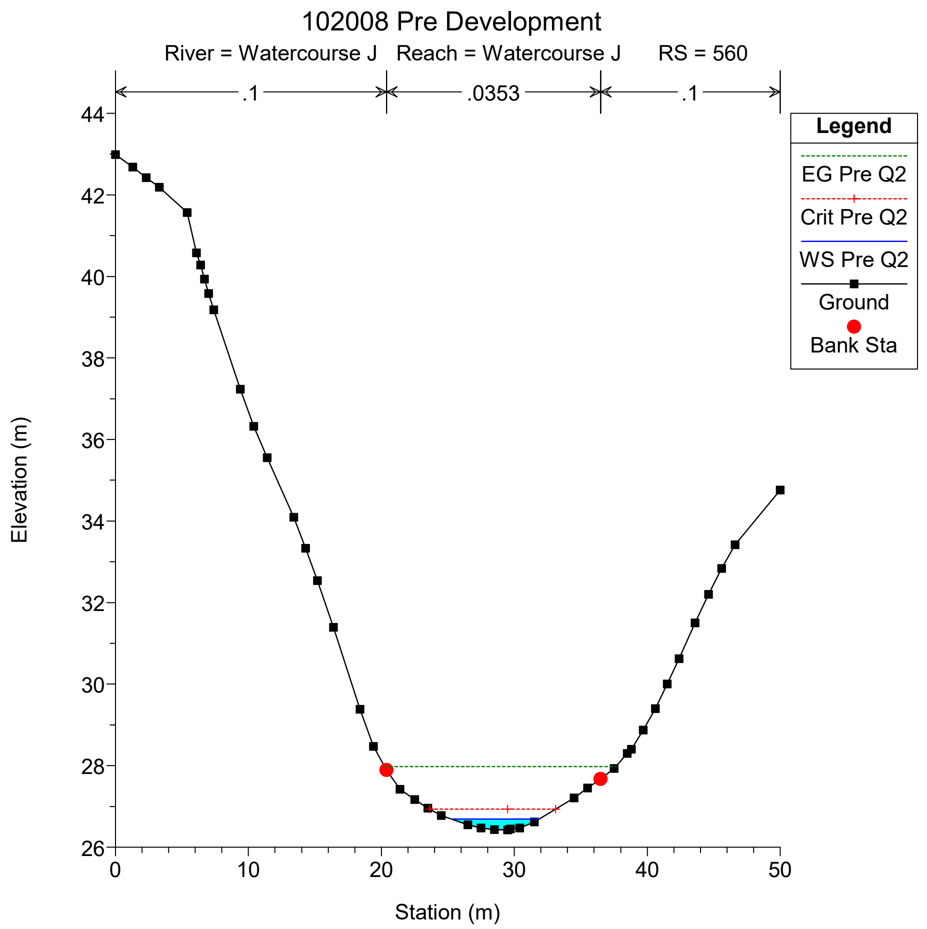

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 710
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 700
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 690
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 680
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 670
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 660
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

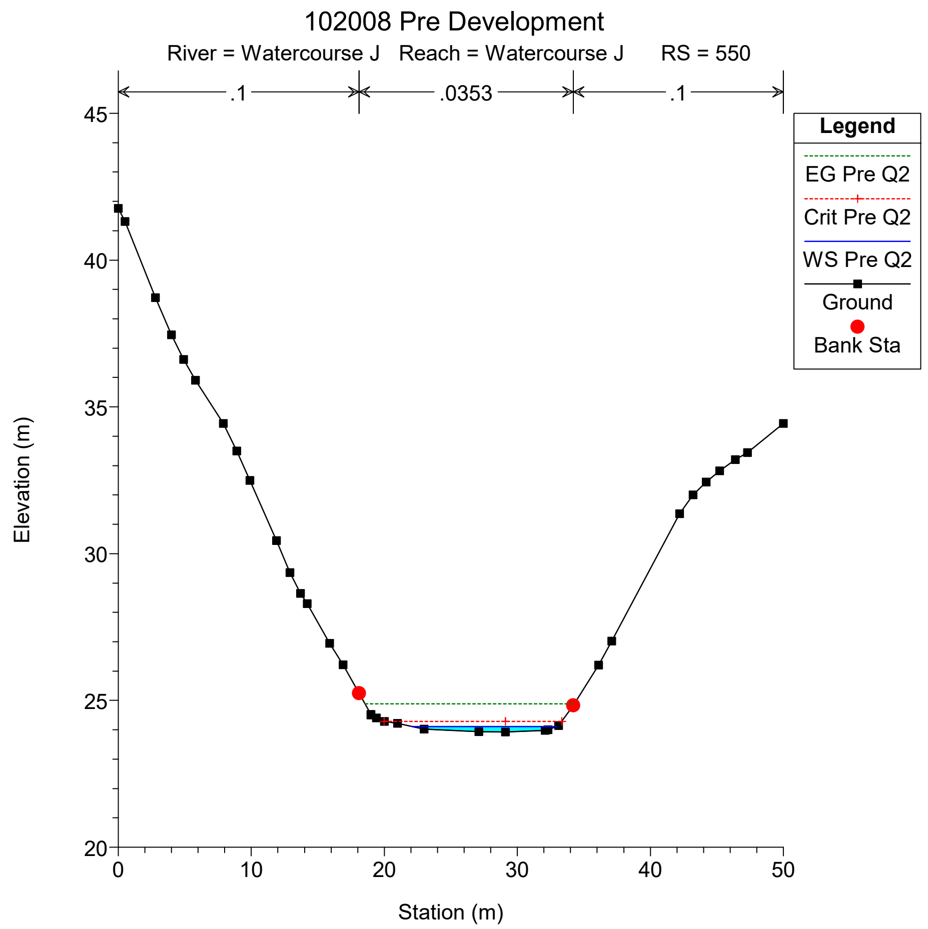

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 650
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 640
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 630
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 620
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 610
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 600
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

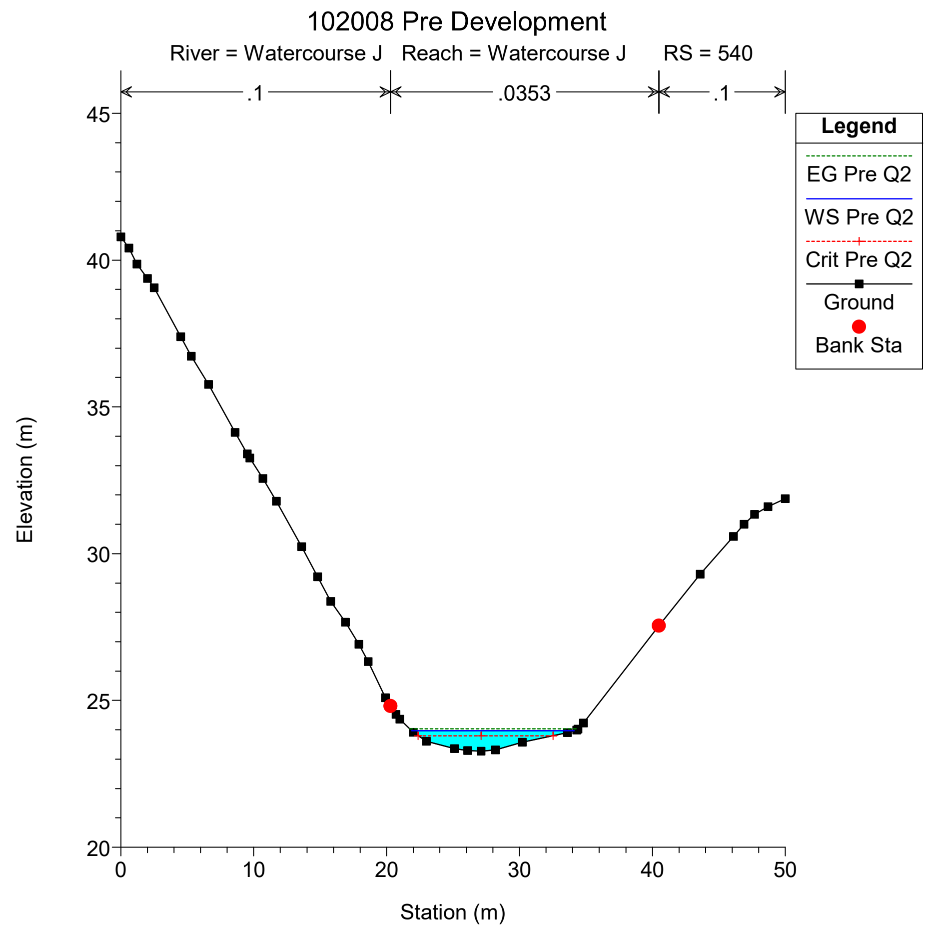

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 590
.1
.0353
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
30
32
34
36
38
40
42
44
46
0
10
20
30
40
50

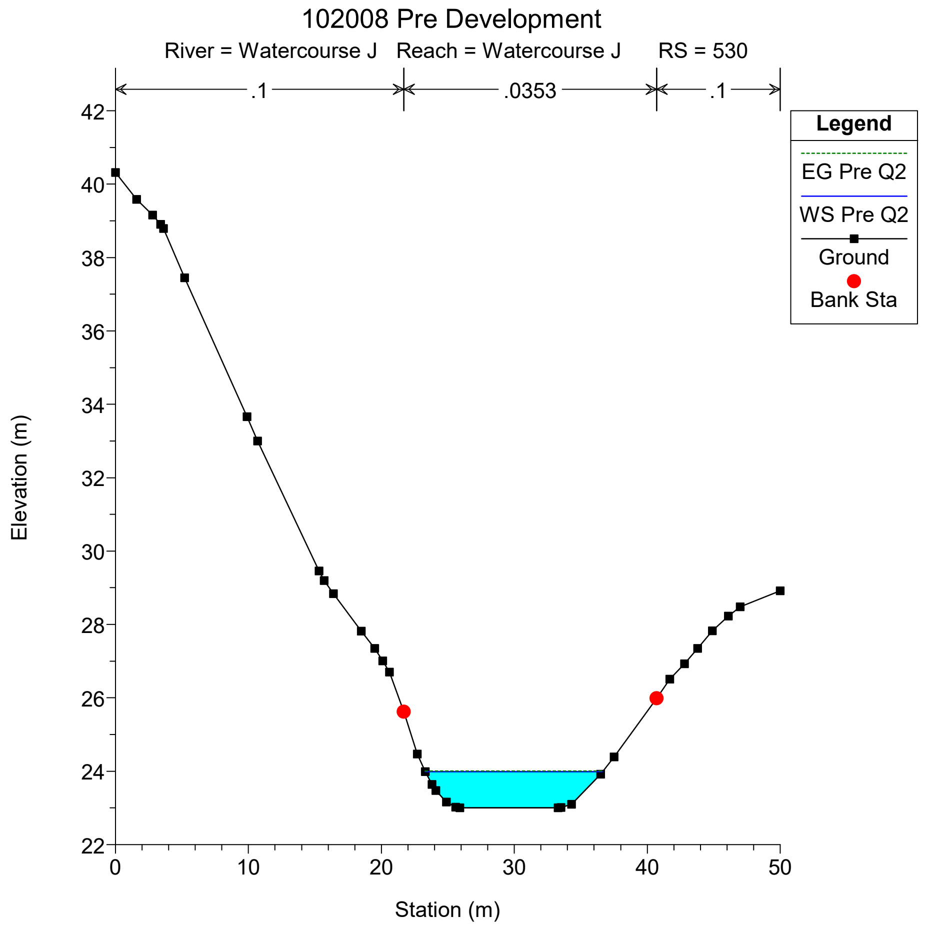

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 580
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
28
30
32
34
36
38
40
42
44
0
10
20
30
40
50

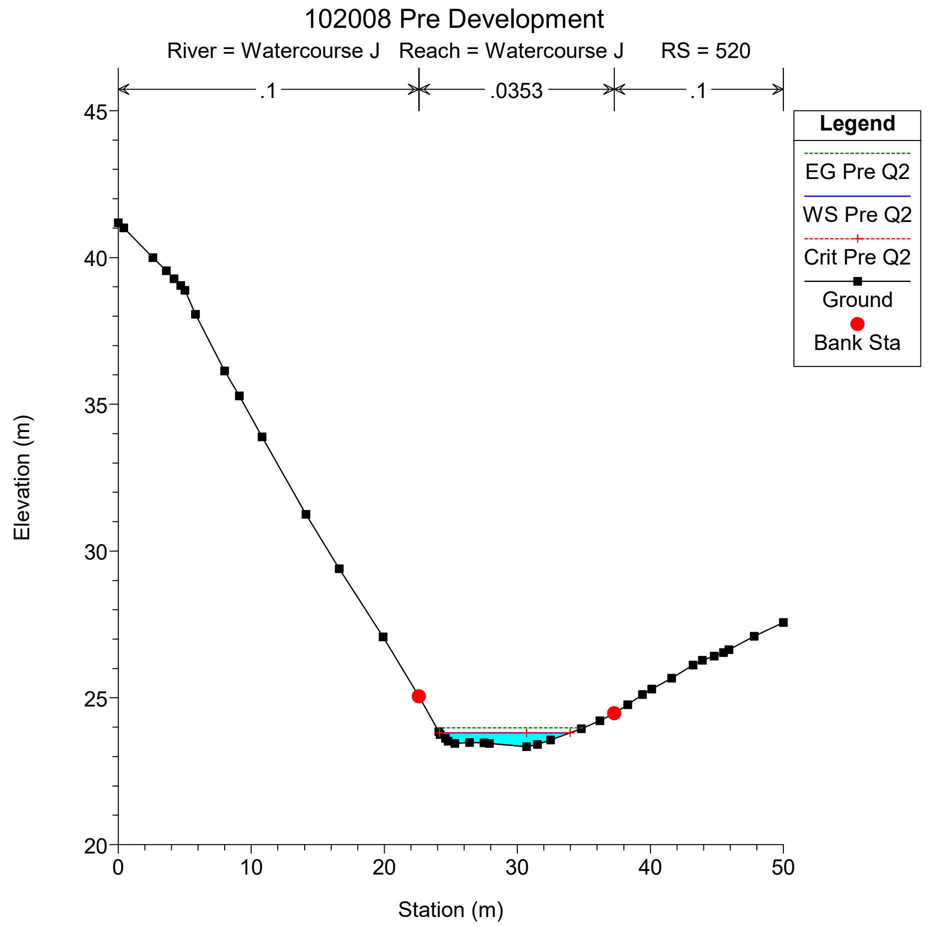

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 570
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
28
30
32
34
36
38
40
42
44
0
10
20
30
40
50

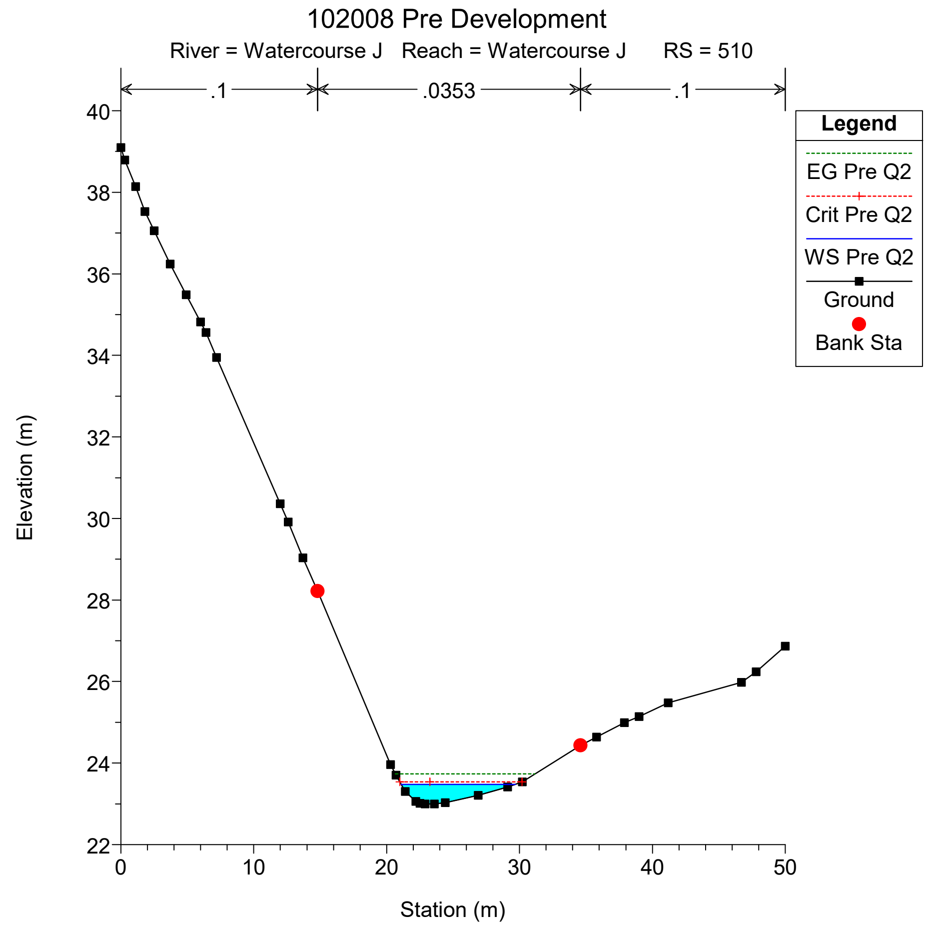

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 560
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
26
28
30
32
34
36
38
40
42
44
0
10
20
30
40
50

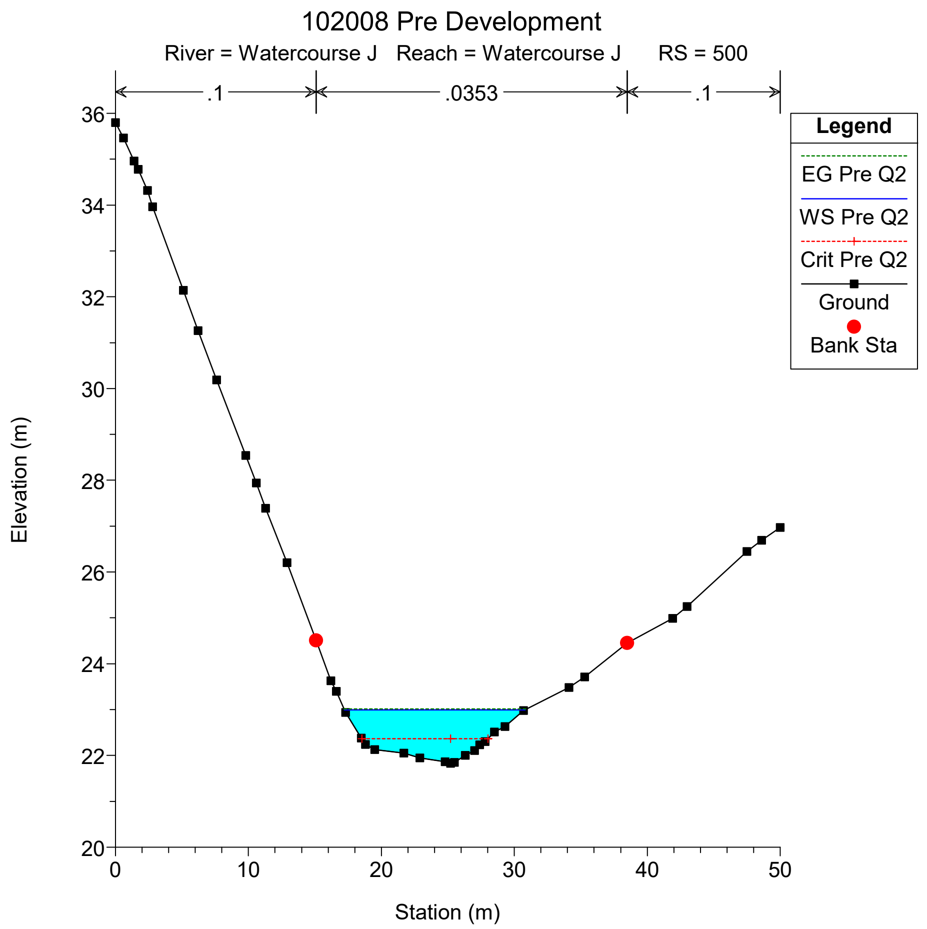

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 550
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
20
25
30
35
40
45
0
10
20
30
40
50

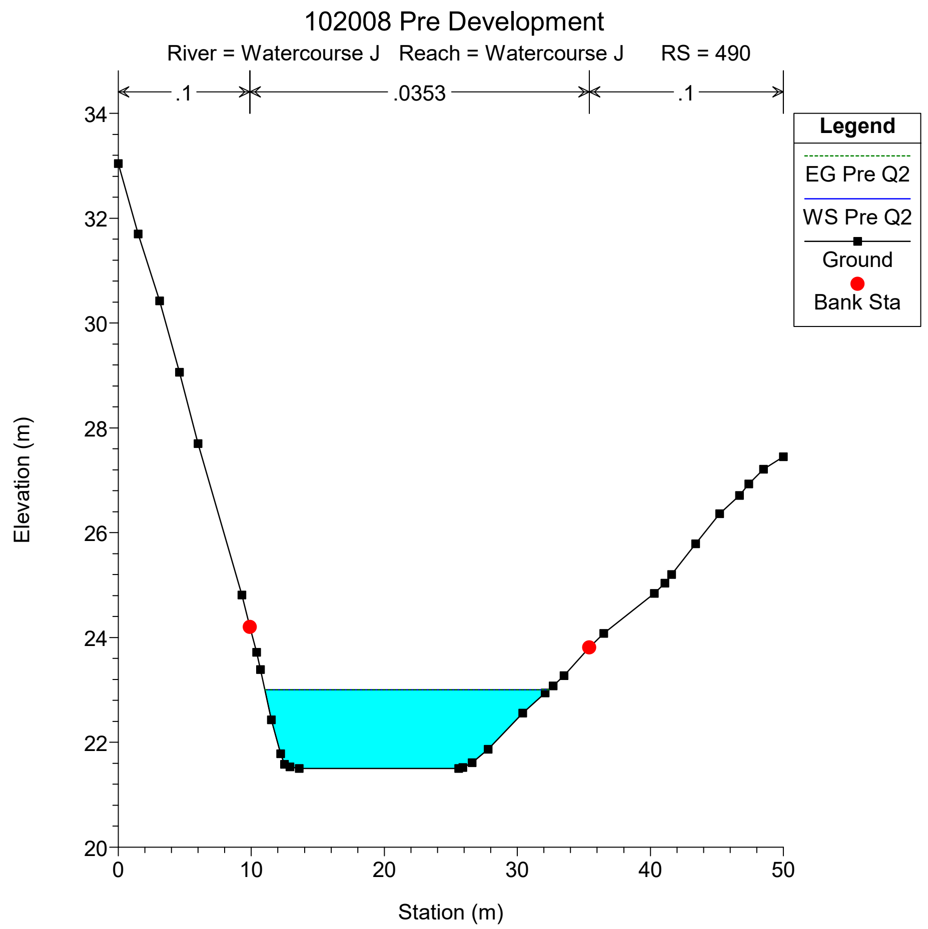

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 540
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
20
25
30
35
40
45
0
10
20
30
40
50

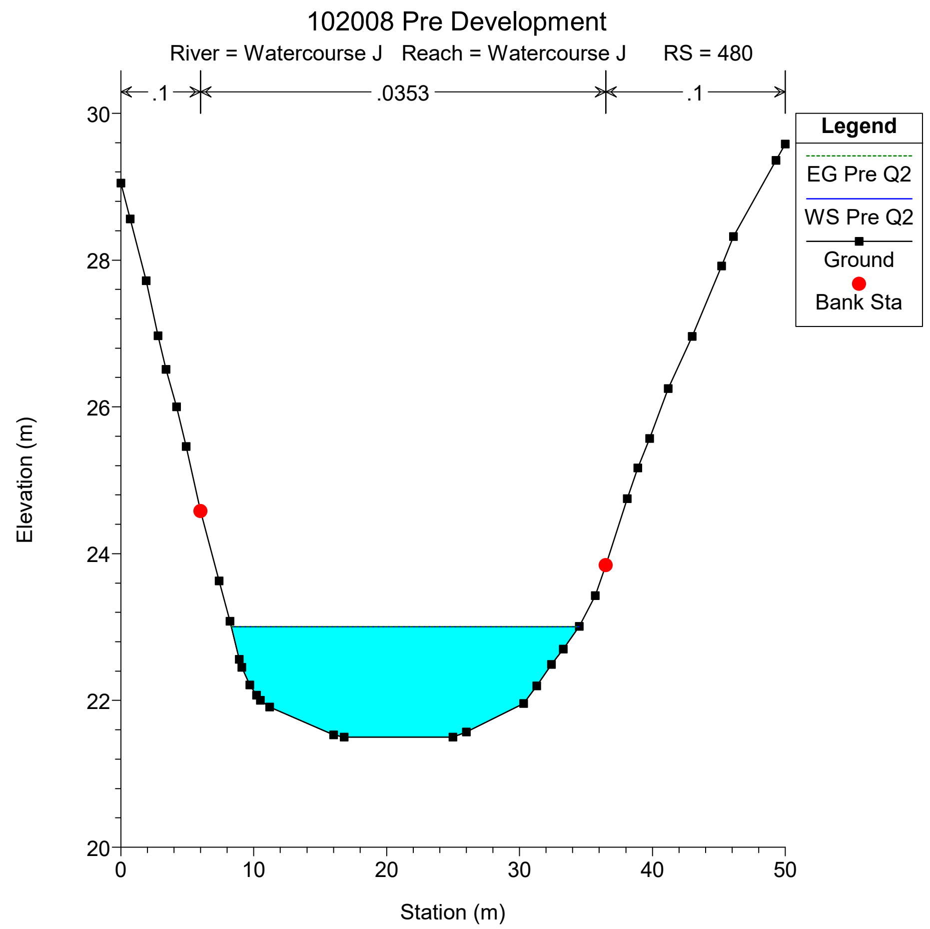

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 530
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

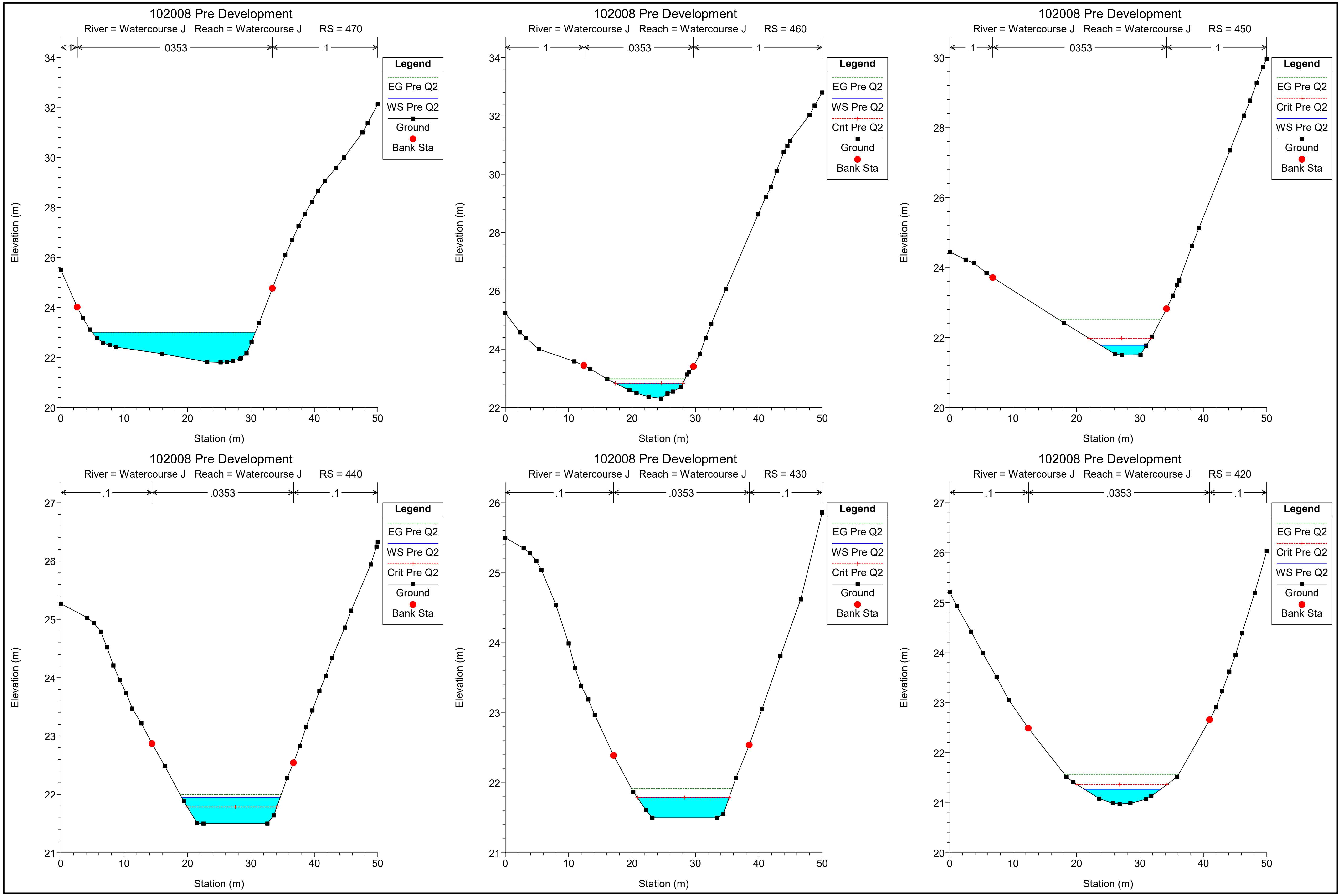

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 520
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

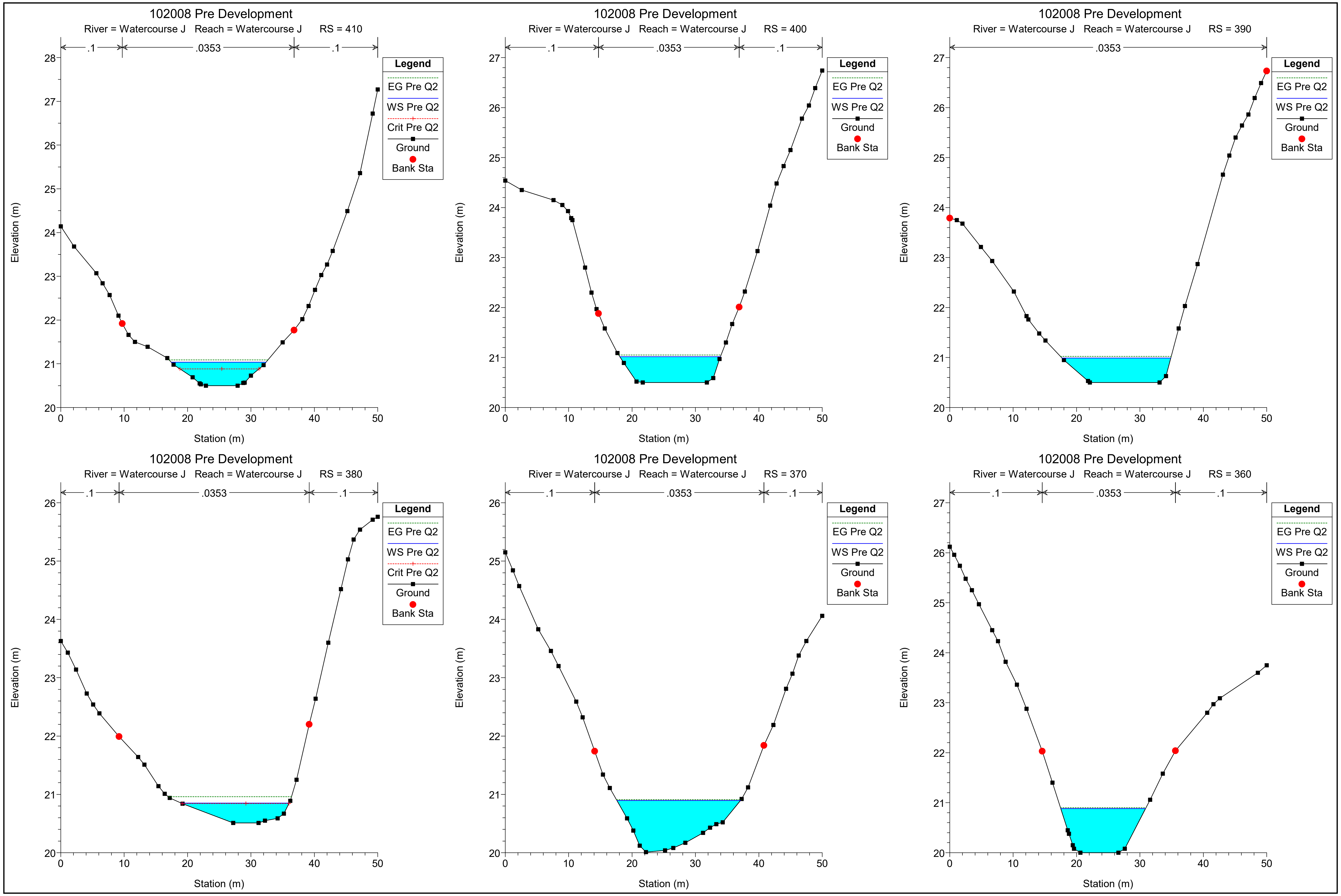

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 510
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

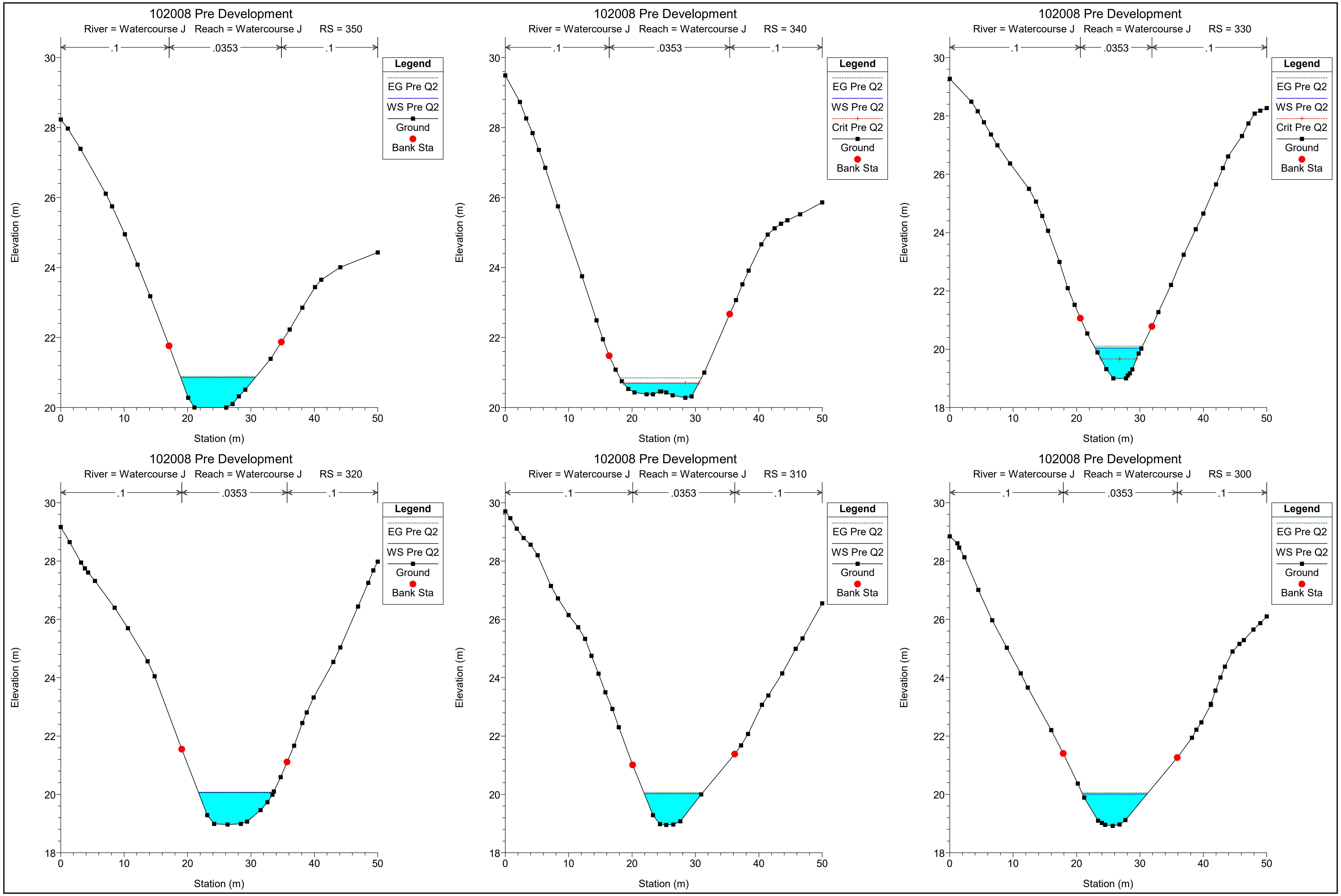

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 500
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

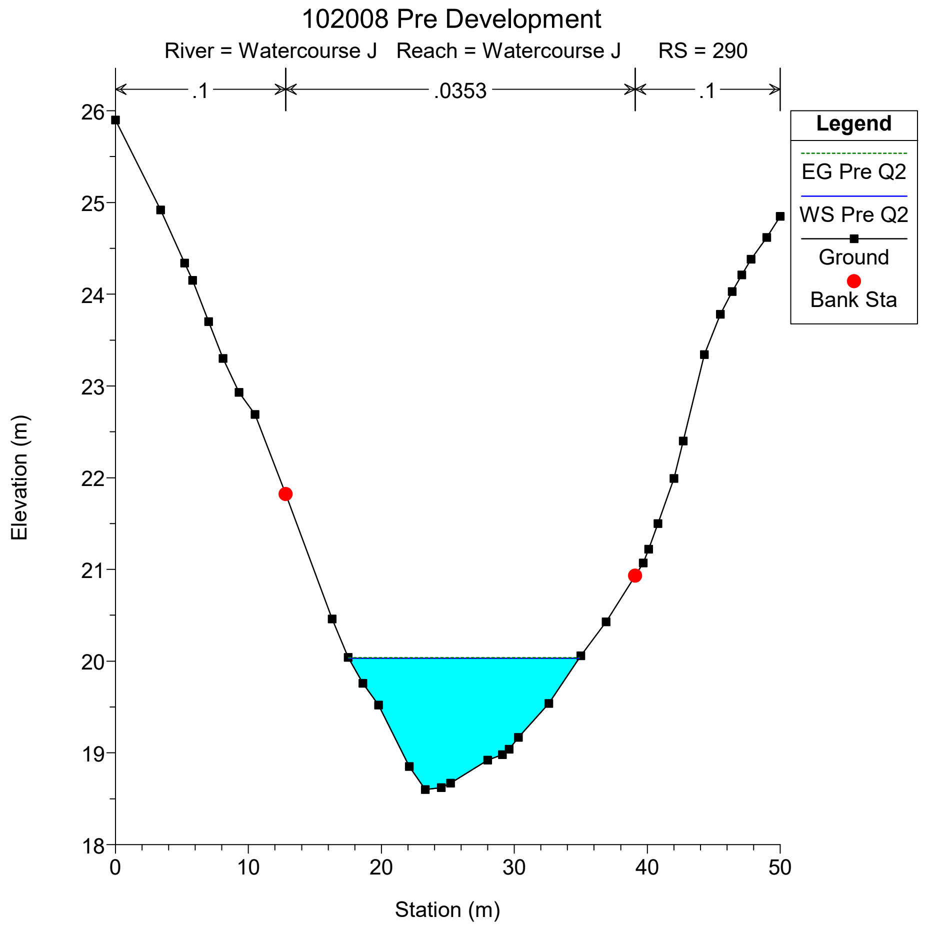

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 490
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

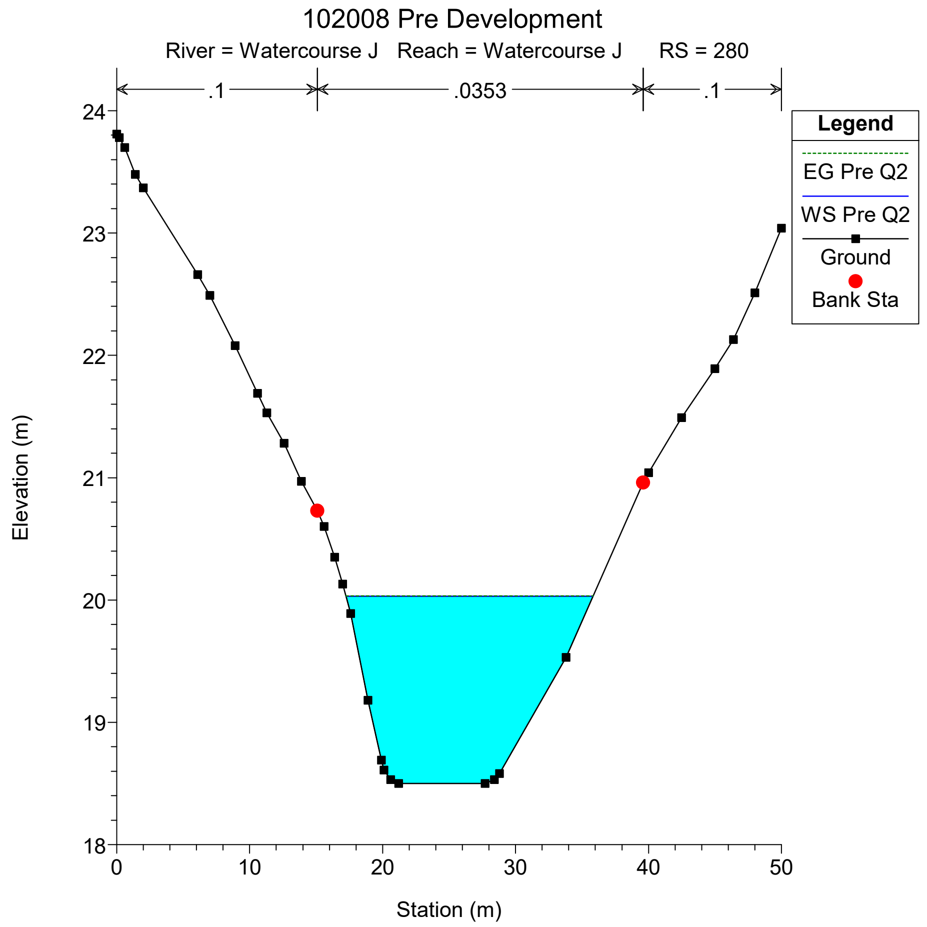

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 480
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

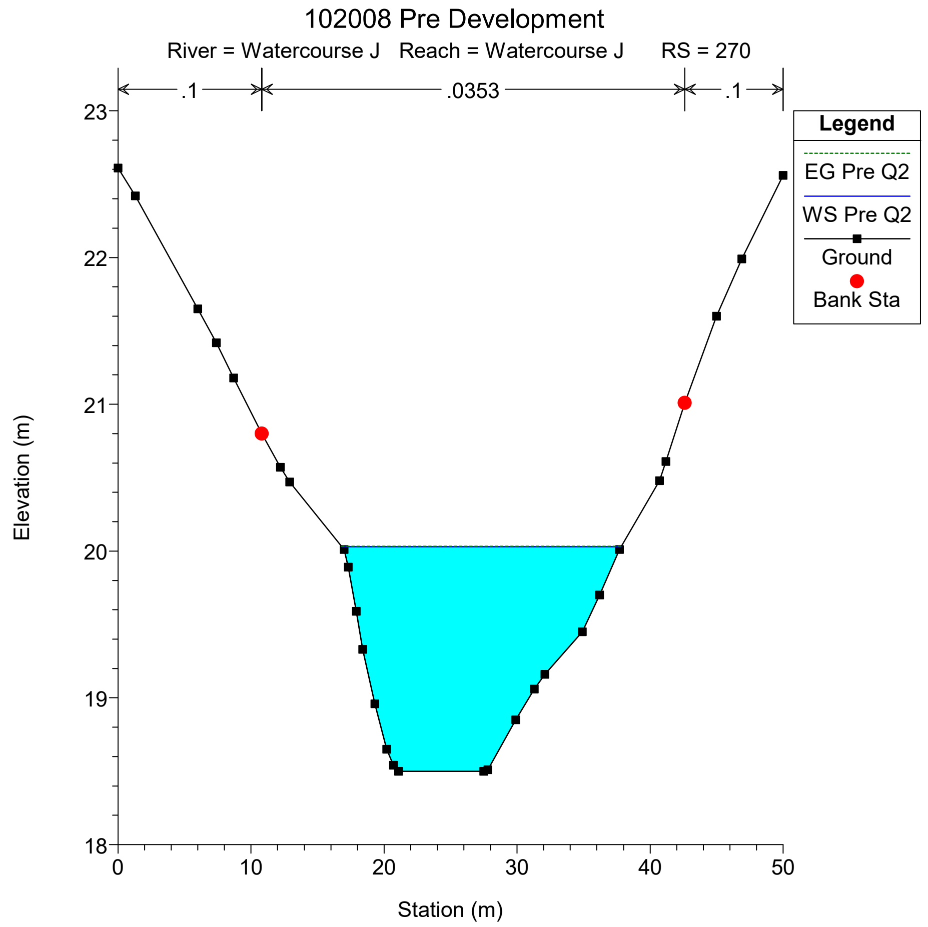

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 470
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 460
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 450
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 440
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 430
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 420
.1
.0353
.1
Elevation (m)
Station (m)
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta

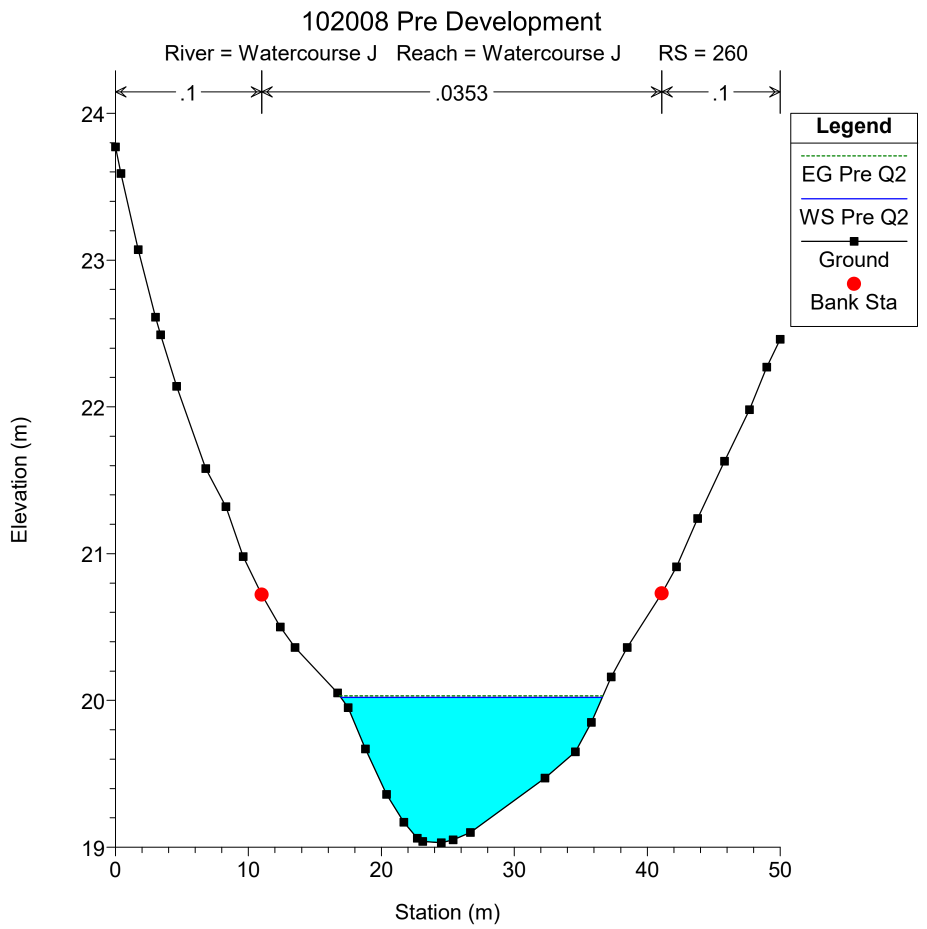

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 410
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 400
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 390
.0353
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 380
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 370
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 360
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

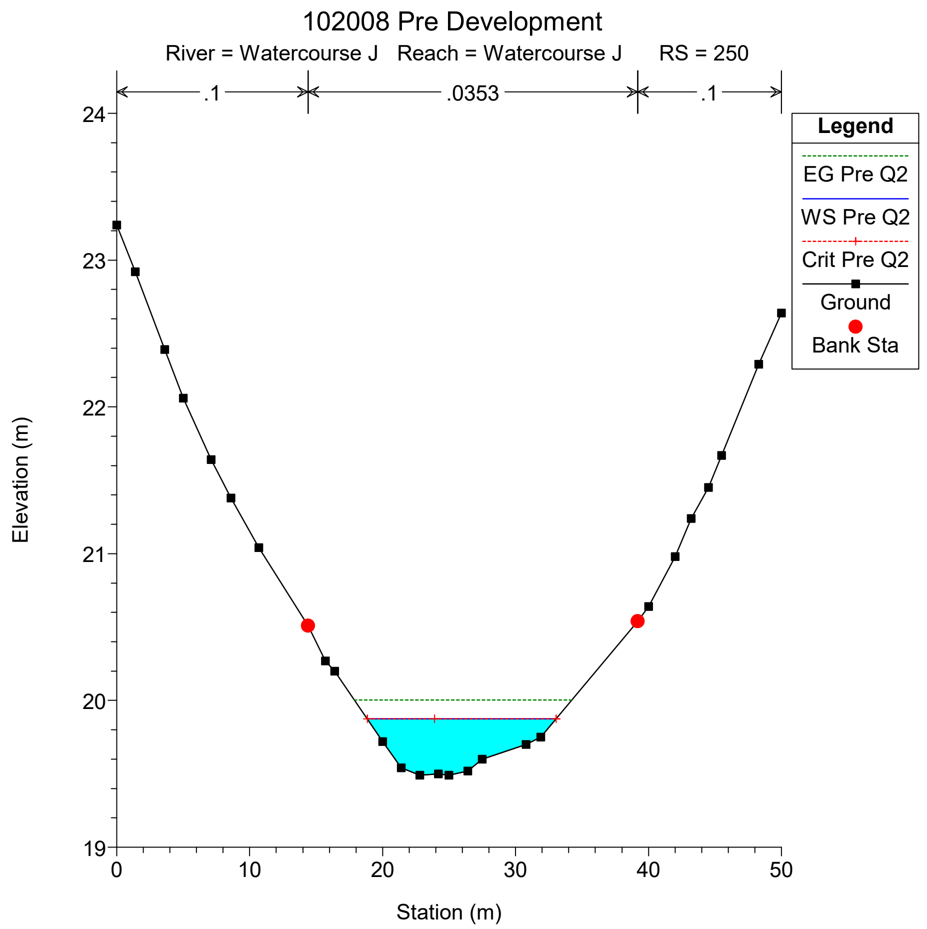

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 350
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 340
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 330
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 320
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 310
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 300
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

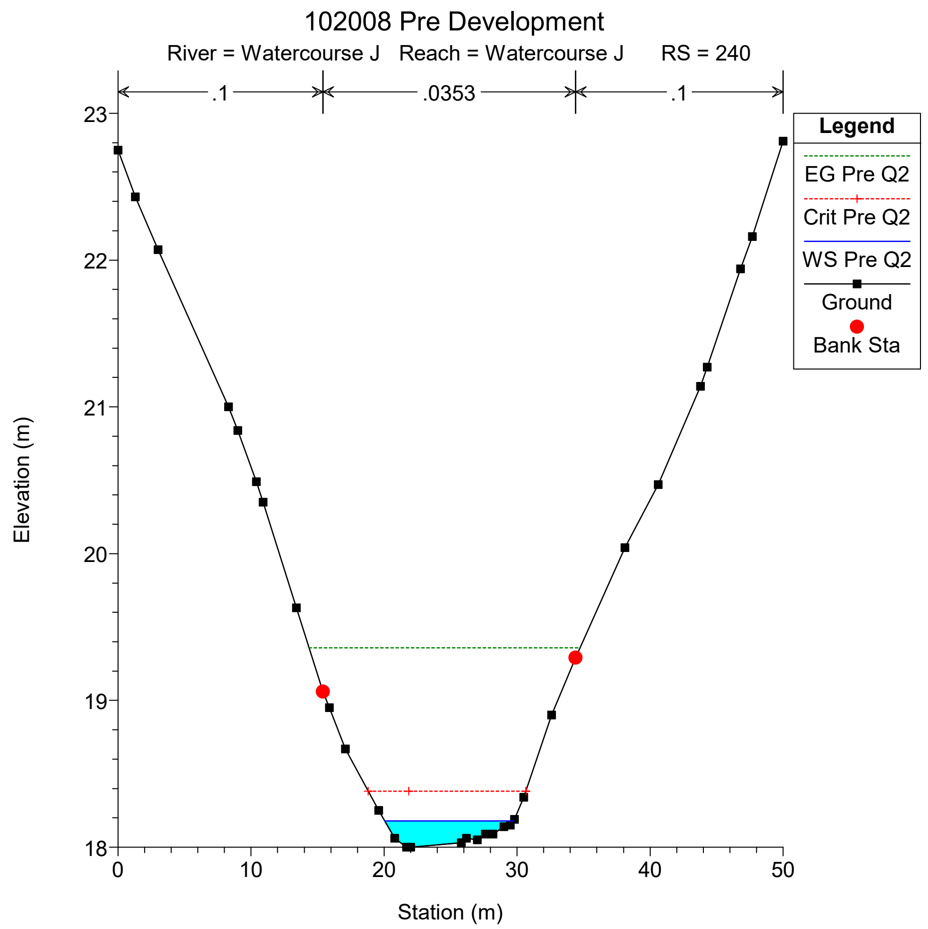

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 290
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

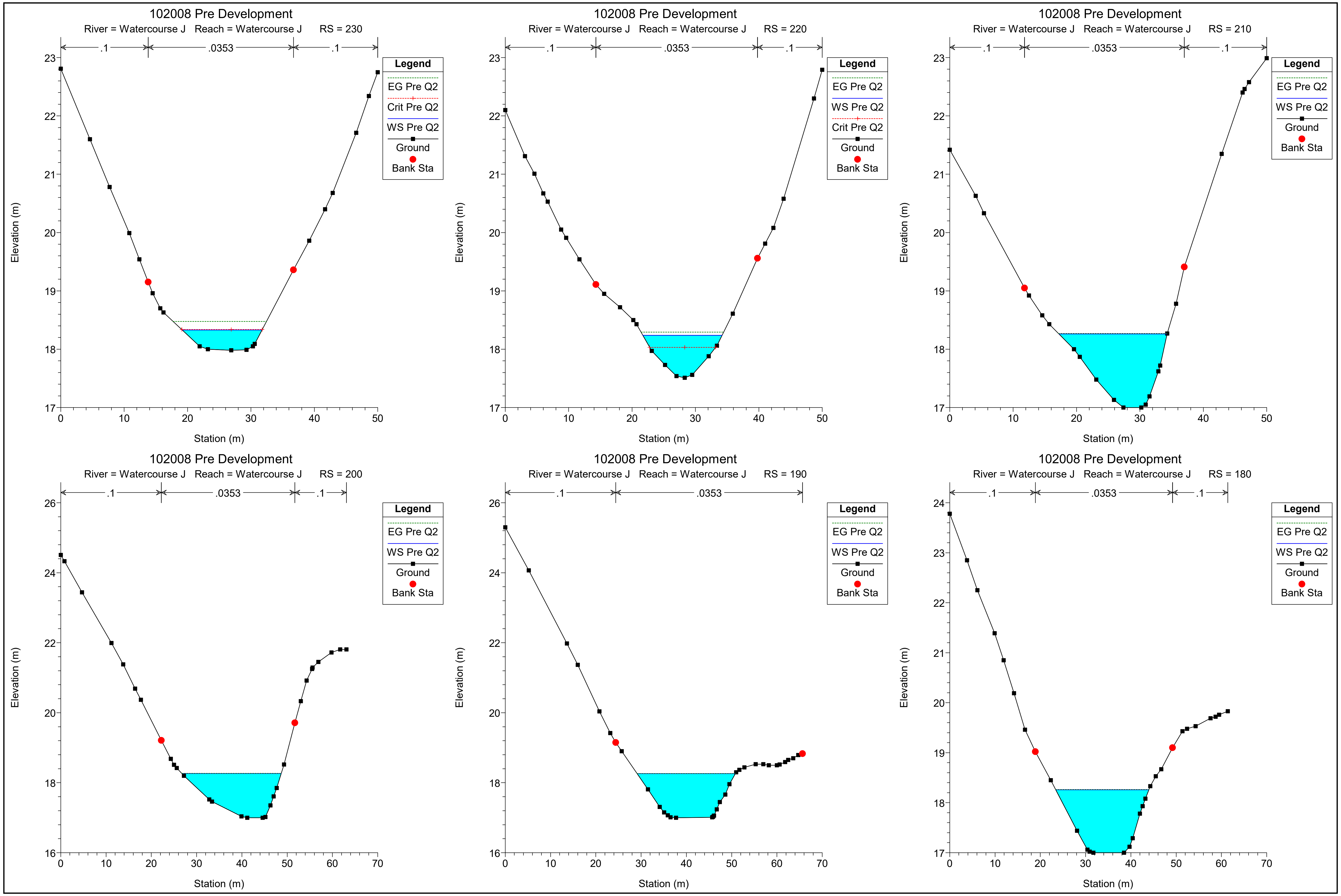

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 280
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

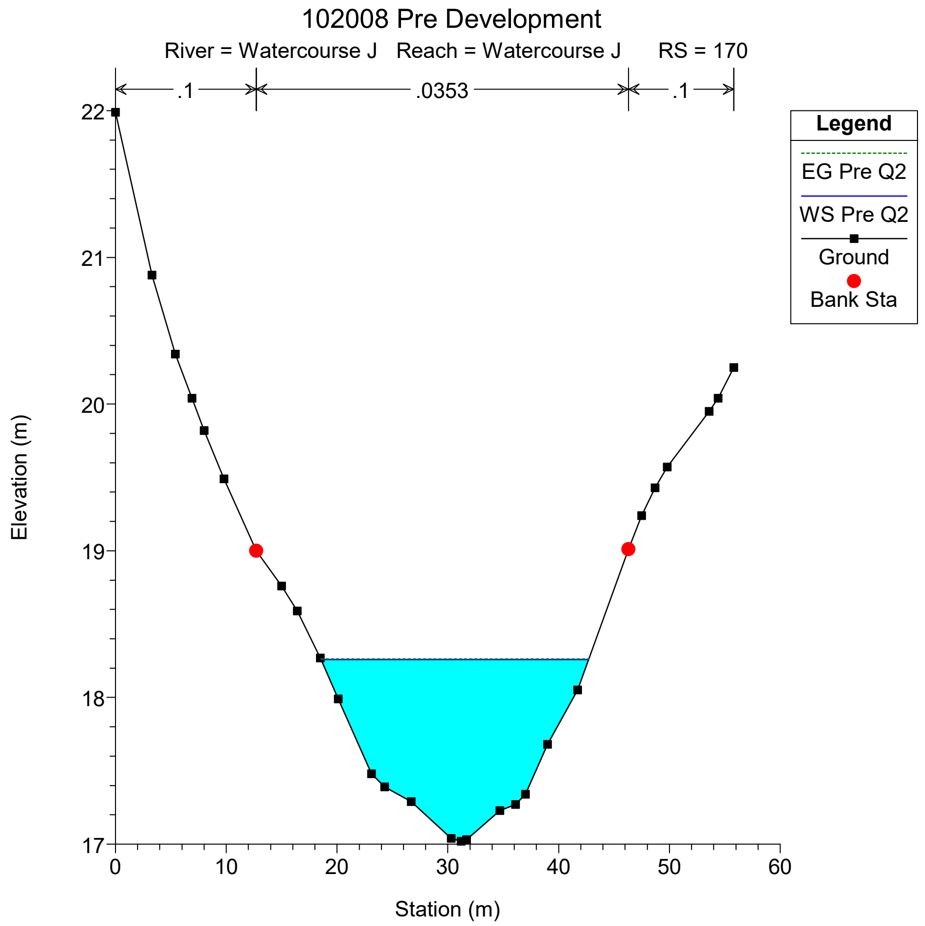

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 270
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

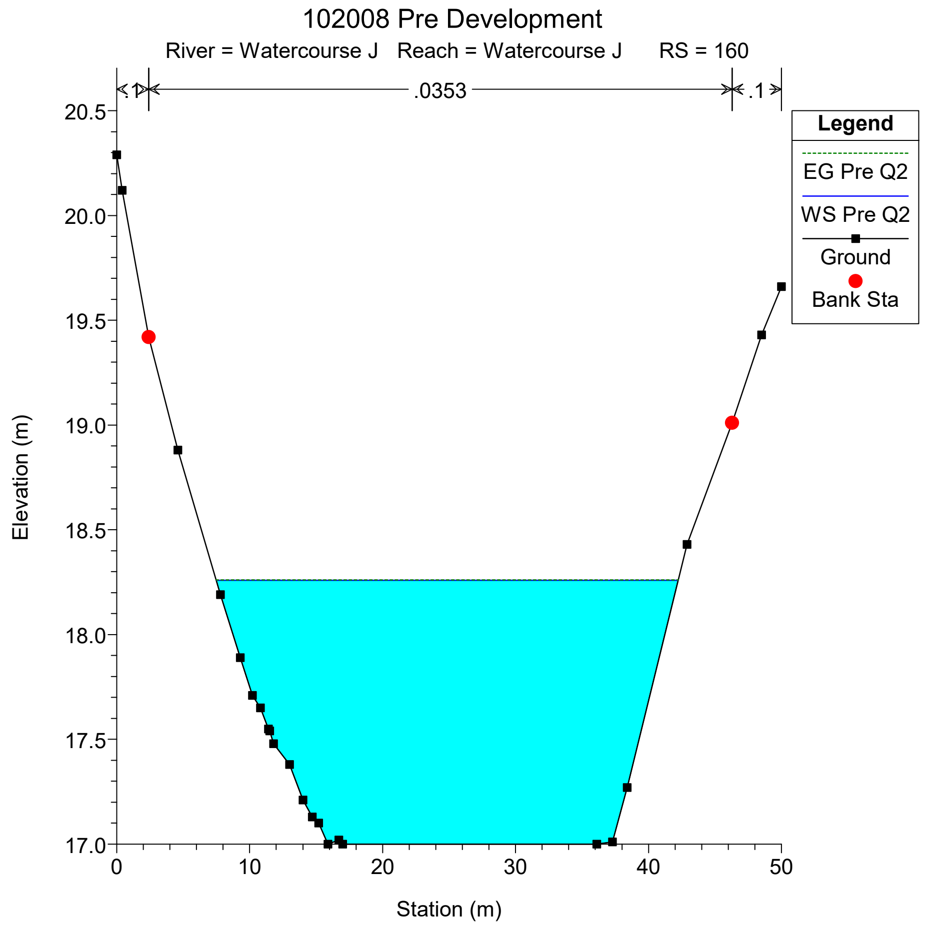

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 260
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

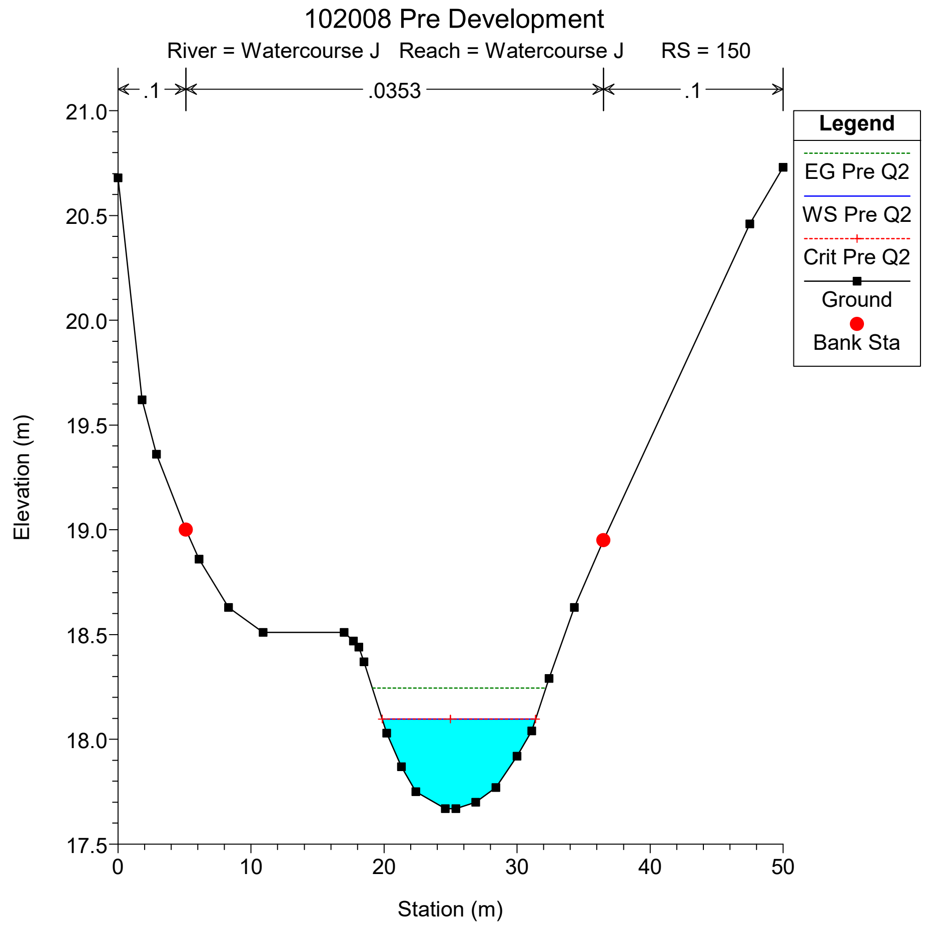

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 250
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

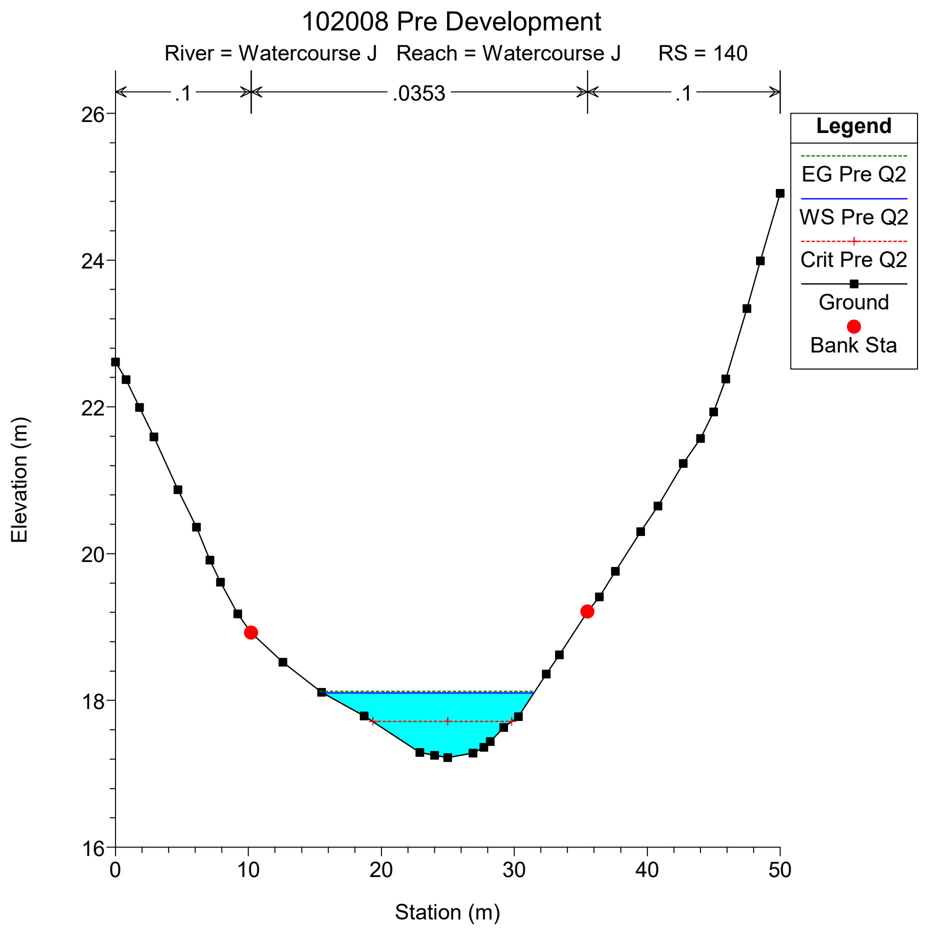

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 240
.1
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

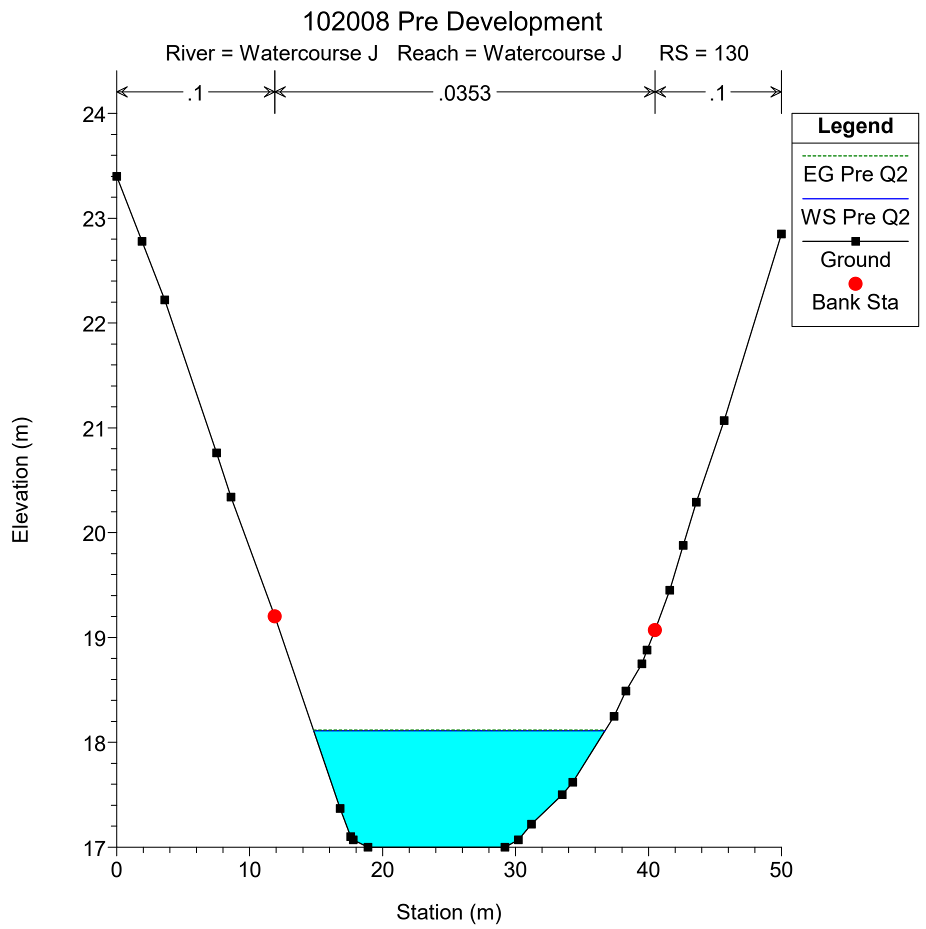

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 230
.1 .0353 .1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 220
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 210
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 200
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 190
.1 .0353
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 180
.1 .0353 .1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

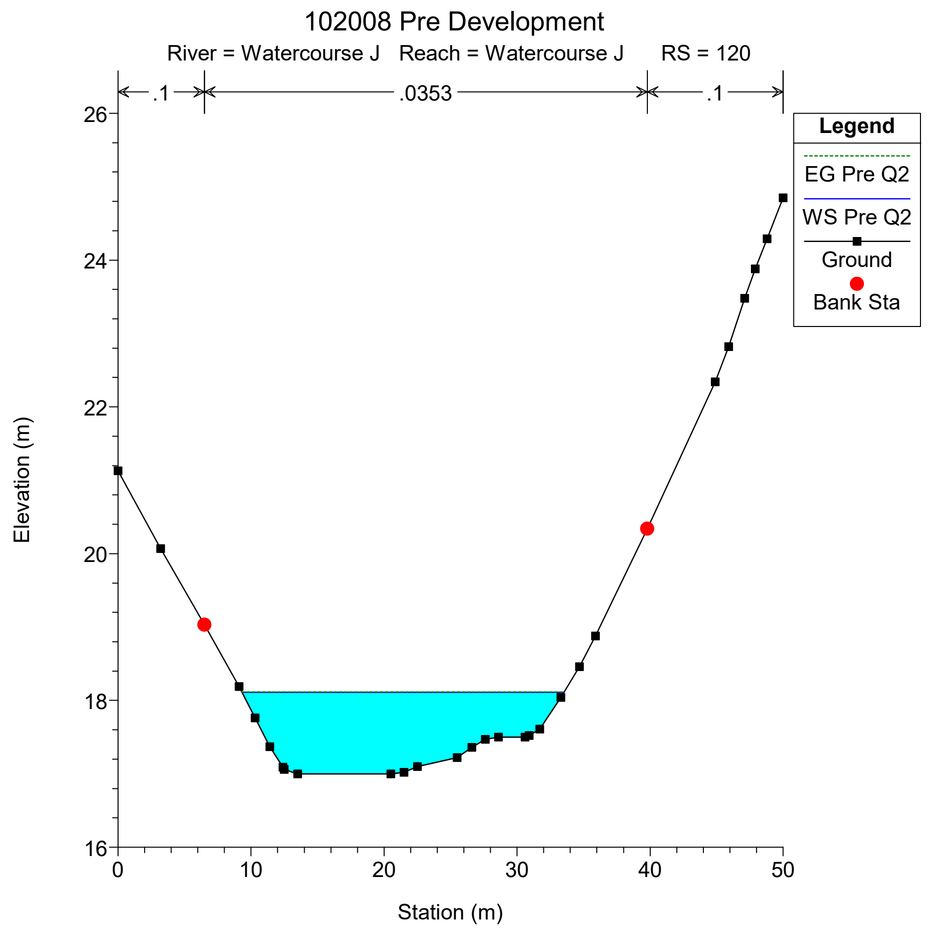

102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 170
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
22
21
20
19
18
17
0
10
20
30
40
50
60


102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 160
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
20.5
20.0
19.5
19.0
18.5
18.0
17.5
17.0
0
10
20
30
40
50


102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 150
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
21.0
20.5
20.0
19.5
19.0
18.5
18.0
17.5
0
10
20
30
40
50


102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 140
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
26
24
22
20
18
16
0
10
20
30
40
50


102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 130
.1
.0353
.1
Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
24
23
22
21
20
19
18
17
0
10
20
30
40
50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.1
.0353
.1
Legend
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WS Pre Q2
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Station (m)
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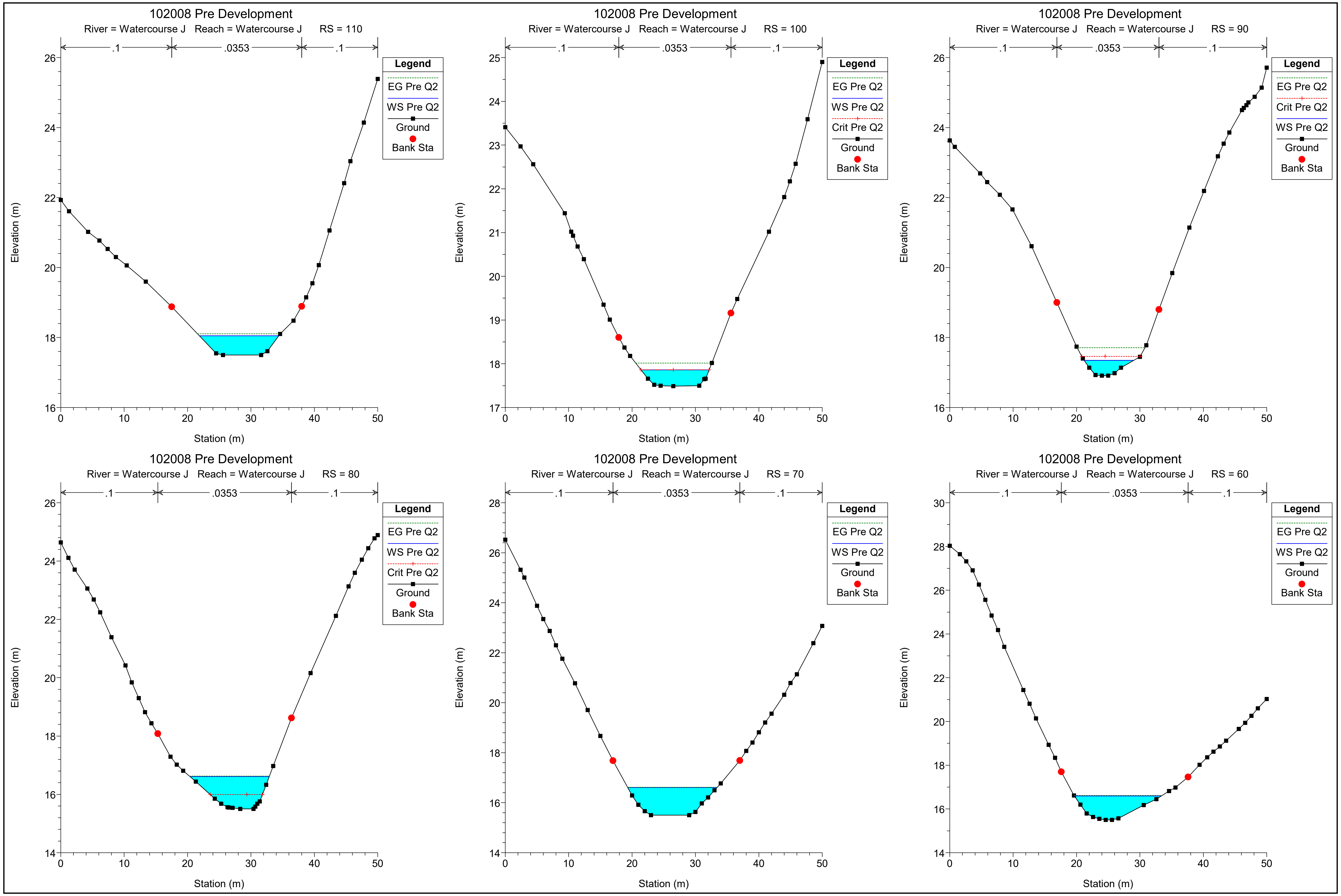
24
22
20
18
16
0
10
20
30
40
50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WS Pre Q2
Crit Pre Q2
Ground
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Elevation (m)
Station (m)
102008 Pre Development
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Legend
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Crit Pre Q2
WS Pre Q2
Ground
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Elevation (m)
Station (m)
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EG Pre Q2
WS Pre Q2
Crit Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
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Legend
EG Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)
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WS Pre Q2
Ground
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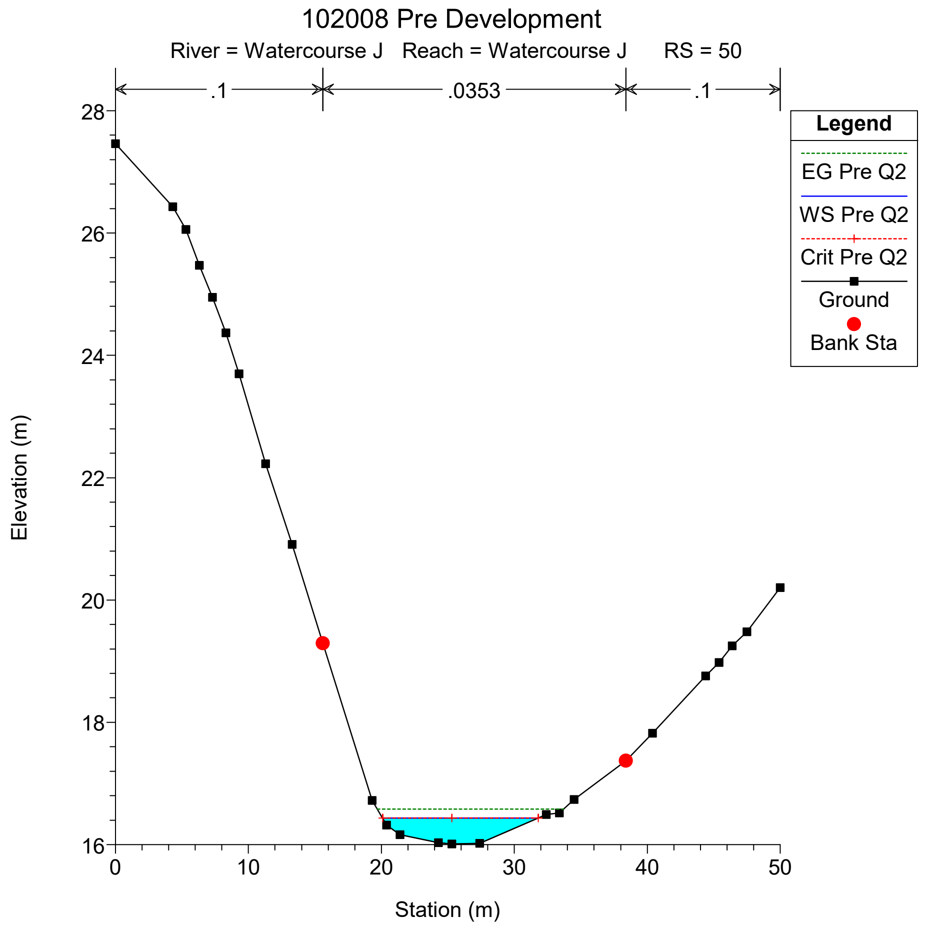
Station (m)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WS Pre Q2
Crit Pre Q2
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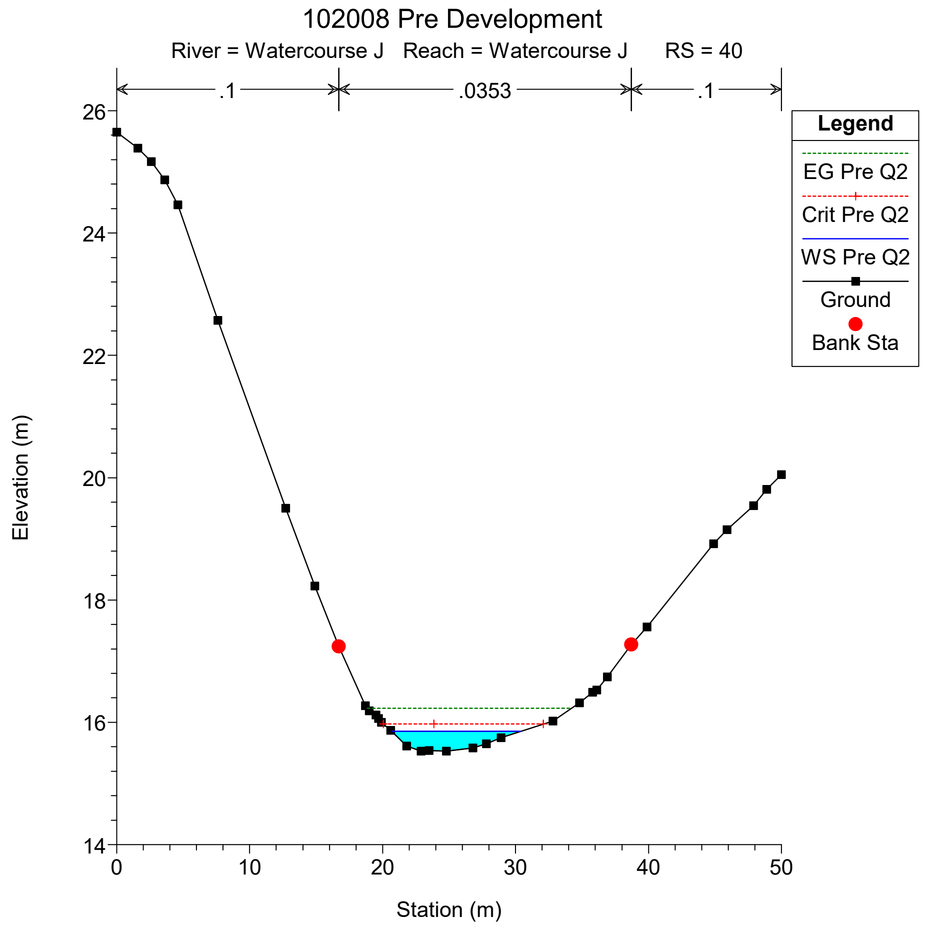
Elevation (m)
Station (m)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Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
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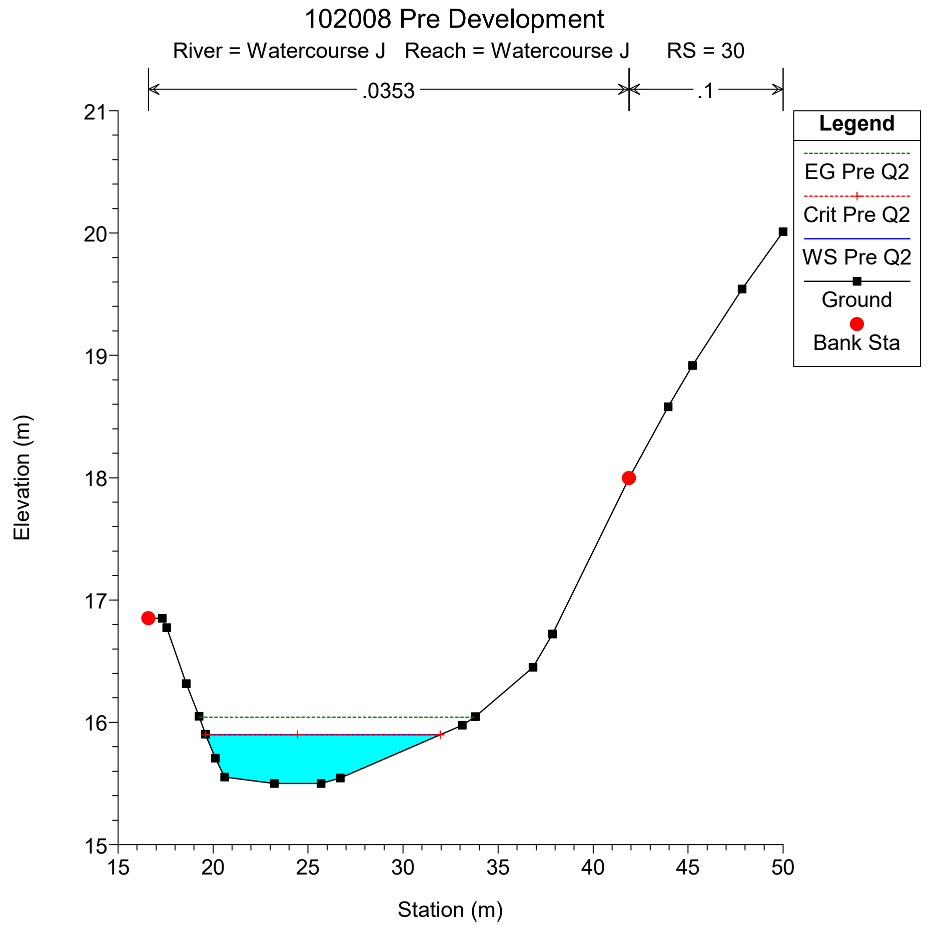
Elevation (m)
Station (m)


102008 Pre Development
River = Watercourse J Reach = Watercourse J RS = 30
.0353
.1
Legend
EG Pre Q2
Crit Pre Q2
WS Pre Q2
Ground
Bank Sta
Elevation (m)
Station (m)

ATTACHMENT H1

STORMWATER MANAGEMENT PLAN BY MAVEN (revised post notification)

CONTENTS

APPENDICES

LIST OF FIGURES:

LIST OF TABLES:

1 STORMWATER MANAGEMENT PLAN - OVERVIEW

The purpose of this Stormwater Management Plan (SMP) is to outline the proposed management of stormwater for the Warkworth North 2 Plan Change Area (PCA), located north of Warkworth. The PCA is contained within the Future Urban Zone of the Auckland Unitary Plan – Operative in Part ('AUP – OP'), the zone which is identifiable in yellow within Figure 1 below (PCA outlined in red). The site is subject to both public and private plan change; the public plan change encompasses the greater Warkworth areas change from future urban to urban zoning, while the proposed private plan change details the subject site providing a higher yield of residential properties considered necessary to make the development economically and financially viable.

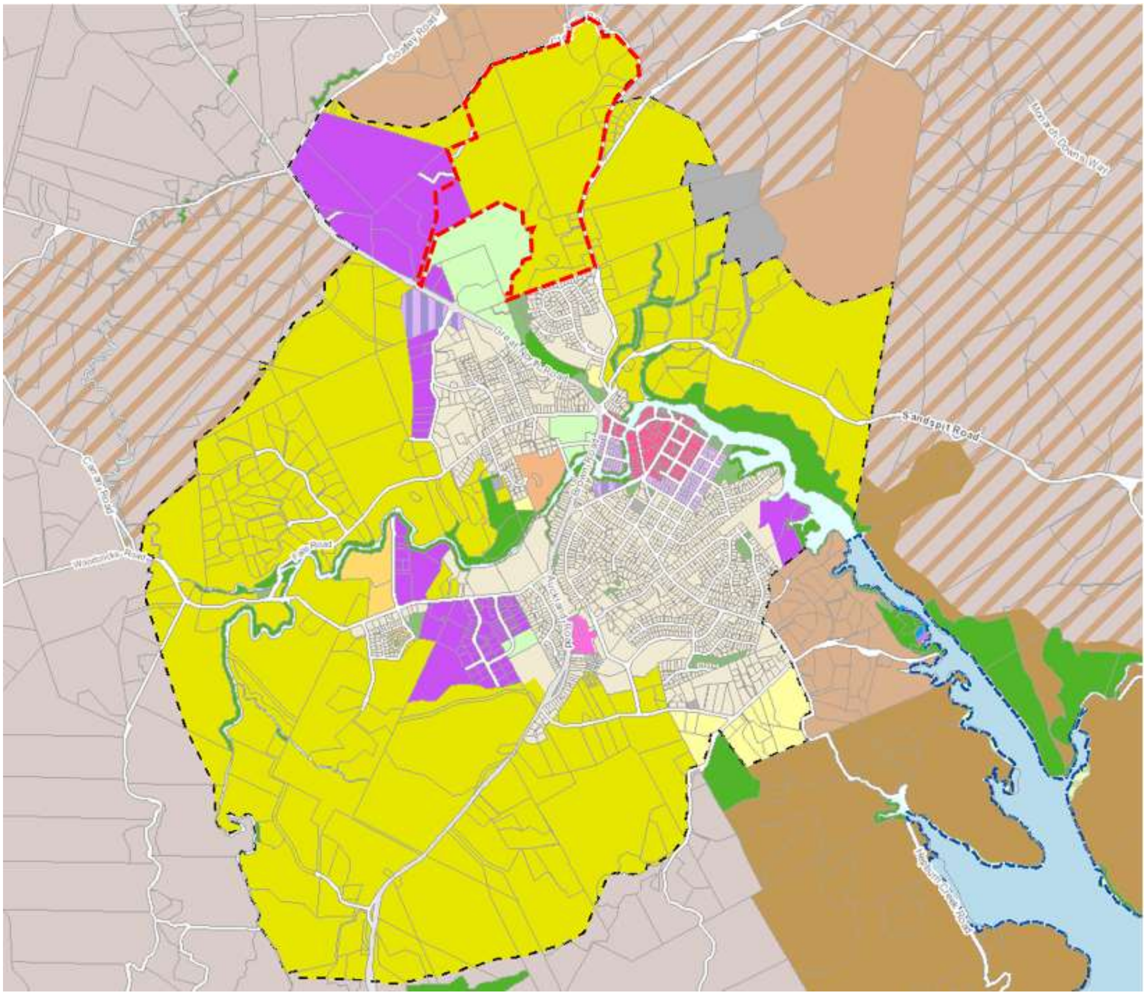


Figure 1: 2019 Warkworth Future Urban Zoning

The proposed Auckland Council public structure plan zoning plan change was accompanied by a "Preliminary SMP" completed by Tonkin Taylor (2018). This report has been reviewed and the proposed outcomes, opportunities and effects adopted or further detailed where necessary specifically for the proposed development within the subject site.

The purpose of this SMP is to ensure that the receiving environment is protected and enhanced as it undergoes change from the current rural environment to an urban form. The outcomes of this SMP will ultimately be adopted under the Auckland-Wide Network Discharge Consent (AWNDC) and also guide any forthcoming Resource Consent ('RC') application. The plan generally provides a standard framework consistent with the Auckland Region but ultimately stormwater design layouts are noted as best achieved by the developer based on their development proposals and site-specific constraints.

The strategy for the stormwater management is outcome focused. The stormwater management plan provides a solution-based approach for the receiving environment. The plan sets up a clear process to mitigate the effects on the receiving environment, which consists of the Waitemata harbour, Mahurangi River and upstream unnamed tributaries.

Detention management forms a key part of the mitigation proposed for the receiving environment. Detention forms the main solution for mitigation of erosion and inundation during storm events.

The management plan also requires – where possible – the use of retention and detention through the development. Water sensitive design is a driving component of the management plan, with such elements guiding stormwater management within both public spaces and development lots.

1.1 STAGING, TIMING, RESPONSIBILITY AND FUNDING

1.1.1 TIMING

The development of the properties within the PCA will be undertaken over several years, depending largely on the demand for residential land in the Warkworth area. However, the first stage is to be progressed in the next construction season (2020/2021) in the construction of infrastructure required to support future urban zoning. These works consist of Watercare Services Ltd projects currently underway including wastewater and water supply network improvements and upgrades and finally the Matakana link road being constructed through the subject site by Auckland Transport in coordination with the NZTA and the NX2 project.

1.1.2 COSTS, FUNDING AND VESTING OF ASSETS

The development and construction of the stormwater management devices will be undertaken by the relevant property owners of the PCA. The stormwater infrastructure will be developed as per the stormwater strategy which includes piped networks, water quality devices and at-source propriety devices where required.

Public assets will be vested to council at the appropriate time as the development progresses. Discussions will be undertaken with council as to the design of the infrastructure, location and purpose, with all public infrastructure subject to future Resource consent and Engineering Plan Approval (“EPA”) processes.

1.1.3 DEPARTURES

CODE OF PRACTICE

There are no known departures from the Stormwater Code of Practice (“SWCOP”).

Please note, the upstream catchment has been assessed as undeveloped within the stormwater modelling. It is proposed that the outcomes of this SMP can guide development within other areas of the Warkworth Precinct, including the intention of stormwater management and mitigation within each development site / area. Given the Urban zoning, this approach is practical and appropriate.

AUP – OP

There are no known departures from the intention of the AUP – OP.

1.1.4 OPERATION, MAINTENANCE AND MONITORING PLAN

Operation and maintenance plans will be provided for all stormwater management devices that will be vested with Council. This will be required as a condition of all future resource consents.

2 CATCHMENT CONTEXT

The greater Warkworth area under assessment by Auckland Council is located within the lower Mahurangi River Catchment which is approximately 5,892ha in area and drains to the Mahurangi Harbour within the Hauraki Gulf. The Warkworth Structure Plan study area comprised of approximately 17% of the wider Mahurangi Catchment. The plan change area makes up 100 hectares or 1.7% of the greater catchment. Within the study area the topography is generally characterised as rolling to moderately sloping with elevations ranging from approximately 100m RL at its northern, western and southern extents to sea level around the existing urban area alongside the Mahurangi River.

The proposed Warkworth North 2 precinct is approximately 5km North (via State Highway 1) of the Warkworth township and about 65km from downtown Auckland City. The development site is currently accessible directly off SH1, Clayden Road (off Matakana Road) and will be accessible from a proposed road, referred to as the Matakana Link Road (MLR) that is to be constructed by Auckland Transport and the NZTA. The location in relation to the greater Auckland Region is illustrated in Figure 2, below.

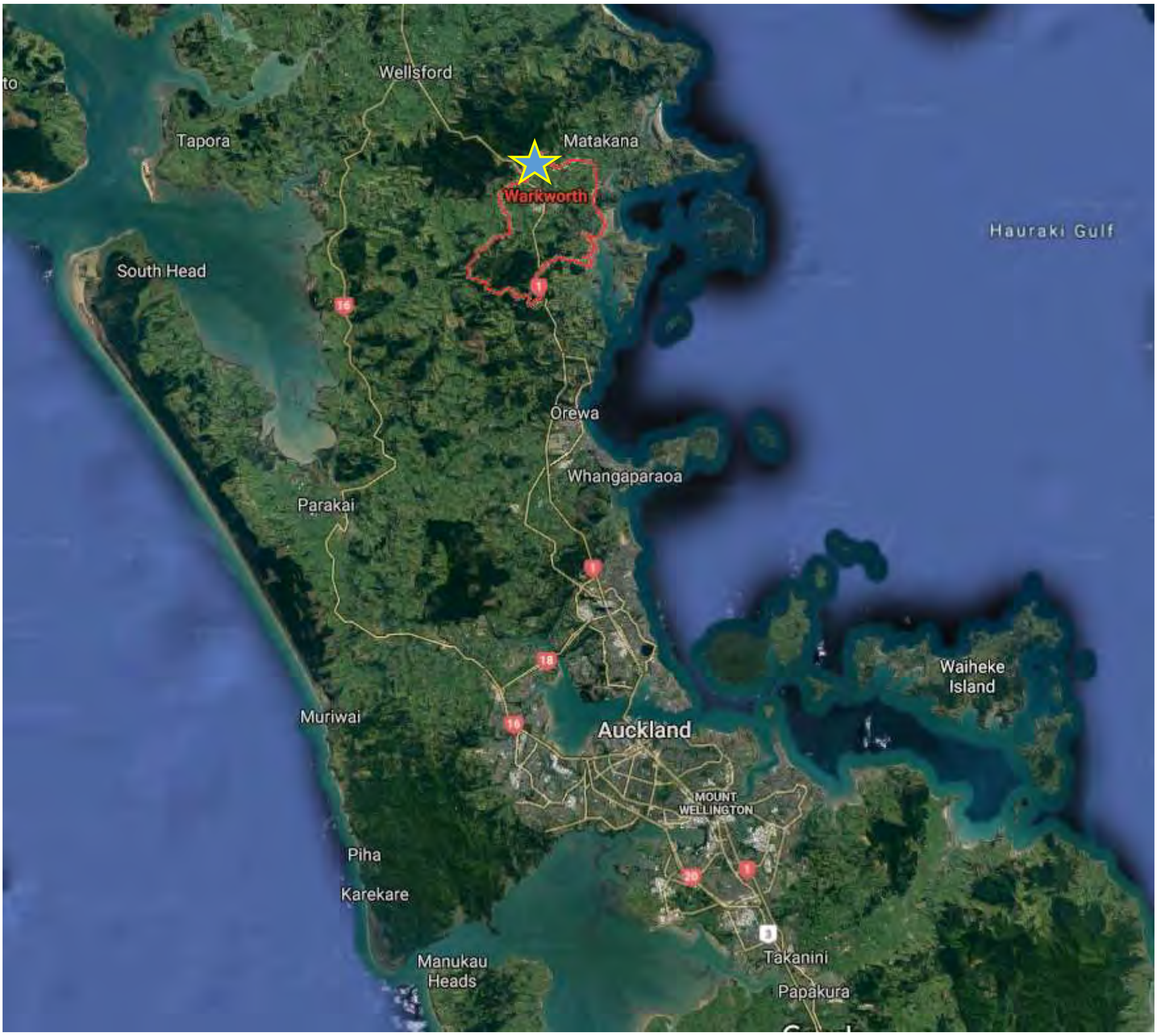


Figure 2: Warkworth North 2 Precinct Location (Star)

The majority of the plan change area (100ha) is zoned Future Urban under the AUP – OP. To date the is no official Stormwater Management plan for the area although a "Prelim SMP" has been prepared by Tonkin and Taylor in 2018 for and on behalf of Auckland Council in support of the proposed structure plan area of the greater Warkworth area.

The Prelim SMP provides the framework for stormwater management in the Warkworth Area. For the most part, the following report is aligned with the recommended approach to stormwater management and that all future development shall be in accordance with AUP(OP) and Stormwater specific guidance documents (e.g. GD01 and GD04)

2.1 CATCHMENT ASSESSMENT

2.1.1 LOCATION AND EXISTING CONDITIONS

The greater Warkworth Structure Plan Area is located within the lower Mahurangi River Catchment in the north of the Auckland Region. The Mahurangi River Catchment is approximately 5892 ha in area and drains to the Mahurangi Harbour within the Hauraki Gulf. In total, 100 ha of land is within the scope of this report and development. The total development site is bordered by State Highway and light industrial zoned property to the west – which is currently undeveloped and rural in nature, Goatley and Clayden Road to the North and the Warkworth Showgrounds to the south.

The catchment is undulating, with a predominant fall and gullies developing southwards. The catchment is currently used for agricultural purposes. The extent of the catchment is illustrated in Figure 2, below.

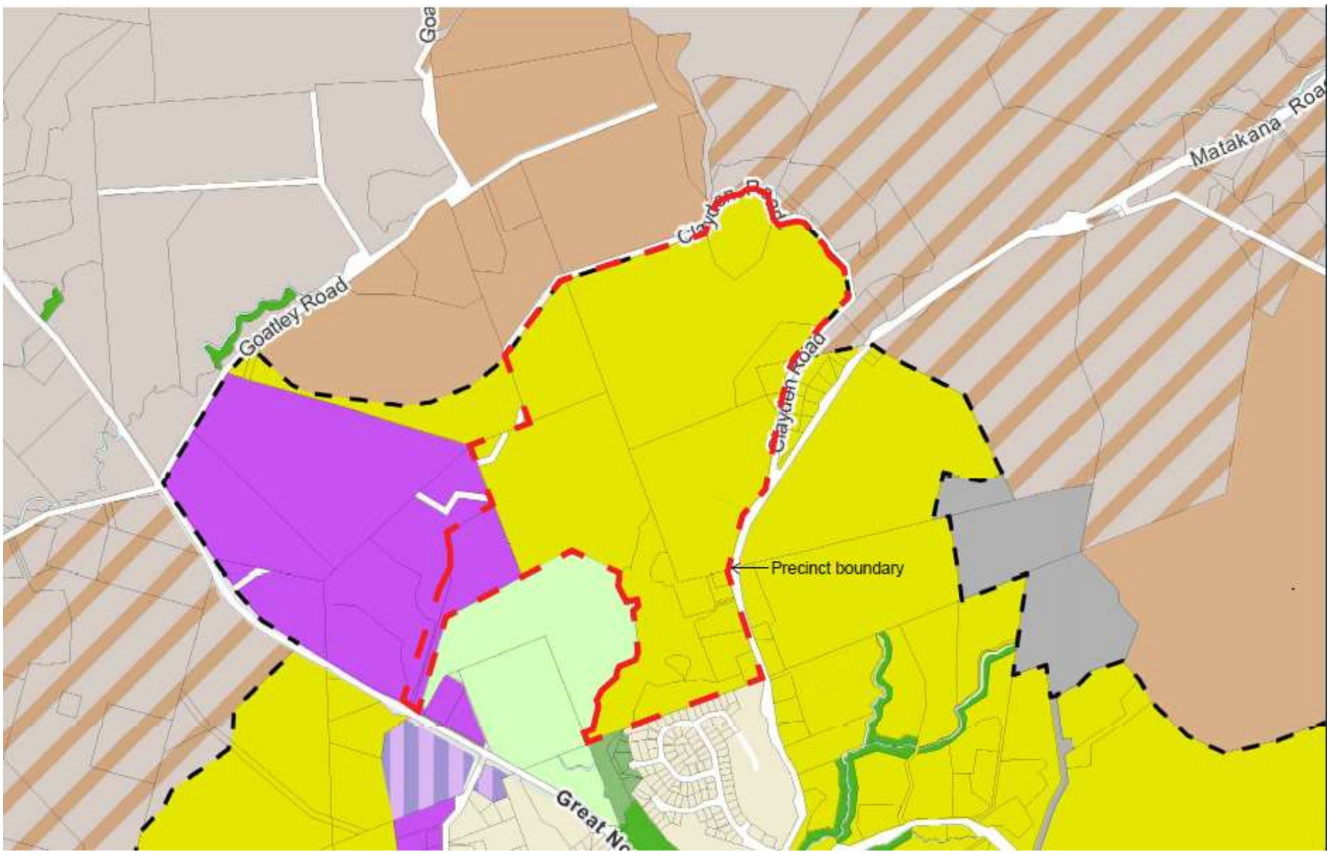


Figure 3: Extent of Plan Change Area (in red) (Source: AC GEOMAPS)

2.1.2 NATURAL FEATURES

Streams within the greater Warkworth precinct are all part of the Mahurangi River system. These streams vary from natural streams with good quality indigenous riparian vegetation to farm drains. The north and south branches of the Mahurangi River join at the intersection of Falls Road and Woodcocks Road and the river then travels west to east, bisecting the study area.

The removal of riparian vegetation, livestock access to waterways and pollution from agricultural runoff have all influenced water quality, as well as reduced habitat diversity and biodiversity. However, as the catchment currently has a low extent of impervious surfaces, a low degree of channel modification, and comparatively low pollution from stormwater and wastewater discharge, the water quality overall for the catchment is rated as "good" in Auckland Council's 2016 freshwater report card.

The Clayden Road site is currently a rural environment, an ecological assessment by Freshwater Solutions (2019) note the watercourses through the site are generally in poor condition representative of longstanding farming use, lack of Riparian planting or Fencing. The Warkworth Clayden Road Development is contained within the Mahurangi Stream catchment and ultimately discharges into the Mahurangi River Please refer to the pre-catchment plans appended within **Appendix A**.

An ecological / watercourse survey has been undertaken by Freshwater Solutions Limited[1]. A copy of the report, inclusive of stream classifications is provided within **Appendix B** to this Report. In summary, the Mahurangi Stream Tributaries catchment the site resides within commences to the north of Elizabeth Street – the main tributary, is identifiable as a permanent stream flow from the north, within the site there is a combination of ephemeral, intermittent and permanent streams. There is a manmade pond, and several artificial farm drains also within the catchment.

2.1.3 Soil conditions

Published Geological Maps and CMW Geosciences fieldwork indicate the proposed development site is predominantly underlain by Pakiri Formation of the Waitemata Group. This geological unit is widespread, of early Miocene age and occurs from the north of Hatfields Beach, west to the Kaipara Harbour and north to Mangawhai. Pakiri Formation is dominated by 10-30m thick, graded medium to coarse grained sandstones alternating with thinner, laminated, siltstones and finer sandstones. This material forms the steeper and more elevated slopes on the north and west part of the site and is generally regarded as competent material for subdivision purposes.

Portions on the southern end of the site are also shown to be underlain with Mahurangi Limestones of the Northland Allochthon. The Mahurangi Limestone is represented by blue-grey to white, muddy limestone and weathered clayey residual soils, which forms the less elevated, gently rolling hills towards the southern end of the site[2]. The soil is best described as poorly draining and are reflective of Category C soils for Auckland Council TP108 runoff calculations.

2.1.4 Hydrology

Freshwater Solutions have classified the watercourses onsite into ephemeral, intermittent and permanent streams. The appended stormwater report also contains a riparian margin assessment to preliminarily determine the extents of both riparian zones and esplanade reserves within the plan change area and Warkworth North 2 precinct.

---

[1] Freshwater Assessment, by Freshwater Solutions Limited, 2019

[2] AKL2018-0228AC Rev 1 by CMW Geosciences, 2019

There are several major and minor overland flow paths ("OLFPs") that originate within or pass through the PCA. These OLFPs represent the natural gullies and low lying areas. The greater, or 'significant' OLFPs are identified within Auckland Council's Geomaps, as illustrated in Figure 4, below.

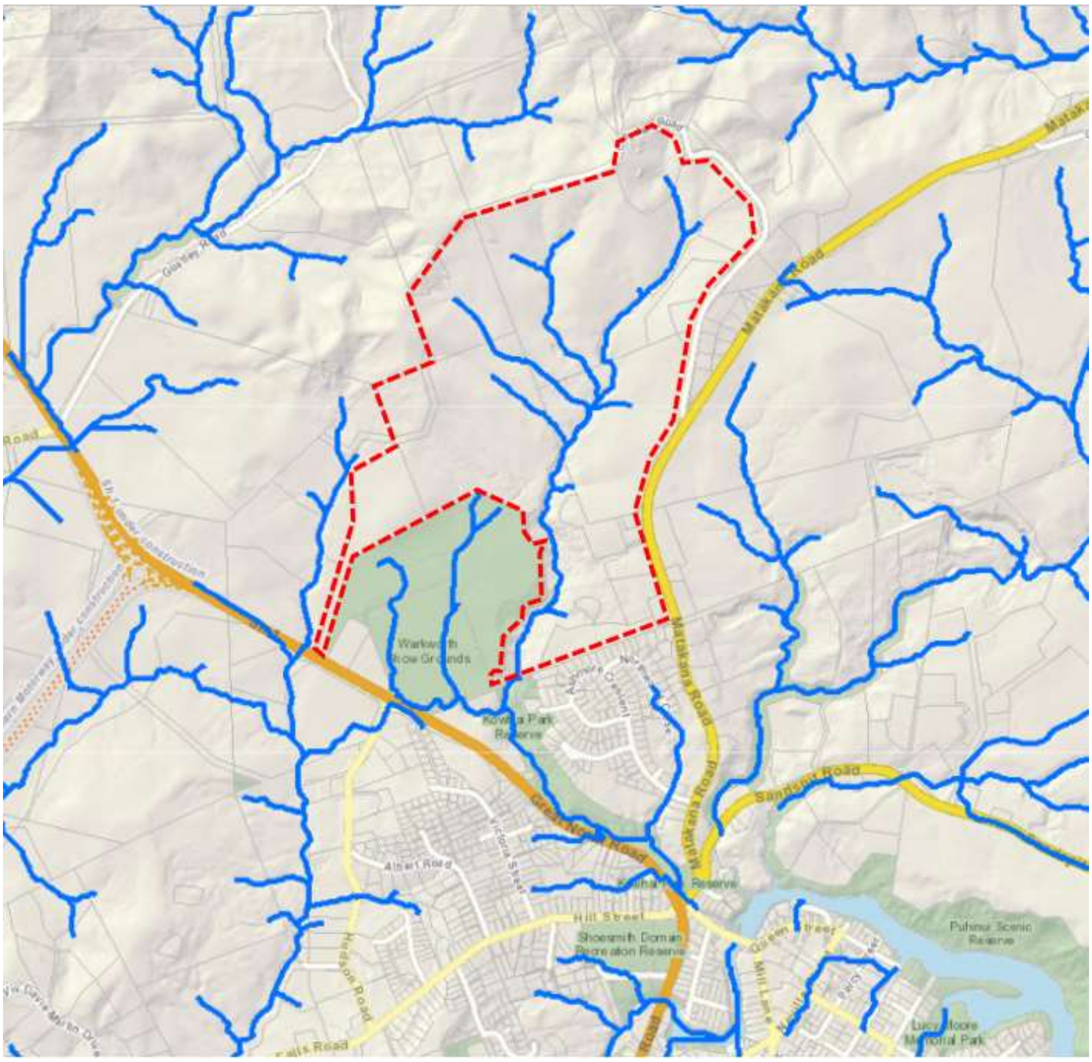


Figure 4: Overland Flow Paths and Streams (Source: AC GEOMAPS)

The overland flow paths and flows under both existing and fully developed catchment conditions have been modelled in support of the Warkworth North 2 precinct plan change application. Full details of the 1% flow modelling are contained within the Maven Associates report titled "HEC -HMS Modelling Report, Warkworth North 2, Warkworth" dated Oct 2019.

Hydrological mitigation

Constraints

- The presence of low permeability ultic clays in the structure plan area may preclude the use of infiltration devices in some areas.
- The viability of water reuse as a stormwater management tool is contingent on land use activity and will need to be assessed on a site by site basis.

Opportunities

- The structure plan area is a greenfield site which provides an opportunity to incorporate integrated stormwater management to maintain pre-development hydrology.

- Providing opportunity for on-site infiltration to improve aquifer recharge and stream baseflows.
- Providing opportunities for water reuse especially for housing and for industrial/commercial activities (depending on water demand).

For ease of referencing within the SMP, the existing OLFPs have been named, as per Freshwater Solutions watercourse plan below.

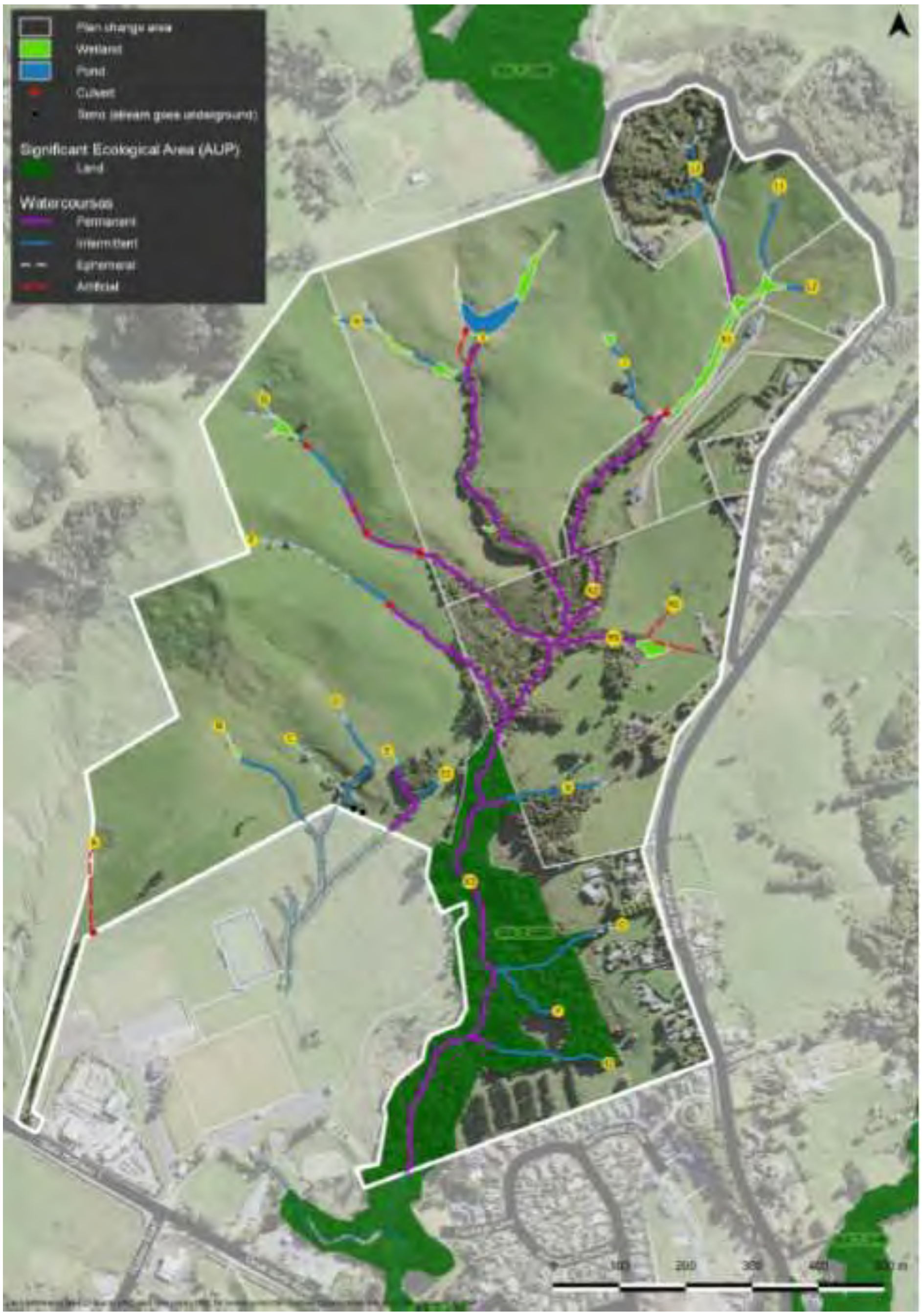


Figure 5: Freshwater Solutions Watercourse Plan (Source: Freshwater Solutions)

Auckland Council's Mahurangi Catchment model has been used to determine the extent of the 100 year floodplain. In the Warkworth study area the 100 year floodplain will act as a constraint for development as generally buildings and infrastructure should not be located within the floodplain. However, the floodplain as a development constraint may overlap with the requirement for protecting permanent and intermittent streams as well as protecting areas of existing riparian vegetation which is prominent along the Mahurangi River.

Identifying and integrating stormwater constraints and opportunities and infrastructure needs for the intended land use is an integral part of the structure plan process. The following stormwater constraints and opportunities for the study area have been identified:

- Upstream development may increase the flood risk to existing buildings in Warkworth. If this is found to be the case, then catchment scale attenuation devices may be required to avoid increasing flooding to habitable floors.
- Any new development should occur outside of the 100 year floodplain.
- Allow for conveyance of overland flow.

Opportunities

- Protection of 100 year floodplain also provides an opportunity to enhance riparian corridors. This provides enhanced stormwater management functions, contributes to the ecological values of stream corridors and provides public amenity. Green corridors should be considered to manage the flood hazard, protect ecological values, provide amenity and for walking and cycling tracks.

2.2 RECEIVING ENVIRONMENT

The ultimate receiving environment is the Coastal Marine Area ('CMA') of the Mahurangi Harbour within the Haruaki Gulf, which is fed by the Mahurangi River and upper tributary streams – one of (at least) which originates and flows through the PCA.

An area of significance immediately downstream of the Warkworth showgrounds and 245 Matakana Road property, of which the the Mahurangi stream tributary traverses is an allotment of land forming part of a QEII trust and is designated as a special ecological area. See Figure 5a below for reference:

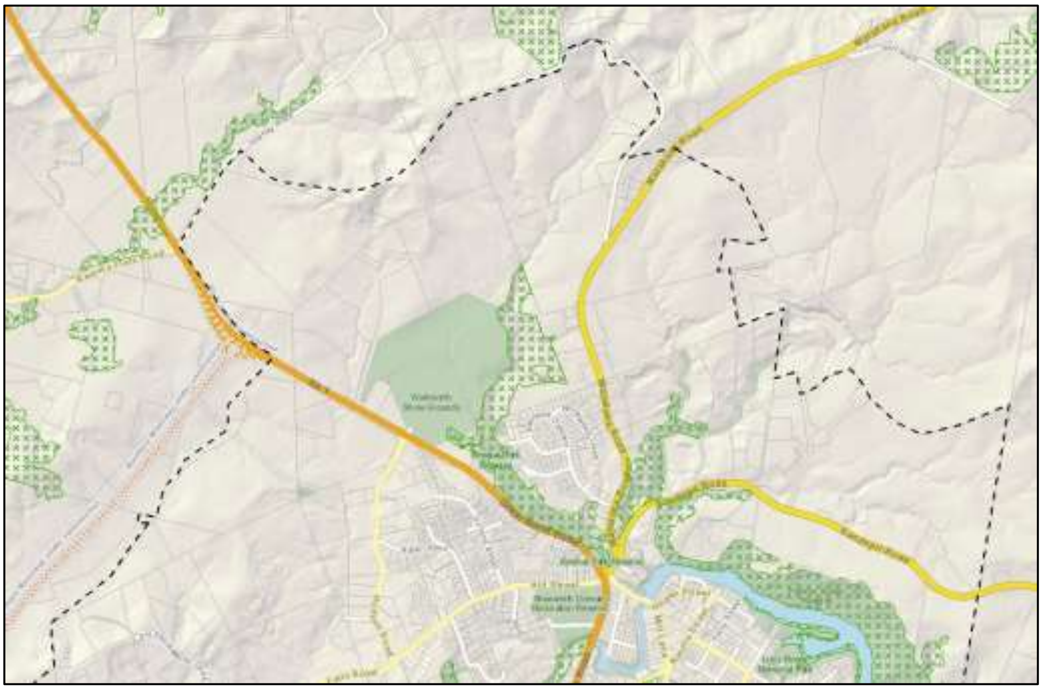


Figure 6: GEOMAPS S.E.A Overlay Overview (Source: AC GEOMAPS)

3 TOPOGRAPHY AND CATCHMENT ANALYSIS

3.1 TOPOGRAPHY AND CATCHMENT BOUNDARIES

The 100ha Warkworth North 2 Precinct site and surrounding catchment area features a moderate slope towards the south, south-east and south-west. A series of ridgelines to the north of the site and catchment delineate the upper catchment extent before defined gullies collect overland flow as seen in figure 7 below, extracted from Auckland Council GEOMAPS.

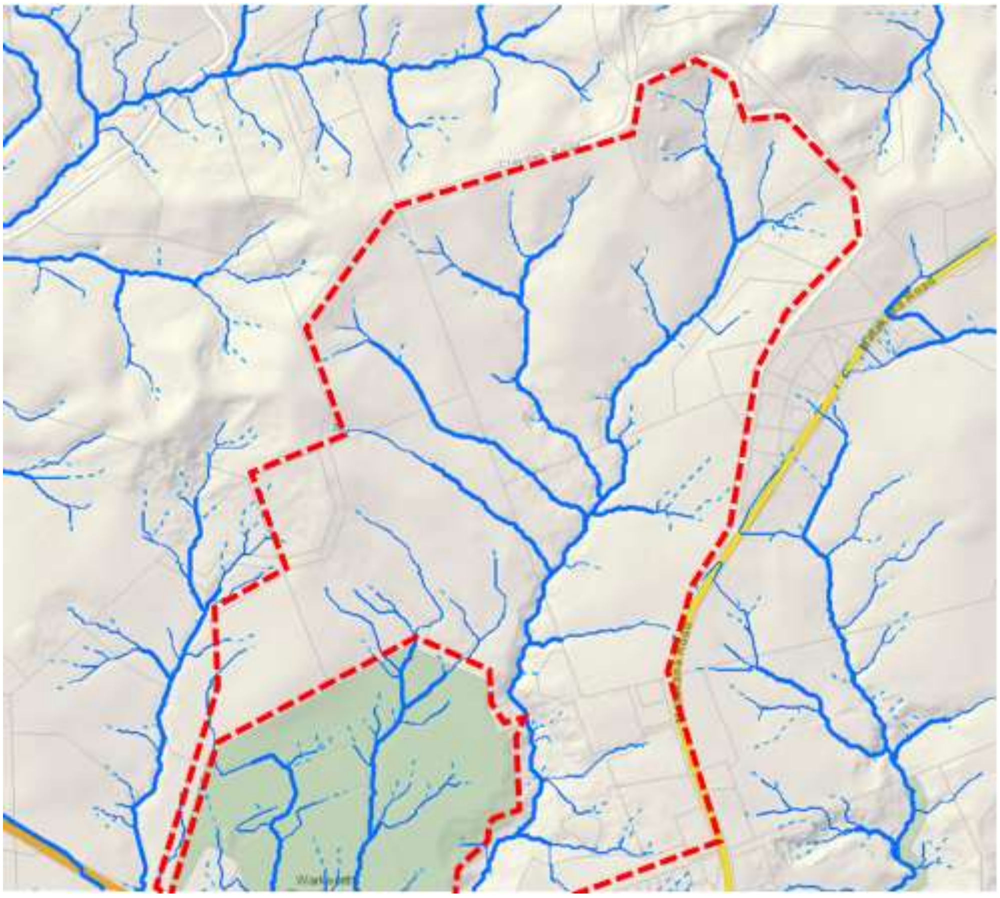


Figure 7: Existing OLFP (Source: AC GEOMAPS)

A series of ridgelines running north-south generally north of the Warkworth showgrounds diverts flows into 3 main catchments considered within this plan. Catchments of the subject and neighbouring properties can be found defined within figure 8 and summarised below:

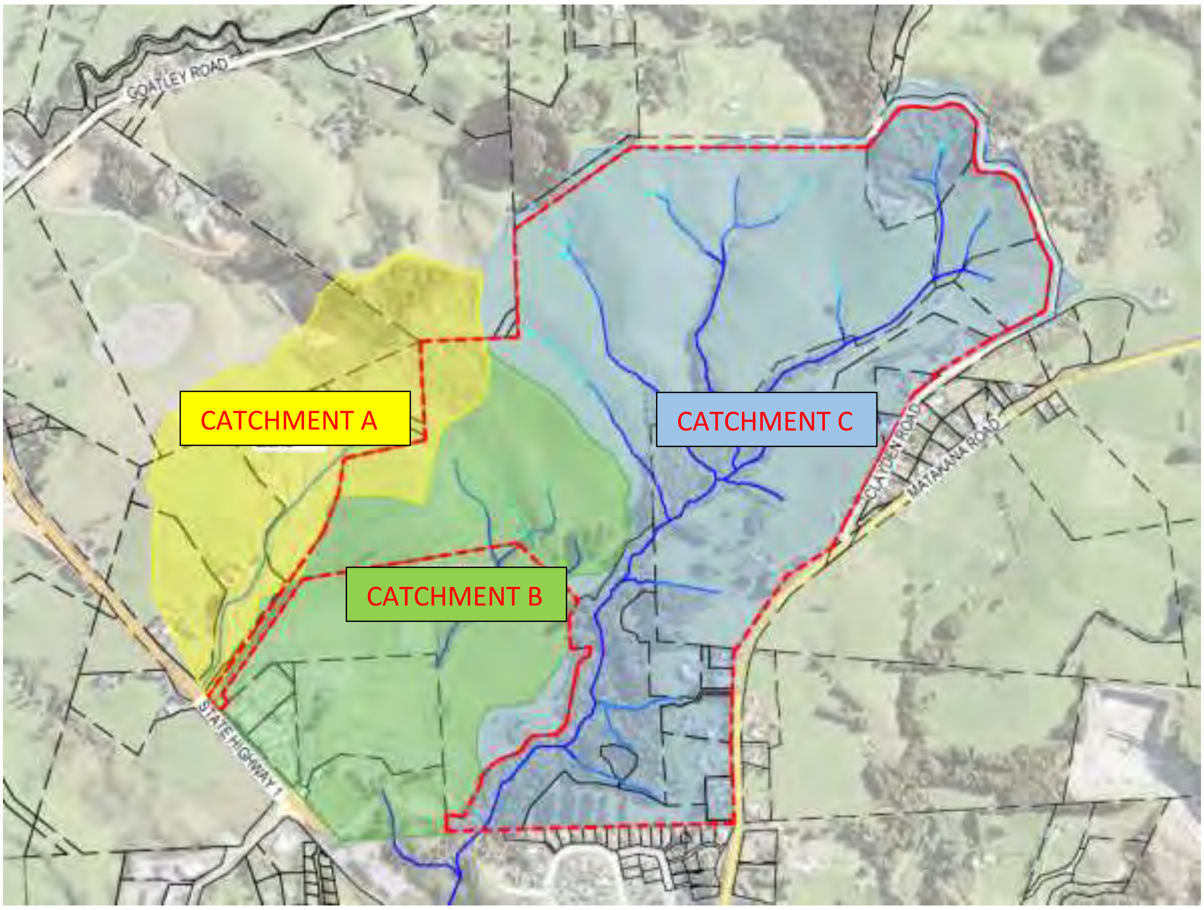


Figure 8: Existing Catchment Extents (Source: Maven)

Catchment A – Highlighted yellow in figure 8 above. The western-most catchment discharges to the neighbouring properties adjacent to the PCA, flows are collected in an intermittent to permanent watercourse outside of the PCA and are collected by a culvert crossing State Highway 1. Flow then traverse an extended series watercourse to the South- South West of the PCA and ultimately discharge to the Mahurangi Stream.

Figure 9: Catchment A Downstream Flow (Source: AC GEOMAPS)

Catchment B – A catchment located north of the Warkworth showgrounds, collecting sheet flows from the PCA above the showgrounds as well as a series of ephemeral and intermittent streams converging with two watercourses at the boundary of the PCA and combine into a single watercourse downstream of the PCA within the showgrounds. The watercourse appears to then be piped under sports fields and discharge back into the main watercourse of Catchment C, immediately downstream of the PCA.

Figure 10: Catchment B Downstream Flow (Source: AC GEOMAPS)

Catchment C – The largest and main catchment of the plan change area. Discharging to the main tributary within the PCA flowing south, being flowing adjacent to State Highway 1 and crossing a culvert at Hill Street and discharging to the Mahurangi Stream.

Figure 11: Catchment C Overland Flow & Collecting Stream (Source: AC GEOMAPS)

3.2 Existing Catchment Flows

A development model has been completed to establish the effects of the PCA and Warkworth North 2 Precinct.

An overview of the catchment hydrological and hydraulic model inputs, is as follows:

- On-site investigation of flow paths
- Flows of both 10yrcc and 100yrcc (including Climate Change) catchments determined in TP108 or HEC-HMS as required.

The model setup is derived from the following characteristics / assumptions:

Table 1: Pre Development Catchment Area Summary

PRE-DEV	AREA (Ha)
Catchment A	28.54
Catchment B	41.06
Catchment C	88.54

- Catchment characteristics as per Auckland Council TP108 parameters.
  - Pre-development CN = 74
    (Based on recommendation from CMW Geosciences on the soil types found during investigation, see Memo appended)

- Rainfall application
  - Site specific rainfall depth have been derived using AC-TP108 maps.
  - Climate change has been applied in accordance with Auckland Council SWCoP, allowance for climate change effects in accordance with Table 5.2 of Climate Change Effects and Impact Assessment: A Guidance Manual for Local Government in New Zealand (Ministry for the Environment, 2008), using a temperature increase of 2.1 degrees by 2090. As per Table 4.1 below extracted from the Auckland Council Stormwater Code of Practice v2.0.

- Table 4.1: Percentage Increase in 24-hour Design Rainfall Depth

Annual Exceedance Probability (AEP)	Percentage Increase in 24-Hour Design Rainfall Depth Due to Future Climate Change*
50%	9.0%
20%	11.3%
10%	13.2%
5%	15.1%
2%	16.8%
1%	16.8%

* assuming 2.1°C increase in temperature

Table 2: Rainfall Depth

Rainfall Depth	TP108	TP108 + CC
10% AEP (10YR)	210	237.7
1% AEP (100YR)	310	362.1

The below flows have been modelled in HEC-HMS and TP108, pre-development catchment plans can be found appended for reference. See below modelled peak flows at each of the existing watercourses that convey accumulated runoff - as there is no existing stormwater drainage infrastructure.

TABLE 3: PRE-DEVELOPMENT 10YR AND 100YR PEAK FLOWS

PRE-DEV	Q_{10} (m^3/s)	Q_{100} (m^3/s)
Catchment A	5.274	8.847
Catchment B	7.760	12.729
Catchment C	11.342	18.664

3.3 EXISTING PCA CATCHMENT FLOWS

A summary of flows generated from within and upstream of the PCA can be found below in addition to the above, as Catchment A and B consist of significant areas outside of the proposed precinct extents. These flows or catchment areas shall form the basis of determining the 'pre-development' scenario for which any attenuation requirement is based in post development modelling.

The existing catchment plans note sub-catchments for which the below relate:

TABLE 4: PRE-DEVELOPMENT CATCHMENT AREA SUMMARY (PCA CATCHMENT)

PRE-DEV	AREA (Ha)
PCA Catchment A1	3.55
PCA Catchment B1	14.97
PCA Catchment C	88.54

TABLE 5: PRE-DEVELOPMENT PEAK FLOW (PCA CATCHMENT)

PRE-DEV	Q_{10} (m^3/s)	Q_{100} (m^3/s)
Catchment A1	0.910	1.519
Catchment B2	2.829	4.641
Catchment C	11.342	18.664

**Note Catchment C unchanged.*

3.4 FLOODING

The developable portions of Warkworth North 2 precinct and plan change area lay outside of any 1% AEP floodplain, this is likely due to the elevation difference across the site, overland flow paths following the natural gullies and, aside from a manmade pond, there being little upstream catchment or storage. Selected watercourses are to be maintained through the development and provide primary flow paths for the developed area to discharge into.

The existing SEA is noted as the only area that appears to be subject to any flooding, this is likely due to the lesser gradients as opposed to the upper reaches and the nature of the existing watercourse slowing flow velocity.

The secondary OLFPs within the proposed development will be contained within road reserves and right of ways and will convey overland flows to the existing or reclaimed watercourses within the site. In selected locations drainage reserves may be required to convey flow form the road across blocks of residential land to watercourses.

Auckland Council Rapid Flood Hazard assessment maps (Figure 12) concur with the conclusion that there is no major flooding outside of the well-defined watercourses of the subject site (outlined in yellow within Figure 12) or directly downstream of the site.

Figure 12: Warkworth North East Rapid Flood Hazard Assessment Map (Source: Auckland Council)

This mapping does identify however the existing downstream flooding issues well documented in various other reports to date, extracts of these areas around the town center of particular interest can be found below:

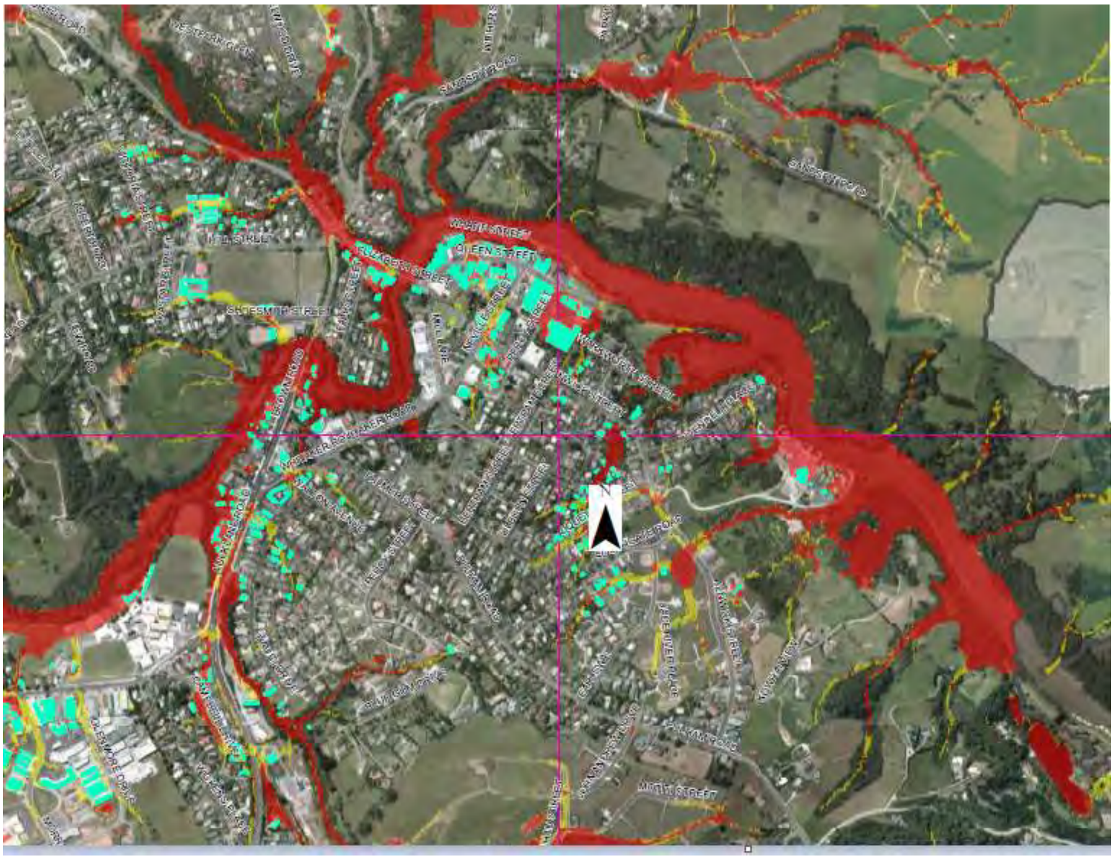


Figure 13: Warkworth Town Center Rapid Flood Hazard Assessment Map (Source: Auckland Council)

3.5 ECOLOGICAL FEATURES

An ecological assessment has been undertaken for the catchment by Freshwater Solutions Environmental Consultants, a copy of which is appended (**Appendix B**). This has identified ephemeral, intermittent and permanent stretches of streams within the Clayden Road site. The permanent reaches are largely contained within the primary tributary of the site. The streams vary in length, quality and status.

Freshwater Solutions have identified that these streams have been affected as part of the historical farming practices. The freshwater habitat is best described as degraded and of low ecological value. Although there are small pockets of native trees in riparian zones that retain value and have potential to be maintained.

The streams and classifications are illustrated in Figure 14, below. Please refer to the Freshwater Solutions report for further detail, within **Appendix B**.

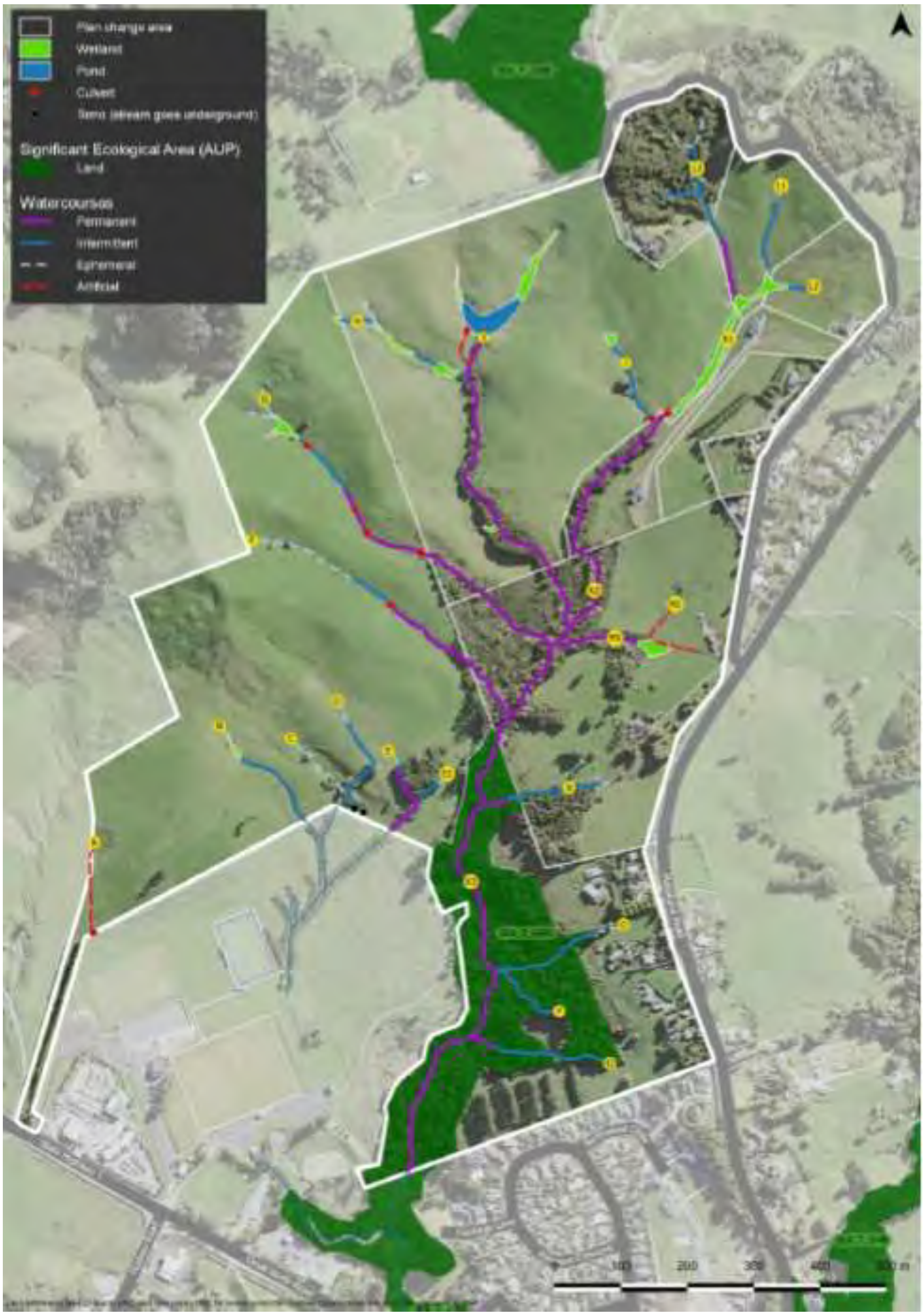


Figure 14: Watercourses within the PCA (Source: Freshwater Solutions)

Opportunities to enhance freshwater systems:

Constraints:

- Permanent and intermittent streams will need to be protected.
- Riparian buffer area around streams needs to be included. In some areas existing riparian vegetation has been classified as a terrestrial Significant Ecological Area and must be protected.
- Development of the site to provide sections and roads of complying grade, while maintaining existing watercourses at existing pre-development RL's.

Opportunities:

- Water quality in the water bodies within the structure plan area is currently relatively good for an urban catchment. Use of integrated stormwater management is an opportunity to maintain or enhance water quality.
- Design stormwater management that provides for a high level of water quality to protect the high ecological values and good water quality present in the area.
- Use riparian margins as part of water conveyance and to provide connections to other freshwater systems and other habitat types.
- The change in land use from rural land to urban is an opportunity to reduce sedimentation loading in freshwater systems and in the harbour

4 WARKWORTH NORTH 2 PRECINCT – CONCEPT

4.1 STRUCTURE PLAN

A-Studio have prepared a precinct plan for the proposed Warkworth North 2 Plan Change Area (Figure 16) proposed to increase density from the current proposed zoning shown in the current Warkworth structure plan (Figure 15)

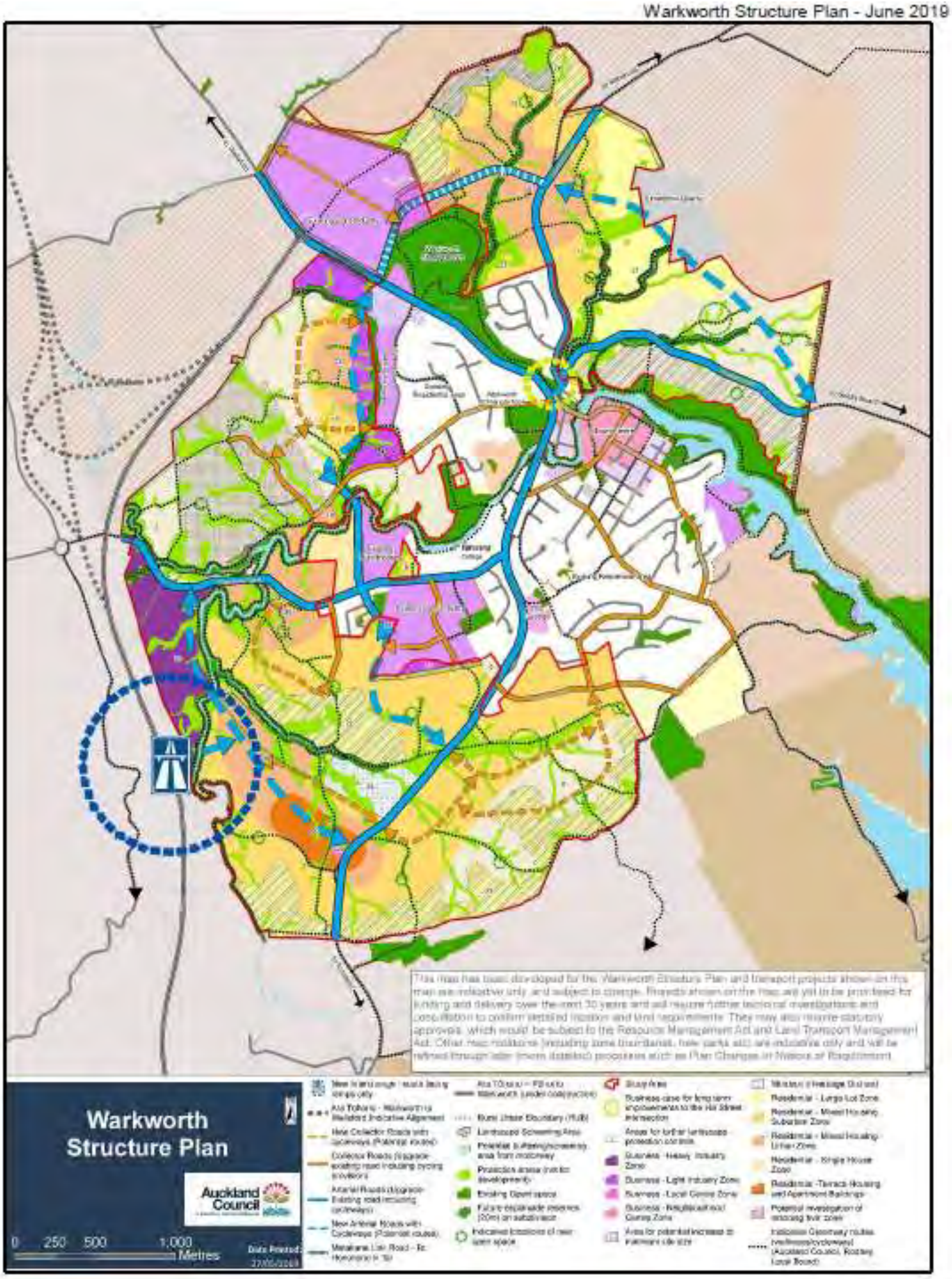


Figure 15: Auckland Council Structure Plan (Source: Auckland Council Warkworth Structure Pan)

Flexibility is retained in the eventual size and location of lots although the general zoning areas and impervious coverage as per the AUP are known. The proposed development layout takes account of this need for flexibility as the concept is developed in accordance with Auckland Council recommendations through the plan change to subdivision process.

The proposed masterplan for the Clayden Rise development is advanced compared to the rest of the PCA as illustrated in Figure 16 below.

Area's preliminarily considered to be protected or that will become protected are assessed are permeable. Developable zones outside of these permeable areas have had impervious coverage assessed as per the proposed precinct zoning plan, a snapshot of which can be found within Figure 17 below:

Figure 16: Warkworth Clayden Road Development – Master Plan (Source: A-Studio Architects)

Figure 17: Proposed Precinct Zoning plan (Source: A-Studio Architects)

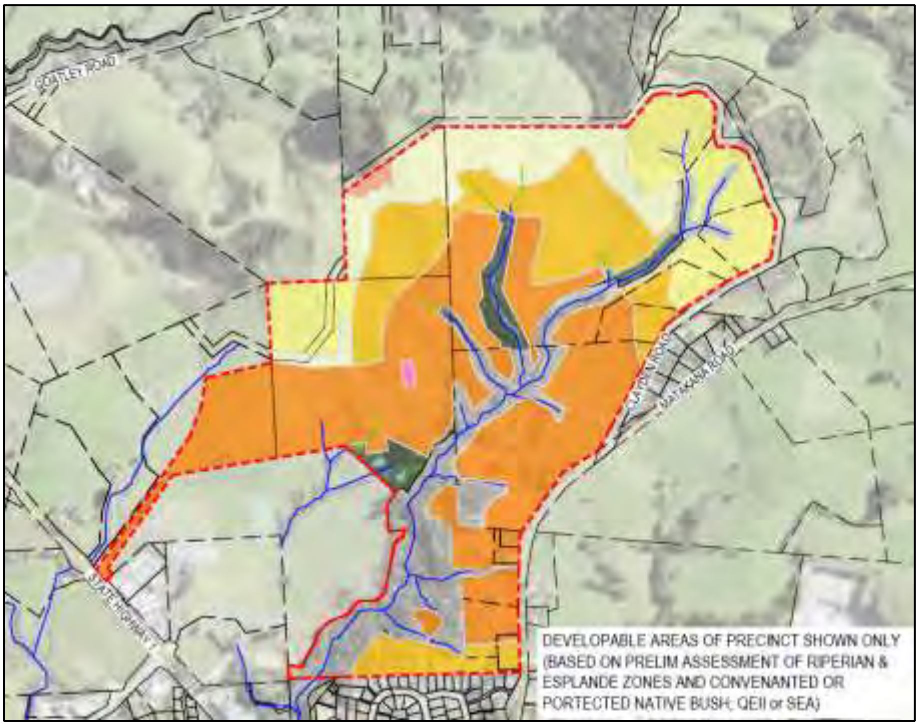


Figure 18: Proposed Developable Precinct Plan (Source: Maven)

4.2 PLANNING CONTROLS

The Warkworth North 2 PCA is currently located in Future Urban zoning and Auckland Council have released a draft zone overlay as part of public plan change process. This location contains both industrial and residential zoning across the subject site and adjoining properties. Zones proposed include; Light Industry, Single House, Suburban and the Mixed Housing Urban zones. Accordingly, there are varied impervious limits, including within riparian yards, whereby Standard H17.6.3 restricts the maximum impervious area to 10% within the riparian yard, defined as 10m from the edge of all permanent and intermittent streams as per the AUP – OP.

The subject site Clayden Road does not currently or within the proposed council structure plan, appear to have any stormwater management overlays, including flow ('SMAF') zoning. Although properties, including the Warkworth showgrounds, immediately downstream are within a SMAF Flow 1 management overlay area. As per Figure 19 below.

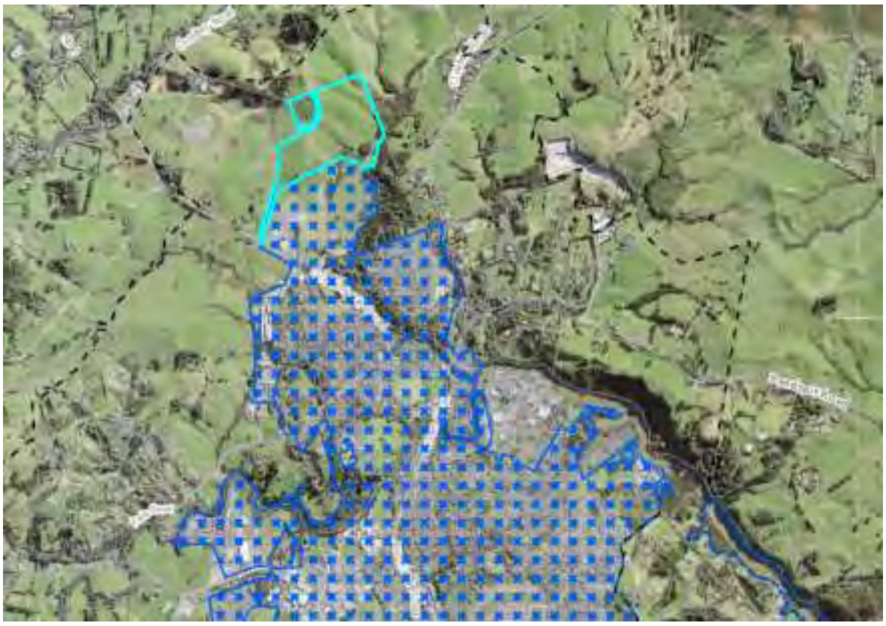


Figure 19: Unitary plan – OP – Stormwater Management Area Control (Source: AC GEOMAPS)

As PCA is directly upstream of a SMAF 1 zone, it is anticipated that any future urban area upstream of this area should be subject to the same stormwater controls. As such applying SMAF 1 level attenuation to control and mitigate additional runoff being generated as a result of the proposed zoning is considered appropriate in providing extended detention for the receiving environment.

The site is located within the Natural Resources: High-Use Aquifer Management Areas Overlay [rp] – Mahurangi Waitemata.

Development within the PCA is not dependent on aquifers (with all water to be supplied via public network), and thus these overlays are not considered to be of immediate concern to this SMP.

4.2.1 Auckland Wide NDC

The Auckland region-wide network discharge consent (NDC) came into effect in October 2019. The NDC allows for the stormwater diversion and discharges from developments to be incorporated under Auckland Council's consent, and for stormwater infrastructure assets to be vested to Auckland Council, provided they comply with the NDC conditions.

The NDC requires that greenfield developments comply with the NDC Schedule 4, unless there is an alternate BPO, those requirements include:

- Treatment of 100% of impervious areas by a water quality device designed in accordance with GD01/TP10 for the relevant contaminants.
- Achieve equivalent hydrology (infiltration, runoff volume, peak flow) to pre-development (grassed state) levels. A method of achieving equivalent hydrology to pre-development (grassed state) is to provide retention (volume reduction) and detention (temporary storage) for all impervious areas equivalent to SMAF 1 and flood attention up to the 100 year ARI design storm.
- Ensure that there is sufficient capacity within the pipe network downstream of the connection point to cater for the stormwater associated with the development in the 10 year ARI event, including incorporating flows from contributing catchment at maximum probable development (MPD). Methods of ensuring sufficient capacity in the downstream pipe network include any one of the following:
  - Demonstrating sufficient capacity is available including flows from the catchment (at maximum probable development) draining to the relevant pipe network in the 10 year ARI event.
  - Attenuating and reducing stormwater flows and volume on-site such that there is no increase in peak flow in a 10 year ARI event from the site compared to that prior to the new development. Note that any devices associated with this option will also require an operation and maintenance plan to ensure the long-term efficiency of such a system.
  - Upgrading the relevant pipe network to a size that can cater for the additional flows from the development in the 10 year ARI event (taking into account existing flows from the contributing catchment).
  - Upgrading the relevant pipe network to a size that is larger than would otherwise be required to cater for the 10 year ARI event for the development, due to the need to cater for flows from the contributing catchment at maximum probable development, subject to a fair and proportionate funding agreement with Healthy Waters.
- Buildings must not be flooded in the 100 year ARI event.
- All new assets are intended to become part of the public stormwater network are to be designed and constructed to be durable and perform to the required level of service for the life of the asset, subject to reasonable asset maintenance.

- Stormwater management assets in the road corridor require approval from Auckland Transport prior to vesting.

The intention is then for any proposed SMP to be adopted to Auckland Council's Regionwide Network Discharge Consent, upon approval from Healthy Waters.

4.3 EXISTING PUBLIC INFRASTRUCTURE

The subject development is currently not serviced by a public infrastructure network. Stormwater runoff is collected and disposed of via an existing watercourse and stream network consistent with the surrounding undeveloped areas.

Runoff from all 3 catchments of the proposed precinct area traverse watercourses that, each intersect one of the two culvert below that have been identified as under being under capacity in their current form.

1) The Hill Road / Sandspit Road intersection Stormwater Culvert (Identified below in figure 20)

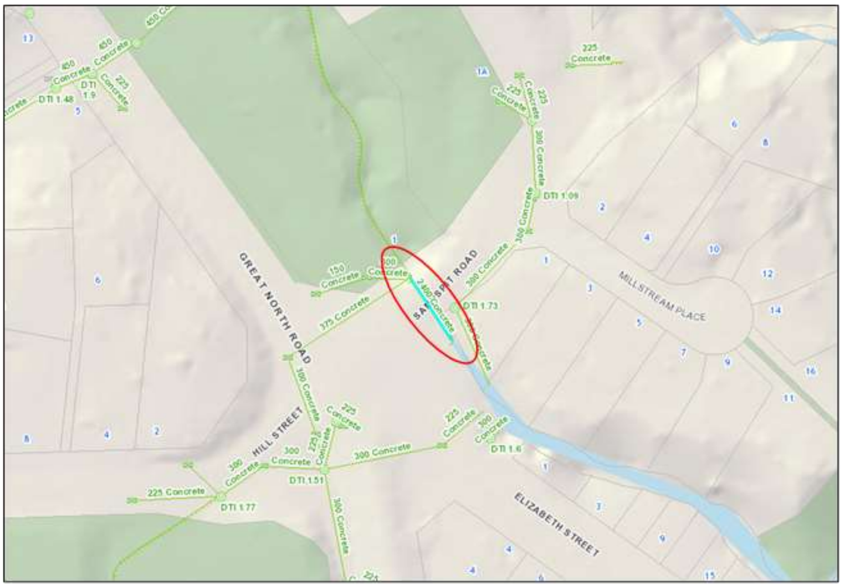


Figure 20: Sandspit Road Culvert Location (Source: AC GEOMAPS)

A 2300mm (from GEOMAMPS) culvert is an existing Auckland Council asset that has been assessed independently and found to be severely undersized for the combination of major (10 and 100yr ARI) storm events and the contributing catchment size. As of the date of issue, no plans to upgrade or replace this culvert are known. As such, the proposed development and precinct will be required to attenuate major storm events to pre-development levels.

2) The NZTA/SH1 Culvert (Known as Culvert E530, as part of the NX2 Puhoi to Warkworth Motorway project currently underway).

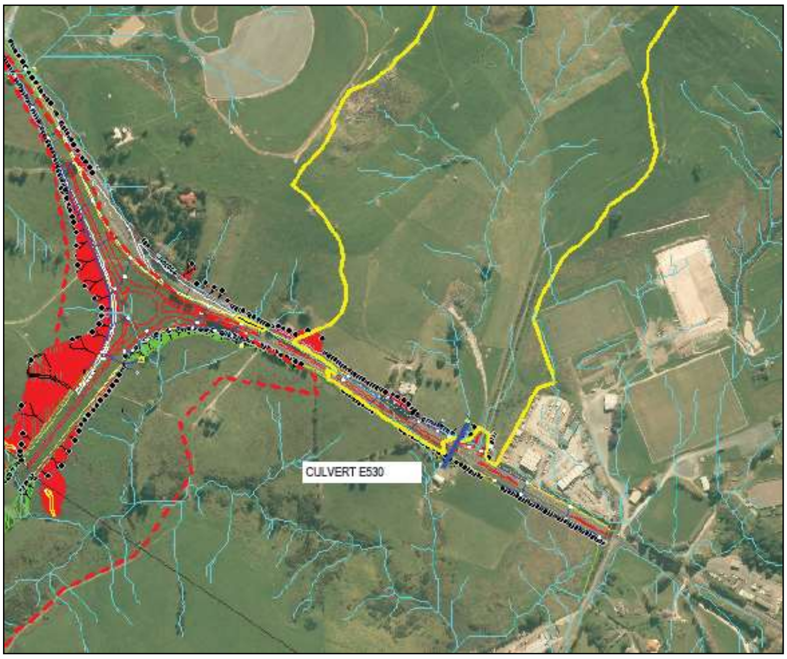


Figure 21: SH1 E530 Culvert Location (Source: AC GEOMAPS)

Culvert E530 is being replaced as part of the NX2 Puhoi to Warkowrth Motorway project. Although reports made public as part of the project (51// SH1 widening stormwater memo V6 28-26-2018) completed by Tonkin and Taylor determine that the hydraulic properties of the replacement culvert are to more of less meet the existing flows expected due to risk of increasing downstream properties. The below extract from this memo surmises reasoning:

The concept design for culvert E530 indicated that an 1,800 mm diameter culvert would be required to meet the Project's design requirements. However, the NX2 draft design report states that to provide a culvert larger than 1,200mm diameter would not result in a non-compliance with respect to RC68(b), and that the modelling results indicate that using a culvert larger than 1,200mm would increase flood levels downstream of the culvert at Lot 2 DP 405448 (CT 419127). However, due to the requirement to include fish passage in this culvert the culvert diameter has been increased to 1,350 mm. The NX2 draft report states that due to the increased hydraulic roughness provided by the fish baffles similar hydraulic performance to the existing culvert would be provided.

Again, the proposed development contributing area within the proposed precinct will be required to attenuate major storm events to pre-development levels.

5 Stormwater Management Issues, Opportunities and Constraints

The key stormwater management opportunities and constraints are assessed within this section of the Report. Emphasis has been placed on protecting, and where possible enhancing, the receiving environment from the development. The Mahurangi stormwater plan incorporates various elements to ensure a holistic approach to stormwater management within the catchment. Overall it is considered that the land uses identified in the structure plan for the Warkworth Future Urban Area generally respond well to the site specific constraints and opportunities identified in the Stage 1 - Preliminary Stormwater Management Plan dated March 2018 by Tonkin and Taylor.

5.1 Watercourses / Streams

A Watercourse Assessment Report (WAR) completed by Morphum Environmental Ltd has more recently been reviewed, that contains a number of recommendations that have been considered to be in general accordance with the below management plan. The proposed precinct catchment in the Morphum report is referred to as Management Zone 2 - Warkworth North – Showgrounds.

An extract (Table 9) below of the WAR specifies issues and recommended objectives of Stormwater Management in the area:

Table 9: MZ2 Issues and Objectives

Specific Issues	Suggested Objectives and Actions
Existing rural land use pressures may be remediated through greenfield development within short time scales.	Primary focus on goals and objectives related to future urban land development outlined above.
Matakana Link Road indicative route crosses the north tributary 3 (at approximately MAHN_TRIB3_6).	Reduce fragmentation of riparian corridor, and advocate for a contiguous green belt forming an ecological corridor linking the stream mouth Mahurangi banks and harbour to the Dome.
Extensive parts of the riparian corridor from the headwaters to the stream mouth are forested however some significant gaps in the connectivity of this corridor exist.	Consider potential to form an esplanade reserve between Kowhai Park and the protected headwaters of North Trib 3. Also see EO1.
The native riparian areas and hard stream bottom upstream provide good potential fish habitat, however the 2009 study indicated a fish barrier at the stream mouth (Trib 14 (2007-2009 data) see MZ 9).	Remediate potential fish barriers in lower reaches (MZ 9).
Large headwater farm pond on MAHN_Trib 3b.	Consideration of removal of online pond and restore natural channel morphology and hydrology.

The above issues specific to the precinct extents have been assessed below:

Existing Rural Land Use – as indicated goals and objectives of development associated with urban land development both resolves existing issues while presenting new risks.

Matakana Link Road – Being completed within the precinct area but for which separate consents are being sought by Auckland Transport. Note that the MLR construction poses its own constraints to be dealt with during detailed design.

Connectivity of Riparian Corridor – Riparian zones/Esplanade Zones are being incorporated into the precinct plan, enhancement of which would be beneficial where watercourses are proposed to be maintained through development. Map 7 of the Morphum WAR correctly identifies an area of existing open pasture and wetland with opportunity for enhancement. An extract of which can be found below:

Figure 22: FUZ WAR, Map 7 Extract (Source: Morphum/AC)

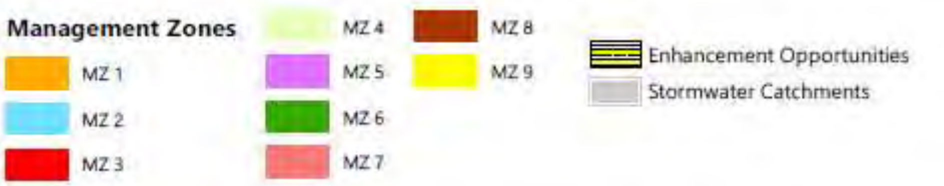


Figure 22: FUZ WAR, Map Key (Source: Morphum/AC)

Fish barrier – Barrier within 'lower reaches of MZ 9' assumed to be outside of the precinct maps based on the above Figure 22 extracted from the Morphum WAR.

Large Headwater Farm pond – Proposed to be removed during development as recommended in this and other ecological assessments.

The report also makes mention of the geology being a contributing factor in the current state of stream erosion. Northern Allochthonous rocks are noted to be weak and prone to failure. The resulting deep incisions of watercourses downstream of the subject are contributable to this. Recommendations made in other reports supporting the Structure plan, as well as the proposed precinct geotechnical report, support that this area is subject to Allochthonous rock and ground discharge (soakage) as a form of retention is, as such, not recommended.

Stormwater is to be managed within the subject site and we would recommend in the neighbouring sites using an integrated stormwater management approach involving water sensitive design involving the following components:

- Minimise the generation of stormwater runoff and contaminants with measures such as reducing impervious surfaces and using inert building materials.
- Manage runoff and contaminants as close to source as possible with measures such as rain gardens, permeable pavements and terrestrial revegetation.
- Use swales for stormwater conveyance where possible as an alternative to pipes where practicable, as pre-treatment to downstream treatment devices.

- Enhance the receiving environment by preserving and restoring riparian vegetation along banks including linking areas of riparian vegetation to create continuous green corridors.
- Utilise existing natural systems for stormwater management function including the restoration/enhancement of intermittent stream into wetlands.
- Methods to improve water quality as well as minimising and mitigating hydrological change are proposed.

Some of the key aspects specific to the site are detailed below:

- Ecological enhancement of the Mahurangi tributaries.
- Maintenance of existing overland flowpaths and waterways that flow through the Clayden Road site.
- Stormwater and flood management within the Clayden Road site.
- Provide stormwater quality treatment for proposed impervious and contaminant generating areas.
- Various options for detention of frequent rainfall events to streams, e.g. wetlands, detention basins, onsite detention devices.
- Flood mitigation for downstream properties, in the absence of an existing piped network.

The following sub-sections provide details on the design elements that are to be incorporated into the development of a robust stormwater strategy which will support and guide development within the Warkworth North 2 precinct.

5.2 POST DEVELOPMENT SUB-CATCHMENTS

Maven Associates have completed post development analysis of the stormwater catchments. The proposed sub-catchments have been aligned with the expected zoning and developable areas in maximum probable developed scenario.

Impervious coverage assumptions categorised by proposed urban zoning can be found below:

TABLE 6: ZONE IMPERVIOUS COVERAGE

PROPOSED PRECINCT ZONE	IMP. COVERAGE (%)
Landscape/Park/Bush	0
Large Lot Zone	35
Single House Zone	60
Mixed Housing Suburban Zone	60
Mixed Housing Urban Zone	70

Note: Urban Zoning modelled as being higher than AUP maximum of 60%, due to likelihood of coverage being increased post occupation in high density housing.

The catchment areas used in stormwater modelling which are the total catchment as per Maven Associates plan C4611, coverage formed by the proposed zones, are presented in Table 7 below:

TABLE 7: PROPOSED CATCHMENT AREAS

POST-DEVELOPMENT	AREA (Ha)	IMP. COVERAGE (%)
Catchment A	29.74	8.96
Catchment B	37.373	18.89
Catchment C	90.53	43.48

The above coverage is determined based on the proposed developable zoning catchment plans appended. All areas outside of the developable zones are considered to remain pervious in nature (as esplanade reserves, covenanted bush…etc), a detailed summary of catchments can be found below:

TABLE 8: DETAILED CATCHMENT AREA SUMMARY

CATCHMENT	ZONE	AREA (Ha)	IMP. AREA	COVERAGE %
Catchment A	MIXED HOUSING URBAN	2.03	1.42	70%
	SINGLE HOUSE	0.63	0.38	60%
	LARGE LOT	2.48	0.87	35%
	NON-DEV / OUTSIDE PCA	24.60	0.00	-
Catchment B	MIXED HOUSING URBAN	9.95	18.89	70%
	NEIGHBOURHOOD CENTER	0.165	0.165	100%
	NON-DEV / OUTSIDE PCA	27.62	0.00	-
Catchment C	MIXED HOUSING URBAN	27.78	19.45	70%
	MIXED HOUSING URBAN	17.49	10.50	60%
	SINGLE HOUSE	9.81	5.89	60%
	LARGE LOT	10.18	3.56	35%
	COUNTRYSIDE LIVING	0.50	0.02	8%
	NON-DEV / OUTSIDE PCA	24.87	0.00	-

Areas within the catchment that are outside of the proposed PCA have been assessed as fully permeable.

5.3 CATCHMENT FLOW ANALYSIS

A hydrological and hydraulic model was created to model the fully developed catchment. The proposed modelling scenario has the following characteristics/assumptions:

- The proposed $10yr_{cc}$ and $100yr_{cc}$ (including Climate Change) catchments are the same
- Catchment characteristics as per pre-development TP108 parameters.
  - CN numbers
    - Pervious areas CN= 74
    - Impervious areas CN= 98
- Primary network will be installed with capacity to convey 10yr ARI peak flow including Climate Change
- Secondary overland flow paths will be contained within the road reserves, right of ways or drainage reserves and will be directed to existing streams.
  - pipe capacity is to be considered as below 100yr ARI flood modelling.
    - Pipelines up to and including 600mm 100% blocked
    - Pipelines between 600mm and 1050mm diameter, capacity reduced by 50%
    - Pipelines in excess of 1050mm, capacity reduced by 10%

- Rainfall application:
  - Site specific rainfall depths have been derived using AC-TP108
  - Climate change has been applied in accordance with Auckland Council with allowances for climate change effects in accordance with Table 5.2 of Climate Change Effects and Impact Assessment: A Guidance Manual for Local Government in New Zealand (Ministry for the Environment, 2008), using a temperature increase of 2.1 degrees by 2090. As per Table 4.1 below extracted from the Auckland Council Stormwater Code of Practice v2.0.

- **Table 4.1: Percentage Increase in 24-hour Design Rainfall Depth**

Annual Exceedance Probability (AEP)	Percentage Increase in 24-Hour Design Rainfall Depth Due to Future Climate Change*
50%	9.0%
20%	11.3%
10%	13.2%
5%	15.1%
2%	16.8%
1%	16.8%

* assuming 2.1°C increase in temperature

TABLE 9: PROPOSED SCENARIO RAINFALL DEPTH

Rainfall Depth	TP108	TP108 + CC
10% AEP (10YR)	210	237.7
1% AEP (100YR)	310	362.1

The outcome of the modelling for rainfall events of 10yr annual recurrence interval ('ARI') and 100yr ARI (including Climate Change) is presented in Table 9, below.

TABLE 10: UNATTENUATED CATCHMENT PEAK FLOWS

POST-DEVELOPMENT	Q_{10} (m^3/s)	Q_{100} (m^3/s)
Catchment A	5.496	9.219
Catchment B	7.131	11.696
Catchment C	11.610	19.105

Note: Flows above are peak flows prior to mitigation

5.4 FLOODING / FLOW MITIGATION

In terms of flood management, the Stormwater Management Plan proposes to:

- Utilise existing streams and their associated riparian margins to provide conveyance to manage flood flows.
- Avoid locating buildings or infrastructure within the 100 year ARI modified floodplain unless it can be designed to be resilient to flood related damage.
- Ensure all development and changes within the 100 year floodplain do not increase adverse effects or increased flood depths or velocities to other properties upstream or downstream of the site.
- Identify overland flowpaths and ensure that they remain unobstructed and able to safely convey runoff.

The existing site and upstream extents of the neighbouring properties are considered low risk and would only be subject to localised minor ponding, as detailed within Section 3.3 of this Report. Rapid flood mapping of the area has been completed and can be found appended (Appendix C) as extracted from the Tonkin Taylor Prelim SMP. The extent of flooding identified has been confirmed from site survey and modelling undertaken and due to topography is characterised as overland flows within defined gulley's/depressions with good longitudinal fall. Ponding or flow through the existing watercourses has been modelled and typical sections produced identifying the extents of flow for reference.

Calculations of the post development scenario for 10 Year and 100 Year AEP or 10% and 1% ARI events has been carried out to determine what the effect downstream might be. A summary of combined flow that will effectively increase downstream of the site can be found below:

TABLE 11: PEAK FLOW COMPARISON – PRE AND POST DEVELOPMENT (NO MITIGATION)

	Pre-Development		Post Development	
CATCHMENT	Q_{10} (m^3/s)	Q_{100} (m^3/s)	Q_{10} (m^3/s)	Q_{100} (m^3/s)
Catchment A	5.496	9.219	5.496	9.219
Catchment B	7.131	11.696	7.131	11.696
Catchment C	11.610	19.105	11.610	19.105

5.4.1 PROPOSED MITIGATION

The general approach to water quantity management for small storm events is to provide a minimum of SMAF 1 hydrological mitigation for all impervious surfaces within the PCA in accordance with the requirements of Schedule 4 of the NDC. SMAF 1 hydrological mitigation objectives outlined in the AUP are:

- Retention of at least 5 mm of runoff depth from impervious surfaces where possible.
- Detention and a drain-down period of 24 hours for the difference between the pre-development and post-development runoff volumes from a 95th percentile, 24-hour rainfall event less the achieved retention volume, over the impervious area for which hydrological mitigation is required.

Retention is the process of storing and using stormwater runoff onsite, reducing the volume of stormwater discharged to the receiving environment. Detention is the temporary storage and slower release of runoff, which effectively reduces peak flows.

The approach is considered necessary to mitigate the effects on stream hydrology and to manage erosion risk. In addition to restoration measures within existing and proposed Watercourses through riparian implementation and enhancement. Planting at discharge points of stormwater devices (i.e. green outfalls or energy dissipation structures to provide erosion protection) aim to minimise and mitigate the erosion risks in the receiving environment attributed to development of the PCA.

To meet the hydrological mitigation objectives, the following management options are proposed:

Retention

- By infiltration, where feasible and possible in a safe, and effective manner. This may be provided in soakage pits, trench drains, or through appropriately designed bio-retention devices. Pervious pavements or porous concrete can be included as part of the driveways / access to the dwellings within the PCA.
- It is noted that Geotechnical investigation within the Clayden Rise site suggest ground soakage, due to ground stability issues, not be provided for unless a qualified geotechnical engineer or otherwise can confirm global stability is not an issue. A such the only form of retention shall be;
    - At source for residential and buildings, through the use of rainwater tanks for collection of roof runoff where there is re-use demand.

Detention

- Raingardens, planter boxes, swales and tree pits are bio-retention devices which can be designed to provide also detention within private residential property or along road corridors and within public impervious spaces, while adding to the landscape value of the PCA
- Above-ground rainwater storage tanks or underground detention tanks will be provided within residential lots to provide storage volumes for reuse, and a separate detention volumes with a controlled discharge rate, with the latter devices minimising land take.

To avoid increasing flood risk downstream, controls of the 10% and 1% AEP rainfall runoff is required to ensure additional flow volume generated as a result of development of adequately mitigated.

Any additional volume shall be temporarily stored onsite and released at a rate which does not exceed pre-development peak flows. Detention basins and wetland are suitable methods that could be provided to limit discharges from the PCA.

There is opportunity to increase flows within catchments discharging to the Mahurangi Stream in catchment B and C should public infrastructure downstream of the PCA be upgraded. The effect of upgrades and assessments confirming no effect on downstream properties would need to be completed confirming this and is to be investigated further at resource consent stage design as detailed coverage figures and further investigation into the downstream infrastructure is completed.

5.5 Overland Flowpaths (OLFPs)

The PCA is subject to numerous OLFPs, as per Figure 4 within Section 2.1.4 of this Report. These OLFPs include both minor and major OFLPs. These natural depressions correspond with the natural intermittent and permanent watercourses that exist.

The PCA will incorporate and allow for all existing OLFPs entering the site. Otherwise existing and proposed watercourses, greenways and roads within the site will convey overland flow through to the closest natural and existing exit point - ensuring any effect on downstream receiving environment is appropriately mitigated.

A preliminary assessment of expected flows, that do not account for mitigation of flow or volume, have been input to HEC-RAS model. Modelling completed to date suggest that a majority of the existing downstream overland flow paths are generally unaffected with minor change to existing flooding or flow extents despite the increase in flow generated as part of the proposed impervious coverage increasing. This is likely due to the deeply defined channels, generous grades and storage available within the riparian zones downstream.

Proposed mitigation of 1% storm events indicates significantly reduced peak flows such that flooding and effects on downstream properties are to be positively influenced by the development or the subject site and greater precinct.

5.5.1 Mitigation option assessment – OFLPs

An options assessment has been undertaken to establish the best practical design criteria for the OLFP design in support of the Warkworth North 2 PCA . These options included:

- Retention and protection of existing OLFPs through the development area.
- Maintaining the flow of OLFPs for 100yr cc ARI rainfall event under the maximum probable development scenario where downstream scenarios are considered acceptable.
- Directing all internal OFLPs within the proposed roading network, greenways or existing streams where possible.

5.6 STORMWATER QUALITY

The proposed Mahurangi Catchment will be developed for residential land which can generate contaminants. The AUP – OP stipulates under Chapter E9 when stormwater quality treatment is required. Treatment is required for high contaminant generating car parks (more than 30 parking spaces) and/or high use roads (more than 5000 vehicle movements / day). Chapter E9 requires treatment in accordance with TP10 and GD01 (subject to Plan Change 14 being approved).

The AUP – OP does not specifically set quality requirements but rather that high contaminant generating areas are treated by an approved stormwater quality device. Auckland Council's Stormwater Management Devices in the Auckland Region (GD01) provides detailed design considerations for stormwater devices. The ability of Auckland Council's GD01 best management practices to comply with any quality requirements and to provide enhanced treatment is summarised in Table 7 of TR2013/035, an extract of which can be found below:

Table 7. Ability of TP10 BMPs to comply with DEQRs and to provide enhanced treatment

	TSS		Total Copper		Total Zinc		Temperature	
	DEQR Compliant	Enhanced Treatment	DEQR Compliant	Enhanced Treatment	DEQR Compliant	Enhanced Treatment	DEQR Compliant	Enhanced Treatment
Pond	✓		✓	✓	✓			
Wetland	✓	✓	✓	✓	✓		✓[1]	
Swale	✓		✓		✓		✓	
Filter Strip	✓		✓		✓		✓	
Wetland Swale	✓		✓	✓	✓	✓	✓	
Sand Filter	✓	✓	✓		✓	✓	✓	
Bioretention (lined)	✓	✓	✓		✓	✓	✓	
Bioretention (unlined)	✓	✓	✓	✓	✓	✓	✓	✓
Permeable Paving (lined)	✓		✓		✓	✓	✓	
Permeable Paving (unlined)	✓	✓	✓	✓	✓	✓	✓	✓
Living Roof	✓	✓	✓[2]		✓		✓	✓

[1] Providing the wetland is highly vegetated and well shaded
[2] Providing design is compliant with Auckland Council guidance (Fassman, Simcock, & Voyde, 2010)

The Mahurangi catchment discharges into a SEA downstream of the precinct and ultimately to a CMA within the Warkworth Inlet, also a Significant Ecological Area, and requires contaminants of concern including sediment, metals and temperature to be treated from high contaminant generating areas. It is expected traffic modelling completed for future planning and subdivision consents will confirm numbers on both proposed collector and local roads, this will confirm whether VPD limit are reached. Conservatively, devices within the public road reserves will likely be required to meet water quality standards as no bulk treatment options outside of the AT MLR SW pond (built by Auckland Transport) are proposed.

5.6.1 MITIGATION OPTIONS ASSESSMENT (STORMWATER QUALITY)

An options assessment has been undertaken to establish the best practical design criteria for the stormwater quality design in support of the Warkworth North 2 PCA. These options include:

- At source stormwater quality control, where required by the AUP – OP. Lot development supported by approved propriety devices such as raingardens, tree pits, stormwater filters etc.
- Treatment of public roads and or right of ways via approved propriety devices (raingardens, stormwater filters etc) where required by the AUP – OP.

- Sub-catchment wide stormwater quality provision through enhancement of existing riparian zones and utilisation of proposed reclaimed greenways as biofiltration devices.
- Planting of riparian areas and protection of existing bush features within the site.

Opportunities

- Water quality in the water bodies within the structure plan area is currently relatively good for a rural catchment. Use of integrated stormwater management is an opportunity to maintain or enhance water quality.
- Design stormwater management that provides for a high level of water quality to protect the high ecological values and good water quality present in the area.
- Use riparian margins as part of water conveyance and to provide connections to other freshwater systems and other habitat types.
- The change in land use from rural land to urban is an opportunity to reduce sedimentation loading in freshwater systems and in the harbour.

5.7 INFRASTRUCTURE

The runoff generated from the developed catchment from the 10-yearCC ARI rainfall event will be conveyed by the proposed primary pipe network. The primary reticulated network will be sized to convey the peak discharge for rainfall events up to and including 10-year (cc) ARI to the existing or proposed Watercourses. There is no significant overland flow predicted for the 10-year (cc) ARI event.

During the 100-year (cc) event the stormwater runoff will be conveyed by a secondary network of overland flow paths within the proposed development, which will follow the road reserves, to existing watercourses, via reserves where required, which in turn discharge via or directly to the tributaries of the Mahurangi River.

5.8 OPPORTUNITIES

The Warkworth FUZ Watercourses Assessment report (may, 2019) raises a number of opportunities for enhancement, one of which (EO 1) is contained within the proposed precinct extents.

The area proposed can be found identified below (Figure 23).

Figure 23: Warkworth FUZ WAR – Enhancement Opportunity 1 Area

The two main tributary of the eastern catchment (Watercourse I and K) provide a natural conveyance corridor for overland flows. This stream environment surrounding Watercourse I is currently protected by an existing covenant and the draft structure plan proposed creates a green corridor through or alongside this location. Watercourse K through EO1 area (as above) also have been assessed and introduction of esplanade reserve through subdivision consent is more than likely, development of which will provide for implementation of vegetation aiding in shading, erosion control connectivity to the upper conservation areas of the area.

Preliminary flow path calculations determine fully developed catchment's flows will not adversely affect the green corridors and watercourses with the appropriate runoff mitigation in place, enhancement of existing understorey planting and armouring of areas of significant erosion. Manning's channel flow calculations (Appendix C) show that assumed increases in impervious area do not increase the risk of flooding of flow depths within or immediately downstream of developable area, as flow is contained to the existing channel extents.

Integration of best practice stormwater management principles is of high importance for the successful management of the catchment and deliverance of the overarching goal of protecting – and where possible – improving the quality of stormwater runoff into the receiving environment.

The development of the stormwater strategy is to take these principles into account and apply as the opportunity permits. The following lists the pillars for which the Mahurangi SMP is derived from:

1) Flood Mitigation;
2) Integration of Landscape values;
3) Water Sensitive Design;
4) Treatment of water prior to discharging into the receiving environment;

5) Enhancement and protection of the existing stream and native bush environments; and

6) Fish passage improvements where obstructions are present.

Furthermore, there is opportunity for the downstream culverts identified within section 4.3 (at; Hill Road and SH1) to be upgraded allowing review of the controls proposed to attenuate both 10 and 1% AEP event flows.

6 Warkworth North 2 Stormwater Management Plan

6.1 Stormwater Management Principals

This stormwater management strategy has been developed for the Warkworth North 2 Precinct and will enable the urbanisation of the live-zoned Residential land. The strategy sets a framework of water sensitive design for the Warkworth North 2 precinct and plan change area. This SMP provides details on stormwater quality, conveyance, hydrological and flood mitigation outcomes, including the management required and the methods available through a variety of toolboxes in each of the subsequent chapter sections.

The following strategy has been developed to ensure compliance with the recently granted Auckland-wide Network Discharge Consent, the objectives and policies of the AUP – OP, Chapter E9 (stormwater quality) and the Auckland Council Stormwater Code of Practice.

The key components of the Mahurangi stormwater management strategy are as follows:

- Compliance with NDC Schedule 4 development requirements
- Providing stormwater conveyance for 10yr $_{cc}$ ARI rainfall event
- Overland flow paths for 100yr $_{cc}$ ARI rainfall event to be accommodated within the site and conveyed to wetlands/detention basins.
- Minimising contaminant generation and treatment of runoff, in accordance with GD01, prior to discharging to receiving environment
- Detention of 10 and 100 yr cc ARI rainfall events due to known restriction in the downstream network, specifically culverts at: SH1 (E530) and the Hill Road-Sandspit Road Intersection.
- Detention (SMAF 1) of 95th Percentile flows to mitigate or minimise changes to hydrology and the erosion associated with higher frequency / low intensity rainfall runoff from impervious surfaces

The rules for development collectively set out to minimise the effects of urbanisation on the receiving environment by managing the post development hydrology, runoff volume and runoff quality. The following elements have been considered in the formation of the stormwater management options for the Mahurangi catchment:

- Quality treatment is required for the entire developable catchment and PCA.
- The developed catchment discharge must not result in, or increase, the flooding of properties, or inundation of buildings up to the 1% AEP event.
- The discharge must not cause or increase scouring or erosion at the point of discharge.
- SMAF 1 zone controls as pe section E10 of the Unitary plan, and;
- Onsite detention to ‘pre-development flow levels’ for 10% AEP events.
- The diversion and discharge must be managed, and where possible dispersed, to minimise erosion and sediment generation.

The proposed stormwater management is considered on both a catchment wide and individual lot basis with respect to the main design elements of:

- Water quality
- Flood management

- Water sensitive design

An outline of each of the stormwater management options is summarised in the following sections. To achieve the stormwater management approach set out above a treatment train approach will be adopted in the PCA. The treatment train toolbox can be found appended and expands on the methods detailed within the following chapter 6 sections. The devices proposed within the treatment train are considered the Best Practicable Option (BPO) for the PCA specific to the constraints identified earlier in the SMP.

6.2 WATER SENSITIVE DESIGN

The key water sensitive design principles outlined in GD04 and how they are incorporated in the stormwater management approach for the PCA are summarised in **Error! Reference source not found.** below table:

TABLE 12: WATER SENSITIVE DESIGN PRINCIPLES

Water sensitive design principles	Application within PCA
Promote interdisciplinary planning and design	• A Stormwater Solutions Workshop for the wider project team was held to discuss and resolve stormwater management issues. • The Assessment of Ecological Effects prepared by Freshwater Solutions provided specialist Ecological input to development of the stormwater management approach.
Protect and enhance the values and functions of natural ecosystem	• Planting of watercourse margins to a minimum width of 10 m on both sides of the watercourses and wetlands to create a natural green corridor, connecting existing native areas and special ecological areas allowing for colonisation and/or movement of flora and fauna across the landscape. Vegetated watercourse margins will also function to filter runoff from surrounding land. • Implementation of esplanade reserve and riparian margins protecting existing natural greenways. • Preservation and enhancement of existing covenanted and protected natural bush land within the PCA
Address stormwater effects as close to source as possible	• Generation of contaminants will be prevented as far as possible through the use of inert building materials • Where contaminants are generated (e.g. road and car parks), green infrastructure will be provided to mimic natural physical, biological and physical treatment processes as close to the source as practicable. • Application of a treatment train approach within the PCA to ensure treatment efficiency as part of an integrated stormwater management approach.
Mimic natural systems and processes for stormwater management	• The enhancement of natural hydrological features (i.e. Watercourse G, I, K, M & N) by restoring riparian margins with vegetation along stream banks. • Stormwater treatment devices and green infrastructure.

6.3 WATER QUALITY

The development of the PCA would result in stormwater contaminant generation due to the consequent land-use changes and increased impervious area. Reduced stormwater quality adversely affects the receiving environments and if left unmitigated would adversely affect the natural receiving environment.

Therefore, provision for stormwater quality treatment is required to satisfy both the requirements of; Schedule 4 of the Auckland Regional NDC; Chapter E1, E9 of the Auckland unitary plan and; Chapter B7 of the regional policy statement.

Due to the precinct being located upstream of a sensitive receiving environment (SEA), it is necessary to ensure a water sensitive design is adopted. Water quality treatment shall be provided, guidelines are well documented on BPO in this field via council resources such as the GD series. Such devices shall be designed in accordance with Auckland Council GD01/04 that would see appropriate water quality devices incorporated into the treatment train of the stormwater network. A treatment train toolbox appended detailed options considered applicable.

As recommended in the “Prelim SMP” by Tonkin Taylor, treatment is be provided for at source when steep gradients and site constraints do not allow for wetlands or ponds. This provides quality treatment from contaminant generating areas, at a minimum, as required by the AUP – OP.

Due to the existing, and expected design level, gradients across the site and a lack of suitably flat area at the interface between developable land, treatment of stormwater runoff from public roads ‘at source’ through green features such as rain gardens will be the primary means of achieving water quality.

Secondary water quality benefits will be provided through green outfalls and runoff from residential areas traversing riparian margins and enhanced watercourses upstream of the SEA (these functions shall not be relied upon exclusively).

The overarching principle of the development is to provide treatment of all stormwater runoff upstream of the “Stream” catchment and also, or dependant on the solution agreed between downstream parties, of the SH1 “Culvert” catchment. Several at source and catchment wide treatment options have been considered for this catchment, which include the following:

- Inert or low contaminant generating cladding material for buildings, in accordance with initiatives such as no longer approving unpainted zinc/galvanised surfaces, aluminium and copper.
- Sub-catchment quality devices, including:
  - Swales
  - Riparian Zone Enhancement
  - Esplanade Zone Vesting
- On-site propriety devices, including:
  - Raingardens
  - Stormwater filters
  - Tree pits
  - Permeable paving in shared spaces, car parking bays and driveways
  - Dispersal Trenches adjacent to watercourses
- Stormwater quality treatment for all public roads and accessways.
  - Raingardens
  - Stormwater filters
  - Swales
  - Tree pits
  - Permeable paving in shared spaces, car parking bays and driveways

- Catch-pits to incorporate gross pollutant traps (such as half siphons)

Stormwater Quality 'Toolbox'

Future design and development within the precinct shall assess and decide on methods of achieving water quality against the below Stormwater Treatment Devices 'Toolbox':

Building cladding (Zinc/Galvanising/Aluminium/copper)
Building designer shall ensure that the above building products are not specified, bare metals shall be painted to prevent discharge to environment.
Protection via consent notices on future residential/commercial lots.

Permeable Paving
Suitable for private sites and low use public areas can only be installed on areas of low grade, otherwise infiltration to achieve water quality treatment will not occur.

Stormwater Filters
Propriety devices supplied by 3rd party and require regular maintenance agreement, provide efficient use of space and flexibility in challenging sites. Typically connected to the pipe network before discharge of paved areas to the public network.
Council are not normally supportive of the use in public areas unless by specific approval due to maintenance costs.

Swales
Design is governed by flow velocity within the channel itself, typical uses for flat to gently sloping site. Check Dams can be used to reduce velocity where required and prevent erosion.

Raingardens
Suitable for treatment of private and public roads final sizing is normally an issue to fit within road reserves, along with ongoing maintenance. Suitable for site from Flat to moderate slope with specific design around the inlet conditions to prevent erosion.

6.4 Stormwater / Flood Management

The detention components of the proposed primary and secondary networks should generally be provided at source (within each lot, or roadway) while flood mitigation be on catchment specific basis achieving outcomes equivalent to those in modelling undertaken - where net pre-post development discharge is achieved before discharging to the downstream receiving environment. Initial assessments based on singular detention devices on a precinct wide level was not favourable due to the known site topographical constraints, including; an expected esplanade reserve dividing the precinct, multiple watercourse (and therefore discharge points) dividing catchments, steep terrain, an SEA at the base of the precinct and issues with uncontrolled ground recharge resulting in slope stability.

The overarching principle of the development is to mitigate effects of increasing stormwater discharge up to the 10 and 100yr $_{cc}$ ARI event. Several practical at source and catchment wide treatment options are considered necessary for this catchment, which include the following;

- Sub-catchment specific devices for 1% AEP flood mitigation, including
  - Detention Basins (Dry)

Note: At source detention of 10% AEP flows has been shown to provide mitigation for a significant initial portion of the 1% rainfall volume.

- On-site/at source propriety devices for 10% AEP flow mitigation, including:
    - o Raingardens, tree-pits, swales
    - o Detention / Rainwater tanks
    - o Permeable paving in shared spaces, car parks and driveways

It is expected the landowners within the PCA shall provide an assessment demonstrating how each development subsequent to the re-zoning of the precinct complies with the requirement to mitigate stormwater runoff and flooding.

An overview of stormwater devices within the PCA has been developed identifying where detention basins, wetlands…etc could be located serving either individual allotments or a greater upstream catchment (depending on landowner co-operation) can be found appended. (Appendix A)

Flood Management 'Toolbox'

Future design and development within the precinct shall assess and decide on methods of achieving flood management against the below Flood Management 'Toolbox':

Detention Basins
Basins specifically designed at the tail of primary and secondary stormwater networks to reduce peak flows and attenuate/flatten flow profiles and volumes being discharged to existing watercourses.

Onsite Detention Tanks
Either above or below ground proprietary/specific design tanks for detention of SMAF volumes and 10% AEP flows. No 'open bottom' designs shall be allowed without input from a suitably qualified geotechnical engineer commenting on site stability and recommendations made within CMW Geosciences investigations.

Permeable Areas

Maximum impervious areas shall be applied in accordance with AUP and precinct zones/coverages, unless specific detention designs for events up to 1% AEP are provided mitigating the effects of increased coverage.

6.5 Erosion & Sedimentation

Erosion within the existing watercourses and solutions proposed during reclamation or introduced conveyance channels will need to be carefully designed and managed due to known geological issues.

Enhancement of existing watercourses is a priority, revegetation of lengths of currently unprotected streams is to be provided, as recommended in the 2019 Warkworth FUZ WAR, along the upper reach of Watercourse K1 (naming nominated by Freshwater Solutions) where an existing wetland is present.

Application of Riparian zones and Esplanade reserves, in combination with enhancement of riparian offsets via planting and/or engineered solutions aim to reduce existing watercourse erosion it documented in both specific upper and lower reaches of the precinct.

SMAF 1 zone controls are proposed to act in an extended detention-like manor, aiding in reduction of flow volumes from higher frequency / lower intensity storm events attributable to long term erosion. While all outlet and discharge points proposed from developed areas shall include mitigation measure as detailed below.

Erosion & Sedimentation 'Toolbox'

Future design and development within the precinct shall assess and decide on methods of achieving flow velocity and erosion control against the below Erosion and Sedimentation 'Toolbox':

Pipe Grades
Future publicly vested network designs shall aim to achieve minimum velocity at downstream discharging through reducing grades in accordance with the SWCoP.

Level Spreaders
Discharge locations into watercourses shall investigate measures and appropriate velocity controls through hydraulic energy management devices, in accordance with TR2013/018

Outfall Rip Rap or Scour Control
Outfall scour control measures in accordance with GD01 / TP10 and TR2013/018

Manhole Baffles
Internal manhole baffles within the primary network where velocities are high at interchanges in landform and pipe grades cannot feasibly be reduced.

Manhole Sumps
Sumps in network manholes where velocities are high or cascades beyond the allowable 1.0m fall are achievable to drop hydraulic energy.

Riparian Vegetation
Planting and naturalisation of riparian margins to ensure effects of increased sheet flow velocity from the site act as a buffer zone before entering watercourses.

6.6 HYDRAULIC CONNECTIVITY

Primary conveyance systems shall make use of the topography and natural watercourses, making sure that water quality and flow velocity is mitigated in accordance with recommendations outlined throughout this plan. Generally off-line wetlands are designed with high-flow bypasses incorporated into the design, for bioretention and water quality devices this methodology shall, where practical, remain the case as recommended in GD01.

Where practical, primary and secondary stormwater networks will connect to existing watercourses through green outfall structures mitigating potential for increased erosion risk. Implementation of dispersal trenches on residential lots adjacent to watercourses will reduce flows at concentrated outfalls and also the need for stormwater networks the traverse the riparian and esplanade reserves.

Connectivity of the secondary conveyance systems and floodplains throughout the proposed development, due to elevation change across the various catchments, shall be maintained. Floodplains, more common in low lying, flat plains, are unlikely due to the topography and natural watercourses throughout the precinct.

It should be noted as a majority of the downstream watercourses, where floodplains may be present, are located in protected native bush or covenanted areas, modification as a result of development in unlikely. Connectivity issues outside of the scope of this precinct has not been assessed in detail, although aside from existing culvert restrictions already identified, flow to the coastline is more or less free flowing. Ecological Connectivity through enhancement of Watercourse K1, noted in section 6.4, also provides for defragmentation of significant conservation area north of the precinct and the SEA in the southern portions of the precinct extents.

6.7 GREENWAYS

The Auckland Council Structure plan urban design proposes multiple greenway routes through and within the site, which have potential to double as flow paths and detention basins for flood management.

Figure 24: Auckland Council Structure Plan Green Space

Existing ephemeral, intermittent and permanent watercourses within the site are to be maintained where practical, reclaimed stream will otherwise provide opportunity to add and fulfil several urban design and stormwater management outcomes:

- Stormwater Quality – GD01 / TP10
- Water Sensitive Design – GD04
- Ecological connectivity through the development site
- Green corridor connectivity
- Flood storage (detention), ensuring additional flood storage and retention of pre-development flow rates for upstream/downstream properties.

Watercourses across the PCA are to receive stormwater runoff from both the existing undeveloped upstream catchment and the developed catchment of the Warkworth North 2 precinct. The proposed primary and secondary stormwater networks will discharge into the closest enhanced or reclaimed watercourse, whilst all OLFPs are designed to discharge into these features or be kept within road carriageways until an adjacent watercourse becomes accessible.

6.8 OVERLAND FLOWPATHS (OLFPS)

The PCA is dissected by a number of natural OLFPs, all of which need consideration as part of this stormwater strategy. A number of options have been explored with respect to the management and protection of the OLFPs as they are to be maintained in their current form, and consideration of the intended development (Predominantly residential land use) to take place around them.

The overarching principle of the development is to provide for all existing OLFPs to remain unaltered where practical, whilst reducing the risk or effects of erosion, contamination and leaching.

Overland Flow Path ‘Toolbox’

Several practical options are proposed for the Warkworth North 2 precinct, design and development within the precinct shall assess and decide on methods against the below Stormwater OLFP ‘Toolbox’:

Road Network
Primary collection and conveyance of runoff via public road carriageways or stormwater reserves where crossing residential blocks is required.

Erosion Control
As per section 6.4 Discharge from the road corridors to natural conveyance channels, either directly or via reserves require specific velocity control designs.

Existing Watercourses
Retention and protection of natural OLFPs and where possible; enhancement, through introduction of green Corridors, pest species control and replanting of riparian/esplanade reserves.

Primary Network
Piping of OLF, where retention of natural paths is not practical (If required and approved).
Onsite Detention via Wetlands to neutralise any effects downstream due to increased runoff from impervious areas.

An overland flow path plan has been generated based on preliminary design contours completed during feasibility and infrastructure assessments of the Clayden Road Development within the PCA. The primary conveyance system for overland flow is the public road carriageways intercepting sheet flow from blocks of residentially zoned areas. The road networks generally follow the existing, but modified, contours that are to ultimately discharge into either headwaters of watercourses or via detention basins spilling over into lower reaches of specific watercourses. It is expected a similar methodology will be adopted by the greater PCA.

7 IMPLANTATION STRATEGY

The outcomes of this SMP provides a framework for stormwater management within the proposed Warkworth North 2 precinct.

The development of the wider catchment can be enabled through the adoption of the preferred outcome. Subject to the inclusion of catchment wide quality and detention control (within the respective ownership / resource consent applications), effects will be adequately mitigated within the PCA, both the receiving environment and downstream properties.

The SMP provides a clear framework that can guide the development of the plan change area, subject to detailed engineering design and ongoing Auckland Council and Healthy Waters input, being addressed through the resource consent process.

7.1 ASSET OWNERSHIP

It is proposed that all local and collector primary stormwater networks, including any stormwater detention and quality devices within road or stormwater reserves be vested to Healthy Waters, Auckland council or Auckland Transport as required.

Lot connections will be the interface between private and public asset ownership as per the Stormwater Code of Practice, the locations of which will be detailed and subject to approval during resource consent and furthermore engineering approval stage.

Stormwater devices located within private property for the purpose of mitigating flow from impervious areas are to be owned and maintained by the landowner.

7.2 ONGOING MAINTENANCE REQUIREMENTS

Provided that all assets are designed in accordance with Auckland council design guidelines, with future proofing and allowances for access and maintenance. It is considered that this requirement would be mandatory and assessed at the relevant design stages through the consenting phases of development

7.3 IMPLEMENTATION OF STORMWATER NETWORK

The driving requirement for stormwater controls to be built will come from a combination of both bulk earthworks; recontouring the site, reclamation of streams, major overland flow paths and detention basins. While the construction of public road systems will entail; local stormwater devices, catch pits and secondary flow networks to controls flows along carriageways and though what will initially be green field development.

Public assets built will be vested with council in accordance with council regulations and be subject to any land-use, subdivision and special engineering consent conditions, ensuring compliance with the NDC.

Private systems, more likely required for servicing of jointly owned accessways, commercial lots and carparks will be constructed and maintained, by the relevant landowners, at the time of construction. Requirements of compliance of which are outlined in this document.

APPENDIX A

ENGINEERING PLANS & DETAILS

APPENDIX B

FRESHWATER SOLUTIONS REPORT

APPENDIX C

STORMWATER MODELLING REPORT

APPENDIX D

TREATMENT TRAIN TOOLBOX

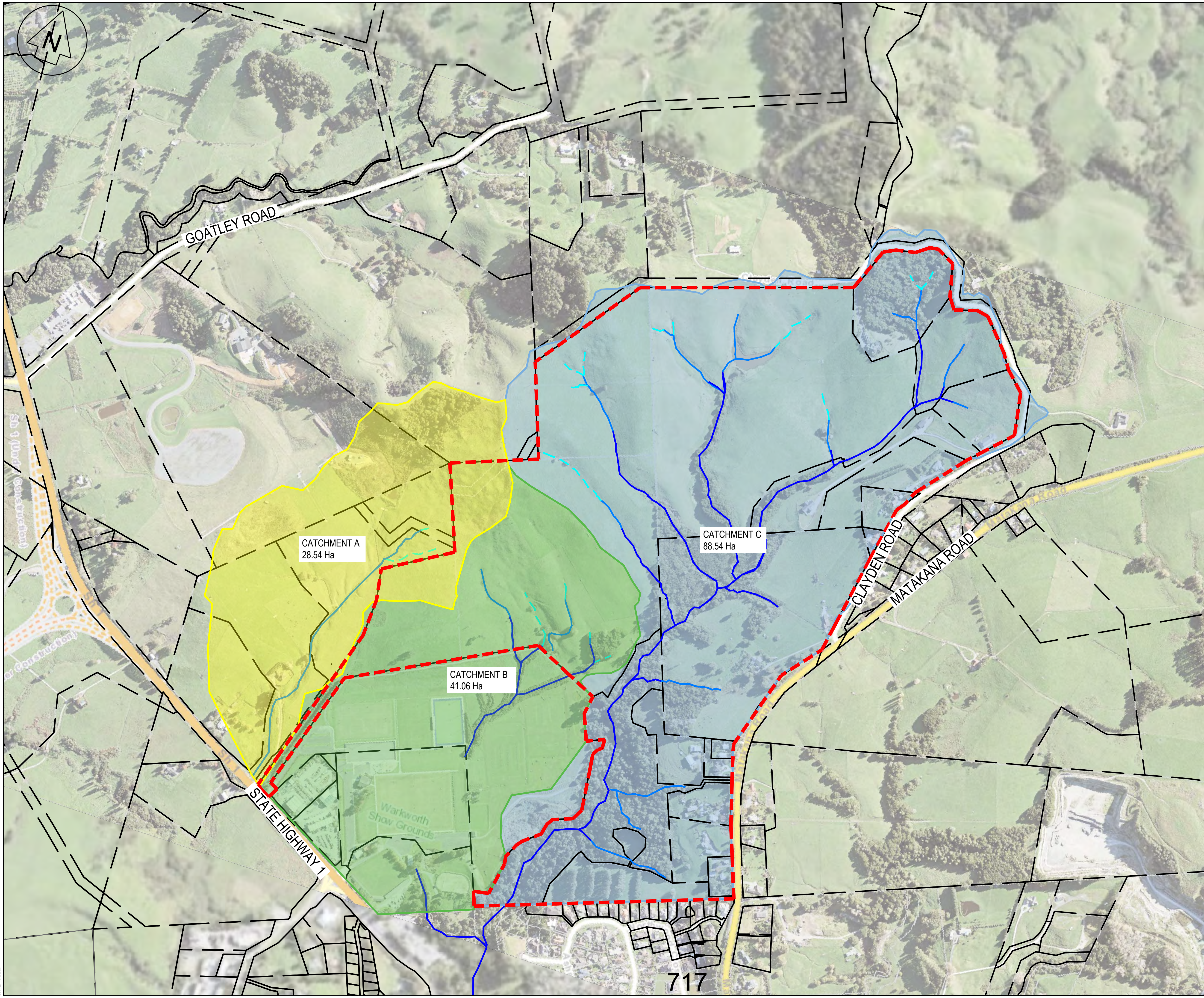
Treatment Train Stage	Outcome	Method	Positives & Negatives
1. Source Control	Eliminate or minimise generation of contaminants	• Use of inert building materials • Erosion and sediment controls during construction • Isolation of hazardous materials	✓ Minimising the use of materials that leach contaminants such as copper, galvanised metal and treated timber
	Reduce impervious surface	• Replacing impervious surfaces with pervious paving, living roofs, etc. to infiltrate stormwater and capture dissolved contaminants • Where impervious surfaces do occur, directing surface runoff to landscape area to allow the 'first flush' to achieve some preliminary level of treatment • Where parking is deemed appropriate, potential strategies to reduce imperviousness include shared area for opening car doors, pervious area forward of wheel stops, and one way angled parking.	✓ Increase opportunities for rainfall to be attenuated within vegetation and soils which in turn will moderate stormwater volumes and reduce the capacity requirements for infrastructure and treatment practices in the catchment. ✓ Reduced imperviousness is also likely to reduce the contaminant load
	Minimise site disturbance	• Minimise extent of bulk earthworks • Retain existing natural systems (discharge points at watercourses and allowance for natural base flows through construction)	✓ Consistent with cultural values and expectations
2. At-source Control	Capture and re-use	• Above-ground rainwater storage and reuse tanks • Below-ground rainwater storage and reuse tanks	✓ Capture of water on-site thus reducing runoff ✓ Possible potable water use reduction ✓ Below-ground rainwater storage tanks minimise land take ✓ Underground storage systems usually have an increased service life and therefore a reduced life cycle cost - Collection of surface water flows from streets, yards, etc. usually requires pre-treatment prior to storage, usually in an underground facility. - Preference for gravity fed situations × Rain tanks are perceived as having significant capital and life cycle costs × Retention and detention capacities may be reduced by multiple storms **For private/single-use reuse system** × Purchasers of property may view rain tanks a liability × Must have asset owner commitment for reuse
	Infiltration	• Pervious paving or porous concrete • Soakage pits • Trench drains • Bioretention devices such as raingardens, tree pits, filter strips/swales and wetlands • Filter strips	✓ Infiltration recharges groundwater - Retention can be provided by infiltration, where it is feasible and assessed appropriately by a qualified geotechnical engineer. - Pre-treatment may be provided prior to infiltration to prevent clogging of the device. × High failure rate of pervious pavement and high maintenance requirements for all infiltration devices × For pervious pavements, drainage area is generally less than 1,000 m²
	Evapotranspiration	• Intensive living roofs • Extensive living roofs • Living walls	✓ Aesthetically and environmentally rewarding ✓ Intensive living roofs have a deep soil medium and can be used to grow food if access is provided for residents ✓ Extensive living roofs are designed for maximum thermal and hydrological performance and minimum weight load ✓ Noise and heat insulation benefits

			✓ Reduced energy costs through insulation of a building and localised cooling around air conditioner intakes ✗ High installation cost and challenging maintenance access ✗ It can be challenging to keep plants healthy in fast-draining media and on sloped roofs
3. Filtering		• Grated catchpits and inlets • Gross pollutant traps or other proprietary treatment device	✓ Extend the maintenance period for other devices in the treatment train by filtering out the first flush of contaminants which may clog downstream devices. ✓ Ease of maintenance
4. Conveyance		• Retain and enhance intermittent streams • Swales and open channels • Road corridor • Pipe network • Filter strips	✓ Filter strips can function as Infiltration treatment devices and conveyance means ✓ Generally, adopting natural flow paths have easy maintenance and are aesthetically and environmentally rewarding - Swales are tolerant to a range of flows and are resilient in drought ✗ Swales and filter strips: gentle slopes and a large footprint are required to accommodate vegetated side slopes ✗ High sediment loads can create unsightly sedimentation within swales and at the edges of filter strips. However, dense planting and/or a reduced mowing regime may localise sediment accumulation for removal and prevent its transport to the base of the swale.
5. Bioretention		• Raingardens • Planter boxes • Swales • Tree pits	✓ Multiple stormwater management functions in one device, including water infiltration, detention and retention. ✓ Ecological value ✓ Devices can be designed to provide also hydrological mitigation within private residential property or along road corridors and within public impervious spaces, while adding to the landscape value of the PCA. - Care should be taken to allow for maintenance in shared spaces, particularly in road corridors where safety is a concern - Tree pits require a sufficient quantity of soil media to support trees through maturity and often have bypass systems to avoid localised ponding from surface runoff. - Stormwater planter boxes may be included in any location where conventional planter boxes are used, including building facades, courtyard spaces or rooftops. ✗ Standing water may be unsightly, may generate odours, and may be a vector for insects ✗ Rubbish and sediment can accumulate and affect performance
6. Detention and Attenuation		• Detention Basins • Surface flow wetlands (including wet swales) • Sub-surface flow wetlands	✓ Multiple stormwater management functions in one device, including attenuation of flood flows and water quality treatment ✓ Ecological value.

			✓ Wetlands with connections to existing riparian environments offer excellent opportunities to provide fish passage for increased habitat offline (upstream of the receiving environment), and this is critical where wetland ponds are online - Potential drawback of end of system detention for attenuation are the required land and the potential for super-position of peak flows downstream - Because of the multipurpose nature of areas being used and the open water, safety is an important consideration and the period of inundation should be less than 24 hours depending on access requirements. ✗ Standing water may be unsightly, may generate odour, and may be a vector for insects ✗ Rubbish and sediment can accumulate and affect performance ✗ Detention capacity may be reduced by multiple storms ✗ Maintenance of wetlands can be significant, especially for the control of sediment
7. Enhancing the receiving environment		• Esplanade Reserve and Riparian Zone buffers • Stream daylighting	✓ The receiving environment can be restored for greater resilience and to enhance the broader environmental framework of the site. ✓ Riparian buffers act as biological filters between catchments and receiving environments, intercepting a significant proportion of groundwater nutrients. ✓ The greater the width of riparian planting the more obvious the benefits to stream health, the greater the contaminant removal rate and the lower the maintenance ✓ Stream channels are comparable in cost to piped systems in the short-term and more accessible for maintenance in the long-term. - One factor that needs to be kept in mind for restored riparian buffers is the likelihood that the stream channel will widen due to an increase in shading and subsequent loss of grasses along the stream bank.

ATTACHMENT H2

STORMWATER CATCHMENT PLANS (revised post notification)



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend
- EX BDY
- EX EASEMENT
- PR PRECINCT BDY
- EX CATCHMENT BDY
- EX EPHEM. STREAM
- EX INT. STREAM
- EX PERM. STREAM

Rev	Description	By	Date

	By	Date
Survey	-	-
Design	GB	01/19
Drawn	LC	01/19
Checked	BV	01/19

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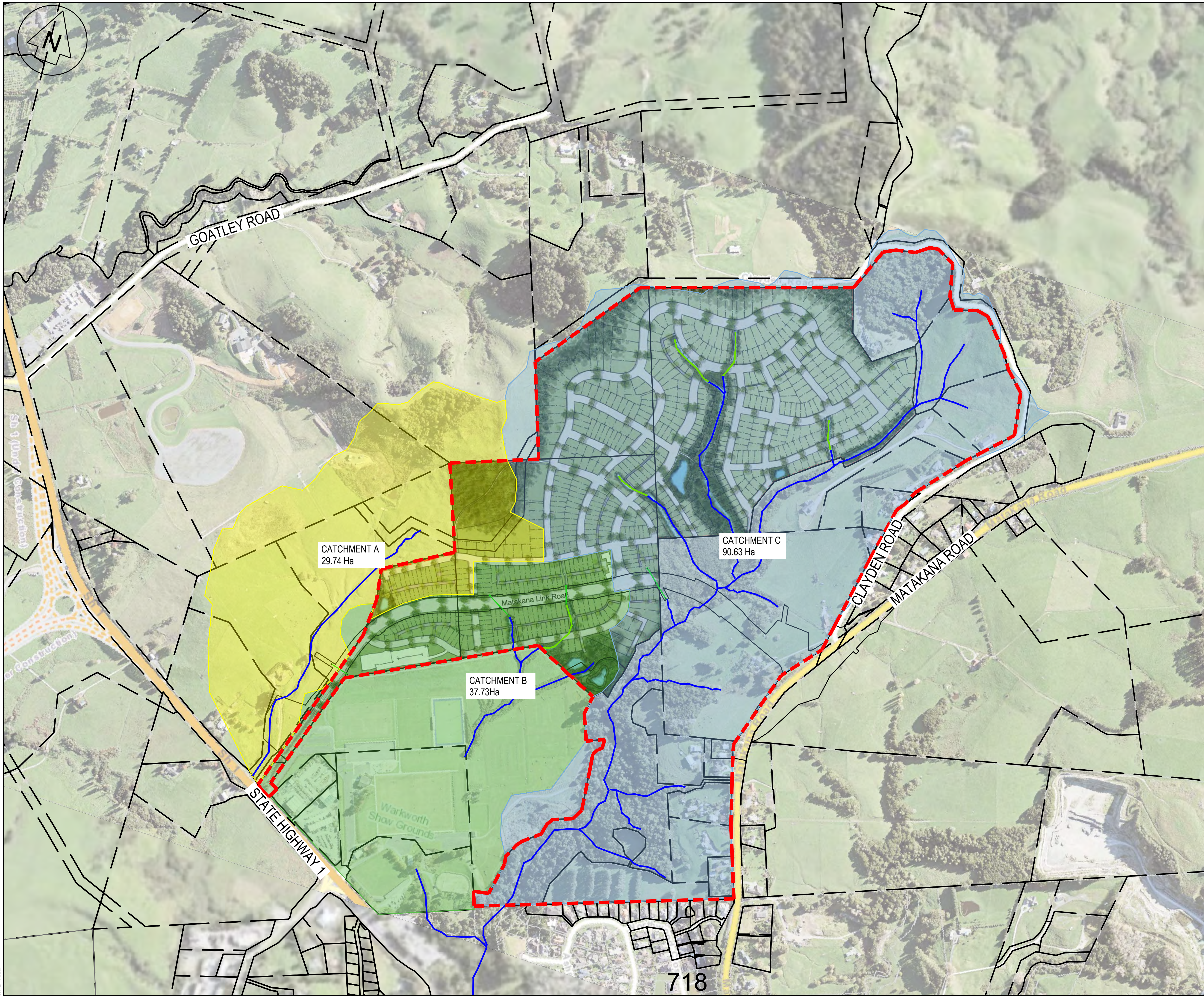
Project
WARKWORTH NORTH 2 PCA WARKWORTH FOR WARKWORTH LAND LTD

Title
EXISTING STORMWATER CATCHMENT PLAN

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C460.DWG
Drawing no.	C4601 · Rev A



Notes
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2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend

EX BDY
EX EASEMENT
PR PRECINCT BDY
EX CATCHMENT BDY
EX WATERCOURSE
PR WATERCOURSE

Rev	Description	By	Date

	By	Date
Survey	-	-
Design	GB	01/19
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Project
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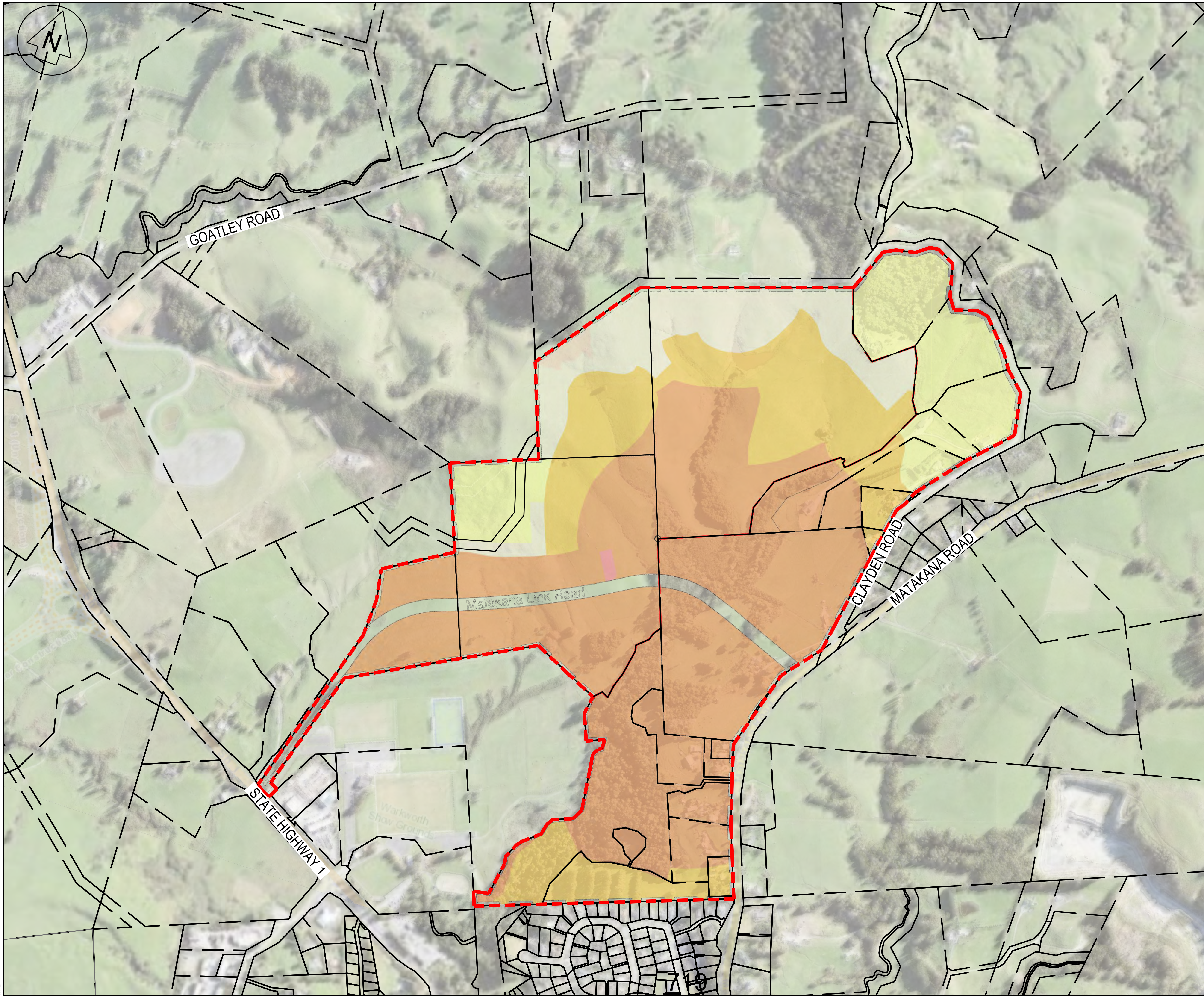
Title
PRELIMINARY PROPOSED STORMWATER CATCHMENT PLAN

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C460.DWG
Drawing no.	C4611 Rev A



Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend

EX BDY
PR PRECINCT BDY

Zoning Key

M.H URBAN ZONE
M.H SUBURBAN ZONE
SINGLE HOUSE ZONE
LARGE LOT ZONE
COUNTRYSIDE LIVING
NEIGHBOURHOOD CTR

Rev	Description	By	Date
A	SMP	LC	08/20

	By	Date
Survey	-	-
Design	LC	08/20
Drawn	LC	08/20
Checked	GB	08/20

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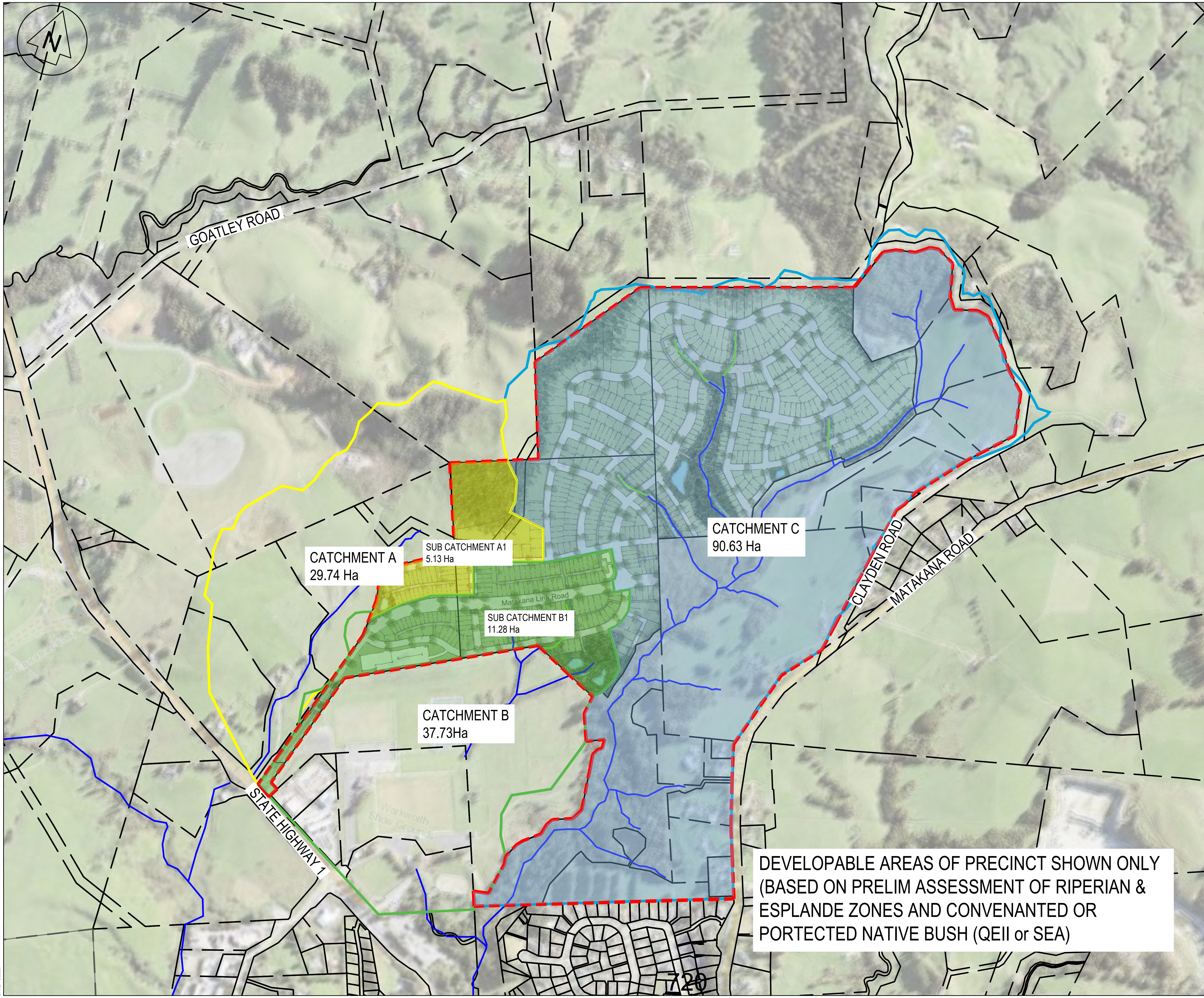
Title

PROPOSED PRECINCT PLAN

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C470.DWG
Drawing no.	C4612
Rev	A



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend

— — —	EX BDY
- - - (red)	PR PRECINCT BDY
—— (orange)	PR CATCHMENT BDY
—— (blue)	EX WATERCOURSE
—— (green)	PR WATERCOURSE

Rev	Description	By	Date
A	SMP	LC	08/20

	By	Date
Survey	-	-
Design	LC	08/20
Drawn	LC	08/20
Checked	GB	08/20

MAVEN
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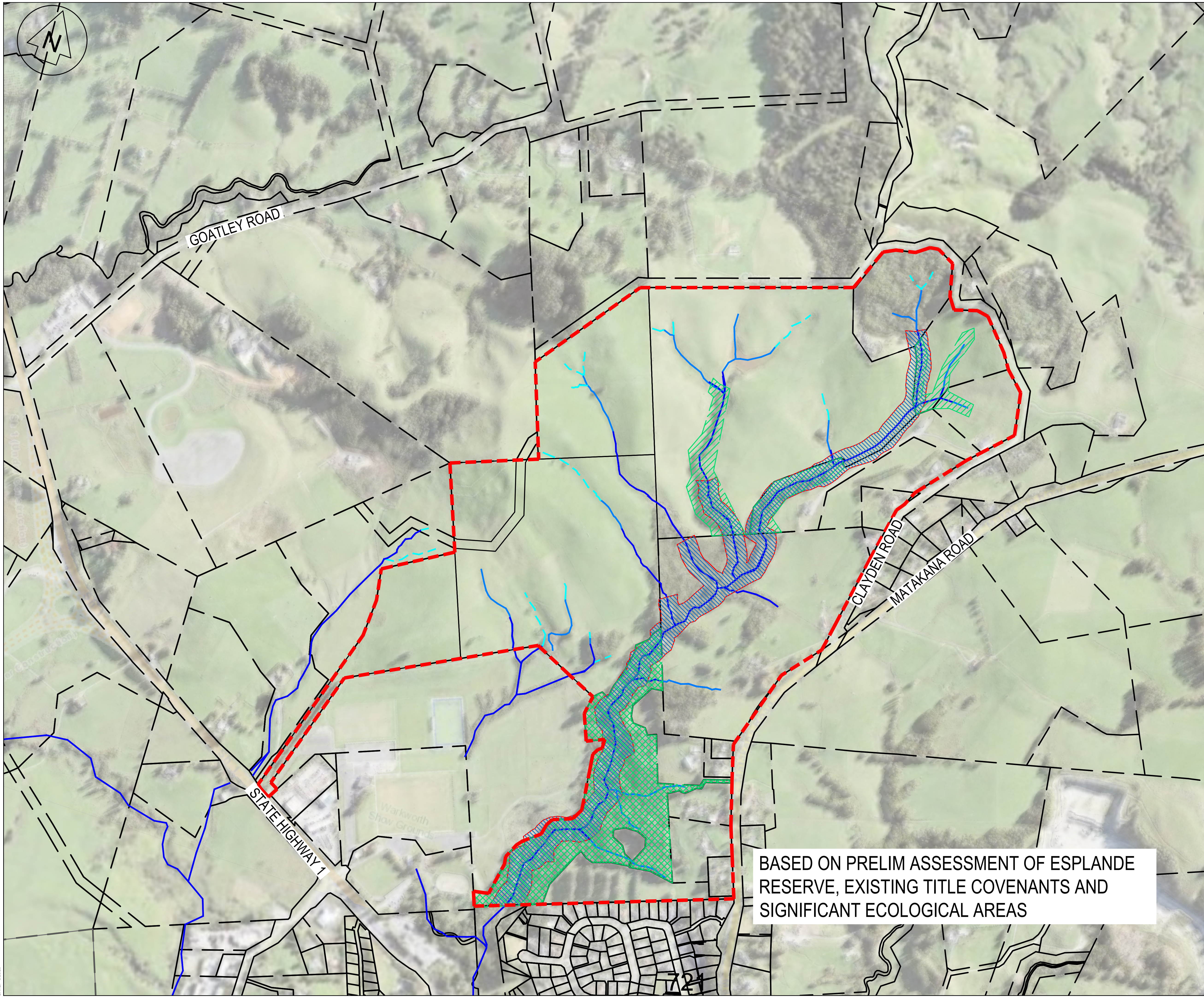
09 571 0050
info@maven.co.nz
www.maven.co.nz
12-14 Walls Road, Penrose

Project
WARKWORTH NORTH 2 PCA WARKWORTH FOR WARKWORTH LAND LTD

Title
PROPOSED CATCHMENT PLAN

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C470.DWG
Drawing no.	C4613
Rev	A



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend
- EX BDY
- PR PRECINCT BDY
- EX WATERCOURSE
- EX COVENANT (BUSH)
- EX S.E.A
- PR ESPLANADE RES.

Rev	Description	By	Date
A	SMP	LC	08/20

	By	Date
Survey	-	-
Design	LC	08/20
Drawn	LC	08/20
Checked	GB	08/20

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Project
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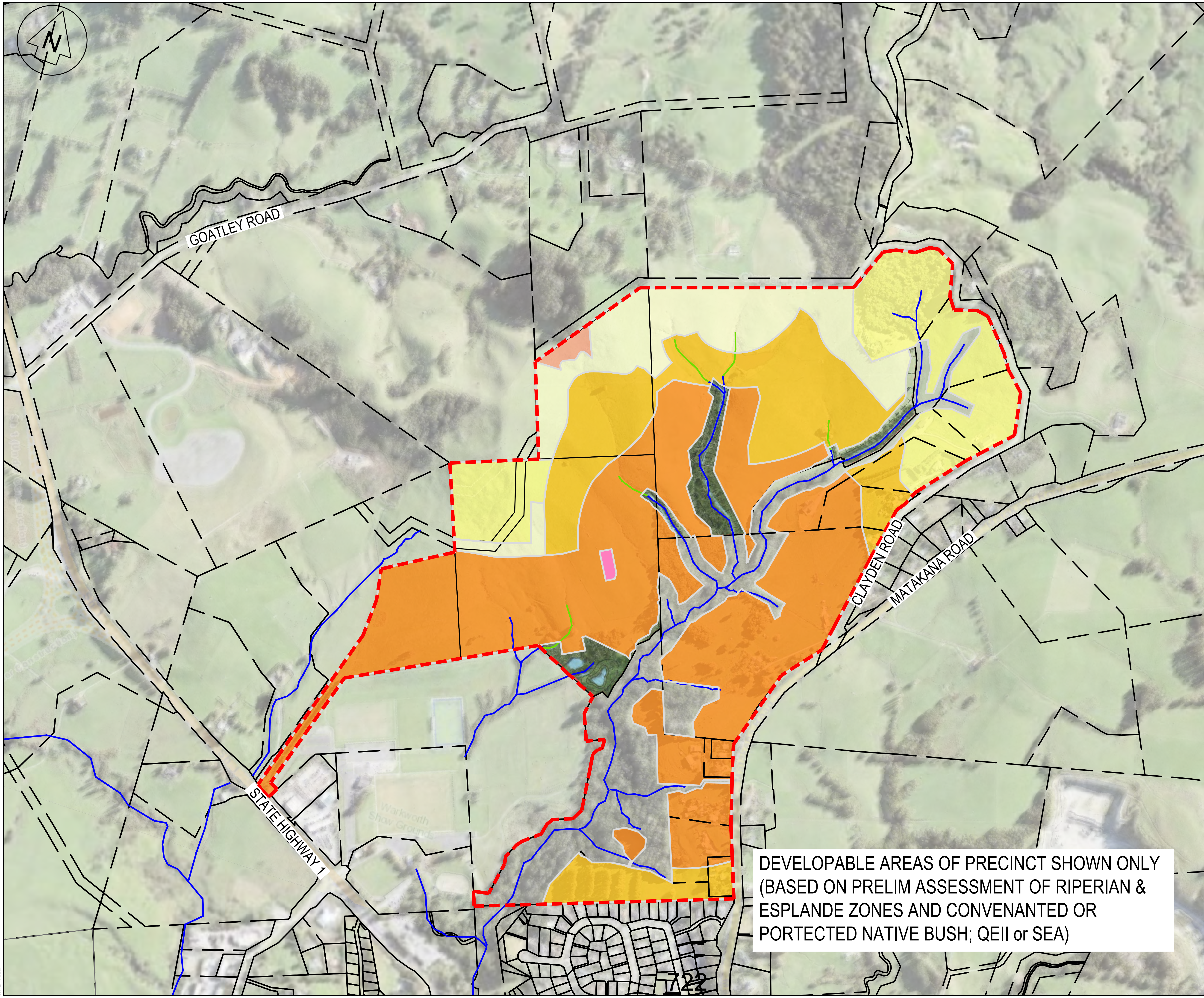
Title
INDICATIVE DEVELOPMENT RESTRICTIONS

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C470.DWG
Drawing no.	C4614
Rev	A



Notes
1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend
- EX BDY
- PR PCA BDY
- PR PRECINCT BDY
- EX WATERCOURSE
- PR WATERCOURSE

Zoning Key
- M.H URBAN ZONE
- M.H SUBURBAN ZONE
- SINGLE HOUSE ZONE
- LARGE LOT ZONE
- COUNTRYSIDE LIVING
- NEIGHBOURHOOD CTR

Rev	Description	By	Date
A	SMP	LC	08/20

	By	Date
Survey	-	-
Design	LC	08/20
Drawn	LC	08/20
Checked	GB	08/20

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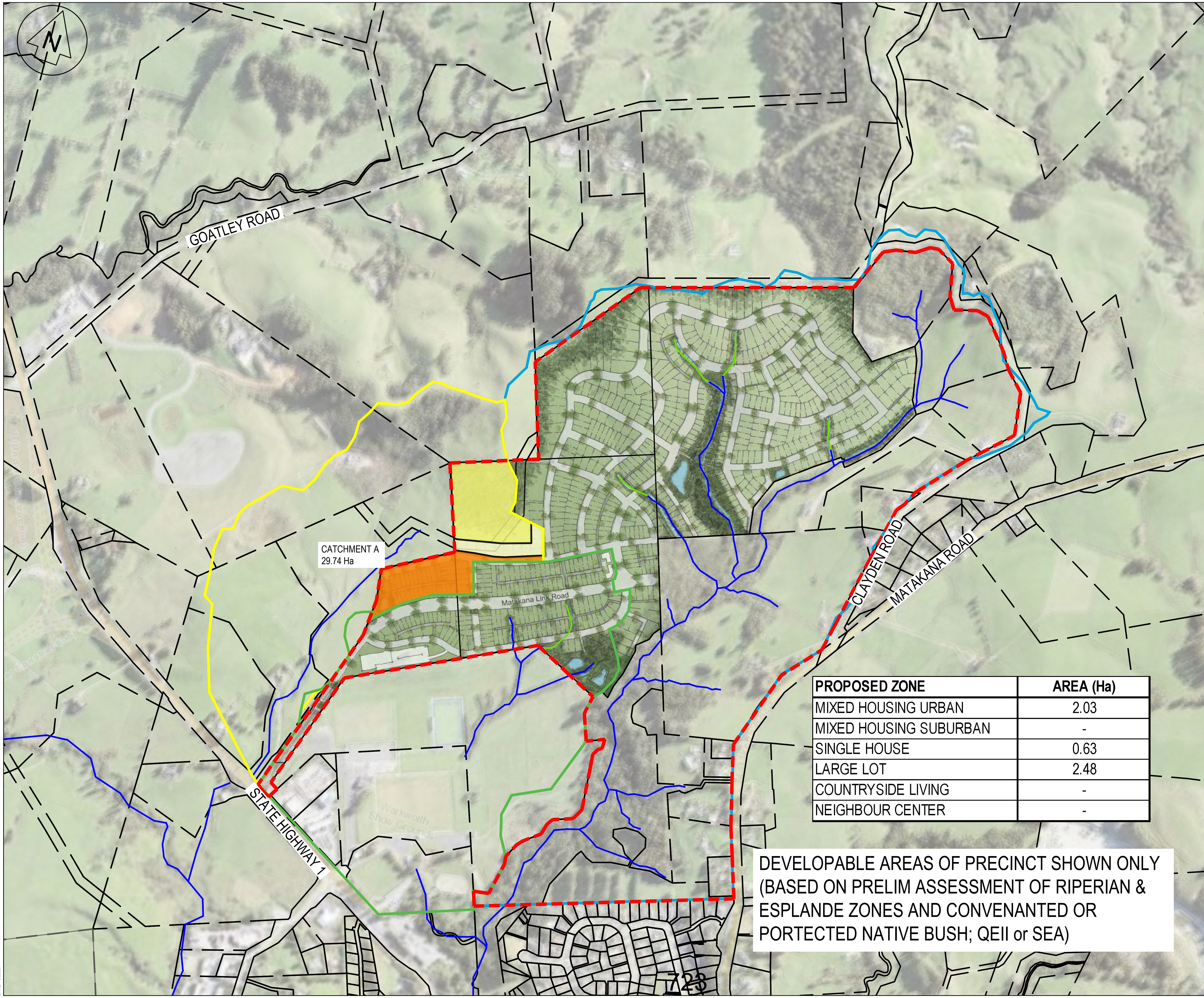
Project
WARKWORTH NORTH 2 PCA WARKWORTH FOR WARKWORTH LAND LTD

Title
INDICATIVE DEVELOPABLE PRECINCT OVERVIEW

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C470.DWG
Drawing no.	C4615
Rev	A



PROPOSED ZONE	AREA (Ha)
MIXED HOUSING URBAN	2.03
MIXED HOUSING SUBURBAN	-
SINGLE HOUSE	0.63
LARGE LOT	2.48
COUNTRYSIDE LIVING	-
NEIGHBOUR CENTER	-

DEVELOPABLE AREAS OF PRECINCT SHOWN ONLY (BASED ON PRELIM ASSESSMENT OF RIPERIAN & ESPLANDE ZONES AND CONVENANTED OR PORTECTED NATIVE BUSH; QEII or SEA)

Notes

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2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend

- EX BDY
- PR PRECINCT BDY
- PR CATCHMENT BDY
- EX WATERCOURSE
- PR WATERCOURSE

Zoning Key

- M.H URBAN ZONE
- M.H SUBURBAN ZONE
- SINGLE HOUSE ZONE
- LARGE LOT ZONE
- COUNTRYSIDE LIVING
- NEIGHBOURHOOD CTR

Rev	Description	By	Date
A	SMP	LC	08/20

	By	Date
Survey	-	-
Design	LC	08/20
Drawn	LC	08/20
Checked	GB	08/20

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Project

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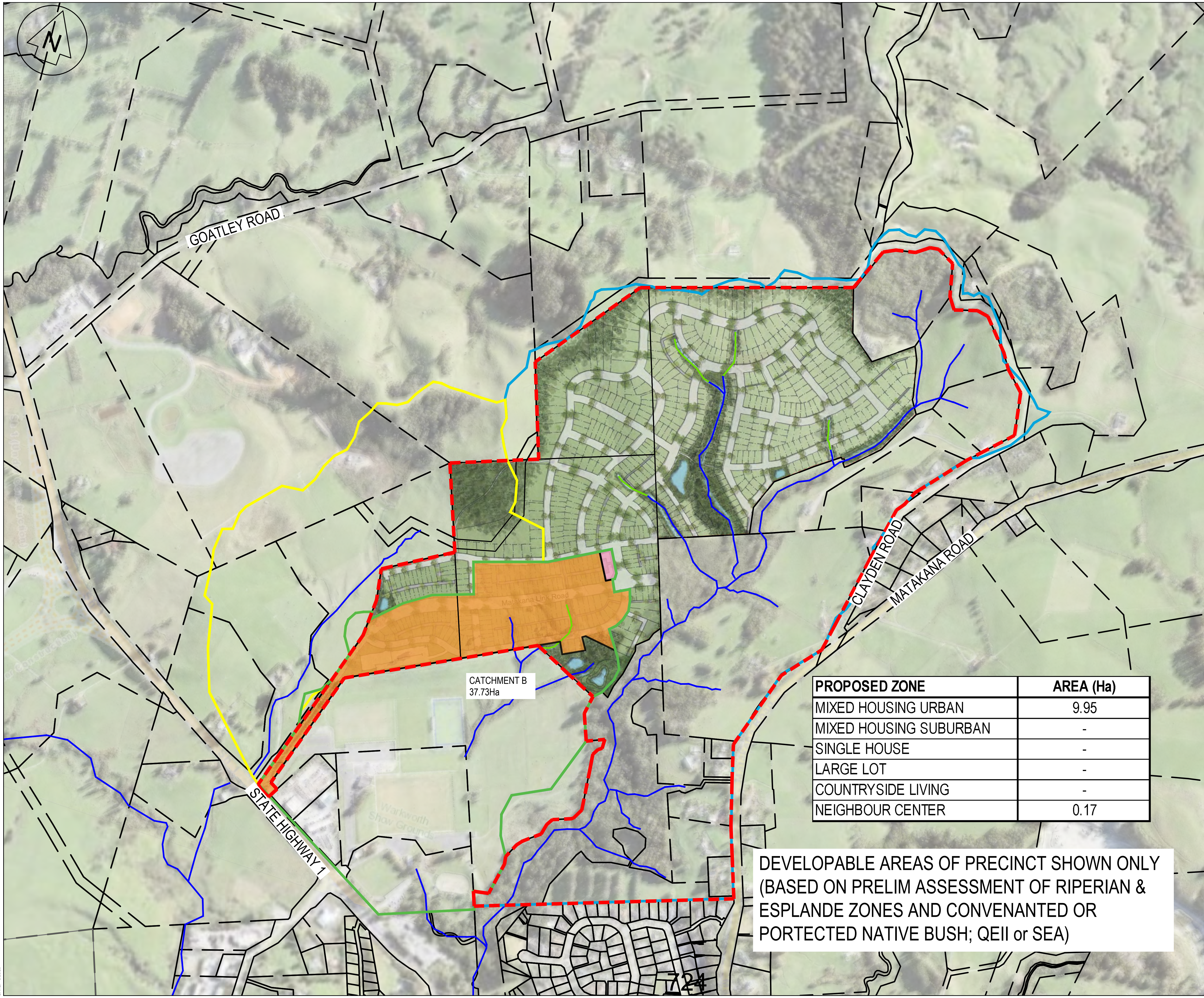
Title

PROP STORMWATER CATCHMENT A OVERVIEW

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C470.DWG
Drawing no.	C4620
Rev	A



PROPOSED ZONE	AREA (Ha)
MIXED HOUSING URBAN	9.95
MIXED HOUSING SUBURBAN	-
SINGLE HOUSE	-
LARGE LOT	-
COUNTRYSIDE LIVING	-
NEIGHBOUR CENTER	0.17

DEVELOPABLE AREAS OF PRECINCT SHOWN ONLY (BASED ON PRELIM ASSESSMENT OF RIPERIAN & ESPLANDE ZONES AND CONVENANTED OR PORTECTED NATIVE BUSH; QEII or SEA)

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1. All works to be in accordance with Auckland council standards.
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3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend
- EX BDY
- PR PRECINCT BDY
- PR CATCHMENT BDY
- EX WATERCOURSE
- PR WATERCOURSE

Zoning Key
- M.H URBAN ZONE
- M.H SUBURBAN ZONE
- SINGLE HOUSE ZONE
- LARGE LOT ZONE
- COUNTRYSIDE LIVING
- NEIGHBOURHOOD CTR

Rev	Description	By	Date
A	SMP	LC	08/20

	By	Date
Survey	-	-
Design	LC	08/20
Drawn	LC	08/20
Checked	GB	08/20

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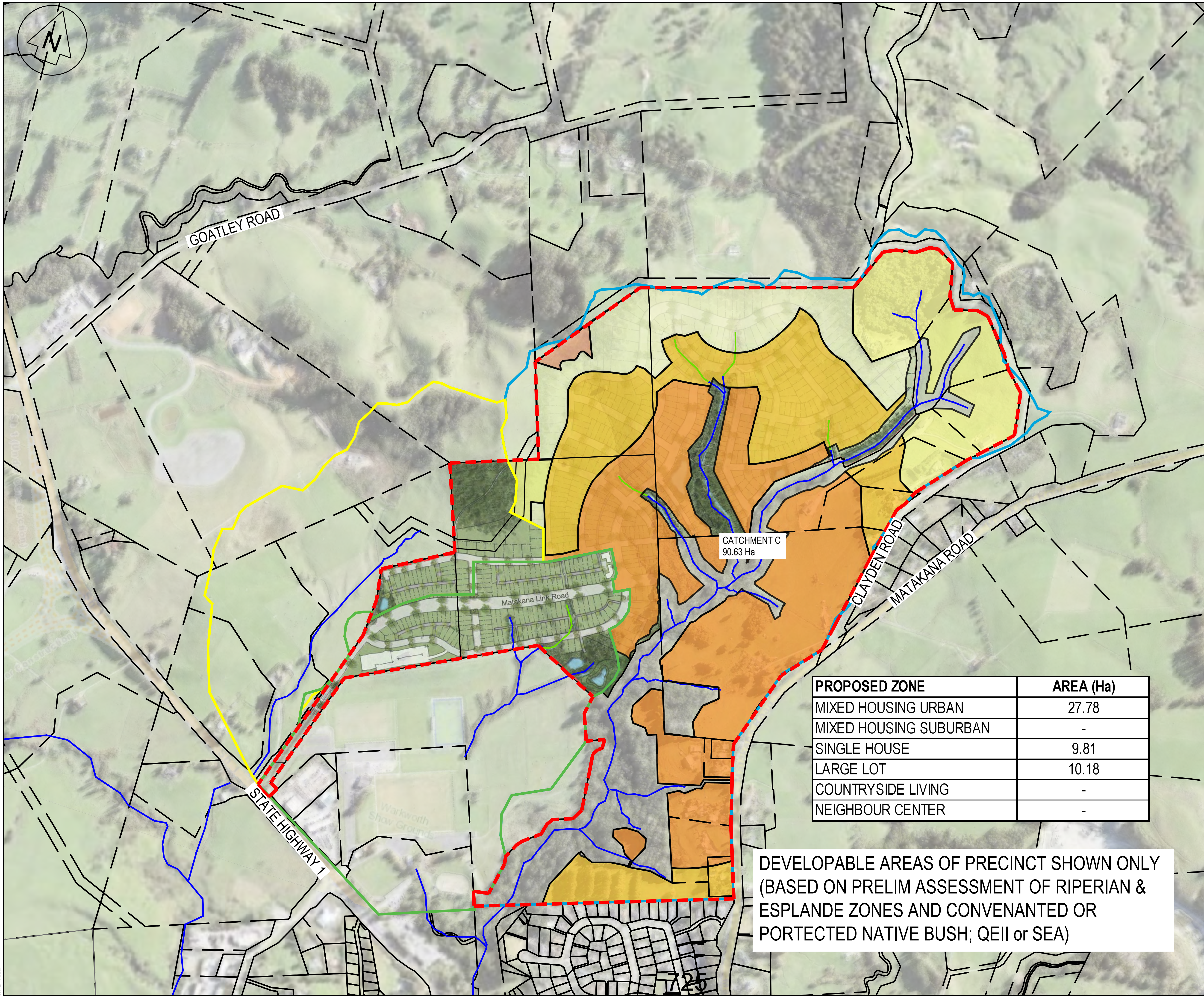
Project
WARKWORTH NORTH 2 PCA WARKWORTH FOR WARKWORTH LAND LTD

Title
PROP STORMWATER CATCHMENT B OVERVIEW

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C470.DWG
Drawing no.	C4621
Rev	A



PROPOSED ZONE	AREA (Ha)
MIXED HOUSING URBAN	27.78
MIXED HOUSING SUBURBAN	-
SINGLE HOUSE	9.81
LARGE LOT	10.18
COUNTRYSIDE LIVING	-
NEIGHBOUR CENTER	-

DEVELOPABLE AREAS OF PRECINCT SHOWN ONLY (BASED ON PRELIM ASSESSMENT OF RIPERIAN & ESPLANDE ZONES AND CONVENANTED OR PORTECTED NATIVE BUSH; QEII or SEA)

Notes
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2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. Boundaries are subject to final survey.
5. Stream classification determined within Freshwater Solutions PPCA documentation

Legend
- EX BDY
- PR PRECINCT BDY
- PR CATCHMENT BDY
- EX WATERCOURSE
- PR WATERCOURSE

Zoning Key
- M.H URBAN ZONE
- M.H SUBURBAN ZONE
- SINGLE HOUSE ZONE
- LARGE LOT ZONE
- COUNTRYSIDE LIVING
- NEIGHBOURHOOD CTR

Rev	Description	By	Date
A	SMP	LC	08/20

	By	Date
Survey	-	-
Design	LC	08/20
Drawn	LC	08/20
Checked	GB	08/20

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Project
WARKWORTH NORTH 2 PCA
WARKWORTH
FOR
WARKWORTH LAND LTD

Title
PROP STORMWATER CATCHMENT C OVERVIEW

Project no.	102008
Scale	1:7500 @ A3
Cad file	102008 C470.DWG
Drawing no.	C4622
Rev	A

ATTACHMENT I

GEOTECHNICAL ASSESSMENT BY GEOSCIENCES – WLC LAND

8 October 2019 Document Ref: AKL2018-0228AC Rev 4

Warkworth Land Company Limited
c/o Development Advisory Services Limited
PO Box 5908
Wellesley Street
Auckland 1141

Attention: Vaughan Bell

Dear Sir

RE: PLAN CHANGE SUBMISSION – GEOTECHNICAL ASSESSMENT
CLAYDEN ROAD, WARKWORTH

1 INTRODUCTION

CMW Geosciences (CMW) have been engaged by Warkworth Land Company Limited to undertake a preliminary geotechnical assessment for the proposed plan change of the Stevenson Land and Clayden Road site, also known as the Warkworth: Clayden Road project, in Warkworth, legally described as Lot 3 & 4 DP 199755, Part Lot 1 DP 61693, PA 97 Mahurangi Parish and Lot 4 DP 492431 respectively.

This letter presents the results of our geotechnical assessment of the proposed scheme plan.

2 RELATED REPORTS

The following documents have been referred to during the development of this assessment:

- CMW, Geotechnical Letter for Structure Plan Submission for Stevensons Land and Clayden Road Land in Warkworth (ref. AKL2018-0105AD Rev0) dated 3 September 2018;
- Jacobs, SH1 to Matakana Link Road Ground Investigation, Geotechnical Factual Report (red. IZ093400-SG-R-01, Rev1) dated 3 November 2017;
- Jacobs, SH1 to Matakana Link Road, Geotechnical Interpretative Report (ref. IZ093400-SG-R-02, Rev1) dated 3 November 2017;
- Aecom – factual data including drill holes, test pits and hand auger borehole records;
- Maven Associates, Clayden Rise Development, Warkworth, Proposed Section Plans - Draft, (ref. 102008), Drawing No.'s C220A, C221 to C228;
- Maven Associates, Clayden Rise Development, Warkworth, Proposed Cut/Fill Plans – Draft, (ref. 102008) Drawing No.'s C210 to C213.

3 GEOLOGY

Published Geological Maps[1,2] and our fieldwork indicate the proposed development site is predominantly underlain by Pakiri Formation of the Waitemata Group. This geological unit is widespread, of early Miocene age and occurs from the north of Hatfields Beach, west to the Kaipara Harbour and north to Mangawhai. Pakiri Formation is dominated by 10-30m thick, graded medium to coarse grained sandstones alternating with thinner, laminated, siltstones and finer sandstones. This material forms the steeper and more elevated slopes on the north and west part of the site and is generally regarded as competent material for subdivision purposes.

Portions on the southern end of the site are also shown to be underlain with Mahurangi Limestones of the Northland Allochthon. The Mahurangi Limestone is represented by blue-grey to white, muddy limestone and weathered clayey residual soils, which forms the less elevated, gently rolling hills towards the southern end of the site.

Faulting is present along the contact of the Pakiri Formation and Mahurangi Limestone extending through the south western corner. It is indicated by GNS as being inactive and the presence of the fault is visible in the site geomorphology.

The geology for the site is interpreted on the cross sections attached as ***Drawing 05***.

4 GEOMORPHOLOGY

The geomorphology of the site has been extensively mapped during site walkovers and from historical aerial stereopair photographs. The geomorphology plan is presented on ***Drawing 11***.

The site contour is structurally controlled by the reverse thrust fault towards the southwest of the site and the changes in geology across the site extent. An associated, large debris flow is present in the southwest area that extends across several site boundaries.

The principal site ridgeline follows much of the northern and western boundaries and multiple spur ridgelines run from here from northwest to southeast across the site with intervening stream alignments. There are multiple head scarps and associated circular failures evident across the extent of the site.

A formed pond is located within the site, towards the northern boundary, at the head of one of the main stream alignments.

Further discussion on the geomorphology of the site can be found in the appended 2018 CMW letter.

5 DEVELOPMENT PROPOSAL

Based on the draft scheme plans provided by Maven Associates and the concept masterplan developed by Development Advisory Services Limited (DASL), the overall site is to be subdivided into a series of residential lots with associated access roads. The Matakana Link Road (MLR) is to be situated through the southern section of the site.

Draft scheme plans indicate cut and fill depths of up to 17.5m and 13.6m respectively across the site. The finished design levels across the site generally show gradients of approximately 7 degrees to the horizontal (contour of 1V:8H).

---

[1] Edbrooke, S.W. (complier) 2001, Geology of the Auckland Area, 1:250,000 Geological Map 3, GNS Science

[2] Markham, G.S. and Crippen. T.F. 1981: “Mangawhai-Warkworth” NZMS 290 Sheet R08/09, 1:100 000. New Zealand Inventory, Rock Types. Department of Lands and Survey, Wellington, New Zealand.

Several existing stream environments are to remain along the southern boundary of the site and extending into the central portion of the site. A number of smaller streams are also proposed to be in-filled as part of the development works.

Draft development plans provided by Maven Associates and DASL are appended and proposed contours are shown on ***Drawing 04***.

6 GEOTECHNICAL INVESTIGATIONS

CMW have undertaken a series of investigations across the site in order to define the ground model and verify design parameters. These include:

- Ten machine boreholes (denoted MH01-19 to MH10-19) to depths of up to 20.5m to determine the ground model through and below the proposed earthworks profile;
- 21 hand auger boreholes (denoted HA01-18 to HA11-18 and HA01-19 to HA10-19) to assist with identifying site features and ground conditions;
- Five test pits (denoted TP01-19 to TP05-19) to assist with laboratory sampling and establishing a ground model beneath the proposed earthworks profile.

Copies of the investigation records are appended and presented on the Site Investigation Plan (***Drawing 03***).

Several investigations have also been undertaken by various consultancies as part of the MLR project. These investigations are also presented on ***Drawing 03***.

7 GEOTECHNICAL ASSESSMENT

7.1 Slope Stability

The draft scheme plans indicate that an overall ground contour of approximately 7 degrees to the horizontal (or 1V:8H) is proposed. However, isolated areas are locally steepened to allow for access road formation to gradients of up to 18 degrees to the horizontal in the south-western Northland Allochthon geology and up to 22 degrees to the horizontal in the eastern Pakiri Formation soils. Along the north-eastern boundary there is an over-steepened batter with gradients of up to 39 degrees to the horizontal to allow for the regrading of the development into the natural ridgeline. It is understood that this area is undergoing additional design review and areas with locally steepened gradients will require further slope stability assessment during the detailed design stage.

The existing ridgelines across the northern boundary are to remain relatively untouched, with the majority of the existing gullies proposed to be filled by up to 13.6m height. This will likely require a number of shear keys in the lower site areas to support the upslope development, keyed into less weathered soil materials at depth. Along the southern boundary some low height retaining or Mechanically Stabilised Earth (MSE) walls will be required to heights of up to approximately 4m.

Shear keys or ground improvement will be required within the southern portion of the site within the unstable Northland Allochthon geology. These will need to be appropriately designed during the detailed design phase and will need to be carefully integrated with the proposed MLR earthworks. Several steep cuts are also proposed along the northern boundary, offset from the natural ridgeline. These cuts will require retaining walls or MSE walls to heights of up to approximately 9m in order to support the upslope land and properties.

Within the western corner of the site, an existing landslide is present extending from the Warkworth: Clayden Road site into the neighbouring Goatley Road development. CMW are engaged on both projects and are working with the developers to obtain a mutually beneficial solution. It is understood that the Warkworth:

Clayden Road site will develop the affected area into a reserve with appropriate stabilisation measures incorporated into the design to ensure the neighbouring development is protected.

Overall, slope instability is considered to be the most significant geotechnical risk for this development, with the principal drivers for instability being the Northland Allochthon geology in the southwest corner, and steeper contour and groundwater pressures within the Pakiri Formation residual soils. These will be addressed by a combination of re-grading and re-working of any existing instability features as part of development earthworks including the provision of shear keys, piles, deep groundwater drainage and other standard geotechnical solutions.

It is also anticipated that retaining walls will be required between lot boundaries on extensive portions of the site to account for the site gradients and accommodate the development of typical dwellings.

7.2 Matakana Link Road

The MLR alignment is depicted on the scheme plans and it is understood that construction of this road will precede the development of the subdivision. The current MLR drawings are understood to include the requirement for Continuous Flight Auger (CFA) piles to stabilise slope areas below the road.

Based on our understanding of the Northland Allochthon geology there are areas of the subdivision uphill of the MLR alignment that will be potentially affected by the road earthworks. This potential instability will be addressed in collaboration with the MLR designers and Auckland Transport to ensure the stability of both the road and the subdivision development.

Economies of geotechnical remediation are best achieved by designing and working these two projects concurrently to minimise the required remedial works. This will avoid expense on any remediation required for short term stabilisation of portions of the road that will require deeper and more extensive stabilisation for the subdivision development. Significant cost savings may be achieved by this integration.

7.3 Liquefaction and Settlement

CPT analysis undertaken by Jacobs as part of the MLR project indicates there is some potential for liquefaction within the gully along the southern boundary of the site. Only the alluvial deposits present within the gullies would be considered susceptible to liquefaction based on the geological age of the deposits. Further analysis is required to quantify this risk, however based on our test pitting and geological review it is considered unlikely that there is any significant risk of liquefaction on this project.

Residual soils of the Pakiri Formation and Mahurangi Limestone deposits across the majority of this site are not typically prone to excessive settlement under load. Conversely, the alluvial soils that may be present in the southern site extremities may be prone to more significant settlement that will require further assessment.

The presence of very stiff and hard soils adjacent to the gullies is expected to provide appropriate founding conditions for proposed MSE walls at comparatively shallow depths and will limit the amount of potential settlement induced by the associated fill loads. Accordingly, settlement is not considered to be a high risk hazard for the majority of this site, but where significant depths of filling are to be placed, they will need to be properly benched out, drained and filled. Settlement monitoring will also be required during construction to monitor any settlement that may occur.

During our site walkover we noted the presence of sinkholes or tomos in some of the gullies. These features are not uncommon in residual soils and slope colluvium derived from either limestone terrain or in the often sandy / silty soils of Pakiri Formation, where water is able to create underground channels and streams, typically where water flows are high. Care will need to be taken during earthworks operations to identify and remedy any such tomos encountered within the works areas.

7.4 Summary

Consideration should be given to the points above when undertaking further scheme design. Significant retaining works will be required to achieve the required site contours and portions of the land and geotechnical stability challenges still need to be investigated and remedial designs developed.

However, based on a review of the data available it is considered that the proposed residential subdivision is geotechnically feasible assuming the full range of remedial earthworks solutions such as development earthwork contouring, shear keys, buttress fills, ground water drainage and similar are available for use on the site.

8 LIMITATIONS

This report has been prepared for use by our client Warkworth Land Company Limited and their consultants for feasibility purposes.

Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

For and on behalf of CMW Geosciences

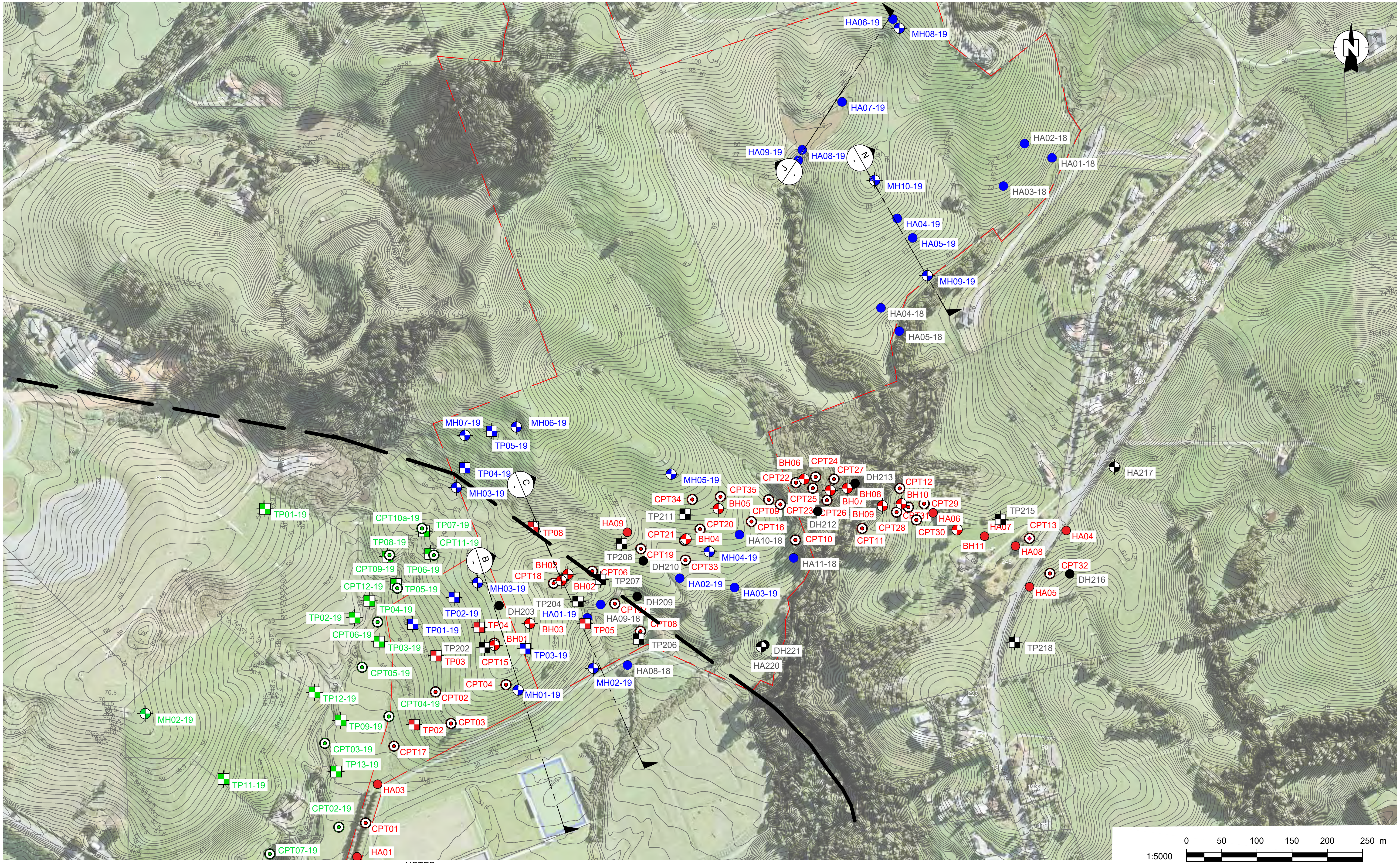
Prepared by:	Reviewed and authorised by:
Olivia Gill	Richard Knowles
Project Geotechnical Engineer	**Principal Geotechnical Engineer, CPEng**

Distribution: 1 electronic copy to Warkworth Land Company Ltd via email
Original held at CMW Geosciences

Appendix A: Drawings
Appendix B: Maven Associates Scheme Plans
Appendix C: Investigation Records
Appendix D: CMW 2018 Letter

Appendix A: Drawings

Drawing 03:	Site Investigation Plan
Drawing 04:	Proposed Contour Plan
Drawing 05:	Geological Sections B and C
Drawing 11:	Geomorphology Plan



LEGEND:

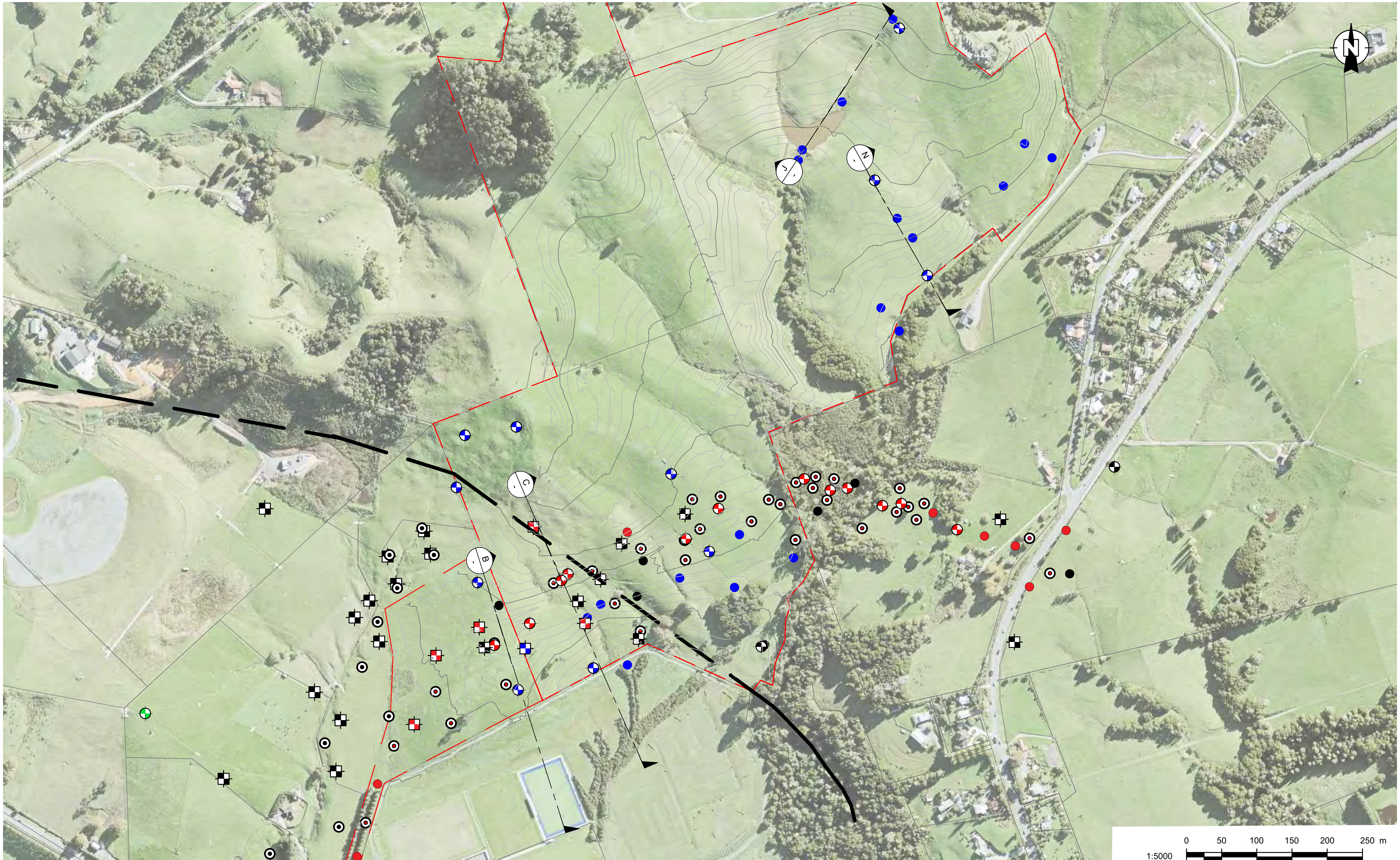
	SITE BOUNDARY
	GEOLOGICAL BOUNDARIES
	FAULT
HA01-18	CMW HA INVESTIGATION LOCATION 2018
MH01-19	CMW BH INVESTIGATION LOCATION 2019
TP01-19	CMW TP INVESTIGATION LOCATION 2019
HA01-19	CMW HA INVESTIGATION LOCATION 2019
CPT01	JACOBS CPT LOCATION
BH01	JACOBS MACHINE BOREHOLE (BH) LOCATION
TP01	JACOBS TEST PIT (TP) LOCATION
HA01	JACOBS HAND AUGER (HA) LOCATION
MH01-19	NEIGHBOURING MACHINE HOLE(MH) LOCATION 2019
TP01-19	NEIGHBOURING TEST PIT (TP) LOCATION 2019
	AECOM HAND AUGER (HA) LOCATION
	AECOM TEST PIT (HA) LOCATION
	AECOM DRILLHOLE (DH) LOCATION
	AECOM CONE PENETRATION (CPT) LOCATION

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS

CMW Geosciences

CLIENT:	WARKWORTH LAND DEVELOPMENT COMPANY	DRAWN:	FMS	PROJECT:	AKL2018-0228
PROJECT:	STEVENSONS LAND & CLAYDEN ROAD LAND, WARKWORTH	CHECKED:	OG	DRAWING:	03
		REVISION:	0	SCALE:	1:5000
TITLE:	SITE INVESTIGATION PLAN	DATE:	28/05/2019	SHEET:	A3



LEGEND:

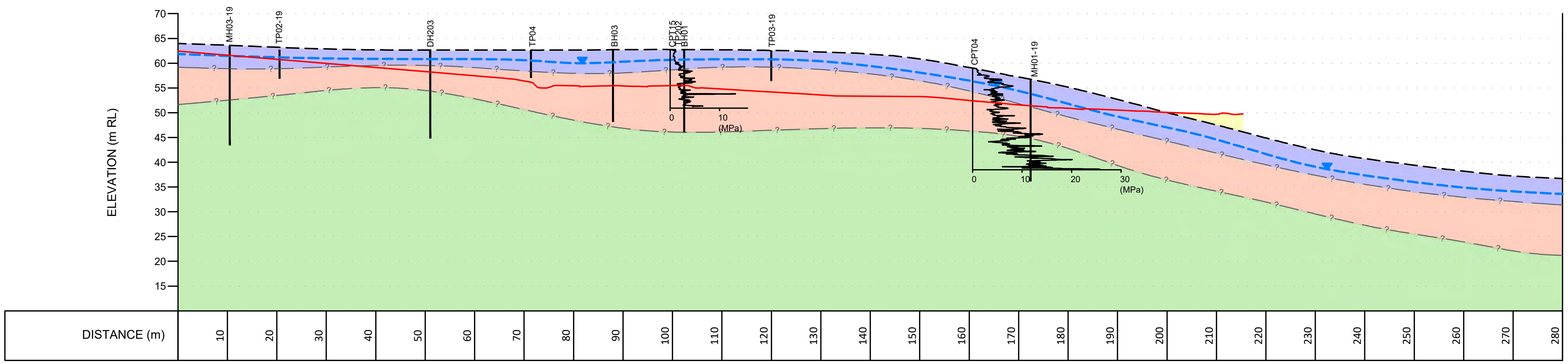
- SITE BOUNDARY
- HA01-18 CMW HA INVESTIGATION LOCATION 2018
- MH01-19 CMW BH INVESTIGATION LOCATION 2019
- TP01-19 CMW TP INVESTIGATION LOCATION 2019
- HA01-19 CMW HA INVESTIGATION LOCATION 2019
- FAULT
- GEOLOGICAL BOUNDARIES
- CPT01 JACOBS CPT LOCATION
- BH01 JACOBS MACHINE BOREHOLE (BH) LOCATION
- TP01 JACOBS TEST PIT (TP) LOCATION
- HA01 JACOBS HAND AUGER (HA) LOCATION
- MH01-19 NEIGHBOURING MACHINE HOLE(MH) LOCATION 2019
- TP01-19 NEIGHBOURING TEST PIT (TP) LOCATION 2019
- AECOM HAND AUGER (HA) LOCATION
- AECOM CONE PENETRATION (CPT) LOCATION
- CPT01-19 NEIGHBOURING CONE PENETRATION TEST (CPT) LOCATION 2019
- AECOM DRILLHOLE (DH) LOCATION
- AECOM TEST PIT (HA) LOCATION

NOTES:

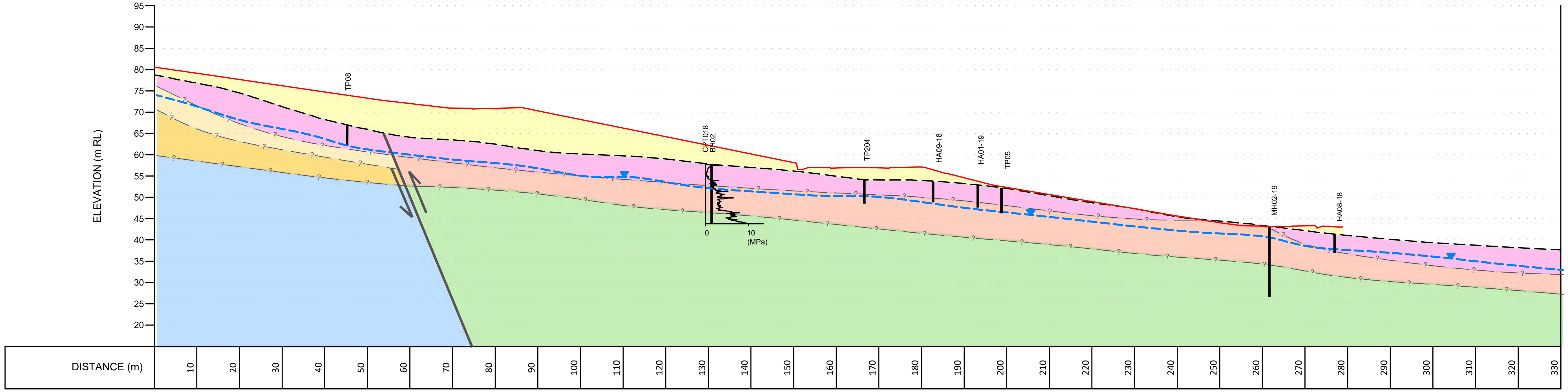
1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS

CMW Geosciences

CLIENT: WARKWORTH LAND DEVELOPMENT COMPANY	DRAWN: FMS	PROJECT: AKL2018-0228	
PROJECT: STEVENSONS LAND & CLAYDEN ROAD LAND, WARKWORTH	CHECKED: OMG	DRAWING: 04	
	REVISION: B	SCALE: 1:5000	
TITLE: PROPOSED SITE CONTOUR PLAN	DATE: 08/10/2019	SHEET: A3	



SECTION B



SECTION C

LEGEND:

- EXISTING PROFILE
- DESIGN PROFILE (08 OCT 2019)
- PROPOSED FAULT
- GROUNDWATER LEVEL
- FIRM TO VERY STIFF SILTY CLAY (COLLUVIUM)
- COMPLETELY WEATHERED MUDSTONE/SILTSONE (NORTHLAND ALLOCHTHON - TRANSITION ZONE)
- ENGINEERED FILL
- HIGHLY WEATHERED MUDSTONE/SILTSTONE (NORTHLAND ALLOCHTHON)
- RESIDUAL SOIL: STIFF TO VERY STIFF SILTY CLAY (NORTHLAND ALLOCHTHON)
- RESIDUAL SOIL (PAKIRI FORMATION)
- COMPLETELY WEATHERED SANDSTONE (PAKIRI FORMATION)
- HIGHLY WEATHERED SANDSTONE (PAKIRI FORMATION)

1:1000 — 0 10 20 30 40 50 m

CMW Geosciences

CLIENT: WARKWORTH LAND DEVELOPMENT COMPANY		DRAWN: FMS	PROJECT No: AKL2018-0228
PROJECT: STEVENSONS LAND & CLAYDEN ROAD LAND, WARKWORTH		CHECKED: OMG	DRAWING: 05
		REVISION: B	SCALE: 1:1000
TITLE: SECTION B & C		DATE: 08/10/2019	SHEET: A3

LEGEND:

- SITE BOUNDARY
- HEAD SCARP
- SLOPE DEBRIS MOUND (ARROW FOR DIRECTION OF MOVEMENT)
- STREAM OR GULLY FORMATION
- DEBRIS FLOW
- R RIDGELINE
- POND

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS

CMW Geosciences

CLIENT: WARKWORTH LAND DEVELOPMENT COMPANY	DRAWN: TG	PROJECT: AKL2018-0228
PROJECT: WARKWORTH: CLAYDEN ROAD	CHECKED: RK	FIGURE: 11
	REVISION: 0	SCALE: 1:5000 @ A3
TITLE: SITE INVESTIGATION PLAN	DATE: 30/05/2018	SHEET: A3 L

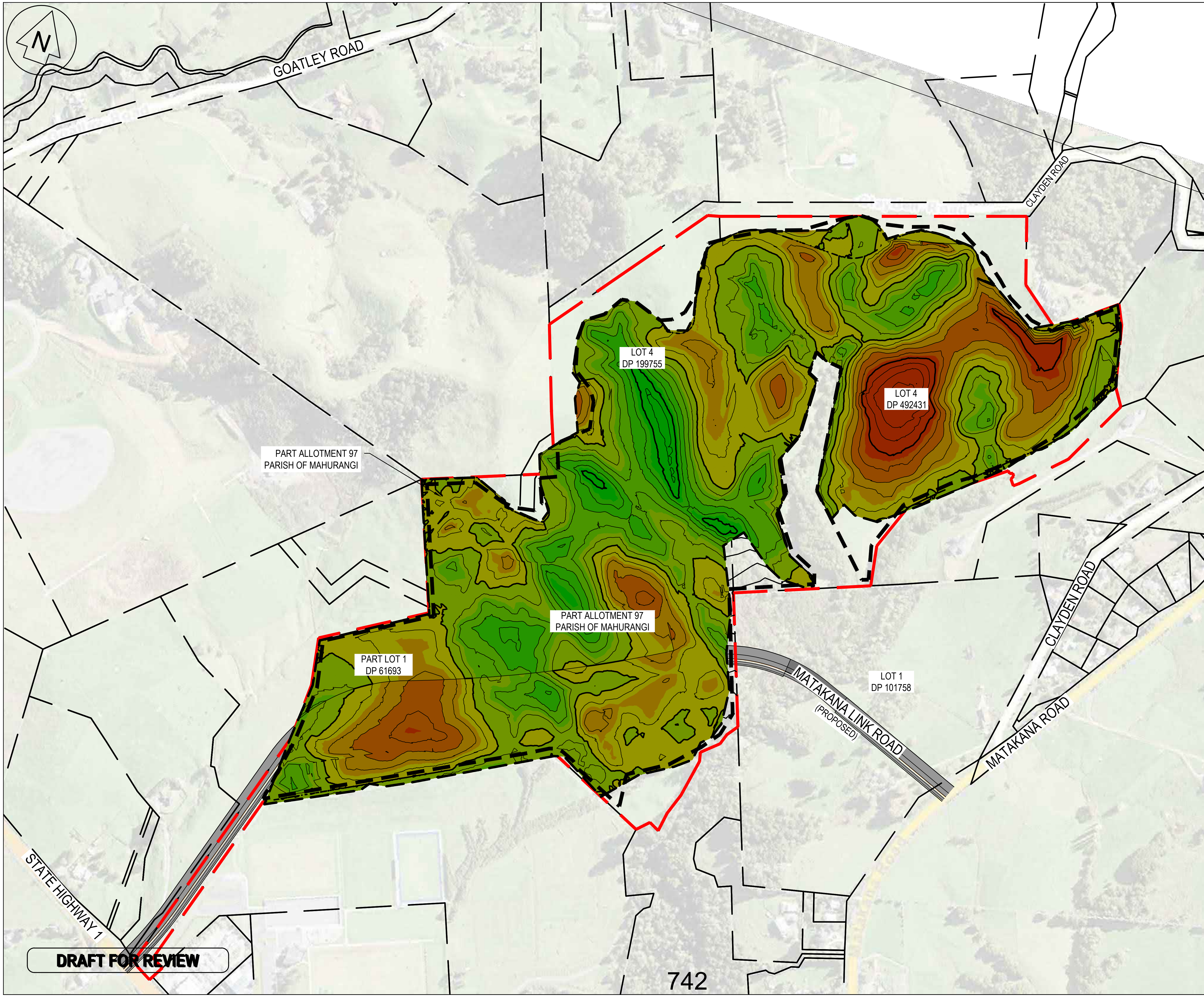
Appendix B: Maven Associates Scheme Plans

Concept Masterplan

Note:
Layout shown is sketch design only, and is subject to further consultant design work, town planning consents, building consents, other council and regulatory body approvals. Layout and lot yield is subject to change as concept design is progressed and further co-ordinated with civil engineering design is undertaken.

A Studio Architects takes no responsibility for information provided by others. We note that there are minor discrepancies between stream positions provided by consultants and have used 'best fit' locations.

0 100 200 300m
Scale: 1.5000 @ A3



Notes

1. All works to be in accordance with Auckland council standards.
2. Co-ordinates in terms of NZ Geodetic Datum Mt Eden 2000
3. Levels in terms of the Auckland Vertical Datum 1946.
4. It is the contractors responsibility to locate all services that may be affected by his operations.
5. The contractor shall comply with all relevant OSH and Health and Safety requirements.
6. The contractor shall obtain all necessary approval from utility operators before commencing work under or near their services.
7. Sediment control shall be installed and operational before earthworks start onsite in accordance with council standards.
8. Contractor shall provide asbuilt of working sediment control devices and confirmation of pond/decent volumes to engineer.

Legend

- EX BDY
- SITE EXTENTS
- PROP EXTENT WORK

Cut/Fill Table

Number #	Minimum Elevation	Maximum Elevation	Color
1	-17.519	-9.000	
2	-9.000	-6.000	
3	-6.000	-3.000	
4	-3.000	0.000	
5	0.000	3.000	
6	3.000	6.000	
7	6.000	9.000	
8	9.000	13.622	

Rev	Description	By	Date
A	STRUCTURE PLAN	JK	03/19

	By	Date
Survey	C220	-
Design	GB	03/19
Drawn	LC	03/19
Checked	BV	03/19

MAVEN
Maven Associates
09 571 0050
info@maven.co.nz
www.maven.co.nz
12-14 Walls Road, Penrose

Project

CLAYDEN RISE DEVELOPMENT WARKWORTH FOR WARKWORTH LAND LTD

Title

PROPOSED CUT/FILL OVERVIEW PLAN

Project no.	102008
Scale	1:5000 @ A3
Cad file	102008 C200.DWG
Drawing no.	C210
Rev	A

Appendix C: Investigation Records

CMW Geosciences – SOIL (Field Logging Guide)

SEQUENCE OF TERMS:
Fine: Soil Symbol – Soil Type – Colour – Structure – (Consistency) – (Moisture) – Bedding – Plasticity – Sensitivity – Additional Comments – Origin/Geological Unit
Coarse: Soil Symbol – Soil Type – Colour – Structure – Grading – Particle shape – (Relative Density) – (Moisture) – Bedding – Additional Comments – Origin/Geological Unit

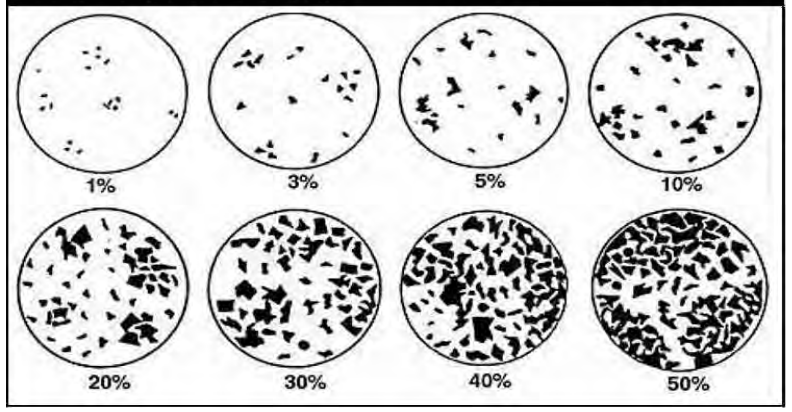
BEHAVIOURAL SOIL CLASSIFICATION SYSTEM

Major Divisions (behaviour based logging)			Soil Symbol	Soil Name
Coarse grained soils more than 65%>0.06mm	Gravel >50% of coarse fraction >2mm	Clean gravel <5% smaller 0.075mm	GW	Well graded gravel, fine to coarse gravel
			GP	Poorly graded gravel
		Gravel with >12% fines	GM	Silty gravel
			GC	Clayey gravel
	Sand ≥50% of coarse fraction <2mm	Clean sand	SW	Well-graded sand, fine to coarse sand
			SP	Poorly graded sand
		Sand with >12% fines	SM	Silty sand
			SC	Clayey sand
Fine grained soils 35% or more <0.06mm	Exhibits dilatant behaviour	inorganic	ML	Silt
			MH	Silt of high plasticity
		organic	OL	Organic silt
	No dilatant behaviour	inorganic	CL	Clay of low plasticity
			CH	Clay of high plasticity
		organic	OH	Organic clay
Highly Organic Soils			Pt	Peat

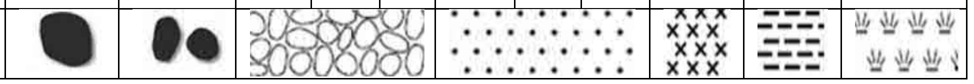
PROPORTIONAL TERMS DEFINITION

Fraction	Term	% of Soil Mass	Example
Major	(…) [UPPER CASE]	≥50 [major constituents]	GRAVEL
Subordinate	(…) [lower case]	20 – 50	Sandy
Minor	with some…	12 – 20	with some sand
	with minor…	5 – 12	with minor sand
	with trace of (or slightly)	< 5	with trace of sand (slightly sandy)

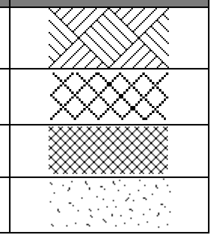
VISUAL PROPORTION PERCENTAGE



GRAIN SIZE CRITERIA

TYPE	COARSE								FINE		ORGANIC
	Boulders	Cobbles	Gravel coarse	Gravel medium	Gravel fine	Sand coarse	Sand medium	Sand fine	Silt	Clay	Organic Soil
Size Range (mm)	200	60	20	6	2	0.6	0.2	0.06	0.002		
Graphic Symbol											

ADDITIONAL GRAPHIC LOG SYMBOLS

Term	Symbol
Topsoil	
Fill	
Bitumen	
Concrete	

ORGANIC SOILS / DESCRIPTORS

Term	Description
Topsoil	Surficial organic soil layer that may contain living matter. However, topsoil may occur at greater depth, having been buried by geological processes or man-made fill, and should be termed a buried topsoil.
Organic clay, silt or sand	Contains finely divided organic matter; may have distinctive smell; may stain; may oxidize rapidly. Describe as for inorganic soils.
Peat	Consists predominantly of plant remains. **Firm:** Fibres already compressed together **Spongy:** Very compressible and open structure **Plastic:** Can be moulded in hand and smears in fingers **Fibrous:** Plant remains recognisable and retain some strength **Amorphous:** No recognisable plant remains
Rootlets	Fine, partly decomposed roots, normally found in the upper part of a soil profile or in a redeposited soil (e.g. colluvium or fill)
Carbonaceous	Discrete particles of hardened (carbonised) plant material.

SHADE AND COLOUR

1	2	3
light dark mottled streaked	pinkish reddish yellowish brownish greenish bluish greyish	pink red orange yellow brown green blue white grey black

SOIL STRUCTURE

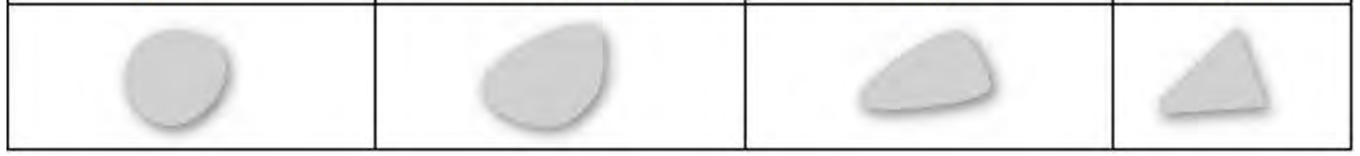
Term	Description
Homogeneous	The total lack of visible bedding and the same colour and appearance throughout
Bedded	The presence of layers
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Polished	Fracture planes are polished or glossy
Slickensided	Fracture planes are striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensoidal	Discontinuous pockets of a soil within a different soil mass

GRADING (GRAVELS & SANDS)

Term	Description	
Well Graded	Good representation of all particle size ranges from largest to smallest	
Poorly Graded	Limited representation of grain sizes – further divided into:	
	Uniformly graded	Most particles about the same size
	Gap graded	Absence of one or more intermediate sizes

ROUNDING/PARTICLE SHAPE

Rounded	Subrounded	Subangular	Angular



CONSISTENCY TERMS FOR FINE SOILS

Descriptive term	Undrained Shear Strength (kPa)	Diagnostic Features	Abbreviation
Very Soft	<12	Easily exudes between fingers when squeezed	VS
Soft	12-25	Easily indented by fingers	S
Firm	25-50	Indented by strong finger pressure and can be indented by thumb pressure	F
Stiff	50-100	Cannot be indented by thumb pressure	St
Very Stiff	100-200	Can be indented by thumb nail	VSt
Hard	200-500	Difficult to indent by thumb nail	H

DENSITY INDEX (RELATIVE DENSITY) TERMS FOR COARSE SOILS

Descriptive term	Density Index (RD)	SPT "N" value (blows/300mm)	Dynamic Cone (blows/100mm)	Abbreviation
Very Dense	> 85	> 50	> 17	VD
Dense	65 - 85	30 - 50	7 - 17	D
Medium dense	35 - 65	10 - 30	3 - 7	MD
Loose	15 - 35	4 - 10	1 - 3	L
Very loose	< 15	< 4	0 - 2	VL

Note:
- Where strength data cannot be confirmed Loosely Packed (LP) and Tightly Packed (TP) may be used.
- No correlation is implied between Standard Penetration Test (SPT) and Dynamic Cone Penetrometer (Scala) Test values.
- SPT "N" values are uncorrected.

MOISTURE CONDITION

Condition	Description	Coarse Soils	Fine Soils	Abbreviation
Dry	Looks and feels dry	Runs freely through hands	Hard, powdery or friable	D
Moist	Feels cool, darkened in colour	Tends to cohere	Weakened by moisture, but no free water on hands when remoulding	M
Wet			Weakened by moisture, free water forms on hands when handling	W
Saturated	Feels cool, darkened in colour and free water is present on the sample			S

BEDDING THICKNESS (Sedimentary)

Term	Bed Thickness
Thinly laminated	< 2mm
Laminated	2mm - 6mm
Very thin	6mm - 20mm
Thin	20mm - 60mm
Moderately thin	60mm - 200mm
Moderately thick	0.2m - 0.6m
Thick	0.6m - 2m
Very thick	> 2m

BEDDING INCLINATION

Term	Inclination (from horizontal)
Sub-horizontal	0° - 5°
Gently inclined	6° - 15°
Moderately inclined	16° - 30°
Steeply inclined	31° - 60°
Very steeply inclined	61° - 80°
Sub vertical	81° - 90°

SENSITIVITY OF SOIL

Descriptive Term	Shear Strength Ratio = $\frac{undisturbed}{remoulded}$
Insensitive, normal	< 2
Moderately sensitive	2 – 4
Sensitive	4 – 8
Extra sensitive	8 – 16
Quick	> 16

PLASTICITY (CLAYS & SILTS)

Term	Description
High plasticity	Can be moulded or deformed over a wide range of moisture contents without cracking or showing any tendency to volume change
Low plasticity	When moulded can be crumbled in the fingers; may show quick or dilatant behaviour

CMW Geosciences – ROCK (Field Logging Guide)

SEQUENCE OF TERMS:

(Weathering) – Colour – Fabric or Bedding – Rock Name – (Strength) – Discontinuities – Additional notes – Origin/Geological Unit

SCALE OF ROCK MASS WEATHERING

Term	Grade	Description
Unweathered (fresh rock)	UW	Rockmass shows no loss of strength, discolouration or other effects due to weathering. There may be slight discolouration on major rock mass defect surfaces or on clasts.
Slightly Weathered	SW	The rock mass is not significantly weaker than when fresh. Rock may be discoloured along defects, some of which may have been opened slightly.
Moderately Weathered	MW	The rock mass is significantly weaker than the fresh rock and part of the rock mass may have been changed to soil. Rock material may be discoloured and defect and clast surfaces will have a greater discolouration, which also penetrates slightly into the rock material. Increase in density of defects due to physical disintegration.
Highly Weathered	HW	Most of the original rock mass strength is lost. Material is discoloured and more than half the mass is changed to a soil by chemical decomposition or disintegration (increase in density of defects/fractures). Decomposition adjacent to defects and at the surface of clasts penetrates deeply into the rock material. Lithorelicts or corestones of unweathered or slightly weathered rock may be present.
Completely Weathered	CW	Original rock strength is lost, and the rock mass changed to a soil either by decomposition (with some rock fabric preserved) or by physical disintegration.
Residual Soil	RS	Rock is completely changed to a soil with the original fabric destroyed (pedological soil).

SHADE AND COLOUR

1	2	3
light dark mottled streaked	pinkish reddish yellowish brownish greenish bluish greyish	pink (pk) red (rd) orange (or) yellow (ye) brown (br) green (gr) blue (bl) white (wh) grey (gy) black (bk)

FABRIC TERMS

Fine (< 25mm)	Folded
Coarse (25 – 100mm)	Foliated
Massive (no fabric)	Gneissose
Banded	Interbedded
Bedded	Laminated
Cleaved	Lineated
Crossbedded	Schistose
Flowbanded	

BEDDING THICKNESS (Sedimentary)

Term	Bed Thickness
Thinly laminated	< 2mm
Laminated	2mm - 6mm
Very thin	6mm - 20mm
Thin	20mm - 60mm
Moderately thin	60mm - 200mm
Moderately thick	0.2m - 0.6m
Thick	0.6m - 2m
Very thick	> 2m

BEDDING INCLINATION

Term	Inclination (from horizontal)
Sub-horizontal	0º - 5º
Gently inclined	6º - 15º
Moderately inclined	16º - 30º
Steeply inclined	31º - 60º
Very steeply inclined	61º - 80º
Sub-vertical	81º - 90º

ROCK GRAPHIC LOG SYMBOLS

Type	Symbol
Siltstone	
Sandstone	
Mudstone	
Limestone	
Coal	
Breccia	
Conglomerate	
Igneous	
Metamorphic	
Pyroclastic (Volcanic Ash)	
Gypsum	

ROCK STRENGTH TERMS

Term	Abbreviation	Field Identification of Specimen	Unconfined uniaxial compressive strength q_u (MPa)	Point load strength $I_{s(50)}$ (MPa)
Extremely strong	ES	Can only be chipped with geological hammer	> 250	> 10
Very strong	VS	Requires many blows of geological hammer to break it	100 - 250	5 - 10
Strong	S	Requires more than one blow of geological hammer to fracture it	50 - 100	2 - 5
Moderately strong	MS	Cannot be scraped or peeled with a pocket knife. Can be fractured with single firm blow of geological hammer	20 - 50	1 - 2
Weak	W	Can be peeled by a pocket knife with difficulty. Shallow indentations made by firm blow with point of geological hammer	5 - 20	< 1
Very weak	VW	Crumbles under firm blows with point of geological hammer. Can be peeled by a pocket knife	1 - 5	
Extremely weak (use soil description)	EW	Indented by thumb nail or other lesser strength terms used for soils	< 1	

Note: No correlation is implied between q_u and $I_{s(50)}$

SAMPLES

Sample	Abbreviation
Undisturbed sample 50mm	U50
Undisturbed sample 63mm	U63
SPT – sample recovered	N*
SPT – solid core	N_c
Bulk disturbed sample	B
Core sample	C

GROUNDWATER

Symbol	Definition
	Water strike or standing groundwater at date given
	Water strike (superseded by piezometer dip)

ADDITIONAL TERMS

Term	Definition
UTP	Unable to penetrate
RQD	Percentage of recovered core in lengths in excess of 100mm
Recovery	Percentage of recovered core

WELL INSTALLATION DETAILS

Term	Symbol
Plain standpipe	
Slotted standpipe	
Inclinometer	

WELL BACKFILL DETAILS

Term	Symbol
Bentonite Seal	
Sand Backfill	
Gravel Backfill	
Grout/Bentonite	
Concrete	

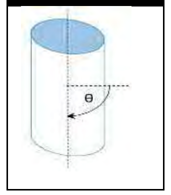
DRILLING METHOD

	Term/Diameter	Abbreviation
Drilling Method	Hand Auger	HA
	Open Barrel	OB
	Triple Tube	TT
	Core Loss	X
	Wash Bore	WB
	Percussion	PER
	Sonic	SNC
	Standard Penetration Test	SPT
Core Size	83.0mm	PQ3
	61.1mm	HQ3

SEQUENCE OF DEFECT TERMS

Sequence	Depth/depth range, number of defects, type, orientation, shape, roughness, aperture, infill description, seepage, block size and block shape
Example (abbreviation)	9.5m: 1, JN, 0º, PL, R, CL, LM
Example (description)	At 9.5 metres is one joint at 0º. Planar, rough, closed, with limonite infill

ORIENTATION



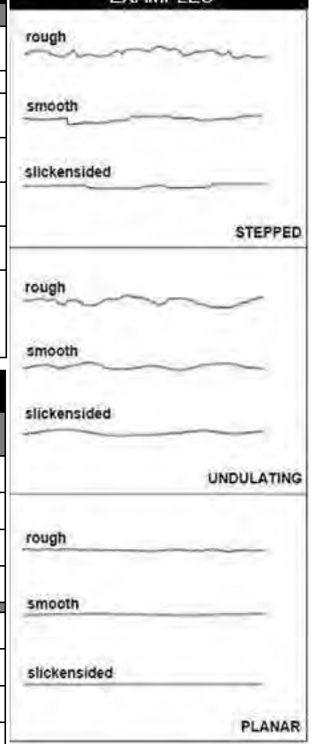
DEFECT TYPE TERMS

Term	Definition	Abbreviation
Drilling induced fracture	Fracture caused by drilling. Commonly smooth (core spun) or irregular (broke in tension)	DI
Contact	Surface between two different lithogies	CN
Bedding (may be open or closed)	Surface that separates each successive layer of stratified rock from its preceeding layer either parallel or sub-parallel to layering	B
Foliation	Repetitive layering in rocks caused by shearing and formed parallel to the direction of shear or perpendicular to the direction of higher pressure	F
Cleavage	Break along a planar anisotropic surface in rock determined by structure and strength of the crystal lattice Smooth surfaces often having reflective surfaces	CV
Joint	Single fracture across which rock has little or no tensile strength, but which is not parallel or sub-parallel to layering or planar anisotropy in the rock substance. May be open or closed.	JN
Sheared Zone	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joint, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	SZ
Sheared Surface	A near planar, curved or undulating surface, which is usually smooth, polished or slickensided	SS
Crushed Seam	Seam with roughly parallel, almost planar boundaries, composed of disorientated, usually angular fragments of the host rock. The seam has soil properties	CS
Decomposed Zone/Seam	Seam or zone of soil substance, often with gradational boundaries. Formed by weathering of the rock substance in place	WS
Infilled Seam/Zone	Seam or zone of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface	IS

PLANARITY AND ROUGHNESS

	Term	Description	Abbreviation
Planarity	Planar	The defect does not vary in orientation.	PL
	Undulating	The defect has a wavy surface.	UN
	Stepped	The defect has one or more well defined steps.	ST
	Note: The assessment of defect shape is partly influenced by the scale of the observation.		
Roughness	Slickensided	Grooved or striated surface usually polished.	SS
	Smooth	Smooth to touch. Few or no surface irregularities.	S
	Rough	Many small surface irregularities (amplitude generally more than 1mm). Feels like fine to coarse sandpaper.	R

PLANARITY AND ROUGHNESS EXAMPLES



APERTURE OF DISCONTINUITY SURFACES

Term	Aperture (mm)	Description	Abbreviation
Tight	Nil	Closed	CL
Very narrow	> 0 - 2		
Narrow	2 - 6		
Moderately narrow	6 - 20	Gapped	GA
Moderately wide	20 - 60	Open	OP
Wide	60 - 200		
Very wide	> 200		

INFILL TYPE

Term	Abbreviation
Clean	CN
Coated (Material)	CO
Infill (Material)	IF
Stained (Material/Colour)	ST

INFILL MATERIAL

Term	Abbreviation
Clay	CL
Silt	Z
Sand	S
Gravel	G
Calcite	CA
Carbonaceous	CB
Limonite	LM
Manganese	MG
Mica	MI
Pyrite	PY
Quartz	QZ
Sulphides	SU

SEEPAGE

Term	Abbreviation
Wet	W
Seepage	SP
Flow	F

SPACING OF DEFECTS/DISCONTINUITIES

Term	Spacing
Very widely spaced	> 2m
Widely spaced	600mm - 2m
Moderately widely spaced	200mm - 600mm
Closely spaced	60mm - 200mm
Very closely spaced	20mm - 60mm
Extremely closely spaced	< 20mm

DESCRIPTION OF BLOCK SIZE IN THE ROCK MASS

Term	Average Dimension	Abbreviation
Very Small	< 60mm	VS
Small	60 - 200mm	S
Medium	200 - 600mm	M
Large	600mm - 2m	L
Very Large	> 2m	VL

ROCK MASS BLOCK SHAPE

Block shape	Discontinuity Arrangement	Abbreviation
Polyhedral	Irregular discontinuities without arrangement into distinct sets, and of small persistence	Po
Tabular	One dominant set of parallel discontinuities (eg bedding planes), with other non-continuous discontinuities; block length and width >> thickness	Ta
Prismatic	Two dominant sets of discontinuities orthogonal and parallel, with a third irregular set; block length and width >> thickness	Pr
Equidimensional	Three dominant orthogonal sets of discontinuities, with some irregular discontinuities	Eq
Rhomboidal	Three or more dominant, mutually oblique sets of discontinuities; oblique shaped equidimensional blocks	Rh
Columnar	Several (usually more than three) sets of continuous, parallel discontinuities crossed by irregular discontinuities; length >> other dimensions	Co

Revision 2 April 2018

BOREHOLE LOG - HA01-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

1:25 | Sheet 1 of 1

Logged by: JW	Position: E.1748909.0m N.5972639.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
							OL: TOPSOIL						
		0.4	Peak = 84kPa Residual = 52kPa				CH: CLAY with trace fine grained sand: brown/orange. High plasticity. Trace rootlets (Alluvium)	M	St				
		0.8	Peak = 84kPa Residual = 44kPa				CH: CLAY with trace fine grained sand, trace silt : brown/ orange. High plasticity. Trace rootlets. (Alluvium)						
					1		CH: CLAY with some silt and minor fine to medium grained sand: orange, streaked grey. High plasticity. (Alluvium)						
	▼	1.2	Peak = >200kPa				CH: Silty CLAY with minor fine grained sand: grey, streaked orange. High plasticity. (Alluvium)				HA		
		1.6	Peak = >200kPa				CL: CLAY with minor fine grained sand, minor silt and coarse, subangular gravel sized clasts: grey, streaked orange. High plasticity. Clay has trace structure with trace limonite staining. (Alluvium)	S	H				
		2.0	Peak = >200kPa		2		... *at 2.00m, 50mm band of limonite*						
							CL: Sandy CLAY with some silt and minor gravel : dark grey, streaked dark and light orange. Low plasticity. Sand is fine grained with limonite nodules. Gravel is fine, sub angular clasts. (Alluvium)						
		2.4	Peak = UTP				MH: Sandy SILT with trace clay: dark grey, streaked orange. Low plasticity. Sand is fine grained. (Alluvium)						
							Borehole terminated at 2.4 m						
					3								
					4								
					5								

Termination reason: Unable to penetrate due to hard ground.

Remarks: Groundwater encountered at 1.20m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA02-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: RD	Position: E.1748870.0m N.5972659.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	

Material Description — Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Structure & Other Observations — Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
OL: TOPSOIL			HA
CH: CLAY: brown. High plasticity. (Pakiri Formation)	M	VSt	HA
CH: CLAY with minor silt: orange/brown. High plasticity. With minor limonite nodules. (Pakiri Formation) ... *at 1.20m, with light grey streaks* ... *at 1.50m, with red streaks*	W	St	HA
CH: CLAY with some silt: light grey/orange, streaked red. High plasticity. (Pakiri Formation) ... *at 2.50m, with trace fine sand. Becoming very stiff*	M to W	St	HA
CH: Silty CLAY with minor fine sand: reddish pink/light grey. High plasticity. (Pakiri Formation)	M to W	VSt	HA
CL: Clayey SILT with some fine sand: reddish pink, mottled light grey. Low plasticity. (Pakiri Formation) ... *at 3.90m, seepage occurring*	W; W to S (from ~4.7m)	St; VSt (from ~4.8m)	HA
Borehole terminated at 5.0 m			

Samples & Insitu Tests

Depth	Type & Results
0.4	Peak = 119kPa Residual = 56kPa
0.8	Peak = 113kPa Residual = 56kPa
1.2	Peak = 70kPa Residual = 35kPa
1.6	Peak = 91kPa Residual = 48kPa
2.0	Peak = 91kPa Residual = 54kPa
2.4	Peak = 85kPa Residual = 42kPa
2.8	Peak = 110kPa Residual = 25kPa
3.2	Peak = 85kPa Residual = 28kPa
3.6	Peak = 99kPa Residual = 28kPa
4.0	Peak = 87kPa Residual = 42kPa
4.4	Peak = 70kPa Residual = 39kPa
4.8	Peak = 100kPa Residual = 28kPa

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 4.7m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA03-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

1:25 Sheet 1 of 1

Logged by: JW	Position: E.1748840.0m N.5972599.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
							OL: TOPSOIL						
							CH: CLAY: orange/brown. High plasticity. (Pakiri Formation)						
		0.4	Peak = 192kPa Residual = 78kPa										
							... at 0.50m, becoming mottled red						
		0.8	Peak = 160kPa Residual = 76kPa										
					1		... at 1.00m, mottled light grey						
		1.2	Peak = 137kPa Residual = 73kPa						VSt				
								M			HA		
		1.6	Peak = 157kPa Residual = 76kPa										
							CH: CLAY with trace silt and trace fine sand: orange, streaked red/brown. High plasticity. (Pakiri Formation)						
		2.0	Peak = 160kPa Residual = 73kPa		2								
		2.4	Peak = 113kPa Residual = 49kPa										
									St				
		2.8	Peak = 87kPa Residual = 55kPa				... at 2.80m, with minor silt and minor limonite staining. WIth trace angular, coarse gravel sized limonite nodules						
					3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Target Depth Reached

Remarks: Groundwater was not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA04-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: JW	Position: E.1748666.0m N.5972426.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support	Groundwater
		0	OL: TOPSOIL				
			CH: CLAY with trace fine grained sand : greyish/brown. High plasticity. Trace rootlets. (Pakiri Formation)				
0.4	Peak = 102kPa Residual = 41kPa		*... at 0.40m, becoming light brown, streaked orange*				
0.8	Peak = 102kPa Residual = 64kPa		*... at 0.90m, becoming grey, streaked orange*				
		1	CH: CLAY: light grey, streaked orange. High plasticity. (Pakiri Formation)				
1.2	Peak = 131kPa Residual = 70kPa						
1.6	Peak = 131kPa Residual = 67kPa			M	VSt		
2.0	Peak = 131kPa Residual = 84kPa	2					
2.4	Peak = 142kPa Residual = 78kPa		CH: CLAY with trace silt and trace fine grained sand: light grey mottled orange. High plasticity. (Pakiri Formation)			HA	
2.8	Peak = 108kPa Residual = 73kPa		*... at 2.90m, trace dark orange limonite streaks*				
		3	CH: CLAY with minor fine grained sand and minor silt: light grey mottled with dark orange limonite and streaked light orange. High plasticity. (Pakiri Formation)				
3.2	Peak = 61kPa Residual = 44kPa		*... at 3.20m, with some silt and becoming wet*	W			▼
3.6	Peak = 61kPa Residual = 55kPa		CH: Silty CLAY with minor fine to medium grained sand: light grey, streaked orange. High plasticity. (Pakiri Formation)		St		
4.0	Peak = 122kPa Residual = 58kPa	4	*... at 4.00m, with red streaks*	S			
4.4	Peak = 110kPa Residual = 58kPa		*... at 4.40m, light grey, streaked red-brown-orange*		VSt		
4.8	Peak = 87kPa Residual = 46kPa				St		
		5	Borehole terminated at 5.0 m				

Termination reason: Target Depth Reached.

Remarks: Groundwater encountered at 3.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA05-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

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Logged by: RD	Position: E.1748692.0m N.5972393.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	

Samples & Insitu Tests

Depth	Type & Results
0.4	Peak = 70kPa Residual = 35kPa
0.8	Peak = 49kPa Residual = 21kPa
1.2	Peak = 56kPa Residual = 17kPa
1.7	Peak = 197+
2.0	Peak = 101kPa Residual = 14kPa
2.4	Peak = 197+
2.8	Peak = UTP
3.2	Peak = UTP
3.6	Peak = UTP
4.0	Peak = UTP
4.4	Peak = UTP
4.8	Peak = UTP

Groundwater: ▼ at 1.7m

Material Description
Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Material Description	Moisture Condition	Consistency/ Relative Density
OL: TOPSOIL	M	St
CH: CLAY: grey, mottled orange. High plasticity. (Colluvium) *... at 0.50m, with minor silt* *... at 0.80m, disturbed structure*	M	St
CL: Silty CLAY: orange. Low plasticity. (Colluvium) *... at 1.50m, with fine gravel sized limonite nodules and minor fine sand*	M	St
ML: Gravelly SILT with some fine sand: orange. Low plasticity. Heavily limonite stained with fine, angular gravel sized nodules. (Colluvium)	M / S	St / VSt
ML: Sandy SILT: grey, streaked orange. Low plasticity. Sand is coarse grained. Occasional limonite nodule. (Alluvium)	S	VSt
SM: Silty SAND: grey. Poorly sorted, medium dense. Sand is medium to coarse grained. (Alluvium)	S	VSt
ML: Sandy SILT with minor clay: dark grey. Low plasticity. Sand is medium to coarse grained. (Alluvium)	W to S	VSt
Borehole terminated at 5.0 m		

Drilling Method/Support: HA

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Structure & Other Observations: Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 1.7m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA06-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

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Logged by: RD	Position: E.1748568.0m N.5972589.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Columns: Well; Groundwater; Samples & Insitu Tests (Depth, Type & Results); RL (m); Depth (m); Graphic Log; Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)); Moisture Condition; Consistency/ Relative Density; Recovery; Drilling Method/ Support; Dynamic Cone Penetrometer (Blows/100mm) 5 10 15; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

Sample Depth	Type & Results
0.4	Peak = 105kPa Residual = 29kPa
0.8	Peak = 105kPa Residual = 29kPa
1.2	Peak = 183kPa Residual = 42kPa
1.6	Peak = 197+
2.0	Peak = 145kPa Residual = 14kPa
2.4	Peak = 96kPa Residual = 24kPa
2.8	Peak = 159kPa Residual = 28kPa
3.2	Peak = UTP
3.6	Peak = UTP
4.0	Peak = 197+
4.4	Peak = 197+
4.8	Peak = 141kPa Residual = 28kPa

Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
OL: TOPSOIL			
CH: CLAY: orange. High plasticity. (Pakiri Formation)	M	VSt	HA
CH: CLAY with some silty: orange, streaked red. High plasticity. (Pakiri Formation)	W	VSt	HA
ML: SILT with some clay and minor fine sand: orange, streaked red. Low plasticity. (Pakiri Formation) *... at 2.20m, becoming wet*	M to W	VSt	HA
ML: SILT with some clay and minor medium sand: brown/ red/light grey. Low plasticity. (Pakiri Formation)	W	St	HA
CL: Silty CLAY: red/orange. Low plasticity. (Pakiri Formation)	W	St	HA
ML: Sandy SILT: orange/brown. Low plasticity. Sand is medium grained with trace fine, sub angular completely weathered mudstone gravel clasts. (Pakiri Formation) *... at 3.00m, with minor coarse nodules of black manganese nodules*	M to W	VSt	HA
CL: Silty CLAY with minor coarse sand: orange, streaked red. High plasticity. (Pakiri Formation)	M to W	VSt	HA
ML: Sandy SILT: orange/red/black. Low plasticity. Sand is medium grained. (Pakiri Formation)	M	VSt	HA
CL: Silty CLAY with some fine sand: pink/orange/red/light grey. Low plasticity. (Pakiri Formation)	W	VSt	HA
ML: Clayey SILT: orange/red. Low plasticity. With minor limonite nodules throughout. (Pakiri Formation)	M to W	VSt	HA
ML: Sandy SILT: red/dark orange. Low plasticity. Sand is medium to coarse grained. Limonite stained throughout. (Pakiri Formation)	M to W	VSt	HA

Borehole terminated at 5.0 m

Termination reason: Target Depth Reached

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA07-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

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Logged by: JW | Position: E.1748547.0m N.5972587.0m | Elevation: | Hole Diameter: 50mm
Checked by: RD | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Samples Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
		0	OL: TOPSOIL	M	VSt	HA
0.4	Peak = 145kPa Residual = 87kPa		CH: CLAY: orange/brown. High plasticity. Trace rootlets/ organics. (Pakiri Formation)			
0.8	Peak = 116kPa Residual = 81kPa		CH: CLAY with trace silt and trace fine grained sand: orange/brown, streaked red. High plasticity. (Pakiri Formation)			
		1	CH: CLAY with minor silt and trace fine to medium grained sand: orange/brown, streaked red and mottled black High plasticity. (Pakiri Formation)			
1.2	Peak = 160kPa Residual = 44kPa		CH: CLAY with trace silt: light grey, streaked orange. High plasticity. Interbedded with Sandy CLAY with some silt: orange/brown mottled grey. (Pakiri Formation)			
1.6	Peak = 145kPa Residual = 41kPa					
			MH: Sandy SILT with minor clay: orange/brown, streaked grey. Low plasticity. Sand is fine grained. (Pakiri Formation)	M to W		
2.0	Peak = >200kPa	2	*... at 2.00m, becoming wet with trace nodules of medium gravel sized angular siltstone*	W	H	
			... at 2.10m, limonite staining and minor angular, medium to coarse grained gravel size clasts			
			... at 2.20m, trace dark grey, completely weathered mudstone clasts with 20mm bed of limonite stained clayey silt			
2.4	Peak = UTP		CL: Silty CLAY with minor fine to medium grained sand and trace coarse gravel sized mudstone clasts: dark reddish orange. Low plasticity. Mudstone clasts are angular and crumbly. (Pakiri Formation)	M to W		
2.8	Peak = UTP					
3.2	Peak = UTP	3				
3.6	Peak = UTP					
4.0	Peak = UTP	4	MUDSTONE: completely weathered, dark greenish/ grey mudstone. Extremely weak. Low plasticity. (Pakiri Formation)			
			Borehole terminated at 4.0 m			
		5				

Termination reason: Unable to penetrate due to hard ground.

Remarks: Groundwater encountered at 3.70m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA08-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

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Logged by: RD	Position: E.1748306.0m N.5971919.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
	▼ (0.2 m)						OL: TOPSOIL						
		0.4	Peak = 56kPa Residual = 7kPa				CH: CLAY: light grey, streaked brown. High plasticity. Decaying bark and rootlets throughout. (Alluvium)	W	St				
		0.8	Peak = 70kPa Residual = 15kPa										
		1.2	Peak = 70kPa Residual = 56kPa		1								
		1.6	Peak = 101kPa Residual = 56kPa				CH: CLAY with minor silt, with minor fine sand.: light greyish white. High plasticity. With trace rootlets. (Alluvium)		VSt		HA		
		2.0	Peak = 124kPa Residual = 49kPa		2								
		2.4	Peak = UTP				ML: Sandy SILT: greyish white. Low plasticity. Sand is medium grained. With completely weathered mudstone clasts. Texture is blocky. (Alluvium)	M to W	H				
		2.8	Peak = UTP										
					3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Unable to penetrate due to hard ground.

Remarks: Groundwater encountered at 0.2m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA09-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

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Logged by: JW	Position: E.1748268.0m N.5972005.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
		0.0–0.1	OL: TOPSOIL	M	VSt	HA
		0.1–0.3	CH: CLAY with trace fine grained sand: greyish/brown. High plasticity. Trace rootlets.	M	VSt	HA
0.4	Peak = 113kPa Residual = 73kPa	0.3–1.3	CH: CLAY: brown, streaked orange. High plasticity.	M	VSt	HA
0.8	Peak = 102kPa Residual = 76kPa		... *at 0.70m, streaked grey*			
1.2	Peak = 145kPa Residual = 58kPa		... *at 1.00m, becoming grey mottled brownish orange*			
1.6	Peak = 169kPa Residual = 64kPa	1.3–2.0	CH: CLAY with trace silt: grey, streaked orange and light grey. High plasticity. (Mangakahia Complex) ... *at 1.60m, becoming streaked greenish grey*	M	VSt	HA
2.0	Peak = UTP	2.0–3.6	CL: CLAY with minor medium to coarse gravel sized mudstone clasts. : brownish-grey streaked grey, low plasticity. Mudstone clasts are angular. (Mangakahia Complex)	M	H	HA
2.4	Peak = UTP		... *at 2.10m, becoming dark brownish grey, streaked black/ grey*			
2.8	Peak = UTP		... *at 2.60m, streaked greenish grey*			
3.2	Peak = UTP		... *at 3.10m, streaked reddish brown*			
3.6	Peak = UTP					

Borehole terminated at 3.6 m

Termination reason: Unable to penetrate due to hard ground.

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA10-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

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Logged by: JW	Position: E.1748465.0m N.5972104.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	

Groundwater	Sample Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
			0.0	OL: TOPSOIL			
				CH: CLAY with minor silt: orange/brown. High plasticity. With trace rootlets.		St	
	0.4	Peak = 87kPa Residual = 49kPa					
				CH: CLAY with trace fine sand and trace silt: orange/ brown, mottled grey/orange. High plasticity.			
	0.8	Peak = 174kPa Residual = 87kPa		CH: CLAY with trace fine sand: orange/grey. High plasticity.			
			1				
	1.2	Peak = 160kPa Residual = 87kPa					
	1.6	Peak = 174kPa Residual = 93kPa					
	2.0	Peak = 131kPa Residual = 102kPa	2		M		
				CH: CLAY: light grey, mottled orange/red. High plasticity.			
	2.4	Peak = 145kPa Residual = 116kPa					HA
				... at 2.60m, with minor fine sand			
	2.8	Peak = 142kPa Residual = 100kPa				VSt	
			3	*... at 3.00m, with trace fine sand*			
	3.2	Peak = 131kPa Residual = 87kPa					
				CH: CLAY with minor fine sand and trace silt: grey, streaked orange/red. High plasticity.			
	3.6	Peak = 116kPa Residual = 76kPa					
▼	4.0	Peak = 105kPa Residual = 64kPa	4	*... at 4.00m, becoming saturated*			
				... at 4.30m, with trace fine sand			
	4.4	Peak = 102kPa Residual = 76kPa			S		
	4.8	Peak = 72kPa Residual = 58kPa					
			5	Borehole terminated at 5.0 m			

Column headings also include: Well; RL (m); Graphic Log; Recovery; Dynamic Cone Penetrometer (Blows/100mm) 5 10 15; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks). Material Description key: Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 4.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA11-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

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Logged by: JW/RD	Position: E.1748542.0m N.5972071.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth; Type & Results); RL (m); Depth (m); Graphic Log; Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)); Moisture Condition; Consistency/ Relative Density; Recovery; Drilling Method/ Support; Dynamic Cone Penetrometer (Blows/100mm) 5 10 15; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

Samples & Insitu Tests

Depth	Type & Results
0.4	Peak = 134kPa Residual = 61kPa
0.8	Peak = 148kPa Residual = 76kPa
1.2	Peak = 96kPa Residual = 41kPa
1.6	Peak = 125kPa Residual = 20kPa
2.0	Peak = >200kPa
2.4	Peak = >200kPa
2.8	Peak = 195kPa Residual = 67kPa
3.2	Peak = 174kPa Residual = 55kPa
3.6	Peak = 145kPa Residual = 41kPa
4.0	Peak = 134kPa Residual = 32kPa
4.4	Peak = 160kPa Residual = 73kPa
4.8	Peak = 189kPa Residual = 87kPa

Material Description

Material Description	Moisture Condition	Consistency/ Relative Density
OL: TOPSOIL		
CH: CLAY with some silt and minor fine grained sand : light brown, streaked orange. High plasticity. (Mangakahia Complex)	M to W	VSt
CH: CLAY with minor silt and minor fine grained sand : light grey, streaked orange and light brown. High plasticity. Trace limonite (Mangakahia Complex) ... *at 1.10m, with trace silt and trace fine grained sand*	M	VSt
CL: CLAY with some silt and minor fine grained sand: light brown, streaked orange. Low plasticity. Trace limonite. (Mangakahia Complex) ... *at 1.30m, becoming light grey, streaked orange*	M	St
MH: Clayey SILT: light grey, streaked orange. Low plasticity. (Mangakahia Complex)	M	St / VSt
MH: Clayey SILT with some fine to medium grained sand: light brownish grey, streaked orange. Low plasticity. Limestone clasts are angular shaped. Becoming blocky. (Mangakahia Complex)	M	H
CL: CLAY with some silt: light brownish grey, streaked orange. Low plasticity. (Mangakahia Complex)	M to W	VSt
CL: CLAY with some fine to medium grained sand and minor silt: light brownish grey to grey. Low plasticity. (Mangakahia Complex)	W	VSt
CL: Sandy CLAY : orange. Low plasticity. Limonite stained throughout. Blocky texture. (Mangakahia Complex)	W to S	VSt
CL: CLAY with some silt and fine to medium grained sand: light brownish grey, streaked orange. Low plasticity. Blocky texture. (Mangakahia Complex)	W to S	VSt
CL: Silty CLAY: dark grey. Low plasticity. (Mangakahia Complex)	M	VSt

Drilling Method/Support: HA

Borehole terminated at 5.0 m

Termination reason: Target Depth Reached.

Remarks: Groundwater encountered at 4.20m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA01-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 05/02/2019
Borehole Location: Refer to site plan

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Logged by: RD | Position: E.1748249.0m N.5971986.0m | Elevation: RL 52.00m | Hole Diameter: 50mm

Checked by: MJC | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Depth	Type & Results	RL (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
		52.0	OL: Topsoil	M	St	HA
		51.9	CL: Silty CLAY: light grey/orange. Low plasticity (Colluvium)			
0.4	Peak = 87kPa Residual = 46kPa					
0.8	Peak = 62kPa Residual = 34kPa					
1.2	Peak = 112kPa Residual = 37kPa		*... at 1.20m, becoming very stiff*		VSt	
		50.7	ML: Clayey SILT: grey mottled orange. Low plasticity (Colluvium)			
1.6	Peak = 152kPa Residual = 37kPa					
		50.2	ML: Clayey SILT: dark grey, streaked orange. Low plasticity. Slight blocky structure with trace completely weathered siltstone clasts throughout. Minor limonite staining. (Colluvium)		VSt to H	
2.0	Peak = 189kPa Residual = 50kPa					
		49.9	ML: SILT with minor Clay: dark grey. Low plasticity (Alluvium)			
2.4	Peak = 186kPa Residual = 59kPa					
2.8	Peak = 217+ kPa				H	
3.2	Peak = UTP					
3.6	Peak = UTP					
		48.3	Dark grey, completely weathered Siltstone; Extremely Weak. Weathered to SILT with trace Clay: dark grey. Blocky texture (Northland Allochthon)	D to M		
4.0	Peak = 217+ kPa					
4.4	Peak = UTP		Borehole terminated at 4.4 m			

Columns also present (no entries): Well; Groundwater; Recovery; Dynamic Cone Penetrometer (Blows/100mm) 5 10 15; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks). Depth (m) scale: 1, 2, 3, 4, 5.

Termination reason: Refusal. Too hard to penetrate further.

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA02-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 05/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

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Logged by: RD	Position: E.1748379.0m N.5972043.0m	Elevation: RL 58.00m	Hole Diameter: 50mm
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support	Structure & Other Observations
		58.0	OL: Topsoil			HA	0.0-5.0m:
0.4	Peak = 217+ kPa	57.8	CH: CLAY: grey/brown mottled orange. High plasticity (Pakiri Formation)	D	VSt		
0.8	Peak = 121kPa Residual = 62kPa	57.3	CH: CLAY with minor silt: light grey, stained orange. High plasticity (Pakiri Formation)	M to W	VSt		
1.2	Peak = 56kPa Residual = 28kPa	56.8	CH: CLAY with minor silt with trace fine Sand: light grey/ orange. High plasticity (Pakiri Formation)	W	St		
1.6	Peak = 59kPa Residual = 22kPa			W	St		
2.0	Peak = 77kPa Residual = 28kPa	56.1	CL: Silty CLAY with minor fine sand: orange/brown/grey. Low plasticity (Pakiri Formation)	W	St		
2.4	Peak = 65kPa Residual = 31kPa	55.7	CH: Clayey SILT: light grey. High plasticity (Pakiri Formation)	W to S	St		
2.8	Peak = 46kPa Residual = 25kPa		*... at 2.60m, with minor fine sand*	S	St		
3.2	Peak = 50kPa Residual = 31kPa	55.0	ML: Clayey SILT with fine to medium sand: brown/grey. Low plasticity (Pakiri Formation)	S	St		
3.6	Peak = 59kPa Residual = 31kPa		*... at 3.40m, becoming grey*	S	St		
4.0	Peak = 53kPa Residual = 31kPa		*... at 3.80m, green sandy glauconite stained lens*	S	St		
4.4	Peak = 53kPa Residual = 31kPa	53.9	ML: fine Sandy SILT with minor clay: grey. Low plasticity (Pakiri Formation)	S	St		
4.8	Peak = 62kPa Residual = 31kPa			S	St		
			Borehole terminated at 5.0 m				

Groundwater: 05-02-2019 (at 2.6 m)

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 2.6m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA03-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 05/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

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Logged by: RD	Position: E.1748458.0m N.5972029.0m	Elevation: RL 56.50m	Hole Diameter: 50mm
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
				56.5			OL: Topsoil						
				56.3			CH: CLAY: brown/orange. High plasticity (Pakiri Formation)						
		0.4	Peak = 186kPa Residual = 53kPa										
		0.8	Peak = 155kPa Residual = 50kPa						VSt				
				55.6	1		CH: CLAY with minor Silt: light grey streaked red and orange. High plasticity (Pakiri Formation)	M					
		1.2	Peak = 108kPa Residual = 50kPa										
		1.6	Peak = 99kPa Residual = 43kPa										
		2.0	Peak = 77kPa Residual = 31kPa		2								
				54.4			CH: CLAY with some Silt and trace fine Sand: grey streaked orange. High plasticity (Pakiri Formation)						
		2.4	Peak = 77kPa Residual = 34kPa										
				54.0			CL: Silty CLAY with minor fine Sand: orange speckled white. Low plasticity (Pakiri Formation)				HA		
		2.8	Peak = 65kPa Residual = 34kPa					W					
		3.2	Peak = 77kPa Residual = 37kPa		3				St				
				53.0			CH: CLAY with some Silt: light grey streaked orange, High plasticity (Pakiri Formation)						
	Groundwater seepage.	3.6	Peak = 59kPa Residual = 37kPa					M					
							... at 3.90m, becoming wet to saturated and orange	W to S					
		4.0	Peak = 62kPa Residual = 40kPa		4								
				52.4			CL: Silty CLAY with minor fine Sand: orange. Low plasticity (Pakiri Formation)						
		4.4	Peak = 90kPa Residual = 43kPa					S					
		4.8	Peak = 81kPa Residual = 46kPa										
					5		Borehole terminated at 5.0 m						

Termination reason: Target Depth Reached

Remarks: Groundwater seepage at 3.9m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA04-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 08/02/2019
Borehole Location: Refer to site plan

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Logged by: MMC	Position: E.1748711.0m N.5972525.0m	Elevation: RL 75.00m	Hole Diameter: 50mm
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
		75.0	OL: Topsoil			
		74.7	CL: CLAY: orangey brown. Low plasticity. (Pakiri Formation)	D (to ~0.9 m)	VSt (to ~2.8 m)	HA
0.4	Peak = 169kPa Residual = 58kPa					
0.8	Peak = 185kPa Residual = 108kPa					
1.2	Peak = 169kPa Residual = 102kPa			M (from ~0.9 m)		
1.6	Peak = 139kPa Residual = 117kPa					
2.0	Peak = 123kPa Residual = 102kPa		... at 2.10m, with orangey red streaks.			
2.4	Peak = 111kPa Residual = 89kPa		... from 2.40m to 3.10m, with limonite staining.			
2.8	Peak = 86kPa Residual = 74kPa				St (~2.8–3.6 m)	
		72.0	CH: CLAY with trace silt: orangey brown with red mottles. High plasticity. (Pakiri Formation)			
3.2	Peak = 92kPa Residual = 82kPa					
3.6	Peak = 117kPa Residual = 92kPa				VSt (~3.6–4.2 m)	
4.0	Peak = 126kPa Residual = 79kPa					
			Borehole terminated at 4.2 m			

Termination reason: Unable to penetrate further

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA05-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 08/02/2019
Borehole Location: Refer to site plan

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Logged by: MMC	Position: E.1748689.0m N.5972553.0m	Elevation: RL 82.00m	Hole Diameter: 50mm
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
				82.0			OL: Topsoil						
				81.7			CH: CLAY : orangey brown. High plasticity. (Pakiri Formation)						
		0.4	Peak = 134kPa Residual = 92kPa										
		0.8	Peak = 126kPa Residual = 86kPa										
					1								
		1.2	Peak = 132kPa Residual = 77kPa					D					
							... from 1.50m to 2.00m, with white streaks.						
		1.6	Peak = 151kPa Residual = 102kPa										
		2.0	Peak = 148kPa Residual = 92kPa		2		*... from 2.00m to 2.40m, with orangey red streaks.*						
		2.4	Peak = 117kPa Residual = 84kPa	79.6			CH: CLAY with minor silt: orange with reddish brown mottles. High plasticity. (Pakiri Formation)		VSt		HA		
		2.8	Peak = 105kPa Residual = 86kPa	79.2			CH: CLAY with minor silt: brownish red with orange mottles. (Pakiri Formation)						
					3								
		3.2	Peak = 105kPa Residual = 86kPa										
				78.5			CH: CLAY with minor silt : red with pink streaks. High plasticity. (Pakiri Formation)						
		3.6	Peak = 111kPa Residual = 92kPa					M					
		4.0	Peak = 108kPa Residual = 102kPa		4								
		4.4	Peak = 108kPa Residual = 98kPa										
		4.8	Peak = 105kPa Residual = 102kPa				*... at 4.80m, with limonite staining.*						
					5		Borehole terminated at 5.0 m						

Termination reason: Target Depth Reached

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA06-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 27/02/2019
Borehole Location: Refer to site plan

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Logged by: SC	Position: E.1748669.7m N.5972813.6m	Elevation: RL 91.00m	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Material Description	Moisture Condition	Consistency/Relative Density	Drilling Method/Support
		91.0	OL: TOPSOIL	M	St	HA
0.4	Peak = 82kPa Residual = 31kPa	90.7	CH: CLAY with trace silt: orangey brown. High plasticity. (Pakiri Formation)	M	St	HA
0.8	Peak = 57kPa Residual = 28kPa	90.4	CH: CLAY: orangey brown. High plasticity. (Pakiri Formation) ... at 1.00m, with minor silt.	M	St	HA
1.2	Peak = 82kPa Residual = 20kPa					
1.6	Peak = 142kPa Residual = 31kPa	89.7	CH: Silty CLAY with minor fine sand: orangey brown. High plasticity. Trace fine to coarse, gravel-sized manganese clasts. (Pakiri Formation) ... at 1.70m, 50mm layer of fine to coarse, gravel-sized manganese clasts.	W	VSt	HA
2.0	Peak = UTP	89.0	CL: Silty CLAY: orange/grey, mottled red. Low plasticity. Trace fine to coarse, gravel-sized manganese clasts. (Pakiri Formation)	M	VSt	HA
2.4	Peak = 170kPa Residual = 23kPa	88.6	CH: Silty CLAY with trace fine sand: brown/red, streaked orange. High plasticity. Trace fine to coarse, gravel-sized manganese clasts. (Pakiri Formation)	S	VSt	HA
2.8	Peak = 114kPa Residual = 28kPa	88.3	CH: CLAY with some silt: grey mottled red. High plasticity. Trace fine to coarse, gravel-sized manganese clasts. (Pakiri Formation)	S	VSt	HA
3.2	Peak = V-199+					
3.6	Peak = UTP					
4.0	Peak = UTP					
4.4	Peak = UTP					
4.8	Peak = V-199+					
			Borehole terminated at 5.0 m			

Groundwater: ▼ at 2.4 m

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 2.4m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA07-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 27/02/2019
Borehole Location: Refer to site plan

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Logged by: RD	Position: E.1748639.8m N.5972768.0m	Elevation: RL 81.00m	Hole Diameter: 50mm
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	

Depth (m)	RL (m)	Samples Depth	Type & Results	Material Description	Moisture Condition	Consistency/Relative Density	Drilling Method/Support	Dynamic Cone Penetrometer (Blows/100mm)
0.0	81.0			OL: TOPSOIL			HA	
0.1	80.9			CH: CLAY: black/grey. High plasticity. Organic stained and mottled throughout. (Alluvium)	W	F	HA	
		0.4	Peak = 28kPa Residual = 9kPa					
0.5	80.5			CH: CLAY: grey/orange/black. High plasticity. (Alluvium) ... *at 0.80m, with woody inclusions throughout*	W	F	HA	
		0.8	Peak = 31kPa Residual = 12kPa					
		1.2	Peak = 50kPa Residual = 15kPa					
1.3	79.7			CH: CLAY with minor fine sand: light blueish grey. High plasticity. (Alluvium)	S	St	HA	
		1.6	Peak = 59kPa Residual = 15kPa					
		2.0	Peak = 54kPa Residual = 31kPa					
2.1	78.9			CH: CLAY with some silt and minor fine sand: blueish grey. High plasticity. (Alluvium)	S	St	HA	
		2.4	Peak = 119kPa Residual = 34kPa					
2.7	78.3			CL: Sandy CLAY with minor silt: blueish grey. Low plasticity. Sand is fine to medium grained. (Alluvium)	S	VSt	HA	
3.0	78.0			SM: Silty SAND: grey. Loose. Poorly sorted. Sand is fine to medium grained. (Alluvium)	S	L	HA	2, 8, 20
3.7	77.3			SW: SAND: grey. Very dense. Poorly sorted. Sand is fine to medium grained. (CW Pakiri Fmn)	S	VD	HA	20

Groundwater: ▼ at 0.8 m

Borehole terminated at 3.8 m

Termination reason: Refusal. Unable to penetrate further.

Remarks: Groundwater encountered at 0.8m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA08-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 27/02/2019
Borehole Location: Refer to site plan

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Logged by: SC	Position: E.1748555.0m N.5972652.7m	Elevation: RL 75.00m	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support	Structure & Other Observations
		75.0	0	OL: TOPSOIL			HA	
		74.9		CH: CLAY with minor silt: orangey browney grey. High plasticity. (Fill)	M	VSt	HA	
0.4	Peak = 142kPa Residual = 43kPa							
0.8	Peak = 88kPa Residual = 40kPa							
1.2	Peak = 116kPa Residual = 48kPa		1					
		73.6		CH: CLAY with trace silt: grey streaked brown. High plasticity. (Pakiri Formation)	M	F	HA	1.4m: approximate depth of pond bund toe.
1.6	Peak = 28kPa Residual = 14kPa							
2.0	Peak = 48kPa Residual = 20kPa		2					
2.4	Peak = 62kPa Residual = 37kPa			... at 2.40m, with trace rootlets.				
2.8	Peak = 48kPa Residual = 23kPa							
3.2	Peak = 57kPa Residual = 31kPa	71.8	3	CH: Silty CLAY: brown/white, mottled grey. High plasticity. (Pakiri Formation)	W	St	HA	
3.6	Peak = 99kPa Residual = 40kPa							
		71.2		CH: CLAY: red/grey. streaked orange. High plasticity. (Pakiri Formation)	M	St	HA	
4.0	Peak = 82kPa Residual = 37kPa		4					
4.4	Peak = 71kPa Residual = 45kPa	70.6		CH: Silty CLAY: dark brown, grey and black. High plasticity. Trace organics. (Pakiri Formation)	M	St	HA	
4.8	Peak = 74kPa Residual = 68kPa							
			5	Borehole terminated at 5.0 m				

Termination reason: Target Depth Reached

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA09-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 27/02/2019
Borehole Location: Refer to site plan

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Logged by: RD	Position: E.1748542.0m N.5972634.0m	Elevation: RL 71.00m	Hole Diameter: 50mm
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
				71.0			OL: TOPSOIL						
				70.9			CH: CLAY: mottled orange/black. High plasticity. (Colluvium)						
	▼ (0.4)	0.4	Peak = 46kPa Residual = 12kPa										
							... at 0.60m, with fine grained, sub rounded completely weathered mudstone gravel fragments throughout						
				70.3			CL: CLAY with some silt and minor sand: brown/grey/ orange. High plasticity. Sand is fine to medium grained. (Colluvium)						
		0.8	Peak = 37kPa Residual = 16kPa						F				
					1								
		1.2	Peak = 38kPa Residual = 15kPa										
		1.6	Peak = 19kPa Residual = 12kPa						S				
		2.0	Peak = 37kPa Residual = 7kPa		2								
								S					
		2.4	Peak = 28kPa Residual = 16kPa								HA		
		2.8	Peak = 32kPa Residual = 10kPa										
					3								
		3.2	Peak = 31kPa Residual = 13kPa	67.8			CH: CLAY: brown/grey. High plasticity. (Alluvium)		F				
		3.6	Peak = 43kPa Residual = 22kPa										
							... from 3.80m to 4.00m, Silty layer with fine to medium grained, sub rounded completely weathered sandstone gravel fragments throughout.						
		4.0	Peak = 31kPa Residual = 23kPa		4								
		4.4	Peak = 31kPa Residual = 12kPa										
				66.4			CL: Silty CLAY: light grey, streaked orange. Low plasticity. (Pakiri Formation)						
		4.8	Peak = 150kPa Residual = 46kPa					M to W	VSt				
					5		Borehole terminated at 5.0 m						

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 0.4m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA10-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 05/02/2019
Borehole Location: Refer to site plan

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Logged by: RD	Position:	E.1748760.0m N.5972448.0m	Elevation:	RL 60.50m	Hole Diameter: 50mm
Checked by: MJC	Survey Source:	Hand Held GPS	Datum:	NZTM	

RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
60.5	0.0	OL: TOPSOIL	M	St	HA
60.3	0.2	CL: Silty CLAY: orange/red/light grey. Low plasticity. (Pakiri Formation) ... at 0.60m, becoming very stiff	M	St / VSt	HA
58.8	1.7	ML: Clayey SILT: light brownish grey, streaked red. Low plasticity. (Pakiri Formation)	M to W	St / VSt	HA
56.7	3.8	ML: SILT: dark grey. Low plasticity. (Pakiri Formation)	M	VSt	HA
	4.4	Borehole terminated at 4.4 m			

Depth	Type & Results
0.4	Peak = 81kPa Residual = 31kPa
0.8	Peak = 112kPa Residual = 47kPa
1.2	Peak = 112kPa Residual = 46kPa
1.6	Peak = 87kPa Residual = 43kPa
2.0	Peak = 124kPa Residual = 25kPa
2.4	Peak = 137kPa Residual = 38kPa
2.8	Peak = 136kPa Residual = 37kPa
3.2	Peak = 108kPa Residual = 35kPa
3.6	Peak = 170kPa Residual = 46kPa
4.0	Peak = 217+
4.4	Peak = UTP

Termination reason: Refusal. Too hard to penetrate.

Remarks: Groundwater was not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT LOG - TP01-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019
Borehole Location: Refer to Site Plan

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Logged by: RD	Position: E.1748001.0m N.5971977.0m	Elevation: RL 49.50m	
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests – Depth	Samples & Insitu Tests – Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			49.5		OL: TOPSOIL (Northland Allochthon)				
			49.2		ML: Clayey SILT: Dark grey, low plasticity. (Northland Allochthon)	D	H		
	0.7	Peak = 77kPa Residual = 54kPa	49.0		CH: Silty CLAY: Light grey, high plasticity. (Northland Allochthon)	M	St to VSt		
	1.2	Peak = 65kPa Residual = 38kPa		1					
	1.8	Peak = 124kPa Residual = 46kPa	47.7		CL: SIlty CLAY: Light blueish grey, low plasticity. With trace brown/black organic streaking. (Northland Allochthon) *... at 1.80m, groundwater seepage.*	M to W			
				2					
	2.5	Peak = 87kPa Residual = 31kPa	47.2		CH: CLAY with some silt: Dark grey with greenish streaking, high plasticity. Becoming completely weathered rock. (Northland Allochthon)		St		
	3.2	Peak = 170kPa Residual = 46kPa		3			St to VSt		
	3.6	Peak = 108kPa Residual = 50kPa							
	4.0	Peak = 112kPa Residual = 46kPa	45.5	4	ML: Clayey SILT: Light blueish grey, low plasticity. Retrieved from bucket in a broken state, occasional clay lumps with minor fine sand retrieved. (Northland Allochthon)				
				5	Test pit terminated at 5.00 m				
				6					

Termination reason: Target depth reached

Remarks:

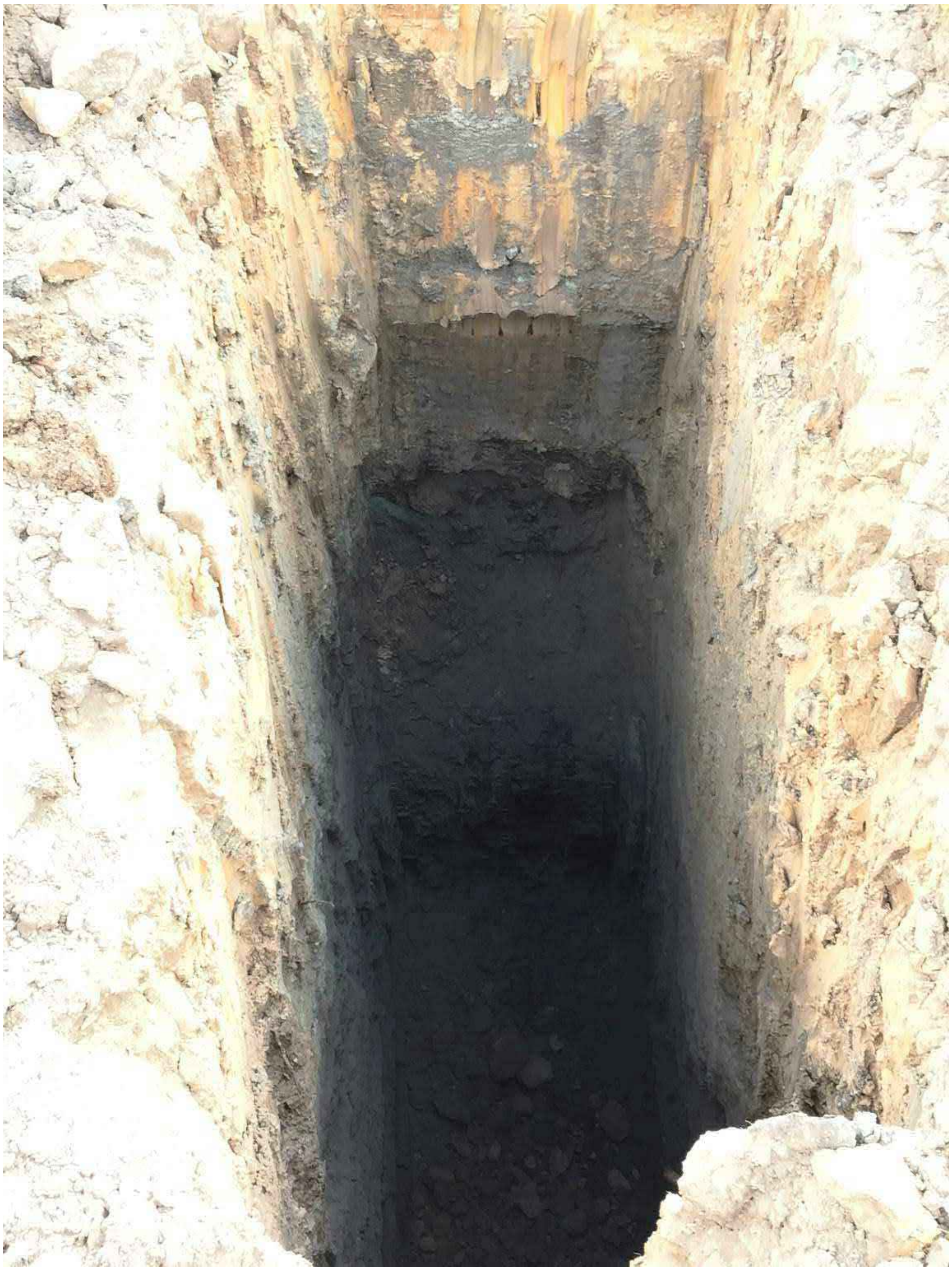
This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT PHOTOGRAPHS: TP01-19

Client: Warkworth Land Development Company Limited
Project: Clayden Road, Warkworth
Location: Warkworth
Project No: AKL2018-0228
Date: 30/01/2019

Sheet No. 1 of 1

Logged by: RD	Position: E 1748001 m N 5971977 m	Dimensions: 1.2 m x 2.5 m	Plant: 13 Tonne Digger
Checked by: JMJ	Elevation: 49.50 m	Termination Depth: 5.0 m	Contractor: Masons



TP01-19 – TEST PIT EXCAVATION

This report of test pit must be read in conjunction with accompanying notes and abbreviations.

TEST PIT LOG - TP02-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019
Borehole Location: Refer to Site Plan

CMW Geosciences

1:30

Logged by: RD
Checked by: MJC

Position: E.1748060.0m N.5972015.0m
Survey Source: Hand Held GPS
Elevation: RL 58.25m
Datum: NZTM
Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15 20	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			58.2			OL: TOPSOIL				
			58.2			CH: CLAY with some silt: Light grey and orange, high plasticity. (Northland Allochthon)				
	0.5	Peak = 59kPa Residual = 31kPa					M	VSt		
			57.4			CH: CLAY: Light grey mottled orange, high plasticity. Trace woody inclusions. (Northland Allochthon)				
	1.0	Peak = 54kPa Residual = 36kPa		1						
	1.5	Peak = 69kPa Residual = 24kPa								
				2						
	2.3	Peak = 77kPa Residual = 35kPa	56.0			CH: CLAY with minor silt: Light blueish grey and grey, high plasticity. (Northland Allochthon)				
	2.9	Peak = 124kPa Residual = 28kPa				*... at 2.90m, with some fine sand*				
				3				St		
			55.0			ML: Sandy gravelly SILT: Blueish grey, low plasticity. Gravel is fine to coarse with angular clasts. (Northland Allochthon)				
			54.8			CL: SILT with minor clay and minor fine to medium-grained sand: Light greenish grey and dark grey. Recovered as broken or highly fractured sample. (Northland Allochthon)				
				4		*... at 4.00m, significant seepage from corner of pit*				
				5						
			52.8			Completely to highly weathered, blue/greenish grey SILTSTONE. Very weak. Weathered to fine Sandy SILT. (Northland Allochthon)				
						Test pit terminated at 5.70 m				
				6						

Termination reason: Target depth reached

Remarks:

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT PHOTOGRAPHS: TP02-19

Client: Warkworth Land Development Company Limited
Project: Clayden Road, Warkworth
Location: Warkworth
Project No: AKL2018-0228
Date: 30/01/2019

Sheet No. 1 of 1

Logged by: RD	Position: E 1748060 m N 5972015 m	Dimensions: 1.2 m x 3.0 m	Plant: 13 Tonne Digger
Checked by: JMJ	Elevation: 58.25 m	Termination Depth: 5.7 m	Contractor: Masons

TP02-19 – TEST PIT EXCAVATION

This report of test pit must be read in conjunction with accompanying notes and abbreviations.

TEST PIT LOG - TP03-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019
Borehole Location: Refer to Site Plan

CMW Geosciences

1:30 | Sheet 1 of 1

Logged by: RD	Position: E.1748161.0m N.5971941.0m	Elevation: RL 61.75m	
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15 20	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			61.8		OL: TOPSOIL: ... *from 0.00m to 1.60m, side of pit collapsing.*				
			61.6		CH: Silty CLAY: Light greyish orange, high plasticity. (Northland Allochthon)	M			
	0.5-2.9 0.5	1 D Peak = 121kPa Residual = 38kPa							Sample for Compaction Curve
	1.0	Peak = 108kPa Residual = 54kPa		1					
	1.5	Peak = 121kPa Residual = 46kPa							
	2.0	Peak = 155kPa Residual = 46kPa		2					
	2.5	Peak = 124kPa Residual = 50kPa							
					... *at 2.70m, minor limonite staining. Becoming completely weathered siltstone. Breaks apart easily in hands along fracture points.*		VSt		
	3.0	Peak = 170kPa Residual = 38kPa	58.8	3	Completely weathered, dark grey SILTSTONE. Weathered to clayey SILT. Dark grey, low plasticity. (Northland Allochthon) ... *from 3.00m to 3.50m, sub-vertical limonite veining in pit wall.*	M to W			
	4.0			4					
					... *at 4.60m, with some areas of highly weathered siltstone.*				
				5	... *at 5.10m, bedding of siltstone present.*				
			56.4		Completely weathered, light greenish grey SILTSTONE; Very weak. Weathered to Sandy SILT (Northland Allochthon)				
					Test pit terminated at 5.70 m				
				6					

Termination reason: Target depth reached

Remarks:

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT PHOTOGRAPHS: TP03-19

Client: Warkworth Land Development Company Limited
Project: Clayden Road, Warkworth
Location: Warkworth
Project No: AKL2018-0228
Date: 30/01/2019

Sheet No. 1 of 1

Logged by: RD	Position: E 1748161 m N 5971941 m	Dimensions: 1.5 m x 3.0 m	Plant: 13 Tonne Digger
Checked by: JMJ	Elevation: 61.75 m	Termination Depth: 5.7 m	Contractor: Masons

TP03-19 – TEST PIT EXCAVATION

This report of test pit must be read in conjunction with accompanying notes and abbreviations.

TEST PIT LOG - TP04-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019
Borehole Location: Refer to Site Plan

CMW Geosciences

1:30 | Sheet 1 of 1

Logged by: RD | Position: E.1748075.0m N.5972199.0m | Elevation: RL 73.50m
Checked by: MJC | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

RL (m)	Material Description	Moisture Condition	Consistency/ Relative Density
73.5	OL: TOPSOIL:		
73.4	CH: CLAY: Orange, high plasticity. (Colluvium)	M to W	
72.3	CL: Silty CLAY with minor fine sand: Light grey mottled orange, low plasticity. With minor limonite staining. (Colluvium)	W	St
71.2	SM: Sandy SILT: Orangish grey, low plasticity. Fine-grained. Limonite staining throughout. Dilatant. (Colluvium)	W	St
69.4	Completely weathered, dark grey SILTSTONE. Extremely weak. Weathered to SILT with some clay. Dark grey, low plasticity. Breaks in hands along fracture points. Manganese staining. (Colluvium) *... at 5.40m, potential slip plane. Polished siltstone with overlying fractured material.*	W	St
68.0	SM: SILT with some fine sand and minor clay: Completely weathered, grey, SILTSTONE; Extremely weak. Weathered to SILT with some fine sand and minor clay. (CW Pakiri Fmn)	S	St
	Test pit terminated at 5.90 m		

Samples & Insitu Tests:

Depth	Type & Results
0.5	Peak = 85kPa Residual = 44kPa
1.2	Peak = 77kPa Residual = 31kPa
2.0	Peak = 77kPa Residual = 31kPa
2.7	Peak = 57kPa Residual = 38kPa
3.8	Peak = 41kPa Residual = 15kPa Peak = Taken from sample.

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15 20

Structure & Other Observations: Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth reached

Remarks:

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT PHOTOGRAPHS: TP04-19

Client: Warkworth Land Development Company Limited
Project: Clayden Road, Warkworth
Location: Warkworth
Project No: AKL2018-0228
Date: 30/1/2019

Sheet No. 1 of 1

Logged by: RD	Position: E 1748075 m N 5972199 m	Dimensions: 1.5 m x 3.0 m	Plant: 13 Tonne Digger
Checked by: JMJ	Elevation: 73.50 m	Termination Depth: 5.9 m	Contractor: Masons

TP04-19 – TEST PIT EXCAVATION

This report of test pit must be read in conjunction with accompanying notes and abbreviations.

TEST PIT LOG - TP05-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019
Borehole Location: Refer to Site Plan

CMW Geosciences

1:30 Sheet 1 of 1

Logged by: RD	Position: E.1748113.0m N.5972251.0m	Elevation: RL 88.50m	
Checked by: MJC	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15 20	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
			88.5		OL: TOPSOIL:				
			88.3		CH: CLAY: Orange, high plasticity. (Colluvium)	M	VSt		
	0.5	Peak = 170kPa Residual = 85kPa							
	0.9	Peak = 85kPa Residual = 46kPa		1					
					... at 1.10m, becoming wet. Limonite staining.	W	St		
	2.0	Peak = 69kPa Residual = 28kPa		2					
	2.5	Peak = 43kPa Residual = 28kPa			*... at 2.50m, water seepage in pit wall.*				
			85.9		CH: CLAY with some silt: Orange, red and light grey, high plasticity. (Pakiri Formation)	W to S			
	2.9	Peak = 77kPa Residual = 34kPa		3	*... at 2.90m, groundwater seepage.*				
			84.4	4	ML: Completely weathered, Dark grey SILTSTONE; Extremely weak. Weathered to SILT with minor clay and minor fine sand. low plasticity. (CW Pakiri Fmn)	S			
	4.3	Peak = 46kPa Residual = 15kPa		5					
					... at 5.60m, becoming slightly blocky structured.				
	5.8	Peak = 65kPa Residual = 15kPa		6	Test pit terminated at 6.00 m				

Termination reason: Target depth reached

Remarks:

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

TEST PIT PHOTOGRAPHS: TP05-19

Client: Warkworth Land Development Company Limited
Project: Clayden Road, Warkworth
Location: Warkworth
Project No: AKL2018-0228
Date: 30/1/2019

Sheet No. 1 of 1

Logged by: RD	Position: E 1748113 m N 5972251 m	Dimensions:1.5 m x 3.0 m	Plant: 13 Tonne Digger
Checked by: JMJ	Elevation: 88.50 m	Termination Depth: 5.9 m	Contractor: Masons

TP05-19 – TEST PIT EXCAVATION

This report of test pit must be read in conjunction with accompanying notes and abbreviations.

BOREHOLE LOG - MH01-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 21/01/2019 - 22/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK | Position: E.1748152.0m N.5971885.0m | Elevation: RL 57.00m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Samples Depth	Samples Type & Results	RL (m)	Material Description	Consistency/Relative Density	Recovery	Drilling Method/Support
		57.0	TOPSOIL			
		56.8	CH: CLAY: light grey streaked orange, high plasticity. (Northland Allochthon)	VSt	80	OB / PQ3
0.5	Peak = 217+					
		56.4	CH: CLAY with minor silt: light grey streaked orange, high plasticity. (Northland Allochthon)		100	OB / PQ3
1.0	Peak = 105kPa Residual = 42kPa				90	OB / PQ3
1.5	Peak = 110kPa					
1.5	SPT = (3,4,7) N* = 11				67	SPT
		55.1	Completely to highly weathered, light grey, SILTSTONE. Extremely weak. Locally weathered to SILT with minor fine to medium sand. Blocky texture with some highly weathered fine to coarse gravel sized SILTSTONE clasts throughout. (Northland Allochthon)		0	W
					50	TT / HQ3
3.5	SPT = (4,8,21) N* = 29					SPT
					70	TT / HQ3
5.0	SPT =					

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH01-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 21/01/2019 - 22/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position: E.1748152.0m N.5971885.0m	Elevation: RL 57.00m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Samples Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Recovery	RQD	Drilling Method/ Support
	(10,20,20/100mm) N* = 50+	51.9		Highly weathered, brownish grey, SILTSTONE. Extremely weak. Highly fractured. (Northland Allochthon)				SPT
			6			63	45	TT / HQ3
6.5	SPT = (10,17,23/120mm) Nc = 50+							SPT
			7			70	76	TT / HQ3
		49.7		Highly weathered, grey, SILTSTONE. Extremely weak to very weak. Highly fractured. (Northland Allochthon)	M			
8.0	SPT = (17,23,10/60mm) Nc = 50+		8					SPT
		48.1	9	Highly weathered, dark grey, SILTSTONE. Locally weathered to completely weathered SILTSTONE. Extremely weak to very weak. (Northland Allochthon)		60	66	TT / HQ3
9.5	SPT = (7,15,20) Nc = 35							SPT
			10					

Weathering: HW–CW (to 49.7 m). Estimated Strength: EW (to 49.7 m), EW–VW below.

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH01-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 21/01/2019 - 22/01/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK | Position: E.1748152.0m N.5971885.0m | Elevation: RL 57.00m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Recovery	RQD	Drilling Method/Support	Structure & Other Observations
					70	66	TT / HQ3	
11.0	SPT = (11,19,27) Nc = 46		11				SPT	
		45.8		Highly weathered, light greenish grey, SILTSTONE. Extremely weak to very weak. Highly fractured. (Northland Allochthon)	60	55	TT / HQ3	
			12	*... at 12.30m, becomes light greenish grey/reddish brown.*				
12.5	SPT = (12,18/100mm (Bouncing)) Nc = 50 +							
			13		80	83	TT / HQ3	
14.0	SPT = (23, (Bouncing)) Nc = 50 +		14				SPT	
					90	75	TT / HQ3	
			15					15.0m:CS,5°,

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH01-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 21/01/2019 - 22/01/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK
Checked by: SP
Position: E.1748152.0m N.5971885.0m
Survey Source: Hand Held GPS
Elevation: RL 57.00m
Datum: NZTM
Angle from horizontal: 90°

Depth (m)	Samples Depth	Type & Results	Material Description	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
15.5			*... at 15.50m, becomes highly weathered to moderately weathered.*			SPT	
15.8							15.8-16.0m:3,JN,40°,
16.1				87	67	TT / HQ3	16.1-16.8m:5,B,3°,
17	17.0	SPT = (10/70mm (Bouncing)) Nc = 50 +				SPT	17.1-18.4m:8,B,3°,
17.6				100	80	TT / HQ3	17.6m:JN,25°,
18.6							18.6-19.9m:9,B,3°,
19.2				80	30	TT / HQ3	19.2m:1,JN,30°,
19.4							19.4m:JN,50°,
20	20.0	SPT = (10/40mm (Bouncing)) Nc = 50 +	Borehole terminated at 20.00 m			SPT	

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH01-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road

Location: Warkworth

Project No: AKL2018-0228

Date: 21/01/2019 - 22/01/2019

Sheet No. 1 of 3

Logged by: TK	Position: E.1748152.0m N.5971885.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 57.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH01-19: 0.0m to 3.7m

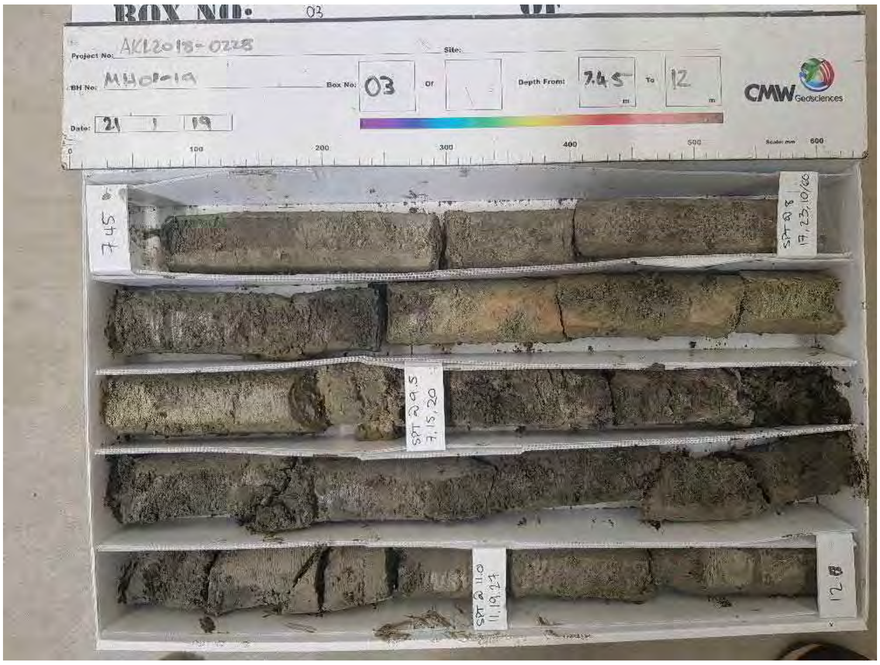
MH01-19: 3.7m to 7.45m

BOREHOLE CORE PHOTOGRAPHS: MH01-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 21/01/2019 - 22/01/2019

Logged by: TK	Position: E.1748152.0m N.5971885.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 57.0m	Angle from Horizontal: 0°	Contractor: Prodrill



MH01-19: 7.45m to 12m

MH01-19: 12m to 15.5m

BOREHOLE CORE PHOTOGRAPHS: MH01-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 21/01/2019 - 22/01/2019

Logged by: TK	Position: E.1748152.0m N.5971885.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 57.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH01-19: 15.5m to 18.65m

MH01-19: 18.65m to 20m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE LOG - MH02-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 22/01/2019 - 23/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position: E.1748255.0m N.5971920.0m	Elevation: RL 45.00m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
		45.0		TOPSOIL				
		44.8		CH: Silty CLAY with trace fine to medium sand: brownish grey mottled light orange, high plasticity. (Northland Allochthon)	M to W	VSt	56	OB / PQ3
0.5	Peak = 187+						40	OB / PQ3
1.0	Peak = 91kPa Residual = 59kPa		1			St	100	OB / PQ3
1.5 1.5	Peak = 80kPa Residual = 32kPa SPT = (5,10,15) N* = 25	43.4		*... at 1.50m, becomes moderately sensitive.* ML: Clayey SILT: light grey mottled orange, low plasticity, moderately sensitive. (Northland Allochthon)		VSt	67	SPT
			2				36	TT / HQ3
		42.0	3	Completely weathered light blueish grey, mottled reddish brown, SILTSTONE. Extremely weak. Weathered to clayey SILT with minor highly weathered fine to coarse gravel sized siltstone fragments. (Northland Allochthon)				
3.5	SPT = (7,8,15) Nc = 23							SPT
			4				57	TT / HQ3
5.0	SPT = (5,10,20) Nc = 30		5					

Column headings also printed: Well; Groundwater; Graphic Log; Weathering (RS, CW, HW, MW, SW, UW); RQD; Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks). Material Description key: Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH02-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 22/01/2019 - 23/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK | Position: E.1748255.0m N.5971920.0m | Elevation: RL 45.00m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Samples Depth	Samples Type & Results	RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
								SPT	
						59		TT / HQ3	
			6						
				... at 6.10m, becomes brown mottled light bluish grey, completely weathered to highly weathered.		100		TT / HQ3	6.4m:1,JN,35°,
6.5	SPT = (10,27/120mm (Bouncing)) Nc = 50 +			... at 6.50m, becomes extremely weak to very weak.				SPT	
			7			70		TT / HQ3	
					M				
8.0	SPT = (15,17/100mm (Bouncing)) Nc = 50 +	37.0	8	Completely to highly weathered, grey, streaked reddish brown SILTSTONE. Extremely weak. (Northland Allochthon)				SPT	
						53	30	TT / HQ3	
			9						9.4m:1,JN,45°, 9.4m:1,DI,0°,
9.5	SPT = (15,20/100mm (Bouncing)) Nc = 50 +							SPT	
			10						

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH02-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 22/01/2019 - 23/01/2019
Borehole Location: Refer to site plan

1:25 Sheet 3 of 4

Logged by: TK	Position: E.1748255.0m N.5971920.0m	Elevation: RL 45.00m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Samples Depth	Samples Type & Results	RL (m)	Depth (m)	Material Description	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
					70	85	TT / HQ3	10.8m:1,JN,5°,
11.0	SPT = (10/90mm (Bouncing)) Nc = 50 +	34.2	11	Highly weathered, dark grey, SILTSTONE. Extremely weak to very weak. Highly fractured. (Northland Allochthon)			SPT	11.0m:1,JN,5°,
				... at 11.60m, becomes grey.	100	80	TT / HQ3	
			12					12.0m:1,JN,5°,
			13		100	50	TT / HQ3	13.4m:1,DI,
								13.8-14.0m:1,CS,IF,angular fine gravel filled
14.0	SPT = (10/100mm (Bouncing)) Nc = 50 +		14				SPT	
			15		93	50	TT / HQ3	

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH02-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 22/01/2019 - 23/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK | Position: E.1748255.0m N.5971920.0m | Elevation: RL 45.00m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Weathering (RS CW HW MW SW UW)	Recovery	RQD	Estimated Strength (EW VW W MS S VS ES)	Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000)	Drilling Method/ Support	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
																15.2m:50°, 15.2m:1,B,3°,
		15.5	SPT = (10/80mm (Bouncing)) Nc = 50 +				Borehole terminated at 15.50 m								SPT	
					16											
					17											
					18											
					19											
					20											

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

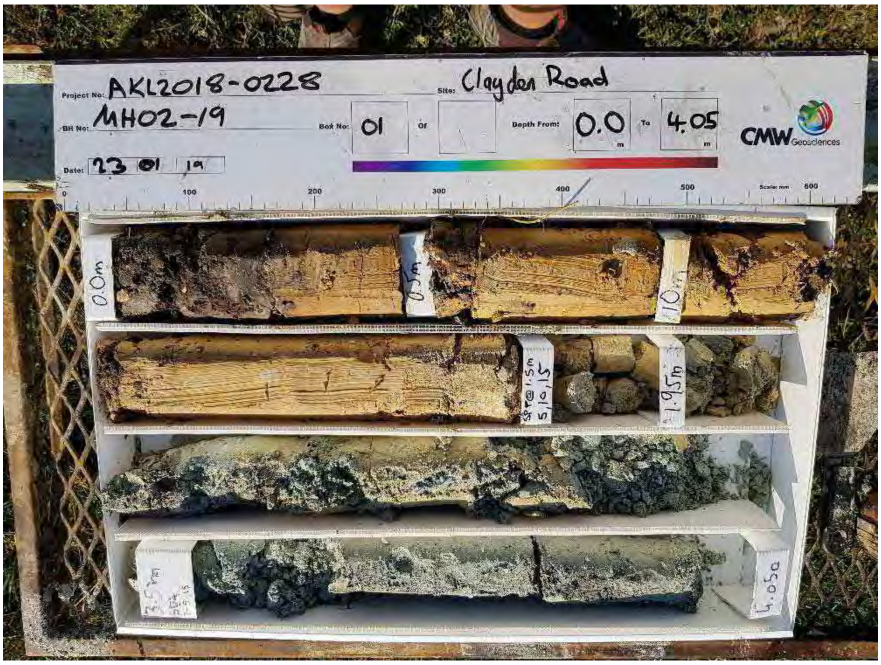
BOREHOLE CORE PHOTOGRAPHS: MH02-19

Client: Warkworth Land Development Company Ltd

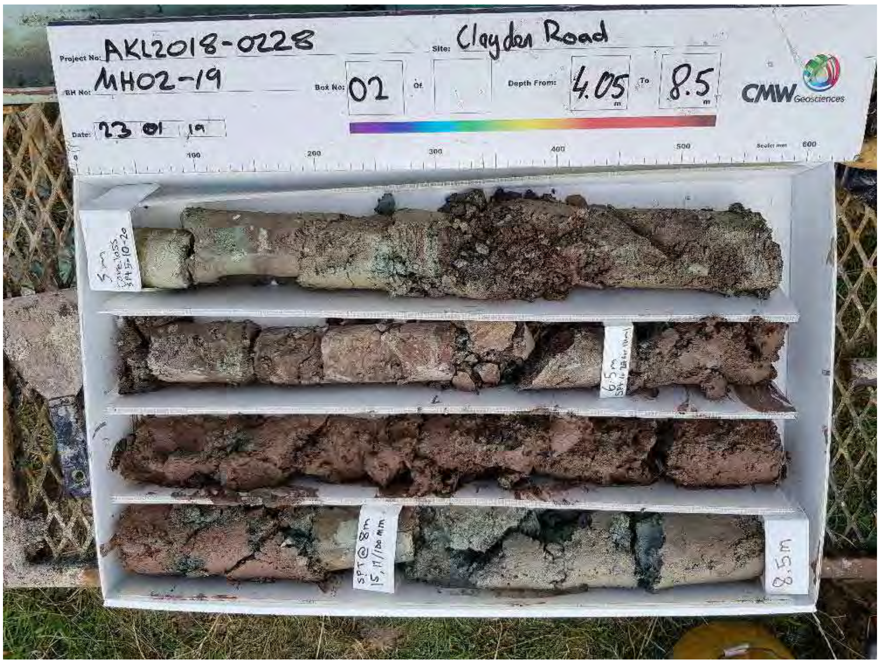
Project: Clayden Road
Location: Warkworth
Project No: AKL2018-0228
Date: 23/01/2019

Sheet No. 1 of 3

Logged by: TK	Position: E.1748255.0m N.5971920.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 45.0m	Angle from Horizontal: 0°	Contractor: Prodrill



MH02-19: 0.0m to 4.05m



MH02-19: 4.05m to 8.5m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

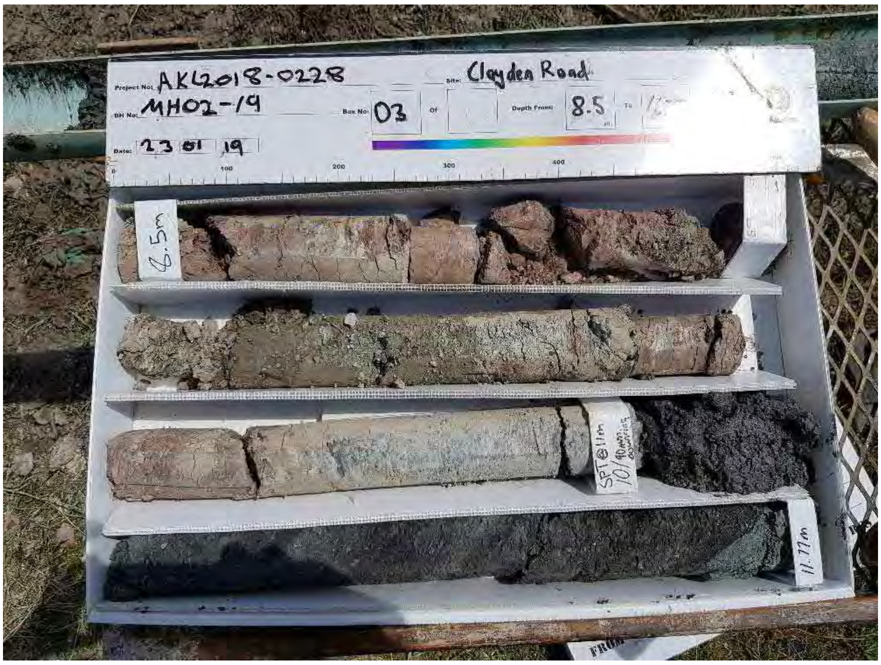
BOREHOLE CORE PHOTOGRAPHS: MH02-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 23/01/2019

Sheet No. 2 of 3

Logged by: TK	Position: E.1748255.0m N.5971920.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 45.0m	Angle from Horizontal: 0°	Contractor: Prodrill



MH02-19: 8.5m to 11.77m

MH02-19: 11.77m to 14.2m

BOREHOLE CORE PHOTOGRAPHS: MH02-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 23/01/2019

Sheet No. 3 of 3

Logged by: TK	Position: E.1748255.0m N.5971920.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 45.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH02-19: 14.2m to 15.5m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE LOG - MH03-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 24/01/2019 - 25/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position: E.1748093.0m N.5972036.0m	Elevation: RL 62.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth; Type & Results); RL (m); Depth (m); Graphic Log; Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)); Moisture Condition; Consistency/ Relative Density; Weathering (RS CW HW MW SW UW); Recovery; RQD; Estimated Strength (EW VW W MS S VS ES); Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000); Drilling Method/ Support; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

RL (m)	Material Description	Consistency/ Relative Density
62.5	TOPSOIL	
62.3	CH: CLAY: orange mottled light grey, high plasticity. (Northland Allochthon) *... from 1.20m to 1.30m, brownish red fine sandy inclusion.*	St
60.2	CH: Silty CLAY with minor fine sand: light grey mottled brown, low plasticity, moderately sensitive. (Northland Allochthon)	St
59.1	CH: Silty CLAY with minor fine gravel: grey mottled dark grey, low plasticity. Completely weathered fine, siltstone gravel fragments throughout. Core loss. (Northland Allochthon)	VSt
57.7	Completely weathered, grey streaked brown and reddish brown, SILTSTONE; Extremely weak. Weathered to clayey SILT	

Sample Depth	Type & Results
0.5	Peak = 100kPa Residual = 65kPa
1.0	Peak = 100kPa Residual = 60kPa
1.5 1.5	Peak = 92kPa Residual = 38kPa SPT = (2,3,3) N* = 6
3.0	SPT = (2,4,6) N* = 10
4.5 4.5	Peak = 155kPa SPT = (5,11,15) N* = 26

Run	Recovery	Drilling Method/ Support
1	100	OB / PQ3
2	100	OB / PQ3
3	100	OB / PQ3
4	100	SPT
5	100	OB / PQ3
6	78	SPT
7	57	OB / PQ3
8	100	SPT

Depth (m) scale: 1, 2, 3, 4, 5

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH03-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 24/01/2019 - 25/01/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK	Position: E.1748093.0m N.5972036.0m	Elevation: RL 62.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Samples Depth	Samples Type & Results	Depth (m)	Material Description	Moisture Condition	Recovery	RQD	Drilling Method/ Support
			with minor fine sand (Northland Allochthon)		65	60	TT / HQ3
		6					
			... at 6.20m, becomes dark grey brown and reddish brown				
6.5	SPT = (5,12,22) Nc = 34						SPT
		7					
			... from 7.25m to 7.80m, core loss.		27	20	TT / HQ3
				M			
8.0	SPT = (5,10,19) Nc = 29	8					SPT
			... from 8.70m to 9.40m, core loss.		27	20	TT / HQ3
		9					
9.5	SPT = (5,12,18) Nc = 30						SPT
		10					

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth; Type & Results); RL (m); Depth (m); Graphic Log; Material Description — Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit); Moisture Condition; Consistency/ Relative Density; Weathering (RS CW HW MW SW UW); Recovery; RQD; Estimated Strength (EW VW W MS S VS ES); Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000); Drilling Method/ Support; Structure & Other Observations — Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH03-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 24/01/2019 - 25/01/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK	Position:	E.1748093.0m N.5972036.0m	Elevation:	RL 62.50m
Checked by: SP	Survey Source:	Hand Held GPS	Datum:	NZTM

Angle from horizontal: 90°

Samples Depth	Type & Results	RL (m)	Depth (m)	Material Description	Recovery	RQD	Drilling Method/ Support
					67	40	TT / HQ3
		51.7		Completely weathered, dark grey mottled grey, SILTSTONE; Extremely weak. Locally weathered to clayey SILT with minor fine sand. (Northland Allochthon)			
11.0	SPT = (7,17,23) Nc = 40		11				SPT
					87	50	TT / HQ3
		50.5	12	Completely weathered, greyish brown, fine gravel CONGLOMERATE. Extremely weak. Weathered to Gravelly CLAY. (Northland Allochthon)			
12.5	SPT = (10,18,21) Nc = 39						SPT
		49.6	13	Completely weathered, dark greyish brown SILTSTONE. Extremely weak. Locally sandy. (Northland Allochthon)	53	0	TT / HQ3
		48.8		Completely weathered to highly weathered, grey streaked light blueish grey and brown SILTSTONE; Extremely weak. (Northland Allochthon)			
14.0	SPT = (4,12,22) Nc = 34		14		80	0	SPT
				... from 14.50m to 17.00m, core loss.			
		47.9		Completely weathered, dark grey, brown and reddish brown SILTSTONE; Extremely weak. Locally weathered to Clayey SILT. (Northland Allochthon)	53	0	TT / HQ3
			15				

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH03-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 24/01/2019 - 25/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position: E.1748093.0m N.5972036.0m	Elevation: RL 62.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Samples Depth	Type & Results	Depth (m)	Material Description	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
15.5	SPT = (6,13,21) Nc = 34			80	0	SPT	15.5m: drilling water loss.
		16				TT / HQ3	
				67	0		
17.0	SPT = (6,15,26) Nc = 41	17				SPT	
				63	0	TT / HQ3	
		18					
18.5	SPT = (5,11,17) Nc = 28					SPT	
		19		100	60	TT / HQ3	
20.0	SPT = (6,13,25) Nc = 38	20	Borehole terminated at 20.00 m				

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth; Type & Results); RL (m); Depth (m); Graphic Log; Material Description — Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit); Moisture Condition; Consistency/ Relative Density; Weathering (RS, CW, HW, MW, SW, UW); Recovery; RQD; Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Drilling Method/ Support; Structure & Other Observations — Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH03-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road

Location: Warkworth

Project No: AKL2018-0228

Date: 24/01/2019 - 25/01/2019 & 30/01/2019

Sheet No. 1 of 4

Logged by: TK	Position: E.1748093.0m N.5972036.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 62.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH03-19: 0.0m to 2.8m

MH03-19: 2.8m to 7.25m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE CORE PHOTOGRAPHS: MH03-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 24/01/2019 - 25/01/2019 & 30/01/2019

Sheet No. 2 of 4

Logged by: TK	Position: E.1748093.0m N.5972036.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 62.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH03-19: 7.25m to 12.05m

MH03-19: 12.05m to 18.24m

BOREHOLE CORE PHOTOGRAPHS: MH03-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road

Location: Warkworth

Project No: AKL2019-0228

Date: 24/01/2019 - 25/01/2019 & 30/01/2019

Logged by: TK	Position: E.1748093.0m N.5972036.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 62.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH03-19: 18.24m to 20m

MH03-19: 12m to 14.5m

BOREHOLE CORE PHOTOGRAPHS: MH03-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 24/01/2019 - 25/01/2019 & 30/01/2019

Sheet No. 4 of 4

Logged by: TK	Position: E.1748093.0m N.5972036.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 62.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH03-19: 14.5m to 17m

BOREHOLE LOG - MH04-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019 - 31/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK
Checked by: SP
Position: E.1748422.0m N.5972080.0m
Survey Source: Hand Held GPS
Elevation: RL 61.50m
Datum: NZTM
Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
		61.5	0.0	TOPSOIL				
		61.4	0.1	CH: Silty CLAY: orange mottled light grey, high plasticity. (Pakiri Formation)	M	VSt	60	OB / PQ3
0.5	Peak = 146kPa Residual = 15kPa						94	OB / PQ3
1.0	Peak = 102kPa Residual = 33kPa		1	*... at 1.00m, becomes light grey mottled orange.*			100	OB / PQ3
1.5 1.5	Peak = 82kPa Residual = 32kPa SPT = (3,3,4) N* = 7			*... at 1.50m, with trace fine to medium sand.*	M to W		100	SPT
			2				100	OB / PQ3
3.0 3.0	Peak = 58kPa Residual = 20kPa SPT = (2,2,2) N* = 4		3			St	100	SPT
		58.2		CH: CLAY with minor silt: light grey mottled orange, high plasticity. (Pakiri Formation)			100	OB / PQ3
			4	*... at 4.00m, becomes light brown grey mottled orange.*				
4.5 4.5	Peak = 58kPa Residual = 32kPa SPT = (2,2,2) N* = 4	57.0		CH: Silty CLAY with trace fine to medium sand: grey, high plasticity. (Pakiri Formation)			100	SPT
			5					

Column headers also printed: Well; Groundwater; Graphic Log; Weathering (RS, CW, HW, MW, SW, UW); RQD; Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Structure & Other Observations — Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks. Material Description: Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH04-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019 - 31/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK
Checked by: SP
Position: E.1748422.0m N.5972080.0m
Survey Source: Hand Held GPS
Elevation: RL 61.50m
Datum: NZTM
Angle from horizontal: 90°

Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
						100	OB / PQ3
6.0 6.0	Peak = 29kPa Residual = 6kPa SPT = (1,0,2) N* = 2	6	*... at 6.00m, becomes moderately sensitive.*			100	SPT
		7				100	OB / PQ3
7.5 7.5	Peak = 23kPa Residual = 6kPa SPT = (1,1,2) N* = 3		*... at 7.40m, with minor fine to medium sand.*	W	F	100	SPT
		8				95	OB / PQ3
9.0 9.0	Peak = 32kPa Residual = 12kPa SPT = (1,0,1) N* = 1	9				100	SPT
		10				100	OB / PQ3

Well | Groundwater | RL (m) | Graphic Log | Weathering: RS CW HW MW SW UW | RQD | Estimated Strength: EW VW W MS S VS ES | Defect Spacing (mm): <20 20-60 60-200 200-600 600-2000 >2000 | Structure & Other Observations: Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Material Description: Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH04-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019 - 31/01/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK | Position: E.1748422.0m N.5972080.0m | Elevation: RL 61.50m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Samples Depth	Type & Results	RL (m)	Depth (m)	Material Description	Recovery	Drilling Method/Support
10.5 10.5	Peak = 41kPa Residual = 12kPa SPT = (1,1,1) N* = 2				100	SPT
			11		100	OB / PQ3
12.0 12.0	Peak = 26kPa Residual = 6kPa SPT = (2,2,5) N* = 7		12	... *at 12.00m, low plasticity.*	100	SPT
		48.4	13	ML: Clayey SILT with trace medium to coarse sand: brownish grey, low plasticity. (Pakiri Formation) ... *at 13.30m, with minor medium to coarse sand.*	95	OB / PQ3
13.5 13.5	Peak = 35kPa Residual = 6kPa SPT = (2,2,3) N* = 5				100	SPT
			14		100	OB / PQ3
15.0 15.0	Peak = 88kPa Residual = 12kPa SPT = (5,6,7) N* = 13		15			

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH04-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019 - 31/01/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK
Checked by: SP
Position: E.1748422.0m N.5972080.0m
Survey Source: Hand Held GPS
Elevation: RL 61.50m
Datum: NZTM
Angle from horizontal: 90°

Samples Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	RQD	Drilling Method/ Support
							100		SPT
			16			St	100		OB / PQ3
16.5 16.5	Peak = 93kPa Residual = 18kPa SPT = (4,4,10) N* = 14						100		SPT
			17		M to W		100		OB / PQ3
18.0 18.0	Peak = 163kPa Residual = 29kPa SPT = (5,11,17) N* = 28		18			VSt	100		SPT
		43.1		Completely weathered to highly weathered, dark grey, fine to medium SANDSTONE. Extremely weak. Locally weathered to Silty SAND with some clay. (CW Pakiri Fmn)			83		OB / PQ3
		42.6	19	Highly weathered, dark grey, SANDSTONE. Extremely weak. Highly fractured. (HW Pakiri Fmn)					TT / HQ3
		42.1	20	Moderately weathered, grey fine grained SANDSTONE. Weak. (MW Pakiri Fmn)			76	0	TT / HQ3

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH04-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 30/01/2019 - 31/01/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK | Position: E.1748422.0m N.5972080.0m | Elevation: RL 61.50m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Sample Depth	Type & Results	Depth (m)	Material Description	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
20.5	SPT = (10/50mm (Bouncing)) Nc = 50 +					SPT	20.5-22.0m:20,B,3°,UN,R,CL, CN,
		21		93	10	TT / HQ3	21.2m:1,JN,50°,UN,R,CL,CN,
							21.4m:1,JN,80°,UN,R,CL,CN,
							21.6m:1,JN,65°,UN,R,CL,CN,
22.0	SPT = (10/30mm (Bouncing)) Nc = 50 +	22					
							22.2-23.2m:11,B,3°,UN,R,CL, CN, 22.2m:1,B,3°,ST,R,CL,CN,
		23		100	43	TT / HQ3	23.2m:1,B,3°,ST,R,CL,CN,
23.5	SPT = (10/50mm (Bouncing)) Nc = 50 +		Borehole terminated at 23.50 m			SPT	
		24					
		25					

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH04-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2018-0228
Date: 30/01/2019 - 31/01/2019

Sheet No. 1 of 5

Logged by: TK	Position: E.1748422.0m N.5972080.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 61.5m	Angle from Horizontal: 0°	Contractor: Prodrill

MH04-19: 0.0m to 2.1m

MH04-19: 2.1m to 4.3m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE CORE PHOTOGRAPHS: MH04-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 30/01/2019 - 31/01/2019

Logged by: TK	Position: E.1748422.0m N.5972080.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 61.5m	Angle from Horizontal: 0°	Contractor: Prodrill

MH04-19: 4.3m to 6.4m

MH04-19: 6.4m to 9m

BOREHOLE CORE PHOTOGRAPHS: MH04-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 30/01/2019 - 31/01/2019

Sheet No. 3 of 5

Logged by: TK	Position: E.1748422.0m N.5972080.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 61.5m	Angle from Horizontal: 0°	Contractor: Prodrill

MH04-19: 9m to 11.75m

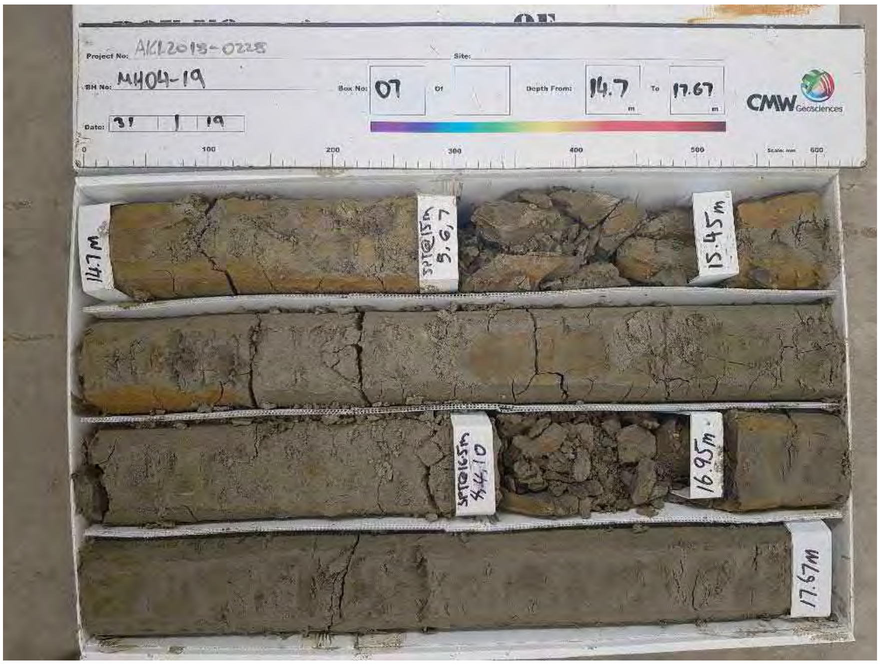
MH04-19: 11.75m to 14.7m

BOREHOLE CORE PHOTOGRAPHS: MH04-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 24/01/2019 - 25/01/2019

Logged by: TK	Position: E.1748422.0m N.5972080.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 61.5m	Angle from Horizontal: 0°	Contractor: Prodrill



MH04-19: 14.7m to 17.67m

MH04-19: 17.67m to 21.5m

BOREHOLE CORE PHOTOGRAPHS: MH04-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 30/01/2019 - 31/01/2019

Sheet No. 5 of 5

Logged by: TK	Position: E.1748422.0m N.5972080.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 61.5m	Angle from Horizontal: 0°	Contractor: Prodrill

MH04-19: 21.5m to 23.5m

BOREHOLE LOG - MH05-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 01/02/2019 - 02/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 5

Logged by: TK	Position: E.1748368.0m N.5972190.0m	Elevation: RL 77.00m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Samples Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/Relative Density	Recovery	Drilling Method/Support
		77.0		TOPSOIL				
		76.9		CH: Silty CLAY: orange mottled dark orange, high plasticity. (Pakiri Formation)	M	VSt	90	OB / PQ3
				... at 0.50m, trace rootlets.			84	OB / PQ3
				... at 0.90m, with trace fine gravel sized limonite nodules.				
1.0	Peak = 140kPa Residual = 61kPa		1	*... at 1.00m, becomes moderately sensitive.*			92	OB / PQ3
				... at 1.20m, becomes orange speckled light grey.				
1.5	Peak = 111kPa Residual = 50kPa						100	U63
				... at 1.80m, becomes orange mottled reddish orange and light grey, with trace fine to coarse gravel sized limonite nodules.			100	OB / PQ3
			2					
3.0	SPT = (2,3,4) N* = 7		3				100	SPT
							100	OB / PQ3
			4					
		72.9		ML: Clayey SILT with trace sand and trace gravel: reddish orange, mottled light grey/orange, low plasticity. Sand is fine to medium grained and gravel is fine grained. (Pakiri Formation)				
4.5	Peak = 50kPa Residual = 12kPa						100	U63
			5					

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH05-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 01/02/2019 - 02/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK
Checked by: SP

Position: E.1748368.0m N.5972190.0m
Survey Source: Hand Held GPS

Elevation: RL 77.00m
Datum: NZTM
Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Weathering	Recovery	RQD	Estimated Strength	Defect Spacing (mm)	Drilling Method/ Support	Structure & Other Observations
							Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)			RS CW HW MW SW UW			EW VW W MS S VS ES	<20 20-60 60-200 200-600 600-2000 >2000		Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
									St		100				OB / PQ3	
		6.0 6.0	Peak = 117kPa Residual = 15kPa SPT = (1,2,2) N* = 4		6						100				SPT	
					7				F to St		100				OB / PQ3	
		7.5 7.5	Peak = 115kPa Residual = 6kPa SPT = (1,1,2) N* = 3								100				SPT	
					8						95				OB / PQ3	
		9.0 9.0	Peak = 137kPa Residual = 29kPa SPT = (1,2,3) N* = 5		9						100				SPT	
					10						100				OB / PQ3	

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH05-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 01/02/2019 - 02/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position: E.1748368.0m N.5972190.0m	Elevation: RL 77.00m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
10.5 10.5	Peak = 70kPa Residual = 20kPa SPT = (3,4,6) N* = 10					100	SPT
		11				100	OB / PQ3
12.0 12.0	Peak = 64kPa Residual = 20kPa SPT = (2,4,5) N* = 9	12		M to W	St	100	SPT
		13				95	OB / PQ3
13.5 13.5	Peak = 64kPa Residual = 15kPa SPT = (1,3,7) N* = 10					100	SPT
		14	*... at 14.30m, grading to orange, streaked light grey/pink.*			100	OB / PQ3
15.0 15.0	Peak = 50kPa Residual = 10kPa SPT = (2,3,6) N* = 9	15					

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth, Type & Results); RL (m); Depth (m); Graphic Log; Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)); Moisture Condition; Consistency/ Relative Density; Weathering (RS CW HW MW SW UW); Recovery; RQD; Estimated Strength (EW VW W MS S VS ES); Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000); Drilling Method/ Support; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH05-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 01/02/2019 - 02/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK | Position: E.1748368.0m N.5972190.0m | Elevation: RL 77.00m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Depth (m)	RL (m)	Sample Depth	Type & Results	Material Description	Consistency/Relative Density	Weathering	Recovery	RQD	Drilling Method/Support	Structure & Other Observations
15.0–16.0				... at 15.40m, becomes light grey mottled orange.		RS	100		SPT	
							100		OB / PQ3	
16.0–19.1	60.9	16.5 16.5	Peak = 117kPa Residual = 18kPa SPT = (4,6,8) N* = 14	Completely weathered, grey, SILTSTONE. Extremely weak. Weathered to clayey SILT with minor fine sand. Low plasticity. (CW Pakiri Fmn)	VSt	CW	100		SPT	
							100		OB / PQ3	
		18.0	SPT = (3,4,9) N* = 13				100		SPT	
							100		TT / HQ3	
19.1–20.2	57.8	19.0	SPT = (4,6,10) Nc = 16	Highly weathered, greenish grey fine Sandy SILTSTONE. Very weak. (HW Pakiri Fmn)		HW			SPT	19.4-19.4m:2,B,3°,UN,R,CL,S-T,(LM), 19.6-20.2m:7,B,3°,UN,R,GA, CN, 19.9m:2,B,3°,PL,R,CL,ST, (LM),
							100	47	TT / HQ3	

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH05-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 01/02/2019 - 02/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK | Position: E.1748368.0m N.5972190.0m | Elevation: RL 77.00m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Depth	Type & Results	RL (m)	Depth (m)	Material Description	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
20.5	SPT = (5,10,25) Nc = 35						SPT	
			21		80	70	TT / HQ3	21.3-21.4m:2,B,3°,UN,R,CL,CN, 21.5m:1,JN,50°,UN,R,CL,CN, 21.6m:1,JN,50°,UN,R,CL,ST,(MG), 21.8-21.9m:3,B,3°,UN,R,CL,CN,
		55.2		Moderately weathered, grey fine SANDSTONE. Very weak. (MW Pakiri Fmn)				
22.0	SPT = (10/32mm (Bouncing)) Nc = 50 +		22				SPT	22.0-22.2m:4,B,3°,UN,R,CL,CN,
					100	63	TT / HQ3	22.3-22.4m:2,B,10°,UN,R,CL,CN, 22.3m:1,B,20°,UN,R,CL,CN, 22.4m:1,JN,40°,UN,R,CL,ST,(MG), 22.4m:1,B,3°,ST,R,CL,ST,(MG), 22.6-23.0m:4,B,3°,UN,R,CL,CN, 22.8m:1,B,3°,ST,R,CL,CN,
			23					23.0-23.1m:2,JN,50°,UN,R,CL,CN, 23.1-23.2m:2,B,3°,ST,R,CL,CN, 23.2m:1,JN,30°,UN,R,CL,CN, 23.4m:1,JN,50°,UN,R,CL,CN,
23.5	SPT = (10/40mm (Bouncing)) Nc = 50 +			Borehole terminated at 23.50 m			SPT	
			24					
			25					

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH05-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2018-0228
Date: 1/02/2019 - 2/02/2019

Sheet No. 1 of 4

Logged by: TK	Position: E.1748368.0m N.5972190.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 77.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH05-19: 0.0m to 2.8m

MH05-19: 2.8m to 6.0m

BOREHOLE CORE PHOTOGRAPHS: MH05-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 1/02/2019 - 2/02/2019

Sheet No. 2 of 4

Logged by: TK	Position: E.1748368.0m N.5972190.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 77.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH05-19: 6.0m to 8.9m

MH05-19: 8.9m to 11.9m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE CORE PHOTOGRAPHS: MH05-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 1/02/2019 - 2/02/2019

Sheet No. 3 of 4

Logged by: TK	Position: E.1748368.0m N.5972190.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 77.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH05-19: 11.9m to 14.9m

MH05-19: 14.9m to 17.7m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE CORE PHOTOGRAPHS: MH05-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 24/01/2019 - 25/01/2019

Sheet No. 4 of 4

Logged by: TK	Position: E.1748368.0m N.5972190.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 77.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH05-19: 17.7m to 20.5m

MH05-19: 20.5m to 23.5m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE LOG - MH06-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 04/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position: E.1748148.0m N.5972257.0m	Elevation: RL 92.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Samples Depth	Samples Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
		92.5		TOPSOIL:	D to M		88	OB / PQ3
		92.3		CH: Silty CLAY: light brownish orange mottled orange, high plasticity, moderately sensitive. (Colluvium)				
0.5	Peak = 193kPa Residual = 58kPa			*... at 0.50m, minor rootlets (possible land slip debris).*		VSt	100	OB / PQ3
1.0	Peak = 29kPa Residual = 15kPa	91.5	1	ML: Clayey SILT with minor rootlets: light brownish orange mottled light grey, low plasticity, moderately sensitive. With limonite staining along fissures. (Colluvium)	M		90	OB / PQ3
1.5	SPT = (2,2,4) N* = 6			*... at 1.50m, becomes light brownish orange mottled orange and light grey*			100	SPT
			2			F	100	OB / PQ3
3.0 3.0	Peak = 85kPa Residual = 18kPa SPT = (2,3,5) N* = 8		3	*... at 3.00m, becomes sensitive.*			100	SPT
				... at 3.50m, occasional completely weathered, fine to medium gravel sized sandstone fragments			100	OB / PQ3
			4	*... at 3.80m, becomes light brownish orange mottled light grey, brownish red and orange.*				
4.5 4.5	Peak = 55kPa Residual = 6kPa SPT = (2,3,3) N* = 6						100	SPT
			5					

Columns Well, Groundwater, Graphic Log, Weathering (RS CW HW MW SW UW), RQD, Estimated Strength (EW VW W MS S VS ES), Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000), Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks) contain no entries.

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH06-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 04/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK	Position: E.1748148.0m N.5972257.0m	Elevation: RL 92.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Samples & Insitu Tests: Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
							100	OB / PQ3
6.0 6.0	Peak = 102kPa Residual = 20kPa SPT = (2,3,3) N* = 6		6	... *at 6.00m, becomes light grey mottled orange.*			100	SPT
		85.6	7	CL: Silty CLAY: light brownish grey, with pink mottles. Low plasticity, (Pakiri Formation)		St	95	OB / PQ3
7.5 7.5	Peak = 58kPa Residual = 6kPa SPT = (2,4,8) N* = 12	85.0		CH: Silty CLAY with trace fine gravel: light brownish orange mottled orange, low plasticity, sensitive. Fine gravel limonite nodules throughout. (Pakiri Formation)	M to W		100	SPT
			8				86	OB / PQ3
9.0 9.0	Peak = 131kPa Residual = 32kPa SPT = (3,6,9) N* = 15		9				100	SPT
		82.8	10	CL: Silty CLAY with trace fine to medium sand: grey mottled dark grey, low plasticity, sensitive. (Pakiri Formation)			100	OB / PQ3

Column headings also include: Well; Groundwater; Graphic Log; Weathering (RS, CW, HW, MW, SW, UW); RQD; Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks).

Material Description heading: Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH06-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 04/02/2019
Borehole Location: Refer to site plan

1:25 | Sheet 3 of 4

Logged by: TK | Position: E.1748148.0m N.5972257.0m | Elevation: RL 92.50m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Consistency	Recovery	RQD	Drilling Method/Support	Structure & Other Observations
10.5 10.5	Peak = 117kPa Residual = 20kPa SPT = (2,5,8) N* = 13				VSt	100		SPT	
			11			81		OB / PQ3	
12.0	SPT = (14,22,28/130mm) N* = 50+	80.7 80.5	12	Completely weathered, dark grey, SANDSTONE; Extremely weak. Weathered to clayey SILT with trace sand. (CW Pakiri Fmn) Highly weathered, dark brownish grey SANDSTONE. Extremely weak. Highly fractured. (HW Pakiri Fmn) *... from 12.50m to 13.80m, highly fractured.*		100		SPT	
			13			68	19	TT / HQ3	12.7-13.8m:12,B,15°,UN,R,CL,CN, 13.4m:1,JN,50°,UN,R,CL,CN, 13.4-13.5m:2,JN,30°,UN,R,CL,CN,
14.0	SPT = (10/60mm (Bouncing)) Nc = 50 +	77.9	14	Moderately weathered, grey, fine to medium grained SANDSTONE; Weak. (MW Pakiri Fmn)		100	83	SPT TT / HQ3	14.0-14.1m:2,B,3°,UN,R,CN, 14.2m:1,B,3°,UN,R,CL,ST,(MG), 14.3m:1,JN,35°,UN,R,CL,ST,(MG), 14.5-14.9m:3,B,3°,UN,R,CL,CN, 15.0-15.1m:3,JN,UN,R,CL,CN,50 to 70°
			15						

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH06-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 04/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position: E.1748148.0m N.5972257.0m	Elevation: RL 92.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Depth	Type & Results	Depth (m)	Material Description	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
							15.2m:1,DI,
15.5	SPT = (10/20mm (Bouncing)) Nc = 50 +						15.5-16.0m:2,JN,UN,R,CL,CN ,30 to 60°
		16		100	90	TT / HQ3	16.1m:1,JN,35°,PL,R,CL,CN,
							16.2m:3,JN,25°,UN,R,CL,CN,
							16.5m:3,B,3°,UN,R,CL,CN,
							16.8m:1,JN,40°,UN,R,CL,ST, (MG),
							16.8m:1,B,3°,UN,R,CL,CN,
17.0	SPT = (10/10mm (Bouncing)) Nc = 50 +	17	Borehole terminated at 17.00 m				
		18					
		19					
		20					

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth; Type & Results); RL (m); Depth (m); Graphic Log; Material Description — Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit); Moisture Condition; Consistency/ Relative Density; Weathering (RS CW HW MW SW UW); Recovery; RQD; Estimated Strength (EW VW W MS S VS ES); Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000); Drilling Method/ Support; Structure & Other Observations — Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH06-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2018-0228
Date: 4/02/2019

Sheet No. 1 of 3

Logged by: TK	Position: E.1748148.0m N.5972257.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 92.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH06-19: 0.0m to 2.72m

MH06-19: 2.72m to 5.7m

BOREHOLE CORE PHOTOGRAPHS: MH06-19

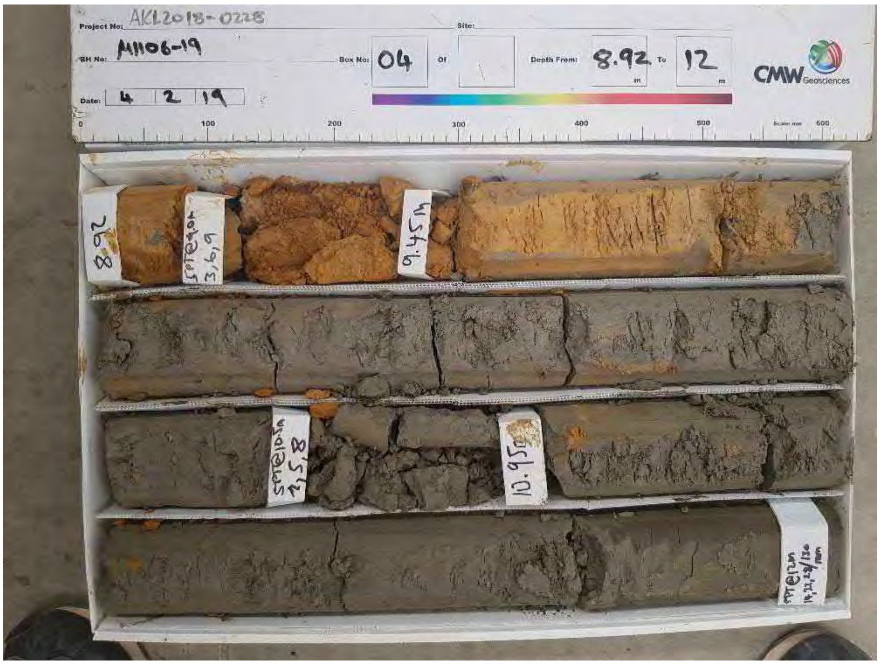
Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 4/02/2019

Sheet No. 2 of 3

Logged by: TK	Position: E.1748148.0m N.5972257.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 92.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH06-19: 5.7m to 8.92m



MH06-19: 8.92m to 12m

BOREHOLE CORE PHOTOGRAPHS: MH06-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 4/02/2019

Sheet No. 3 of 3

Logged by: TK	Position: E.1748148.0m N.5972257.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 92.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH06-19: 12m to 15.2m

MH06-19: 15.2m to 17m

BOREHOLE LOG - MH07-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 05/02/2019
Borehole Location: Refer to site plan

1:25 Sheet 1 of 4

Logged by: TK	Position: E.1748075.0m N.5972245.0m	Elevation: RL 82.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
		82.5	0.0	TOPSOIL	D to M		64	OB / PQ3
		82.2	0.3	CH: Silty CLAY: orange mottled dark orange, high plasticity, moderately sensitive. (Colluvium)	M	St		
0.5	Peak = 199+						100	OB / PQ3
1.0	Peak = 145kPa Residual = 71kPa		1				100	OB / PQ3
1.5 / 1.5	Peak = 57kPa Residual = 20kPa SPT = (1,1,2) N* = 3						100	SPT
			2					
				... at 2.30m, becomes orange mottled light grey.			83	OB / PQ3
				... at 2.90m, trace fine to medium gravel sized limonite nodules.				
3.0 / 3.0	Peak = 71kPa Residual = 20kPa SPT = (1,2,2) N* = 4		3	*... at 3.00m, becomes orange mottled light grey and reddish orange, minor fine to medium gravel sized limonite nodules.*			22	SPT
			4				48	OB / PQ3
				... from 4.30m to 4.40m, band of angular fine to medium gravel sized limonite nodules.				
4.5 / 4.5	Peak = 40kPa Residual = 14kPa SPT = (1,2,2) N* = 4						100	SPT
			5					

Column headings also printed: Well; Groundwater; Graphic Log; Material Description — Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit); Weathering (RS CW HW MW SW UW); RQD; Estimated Strength (EW VW W MS S VS ES); Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000); Structure & Other Observations — Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH07-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 05/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position: E.1748075.0m N.5972245.0m	Elevation: RL 82.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Samples Depth	Type & Results	RL (m)	Depth (m)	Material Description	Consistency/Relative Density	Recovery	Drilling Method/Support
		77.4			F		
		77.3		ML: Clayey SILT with some fine to medium sand: grey streaked orange, low plasticity, sensitive. (Colluvium)		100	OB / PQ3
5.5	Peak = 57kPa Residual = 20kPa			CH: Silty sandy CLAY: grey streaked orange, high plasticity, sensitive. (Pakiri Formation)		100	
6.0 6.0	Peak = 85kPa Residual = 26kPa SPT = (2,3,3) N* = 6		6		St	100	SPT
		76.0		ML: Sandy SILT with some clay: grey streaked dark grey, low plasticity, sensitive. (Pakiri Formation)		71	OB / PQ3
			7				
7.5 7.5	Peak = 114kPa Residual = 26kPa SPT = (3,3,4) N* = 7				VSt	100	SPT
			8			100	OB / PQ3
9.0 9.0	Peak = 156kPa Residual = 26kPa SPT = (5,8,11) N* = 19	73.5	9	Completely weathered, dark grey, SANDSTONE. Extremely weak. (CW Pakiri Fmn)		100	SPT
						100	OB / PQ3
10.0	Peak = 170kPa Residual = 17kPa		10				

Column headings also printed: Well; Groundwater; Graphic Log; Moisture Condition; Weathering (RS, CW, HW, MW, SW, UW); RQD; Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks).

Material Description: Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH07-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 05/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK
Checked by: SP
Position: E.1748075.0m N.5972245.0m
Survey Source: Hand Held GPS
Elevation: RL 82.50m
Datum: NZTM
Angle from horizontal: 90°

Samples Depth	Samples Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
10.5	SPT = (3,4,5) N* = 9					100		SPT	
			11			100		OB / PQ3	
		70.7		Highly weathered, dark grey SANDSTONE. Extremely weak. (HW Pakiri Fmn)					
12.0 12.0	SPT = (13,23,27/60mm) N* = 50+ Peak = 199+		12			100		SPT	
				... at 12.50m, becomes completely weathered to highly weathered and extremely weak to very weak.	M to W				
									12.8m:1,JN,30°,UN,R,CL,CN,
			13			82		TT / HQ3	
									13.5m:1,JN,30°,UN,R,CL,CN,
14.0	SPT = (10,26,24/45mm) Nc = 50+		14					SPT	
									14.3-14.6m:2,B,3°,UN,R,CL,CN,
						60	60	TT / HQ3	
				... at 14.75m, becomes highly weathered.					
			15						15.0m:1,B,3°,UN,R,CL,CN,
									15.0-15.2m:2,JN,45°,PL,R,CL,CN,

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH07-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 05/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK | Position: E.1748075.0m N.5972245.0m | Elevation: RL 82.50m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Recovery	RQD	Drilling Method/Support	Structure & Other Observations
								15.2m:1,B,3°,ST,R,CL,CN,
15.5	SPT = (10/50mm (Bouncing)) Nc = 50 +						SPT	
		66.9		Moderately weathered, dark grey SANDDSTONE; Very weak (MW Pakiri Fmn)				15.6m:1,B,3°,UN,R,CL,CN,
				... at 15.60m, becomes moderately weathered and very weak.				15.7-16.0m:2,B,3°,ST,R,CL,CN, 15.8m:1,JN,25°,PL,R,CL,CN, 15.8m:1,B,3°,UN,R,CL,CN,
			16		93	80	TT / HQ3	16.2m:2,B,3°,UN,R,CL,CN, 16.3-16.9m:5,JN,45°,PL,R,CL,CN,
17.0	SPT = (10/60mm (Bouncing)) Nc = 50 +		17				SPT	
				... from 17.15m to 17.40m, limonite staining.				17.2m:1,B,3°,UN,R,CL,CN, 17.2-18.4m:10,JN,PL,R,CL,CN,30 to 60° 17.4m:1,B,3°,UN,R,CL,CN,
					100	67	TT / HQ3	
			18					
		64.4		Moderately to slightly weathered, dark grey SANDSTONE; Weak (MW Pakiri Fmn)				
				... at 18.10m, becomes moderately weathered to slightly weathered and weak.				18.4m:1,B,3°,UN,R,CL,CN,
								18.7m:1,B,3°,UN,R,CL,CN,
			19		83	57	TT / HQ3	19.0m:2,JN,30°,UN,R,CL,CO,(CA), 19.0m:1,JN,50°,UN,R,CL,CN, 19.2-20.0m:4,B,3°,UN,R,CL,CN,
20.0	SPT = (10/60mm (Bouncing)) Nc = 50 +		20	Borehole terminated at 20.00 m			SPT	

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH07-19

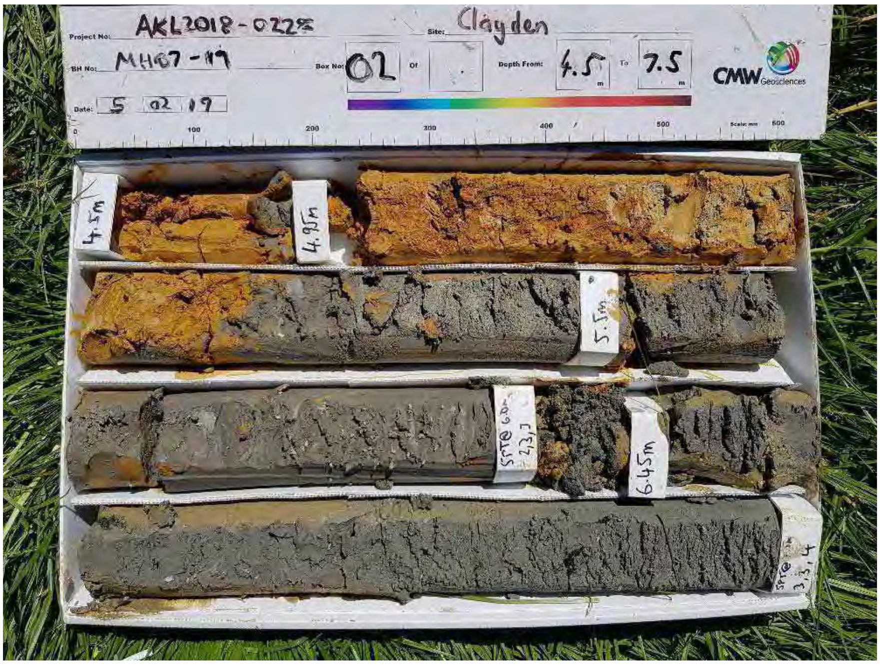
Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2018-0228
Date: 5/02/2019

Sheet No. 1 of 3

Logged by: TK	Position: E.1748075.0m N.5972245.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 92.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH07-19: 0.0m to 4.5m



MH07-19: 4.5m to 7.5m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE CORE PHOTOGRAPHS: MH07-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 5/02/2019

Logged by: TK	Position: E.1748075.0m N.5972245.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 92.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH07-19: 7.5m to 10.35m

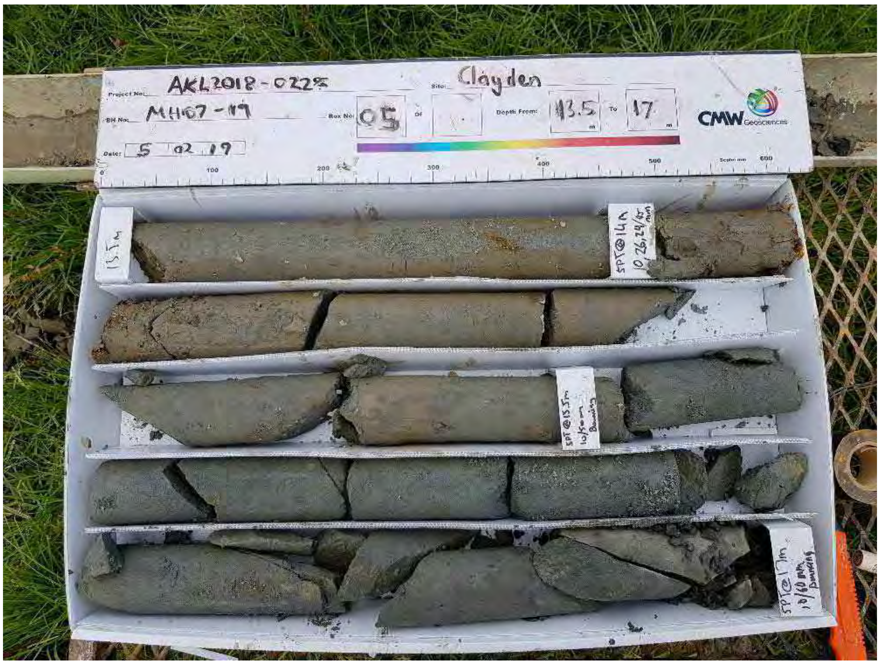
MH07-19: 10.35m to 13.5m

BOREHOLE CORE PHOTOGRAPHS: MH07-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 5/02/2019

Logged by: TK	Position: E.1748075.0m N.5972245.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 92.50m	Angle from Horizontal: 0°	Contractor: Prodrill



MH07-19: 13.5m to 17m

MH07-19: 17m to 20m

BOREHOLE LOG - MH08-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 06/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK
Checked by: SP
Position: E.1748692.0m N.5972823.0m
Survey Source: Hand Held GPS
Elevation: RL 97.00m
Datum: NZTM
Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
		97.0	0.0	TOPSOIL			100	OB / PQ3
		96.8	0.2	CH: Silty CLAY: light brownish orange mottled dark orange, high plasticity. (Colluvium)	M	VSt		
				... at 0.50m, trace rootlets.			100	OB / PQ3
			1	*... at 1.00m, becomes light brownish orange speckled light grey.*			80	OB / PQ3
1.5	SPT = (1,1,2) N* = 3						100	SPT
				... at 1.90m, becomes light brownish orange mottled light grey and dark red.				
		94.6	2.4	ML: Clayey SILT: reddish orange mottled light grey and orange, low plasticity. (Colluvium)	M to W	St	100	OB / PQ3
				... at 2.60m, with minor fine to medium sand.				
3.0	SPT = (1,1,1) N* = 2		3				100	SPT
			4	*... at 4.10m, trace manganese oxide staining.*			95	OB / PQ3
4.5	SPT = (2,1,2) N* = 3		5				100	SPT

Column headings also printed: Well; Groundwater; Graphic Log; Weathering (RS, CW, HW, MW, SW, UW); RQD; Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks). Material Description key: Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH08-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 06/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK
Checked by: SP

Position: E.1748692.0m N.5972823.0m
Survey Source: Hand Held GPS

Elevation: RL 97.00m
Datum: NZTM
Angle from horizontal: 90°

Columns: Well | Groundwater | Samples & Insitu Tests (Depth; Type & Results) | RL (m) | Depth (m) | Graphic Log | Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)) | Moisture Condition | Consistency/ Relative Density | Weathering (RS, CW, HW, MW, SW, UW) | Recovery | RQD | Estimated Strength (EW, VW, W, MS, S, VS, ES) | Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000) | Drilling Method/ Support | Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Structure & Other Observations
							95	OB / PQ3	
6.0	SPT = (2,3,5) N* = 8	91.0	6	ML: Sandy SILT with trace clay: light brownish grey mottled orange, low plasticity. (Colluvium)			100	SPT	
			7				97	OB / PQ3	
7.5	SPT = (4,6,9) N* = 15			*... from 7.50m to 8.00m, manganese staining throughout*	M to W	VSt	100	SPT	
			8				97	OB / PQ3	
9.0	SPT = (7,9,18) N* = 27		9				100	SPT	
							91	OB / PQ3	
		87.1	10	Completely to highly weathered, dark grey, SILTSTONE. Extremely weak.					10.0-10.4m:4,B,3°,UN,R,CL,C-N,

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH08-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 06/02/2019
Borehole Location: Refer to site plan

1:25 | Sheet 3 of 4

Logged by: TK	Position: E.1748692.0m N.5972823.0m	Elevation: RL 97.00m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
				(Colluvium)						10.2-10.2m:2,B,20°,UN,R,CL,ST,(LM),
		86.6		ML: Sandy SILT: light brownish grey mottled orange, very dense. (Colluvium)	M to W	VD	100	10	TT / HQ3	
11.0	SPT = (10,15,20) Nc = 35	86.0	11	Moderately to slightly weathered, dark grey, medium to coarse SANDSTONE. Very weak. (Pakiri Formation)					SPT	11.1m:1,B,3°,UN,R,CL,CN,
							83	78	TT / HQ3	11.6-12.2m:3,DI,
			12							
12.5	SPT = (10/60mm (Bouncing)) Nc = 50 +								SPT	12.5m:1,B,3°,UN,R,CL,CN, 12.6-13.9m:13,B,0°,UN,R,CL,CN,
			13				97	47	TT / HQ3	13.0m:1,B,3°,UN,R,CL,CO,(CA),
14.0	SPT = (10/65mm (Bouncing)) Nc = 50 +		14						SPT	14.0-15.2m:14,B,3°,UN,R,CL,CN, 14.0-15.2m:2,JN,UN,R,CL,CN,80 to 90° 14.3m:1,B,10°,ST,R,CL,CN,
							93	27	TT / HQ3	
15.0	SPT = (10/50mm (Bouncing)) Nc = 50 +		15	*... at 15.00m, highly fractured.*						

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH08-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 06/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK	Position: E.1748692.0m N.5972823.0m	Elevation: RL 97.00m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Moisture Condition	Consistency/ Relative Density	Weathering (RS CW HW MW SW UW)	Recovery	RQD	Estimated Strength (EW VW W MS S VS ES)	Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000)	Drilling Method/ Support	Structure & Other Observations Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
							Borehole terminated at 15.50 m								SPT	
					16											
					17											
					18											
					19											
					20											

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH08-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2018-0228
Date: 6/02/2019

Sheet No. 1 of 3

Logged by: TK	Position: E.1748692.0m N.5972823.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 97.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH08-19: 0.0m to 2.6m

MH08-19: 2.6m to 5.6m

BOREHOLE CORE PHOTOGRAPHS: MH08-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 6/02/2019

Sheet No. 2 of 3

Logged by: TK	Position: E.1748692.0m N.5972823.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 97.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH08-19: 5.6m to 8.6m

MH08-19: 8.6m to 12m

BOREHOLE CORE PHOTOGRAPHS: MH08-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 6/02/2019

Sheet No. 3 of 3

Logged by: TK	Position: E.1748692.0m N.5972823.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 97.0m	Angle from Horizontal: 0°	Contractor: Prodrill

MH08-19: 12m to 15m

MH08-19: 15m to 15.5m

BOREHOLE LOG - MH09-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 07/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK	Position:	E.1748731.7m N.5972471.7m	Elevation:	RL 62.25m
Checked by: SP	Survey Source:	Hand Held GPS	Datum:	NZTM

Angle from horizontal: 90°

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth; Type & Results); RL (m); Depth (m); Graphic Log; Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)); Moisture Condition; Consistency/ Relative Density; Weathering (RS CW HW MW SW UW); Recovery; RQD; Estimated Strength (EW VW W MS S VS ES); Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000); Drilling Method/ Support; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

RL (m)	Material Description	Moisture Condition	Consistency/ Relative Density
62.2	TOPSOIL	M	VSt
62.2	CH: Silty CLAY with minor fine to medium sand: light brown mottled dark orange, low plasticity. (Pakiri Formation)	M	VSt
61.2	CH: Silty CLAY with trace fine to medium sand: light grey mottled dark orange, high plasticity. (Pakiri Formation)	M / W	St
60.0	ML: Clayey SILT: light brownish grey mottled orange, low plasticity. (Pakiri Formation)	W	St
58.8	ML: SILT with some clay and trace fine to medium sand: light grey streaked dark grey, low plasticity. (Pakiri Formation)	W	VSt

Depth	Type & Results
1.0	Peak = 142kPa Residual = 79kPa
1.5 1.5	Peak = 68kPa Residual = 28kPa SPT = (1,1,2) N* = 3
3.0 3.0	Peak = 54kPa Residual = 9kPa SPT = (1,1,3) N* = 4
4.5 4.5	Peak = 156kPa Residual = 17kPa SPT = (2,2,5) N* = 7

Recovery	Drilling Method/ Support
80	OB / PQ3
50	OB / PQ3
100	OB / PQ3
100	SPT
76	OB / PQ3
100	SPT
100	OB / PQ3
100	SPT

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH09-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 07/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK | Position: E.1748731.7m N.5972471.7m | Elevation: RL 62.25m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Recovery	RQD	Drilling Method/Support	Structure & Other Observations
		56.8		Completely weathered, dark grey streaked grey, fine Sandy SILTSTONE. Extremely weak. Locally weathered to clayey SILT with minor sand. (Pakiri Formation)	71		OB / PQ3	
6.0	SPT = (7,9,13) N* = 22		6		89		SPT	
			7				TT / HQ3	
		55.2		Highly to moderately weathered, grey fine Sandy SILTSTONE. Very weak. (HW Pakiri Fmn)	97	13	TT / HQ3	7.1m:JN,50°,PL,R,CL,CN, 7.2-7.9m:6,JN,UN,S,CL,CN,30 to 50° 7.3m:1,B,5°,UN,R,CL,CN,
8.0	SPT = (10/60mm (Bouncing)) N* = 50 +		8				SPT	8.1m:1,JN,50°,UN,R,CL,CN, 8.2m:2,JN,50°,ST,R,CL,CN, 8.4m:1,B,5°,UN,R,CL,CN, 8.4m:1,JN,30°,UN,R,CL,CN, 8.6-8.8m:2,JN,50°,UN,R,CL,CO,(CA),
			9		83	27	TT / HQ3	9.2m:1,JN,40°,ST,R,CL,CN,
9.5	SPT = (10/90mm (Bouncing)) Nc = 50 +						SPT	
			10					9.9m:1,JN,80°,PL,R,CL,CO,(Z),

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH09-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 07/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK	Position: E.1748731.7m N.5972471.7m	Elevation: RL 62.25m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	RL (m)	Depth (m)	Material Description	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
					90	33	TT / HQ3	10.2m:1,B,3°,UN,R,CL,CN, 10.3m:1,JN,50°,ST,R,CL,CN, 10.4m:1,B,3°,ST,R,GA,CN,
		51.8		Moderately weathered, grey coarse grained SANDSTONE. Weak. (MW Pakiri Fmn)				10.8-10.9m:2,DI,
11.0	SPT = (10/35mm (Bouncing)) Nc = 50 +		11				SPT	
					87	40	TT / HQ3	11.3m:JN,45°,UN,R,CL,CN, 11.4-11.7m:3,B,3°,UN,R,CL,CN, 11.8m:2,JN,45°,UN,R,GA,IF,(G), 11.9m:1,JN,30°,UN,R,CL,CN,
			12					12.4m:1,JN,20°,UN,R,CL,CN,
		49.8		Moderately weathered, grey SILTSTONE. Very weak. (MW Pakiri Fmn)				12.5-13.0m:6,B,3°,ST,R,CL,CN,
		49.6		Moderately weathered, dark grey coarse grained SANDSTONE. Weak. (MW Pakiri Fmn)	100	50	TT / HQ3	
			13					13.0-13.5m:4,JN,UN,R,CL,CN,40 to 70° 13.2-13.2m:2,B,3°,UN,R,CL,CN, 13.7m:1,B,5°,ST,R,CL,CN,
14.0	SPT = (10/60mm (Bouncing)) Nc = 50 +		14	Borehole terminated at 14.00 m			SPT	14.0m:2,DI,
			15					

Column headings also printed: Well; Groundwater; Samples & Insitu Tests; Graphic Log; Material Description — Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit); Moisture Condition; Consistency/ Relative Density; Weathering (RS, CW, HW, MW, SW, UW); Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Structure & Other Observations — Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH09-19

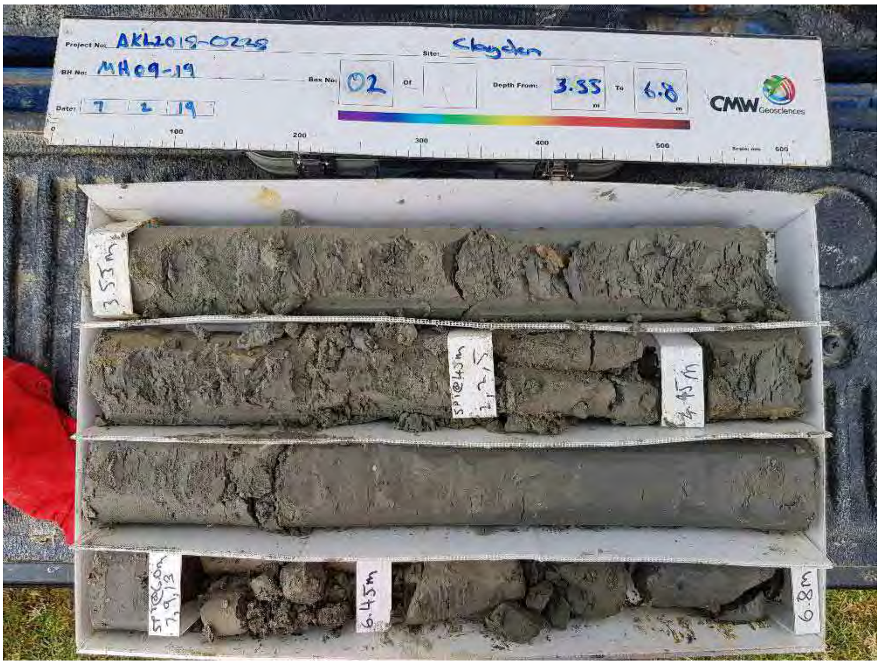
Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2018-0228
Date: 7/02/2019

Sheet No. 1 of 3

Logged by: TK	Position: E.1748731.7m N.5972471.7m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 62.25m	Angle from Horizontal: 0°	Contractor: Prodrill

MH09-19: 0.0m to 3.55m



MH09-19: 3.55m to 6.8m

BOREHOLE CORE PHOTOGRAPHS: MH09-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 7/02/2019

Logged by: TK	Position: E.1748731.7m N.5972471.7m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 62.25m	Angle from Horizontal: 0°	Contractor: Prodrill

MH09-19: 6.8m to 10.15m

MH09-19: 10.15m to 13.25m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

BOREHOLE CORE PHOTOGRAPHS: MH09-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 7/02/2019

Sheet No. 3 of 3

Logged by: TK	Position: E.1748731.7m N.5972471.7m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 62.25m	Angle from Horizontal: 0°	Contractor: Prodrill

MH09-19: 13.25m to 14m

BOREHOLE LOG - MH10-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 08/02/2019
Borehole Location: Refer to site plan

1:25

Sheet 1 of 5

Logged by: TK	Position: E.1748657.0m N.5972607.0m	Elevation: RL 91.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

RL (m)	Depth (m)	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit). Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density
91.5	0.0	TOPSOIL:	M	VSt
91.4	0.1	CH: Silty CLAY with trace fine to medium sand: orange mottled dark orange, high plasticity. (Colluvium)	M	VSt
	1.0	*... at 1.00m, becomes orange mottled light grey.*	M	St
90.0	1.5	CH: CLAY with minor silt: light grey, streaked orange. High plasticity. (Pakiri Formation)	M	St
	2.2	*... at 2.20m, becomes light grey mottled orange and reddish pink, with trace fine to medium sand.*	M to W	St
87.2	4.3	ML: Clayey SILT with trace fine to medium sand: reddish pink mottled orange and light grey, low plasticity. (Pakiri Formation)	W	

Moisture condition: M (0.0–2.2 m); M to W (2.2–3.0 m); W (3.0–5.0 m). Consistency: VSt (0.0–1.0 m); St (1.0–2.5 m).

Samples & Insitu Tests

Depth	Type & Results
1.0	Peak = 99kPa Residual = 45kPa
2.5	Peak = 77kPa Residual = 34kPa
3.0	SPT = (1,2,2) N* = 4
4.5	Peak = 40kPa Residual = 17kPa
4.5	SPT = (1,2,3) N* = 5

Core runs

Run (m)	Recovery	Drilling Method/ Support
0.0–0.5	80	OB / PQ3
0.5–1.0	60	OB / PQ3
1.0–1.5	100	OB / PQ3
1.5–2.0	100	U63
2.0–2.5	60	OB / PQ3
2.5–3.0	100	U63
3.0–3.45	100	SPT
3.45–4.5	95	OB / PQ3
4.5–4.95	100	SPT

Columns also shown: Well; Groundwater; Graphic Log; Weathering (RS, CW, HW, MW, SW, UW); RQD; Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks).

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH10-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 08/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK | Position: E.1748657.0m N.5972607.0m | Elevation: RL 91.50m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
			... from 5.50m to 6.00m, band of yellowish orange limonite staining. Fine to medium gravel sized limonite nodules.			86	OB / PQ3
6.0 6.0	Peak = 40kPa Residual = 14kPa SPT = (1,2,3) N* = 5	6				100	SPT
		7				100	OB / PQ3
7.5 7.5	Peak = 28kPa Residual = 11kPa SPT = (1,2,3) N* = 5			W	F	100	SPT
		8	*... at 7.90m, becomes pink mottled reddish orange.*			95	OB / PQ3
9.0 9.0	Peak = 28kPa Residual = 11kPa SPT = (1,1,2) N* = 3	9				100	SPT
		10	*... at 9.80m, becomes light grey mottled orange and reddish pink.*			100	OB / PQ3

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth, Type & Results); RL (m); Depth (m); Graphic Log; Material Description — Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit); Moisture Condition; Consistency/ Relative Density; Weathering (RS, CW, HW, MW, SW, UW); Recovery; RQD; Estimated Strength (EW, VW, W, MS, S, VS, ES); Defect Spacing (mm) (<20, 20-60, 60-200, 200-600, 600-2000, >2000); Drilling Method/ Support; Structure & Other Observations — Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH10-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 08/02/2019
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: TK | Position: E.1748657.0m N.5972607.0m | Elevation: RL 91.50m
Checked by: SP | Survey Source: Hand Held GPS | Datum: NZTM | Angle from horizontal: 90°

Samples Depth	Type & Results	RL (m)	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support
10.5 10.5	Peak = 60kPa Residual = 23kPa SPT = (1,4,5) N* = 9	81.0		CL: Silty CLAY with minor fine sand: yellowish orange. Low plasticity. (Pakiri Formation)	W	St	100	SPT
			11				100	SPT
				... *at 11.50m, becomes dark grey.*				
12.0 12.0	Peak = 54kPa Residual = 14kPa SPT = (1,3,6) N* = 9		12				100	SPT
				... *at 12.60m, becomes orange mottled light grey.*			86	OB / PQ3
			13			VSt		
13.5 13.5	Peak = 111kPa Residual = 40kPa SPT = (2,5,10) N* = 15						78	SPT
				... *at 13.70m, limonite staining with fine gravel sized limonite nodules*				
			14				95	OB / PQ3
15.0 15.0	Peak = 99kPa Residual = 28kPa SPT = (2,5,10) N* = 15		15					

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH10-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 08/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK	Position: E.1748657.0m N.5972607.0m	Elevation: RL 91.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Depth (m)	RL (m)	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	Material Description	Moisture Condition	Weathering	Recovery	RQD	Drilling Method/ Support	Structure & Other Observations
15.15–15.3						RS	100		SPT	
15.3–16.2						RS	95		OB / PQ3	
16.2–20.25	75.3	16.5 16.5	Peak = 79kPa Residual = 14kPa SPT = (2,3,6) N* = 9	Completely weathered, grey streaked dark grey, Sandy SILTSTONE. weathered to clayey SILT with minor sand Extremely weak. (CW Pakiri Fmn)	W	CW	100		SPT	
				... at 17.30m, becomes dark grey streaked grey.			93		OB / PQ3	
		18.0	SPT = (5,6,5) N* = 11				100		SPT	
							100		OB / PQ3	
19.5–20.2	72.0			Moderately weathered, grey SILTSTONE. Very weak. (MW Pakiri Fmn)		MW	77	15	TT / HQ3	19.8m:1,B,3°,UN,R,CL,CN, 20.0m:1,B,3°,UN,R,CL,CN, 20.1m:1,JN,80°,UN,R,CL,CN, 20.2m:1,B,20°,ST,R,CL,CN,

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth; Type & Results); RL (m); Depth (m); Graphic Log; Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)); Moisture Condition; Consistency/ Relative Density; Weathering (RS CW HW MW SW UW); Recovery; RQD; Estimated Strength (EW VW W MS S VS ES); Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000); Drilling Method/ Support; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

Depth markers: 16, 17, 18, 19, 20

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - MH10-19

Client: Warkworth Land Development Company Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0228
Date: 08/02/2019
Borehole Location: Refer to site plan

1:25

Logged by: TK	Position: E.1748657.0m N.5972607.0m	Elevation: RL 91.50m	
Checked by: SP	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Weathering (RS CW HW MW SW UW)	Recovery	RQD	Estimated Strength (EW VW W MS S VS ES)	Defect Spacing (mm) (<20 20-60 60-200 200-600 600-2000 >2000)	Drilling Method/ Support	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
		20.5	SPT = (10/75mm (Bouncing)) Nc = 50 +				Borehole terminated at 20.50 m								SPT	
					21											
					22											
					23											23.5m:1,B,3°,ST,R,CL,CN,
					24											
					25											

Termination reason: Target depth reached

Remarks: Vane shear strength testing was completed in the bottom of each run within cohesive soils.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE CORE PHOTOGRAPHS: MH10-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2018-0228
Date: 8/02/2019

Logged by: TK	Position: E.1748657.0m N.5972607.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 91.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH10-19: 0.0m to 4.7m

MH10-19: 4.7m to 7.95m

BOREHOLE CORE PHOTOGRAPHS: MH10-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road

Location: Warkworth

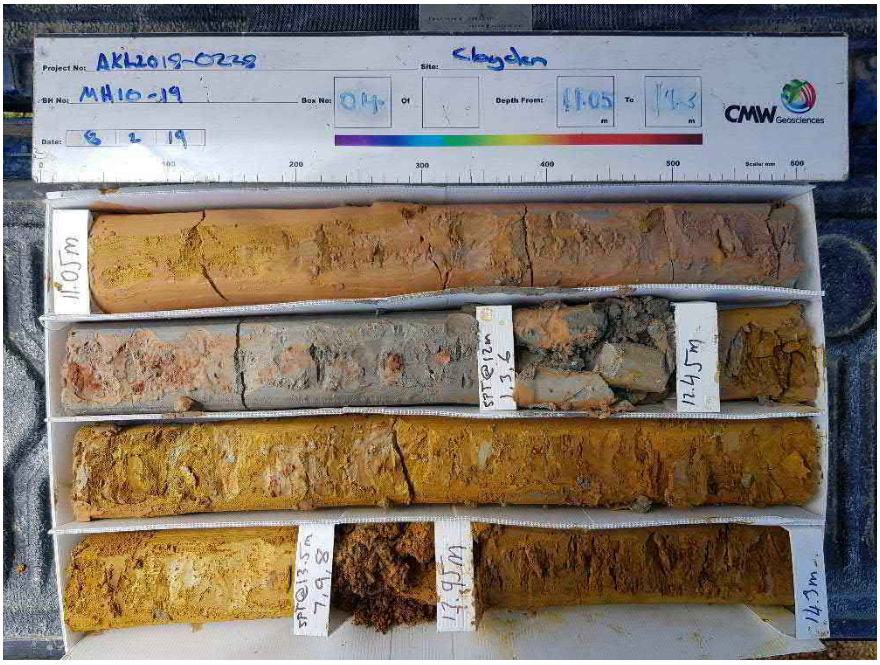
Project No: AKL2019-0228

Date: 8/02/2019

Sheet No. 2 of 3

Logged by: TK	Position: E.1748657.0m N.5972607.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by:	Elevation: RL 91.50m	Angle from Horizontal: 0°	Contractor: Prodrill

MH10-19: 7.95m to 11.05m



MH10-19: 11.05m to 14.3m

This report of boreholes must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination.

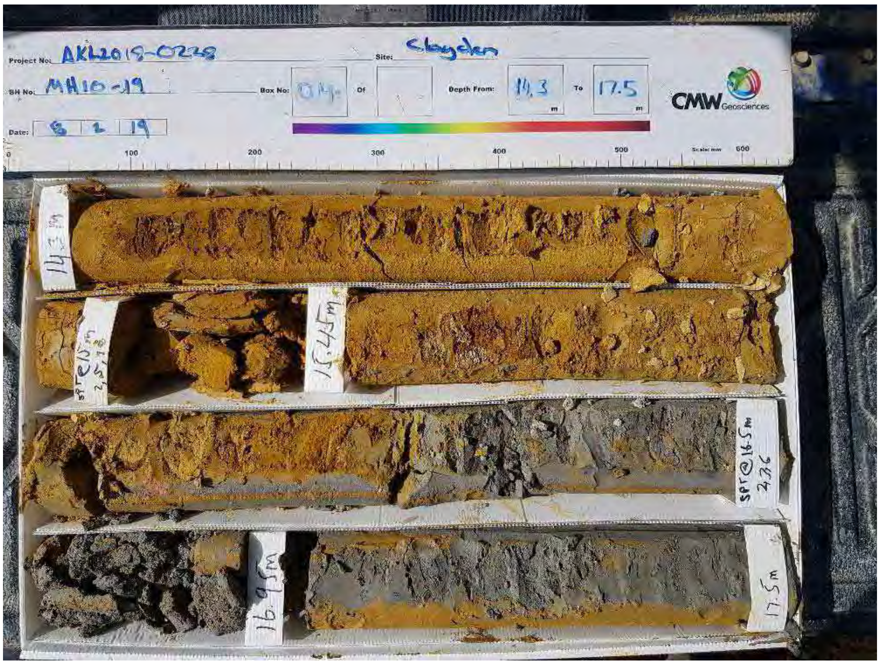
BOREHOLE CORE PHOTOGRAPHS: MH10-19

Client: Warkworth Land Development Company Ltd

Project: Clayden Road
Location: Warkworth
Project No: AKL2019-0228
Date: 8/02/2019

Sheet No. 3 of 3

Logged by: TK	Position: E.1748657.0m N.5972607.0m	Hole Diameter: 100 mm	Plant: Tractor rig
Checked by: RD	Elevation: RL 91.50m	Angle from Horizontal: 0°	Contractor: Prodrill



MH10-19: 14.3m to 17.5m

MH10-19: 17.5m to 20.5m

Appendix D: CMW 2018 Letter

3 September 2018 AKL2018-0105AD Rev. 0

Warkworth Land Company Limited
C/o Mr V Bell
Development Advisory Services
PO Box 5908
Wellesley Street
Auckland 1141

Dear Vaughan,

RE: GEOTECHNICAL LETTER FOR STRUCTURE PLAN SUBMISSION FOR STEVENSONS LAND AND CLAYDEN ROAD LAND IN WARKWORTH

1 INTRODUCTION

CMW Geosciences has been engaged by Warkworth Land Company Limited to carry out a preliminary geotechnical assessment for the potential development of the Stevenson Land (Lot 3&4 DP 199755, Part Lot 1 DP 61693, PA 97 Mahurangi Parish) and Clayden Road site, Lot 4 DP 492431 Warkworth, Auckland and to provide input for a submission to Structure Plan changes that are currently under consideration.

Our scope of work has been carried out in accordance with our proposal referenced AKL2018-0105AC Rev.2 and incorporated a site walkover and geomorphological mapping, review of related reports, preliminary field investigations and preparation of this report outlining key geotechnical considerations. This letter has been prepared with reference to draft documents prepared by members of the consultancy team as follows:

- Civil Engineering Structure Plan Assessment, including earthworks layout by Riley Consultants referenced 180226-D, dated 3 September 2018.
- Concept Urban Design Report by A Studio Architects, Revision A dated 3 September 2018.
- Ecological Constraints Memo from Bioresearches referenced 61670 dated 25 May 2018.

2 RELATED GEOTECHNICAL REPORTS

In preparation of this letter, two previous geotechnical reports for the SH1 to Matakana Link Road (to the south of the proposed development site) have been reviewed. These reports have been prepared by Jacobs and are referenced as follows:

- SH1 To Matakana Link Road Ground Investigation, Geotechnical Factual Report, report number IZ093400-SG-R-01, Revision 1, dated 3 November 2017;
- SH1 to Matakana Road, Geotechnical Interpretative Report, report number IZ093400-SG-R-02, Revision 1, dated 3 November 2017.

3 GEOLOGY

Published Geological Maps[1,2] indicate the proposed development site is predominantly underlain by Pakiri Formation of the Waitemata Group. This geological unit is widespread, of early Miocene age and occurs from the north of Hatfields Beach, west to the Kaipara Harbour and north to Mangawhai. Pakiri Formation is dominated by 10-30m thick, graded medium to coarse grained sandstones alternating with thinner, laminated, siltstones and finer sandstones, which form the elevated slopes to the north and west of the site.

Portions on the southern end of the site are also shown to be underlain with Mahurangi Limestone of the Motatau Complex in the Northland Allochthon. The Mahurangi Limestone is represented by blue-grey to white, micritic, muddy limestone, which forms the less elevated, gently rolling hills towards the southern end of the site.

Faulting is present along the contact of the Pakiri Formation and Mahurangi Limestone extending through the south western corner. It is indicated by GNS as being inactive and the presence of the fault appears to be strongly manifested in the site geomorphology as described in Section 4 below.

Using this information and ground investigations from both the CMW and the Jacobs geotechnical reports, the geology of the subject site has been overlaid over a map of the area, as shown on the appended Geology Plan, Figure 01, although we note that the boundaries between the geological units may vary from those depicted.

4 GEOMORPHOLOGY AND STRUCTURAL GEOLOGY

The geomorphology of the site was mapped from an initial site walkover, as well as using historical aerial photographs, and is shown on the appended Geomorphology Plan, Figure 02.

The site contour is structurally controlled by the reverse thrust fault towards the southwest of the site and the changes in geology across the extent of the site. An associated, large debris flow is present in this area that extends across several site boundaries.

The principal site ridgeline follows much of the northern and western boundaries and multiple spur ridgelines run from here from northwest to southeast across the site with intervening stream alignments.

A formed pond is located within the site, towards the northern boundary, at the head of one of the main stream alignments.

There are multiple head scarps and associated circular failures evident across the extent of the site and outside the site boundaries. These are primarily located below the crests of ridgelines and at the heads of steep gullies. However, small scale scarps and areas of shallow instability can be seen across all the steeper portions of the site, particularly close to stream areas.

Hummocky and slumped ground associated with a large debris flow is evident along the south-western boundary of the site, most likely relating to instability along the fault projection.

Gullies and streams all appear relatively broad, with rock mass present in the stream below the pond. Swampy ground is found along the flanks of the gullies and tributaries, and some low-lying flats.

Hard deposits of weathered bedrock have been identified outcropping in the bases of some stream areas in the northern portions of the site such as below the pond in the northern gully. In addition, two low height waterfalls with bedrock outcropping are present immediately north of the location of the MLR where it crosses the main gully.

[1] Edbrooke, S.W. (complier) 2001, Geology of the Auckland Area, 1:250,000 Geological Map 3, GNS Science

[2] Markham, G.S. and Crippen. T.F. 1981: “Mangawhai-Warkworth” NZMS 290 Sheet R08/09, 1:100 000. New Zealand Inventory, Rock Types. Department of Lands and Survey, Wellington, New Zealand.

5 INVESTIGATIONS AND FINDINGS TO DATE

Eleven, 50mm diameter hand auger boreholes were drilled on the site in mid-August 2018 to further assist in identifying site features and ground conditions. Copies of the borehole records are appended and their locations are depicted on the appended Site Investigation Plan, Figure 03.

Most of the boreholes were concentrated around stream fringe areas and in locations likely to be subject to significant fills with MSE walls to reduce site contours. Deposits of alluvial soils, Pakiri Formation soils and Northland Allochthon soils were all encountered with strengths typically being stiff to hard. Where the locations of potential MSE walls were investigated at the northern end of the site, very stiff to hard deposits were found to be present within 3m of the existing ground surface.

6 GEOTECHNICAL CONSIDERATIONS

6.1 Slope Instability and Land Gradients

Slope instability is considered to be the most significant geotechnical risk for this development, with the principal drivers for instability being steep contour and groundwater pressures. These will need to be addressed by a combination of re-grading and re-working of any existing instability features that remain.

Consideration has been given in the preliminary design work by the consulting team to the works required to form an appropriate development contour with a typical overall contour not exceeding 1v:8h. The preliminary drawings that reflect this work indicate that ridgeline areas will remain largely untouched and that significant height (up to approximately 15m) retaining will be constructed around lower site areas using Mechanically Stabilized Earth (MSE) walls to reduce overall site gradients.

Maintaining existing stream environments as best possible has also been a key focus of the preliminary development planning. Inevitably this will result in the re-engineering of some portions of existing stream environments and also in the presence of localised, steeper batters near the gullies where the extents of the works are minimised to fit as best possible with the existing contour.

It is anticipated therefore that retaining walls will also be required between lot boundaries on extensive portions of the site to account for the site gradients and accommodate the development of typical dwellings.

As depicted on the Geomorphology Plan, almost the entire area of the land parcel that is zoned as Countryside Living and is accessed off Goatley Road is incorporated in large, deep seated instability and accordingly the development proposals do not depict re-development of this area.

6.2 Matakana Link Road Interaction

The Matakana Link Road (MLR) alignment is depicted on the scheme plans and it is understood that construction of this road will precede the development of the subdivision. The current MLR drawings are understood to include the requirement for a shear key to stabilise slope areas below the road.

Economies of geotechnical remediation are best achieved by designing and working these two projects concurrently to minimise the required remedial works. This would avoid expense on any remediation required for short term stabilisation of portions of the subdivision that are not required in the long term by the development. Significant cost savings may be achieved by this integration.

6.3 Liquefaction, Settlement and Earthworks

CPT testing carried out by Jacobs just past the southern boundary of the site around the stream valley has shown some potential for liquefaction in this location, although it has not been fully quantified. We consider that there is a small potential for the alluvial deposits in the stream alignments to undergo liquefaction, however it would be uncommon for liquefaction to occur in the other geologies onsite such as the Pakiri Formation and Mahurangi Limestone. At this stage we do not anticipate a significant risk of liquefaction at this site, although additional assessment will be required along the southern boundary, south of the MLR alignment.

The Pakiri Formation and Mahurangi Limestone deposits across the majority of this site are not typically prone to excessive settlement under load. Conversely, the alluvial soils that may be present in the southern site extremities may be prone to more significant settlement that will require further assessment.

Nevertheless, the presence of very stiff and hard soils adjacent to the gullies is expected to provide appropriate founding conditions for proposed MSE walls at comparatively shallow depths and will limit the amount of potential settlement induced by the associated fill loads. Accordingly, settlement is not considered to be a high risk hazard for the majority of this site, but where significant depths of filling are to be placed, they will need to be properly benched out, drained and filled. Settlement monitoring may also be required.

During our site walkover we noted the presence of sinkholes or tomos in some of the gullies. These features are not uncommon in either limestone terrain or in the often sandy / silty soils of Pakiri Formation, where water is able to create underground channels and streams, typically where water flows are high. Care will need to be taken during earthworks operations to identify and remedy any such tomos encountered within the works areas.

As noted above, the soils of Pakiri Formation are often very silty and sandy and can therefore be very wet in deeper cut formations, making them difficult to handle and requiring extensive drying prior to compaction. While this is at times a relatively costly inconvenience (in both time and economic terms) to be noted for any earthworks operations, it is an issue commonly dealt with by contractors in this terrain.

7 CONCLUSIONS

The development proposals seek to strike a balance between maintaining extensive areas of stream and bush amenity and ridgeline character, while providing for developable site contours. As discussed above, significant retaining works will be required to achieve the required site contours and portions of the land and geotechnical challenges still need to be investigated and remedial designs developed.

Nevertheless, based on the information available to date and our extensive experience in land development in this terrain, we consider that the underlying geological conditions across the site are generally suitable for residential development depicted by the development team.

8 LIMITATIONS

This report has been prepared for use by our client Warkworth Land Company Limited and their consultants based on a desktop study and site walkover for feasibility purposes.

Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

For and on behalf of CMW Geosciences

Prepared by:

Maurice Fraser

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Approved by:

Richard Knowles

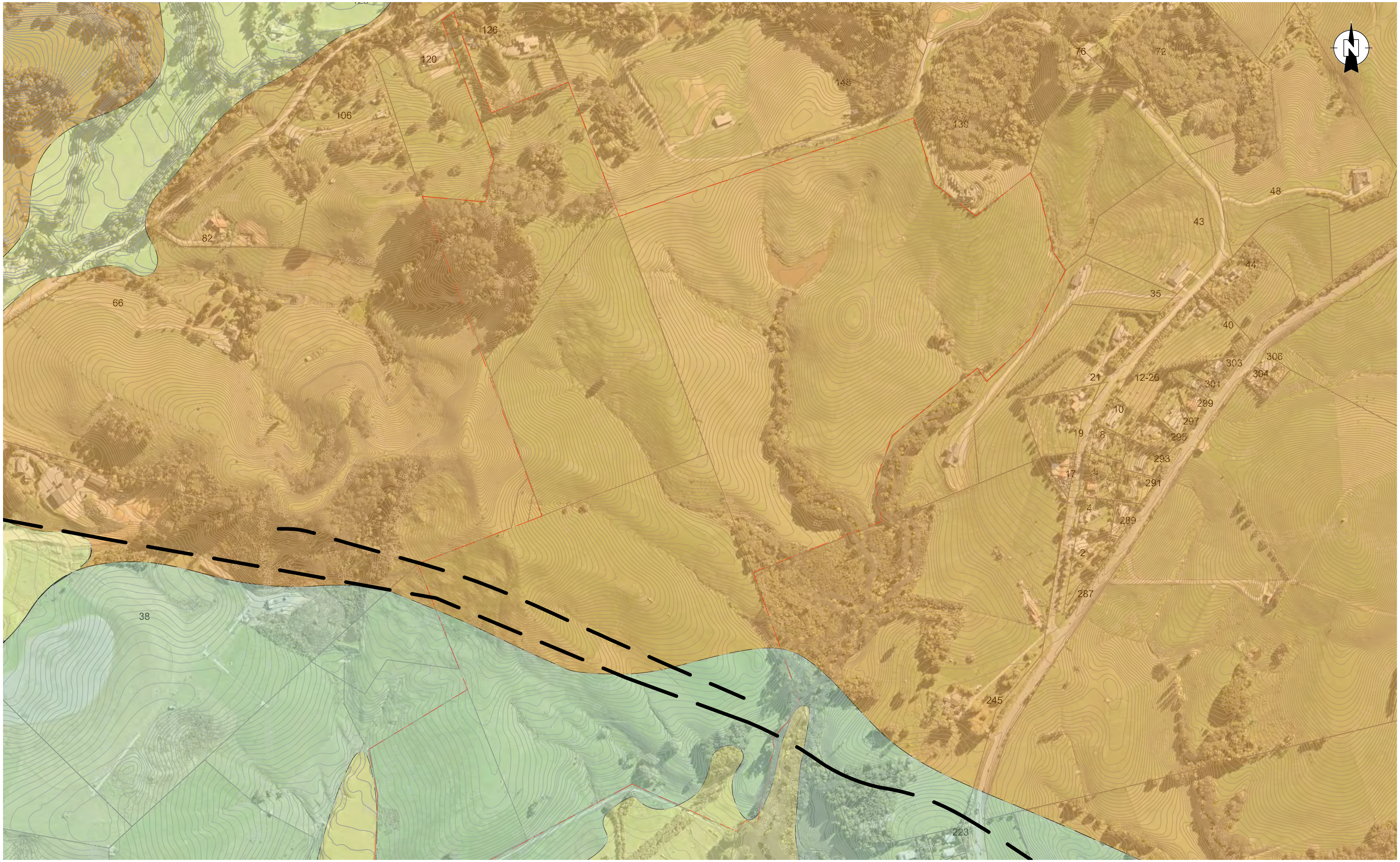
Principal Geotechnical Engineer, CPEng

richardk@cmwgeosciences.com

Distribution:	1 copy to Client (electronic)	Original held by CMW Geosciences
Appendices:	Appendix A	Plans
	Appendix B	Hand Auger Borehole Records

APPENDIX A –

GEOLOGY PLAN
GEOMORPHOLOGY PLAN
SITE INVESTIGATION PLAN



LEGEND:

SITE BOUNDARY

FAULT

GEOLOGICAL BOUNDARIES

ALLUVIUM (TAURANGA GROUP)

MAHURANGI LIMESTONE (MOTATAU COMPLEX) IN NORTHLAND ALLOCHTHON

PAKIRI FORMATION OF WARKWORTH SUBGROUP (WAITEMATA GROUP)

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS

0 50 100 150 200 250 m

1:5000

CMW Geosciences

CLIENT: WARKWORTH LAND DEVELOPMENT COMPANY		DRAWN: TG	PROJECT: AKL2018-0105
PROJECT: STEVENSONS LAND & CLAYDEN ROAD LAND, WARKWORTH		CHECKED: RK	FIGURE: 01
		REVISION: 0	SCALE: 1:5000
TITLE: GEOLOGY PLAN		DATE: 03/09/2018	SHEET: A3

LEGEND:

- SITE BOUNDARY
- HEAD SCARP
- SLOPE DEBRIS MOUND (ARROW FOR DIRECTION OF MOVEMENT)
- STEAM OR GULLY FORMATION
- DEBRIS FLOW
- RIDGE LINE
- POND

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS

0 50 100 150 200 250 m

1:5000

CMW Geosciences

CLIENT:	WARKWORTH LAND DEVELOPMENT COMPANY	DRAWN:	FMS	PROJECT:	AKL2018-0105
PROJECT:	STEVENSONS LAND & CLAYDEN ROAD LAND, WARKWORTH	CHECKED:	RK	FIGURE:	02
		REVISION:	0	SCALE:	1:5000
TITLE:	GEOMORPHOLOGY PLAN	DATE:	03/09/2018	SHEET:	A3

LEGEND:

SITE BOUNDARY

HA01-18 HAND AUGER (HA) LOCATION

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS

0 50 100 150 200 250 m

1:5000

CLIENT: WARKWORTH LAND DEVELOPMENT COMPANY	DRAWN: FMS	PROJECT: AKL2018-0105
PROJECT: STEVENSONS LAND & CLAYDEN ROAD LAND, WARKWORTH	CHECKED: RK	FIGURE: 03
	REVISION: 0	SCALE: 1:5000
TITLE: SITE INVESTIGATION PLAN	DATE: 03/09/2018	SHEET: A3

CMW Geosciences

APPENDIX B –

HAND AUGER BOREHOLE RECORDS

BOREHOLE LOG - HA01-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: JW	Position: E.1748909.0m N.5972639.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
							OL: TOPSOIL						
		0.4	Peak = 84kPa Residual = 52kPa				CH: CLAY with trace fine grained sand: brown/orange. High plasticity. Trace rootlets (Alluvium)	M	St				
		0.8	Peak = 84kPa Residual = 44kPa				CH: CLAY with trace fine grained sand, trace silt : brown/ orange. High plasticity. Trace rootlets. (Alluvium)						
					1		CH: CLAY with some silt and minor fine to medium grained sand: orange, streaked grey. High plasticity. (Alluvium)						
	▼	1.2	Peak = >200kPa				CH: Silty CLAY with minor fine grained sand: grey, streaked orange. High plasticity. (Alluvium)				HA		
		1.6	Peak = >200kPa				CL: CLAY with minor fine grained sand, minor silt and coarse, subangular gravel sized clasts: grey, streaked orange. High plasticity. Clay has trace structure with trace limonite staining. (Alluvium)	S	H				
		2.0	Peak = >200kPa		2		... *at 2.00m, 50mm band of limonite*						
							CL: Sandy CLAY with some silt and minor gravel : dark grey, streaked dark and light orange. Low plasticity. Sand is fine grained with limonite nodules. Gravel is fine, sub angular clasts. (Alluvium)						
		2.4	Peak = UTP				MH: Sandy SILT with trace clay: dark grey, streaked orange. Low plasticity. Sand is fine grained. (Alluvium)						
							Borehole terminated at 2.4 m						
					3								
					4								
					5								

Termination reason: Unable to penetrate due to hard ground.

Remarks: Groundwater encountered at 1.20m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA02-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: RD	Position: E.1748870.0m N.5972659.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	

Dynamic Cone Penetrometer (Blows/100mm): 5 10 15

Structure & Other Observations: Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Sample Depth	Type & Results
0.4	Peak = 119kPa Residual = 56kPa
0.8	Peak = 113kPa Residual = 56kPa
1.2	Peak = 70kPa Residual = 35kPa
1.6	Peak = 91kPa Residual = 48kPa
2.0	Peak = 91kPa Residual = 54kPa
2.4	Peak = 85kPa Residual = 42kPa
2.8	Peak = 110kPa Residual = 25kPa
3.2	Peak = 85kPa Residual = 28kPa
3.6	Peak = 99kPa Residual = 28kPa
4.0	Peak = 87kPa Residual = 42kPa
4.4	Peak = 70kPa Residual = 39kPa
4.8	Peak = 100kPa Residual = 28kPa

Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
OL: TOPSOIL			HA
CH: CLAY: brown. High plasticity. (Pakiri Formation)	M	VSt	HA
CH: CLAY with minor silt: orange/brown. High plasticity. With minor limonite nodules. (Pakiri Formation) ... *at 1.20m, with light grey streaks* ... *at 1.50m, with red streaks*	W	St	HA
CH: CLAY with some silt: light grey/orange, streaked red. High plasticity. (Pakiri Formation) ... *at 2.50m, with trace fine sand. Becoming very stiff*	M to W	St	HA
CH: Silty CLAY with minor fine sand: reddish pink/light grey. High plasticity. (Pakiri Formation)	M to W	VSt	HA
CL: Clayey SILT with some fine sand: reddish pink, mottled light grey. Low plasticity. (Pakiri Formation) ... *at 3.90m, seepage occurring*	W; W to S	St; VSt	HA

Groundwater: ▼ at 4.7m

Borehole terminated at 5.0 m

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 4.7m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA03-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: JW	Position:	E.1748840.0m N.5972599.0m	Elevation:		Hole Diameter: 50mm
Checked by: RD	Survey Source:	Hand Held GPS	Datum:	NZTM	

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
							OL: TOPSOIL						
							CH: CLAY: orange/brown. High plasticity. (Pakiri Formation)						
		0.4	Peak = 192kPa Residual = 78kPa										
							... at 0.50m, becoming mottled red						
		0.8	Peak = 160kPa Residual = 76kPa										
					1		*... at 1.00m, mottled light grey*						
		1.2	Peak = 137kPa Residual = 73kPa						VSt				
								M			HA		
		1.6	Peak = 157kPa Residual = 76kPa										
							CH: CLAY with trace silt and trace fine sand: orange, streaked red/brown. High plasticity. (Pakiri Formation)						
		2.0	Peak = 160kPa Residual = 73kPa		2								
		2.4	Peak = 113kPa Residual = 49kPa										
									St				
		2.8	Peak = 87kPa Residual = 55kPa				*... at 2.80m, with minor silt and minor limonite staining. WIth trace angular, coarse gravel sized limonite nodules*						
					3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Target Depth Reached

Remarks: Groundwater was not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA04-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

1:25 | Sheet 1 of 1

Logged by: JW	Position: E.1748666.0m N.5972426.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Groundwater	Sample Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/Relative Density	Drilling Method/Support
				OL: TOPSOIL			
				CH: CLAY with trace fine grained sand : greyish/brown. High plasticity. Trace rootlets. (Pakiri Formation)	M	VSt	HA
	0.4	Peak = 102kPa Residual = 41kPa		*... at 0.40m, becoming light brown, streaked orange*			
	0.8	Peak = 102kPa Residual = 64kPa		*... at 0.90m, becoming grey, streaked orange*			
			1	CH: CLAY: light grey, streaked orange. High plasticity. (Pakiri Formation)			
	1.2	Peak = 131kPa Residual = 70kPa					
	1.6	Peak = 131kPa Residual = 67kPa					
	2.0	Peak = 131kPa Residual = 84kPa	2				
	2.4	Peak = 142kPa Residual = 78kPa		CH: CLAY with trace silt and trace fine grained sand: light grey mottled orange. High plasticity. (Pakiri Formation)			
	2.8	Peak = 108kPa Residual = 73kPa		*... at 2.90m, trace dark orange limonite streaks*			
			3	CH: CLAY with minor fine grained sand and minor silt: light grey mottled with dark orange limonite and streaked light orange. High plasticity. (Pakiri Formation)			
▼	3.2	Peak = 61kPa Residual = 44kPa		*... at 3.20m, with some silt and becoming wet*	W	St	
	3.6	Peak = 61kPa Residual = 55kPa		CH: Silty CLAY with minor fine to medium grained sand: light grey, streaked orange. High plasticity. (Pakiri Formation)	S		
	4.0	Peak = 122kPa Residual = 58kPa	4	*... at 4.00m, with red streaks*		VSt	
	4.4	Peak = 110kPa Residual = 58kPa		*... at 4.40m, light grey, streaked red-brown-orange*			
	4.8	Peak = 87kPa Residual = 46kPa				St	
			5	Borehole terminated at 5.0 m			

Termination reason: Target Depth Reached.

Remarks: Groundwater encountered at 3.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA05-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: RD	Position: E.1748692.0m N.5972393.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	

Depth (m)	Sample Depth	Type & Results	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
0.0			OL: TOPSOIL			
0.15			CH: CLAY: grey, mottled orange. High plasticity. (Colluvium)	M	St	HA
	0.4	Peak = 70kPa Residual = 35kPa				
0.50			*... at 0.50m, with minor silt*			
0.80	0.8	Peak = 49kPa Residual = 21kPa	*... at 0.80m, disturbed structure*			
1						
1.2	1.2	Peak = 56kPa Residual = 17kPa	CL: Silty CLAY: orange. Low plasticity. (Colluvium)			
1.50			*... at 1.50m, with fine gravel sized limonite nodules and minor fine sand*			
	1.7	Peak = 197+	ML: Gravelly SILT with some fine sand: orange. Low plasticity. Heavily limonite stained with fine, angular gravel sized nodules. (Colluvium)	S	VSt	
2	2.0	Peak = 101kPa Residual = 14kPa	ML: Sandy SILT: grey, streaked orange. Low plasticity. Sand is coarse grained. Occasional limonite nodule. (Alluvium)			
	2.4	Peak = 197+				
	2.8	Peak = UTP				
3	3.2	Peak = UTP				
			SM: Silty SAND: grey. Poorly sorted, medium dense. Sand is medium to coarse grained. (Alluvium)			
	3.6	Peak = UTP	ML: Sandy SILT with minor clay: dark grey. Low plasticity. Sand is medium to coarse grained. (Alluvium)	W to S		
4	4.0	Peak = UTP				
	4.4	Peak = UTP				
	4.8	Peak = UTP				
5			Borehole terminated at 5.0 m			

Groundwater: encountered at 1.7 m (▼).

Column headings: Well; Groundwater; Samples & Insitu Tests (Depth, Type & Results); RL (m); Depth (m); Graphic Log; Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)); Moisture Condition; Consistency/ Relative Density; Recovery; Drilling Method/ Support; Dynamic Cone Penetrometer (Blows/100mm) 5 10 15; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 1.7m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA06-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

1:25 Sheet 1 of 1

Logged by: RD	Position: E.1748568.0m N.5972589.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
		0.0–0.1	OL: TOPSOIL			HA
0.4	Peak = 105kPa Residual = 29kPa	0.1–0.9	CH: CLAY: orange. High plasticity. (Pakiri Formation)	M	VSt	HA
0.8	Peak = 105kPa Residual = 29kPa					
		0.9–1.1	CH: CLAY with some silty: orange, streaked red. High plasticity. (Pakiri Formation)	W	VSt	HA
1.2	Peak = 183kPa Residual = 42kPa	1.1–2.3	ML: SILT with some clay and minor fine sand: orange, streaked red. Low plasticity. (Pakiri Formation)	M to W	VSt	HA
1.6	Peak = 197+					
2.0	Peak = 145kPa Residual = 14kPa					
		2.2	*... at 2.20m, becoming wet*			
2.4	Peak = 96kPa Residual = 24kPa	2.3–2.5	ML: SILT with some clay and minor medium sand: brown/ red/light grey. Low plasticity. (Pakiri Formation)	W	St	HA
		2.5–2.7	CL: Silty CLAY: red/orange. Low plasticity. (Pakiri Formation)	W	St	HA
2.8	Peak = 159kPa Residual = 28kPa	2.7–3.1	ML: Sandy SILT: orange/brown. Low plasticity. Sand is medium grained with trace fine, sub angular completely weathered mudstone gravel clasts. (Pakiri Formation)	M to W	VSt	HA
		3.0	*... at 3.00m, with minor coarse nodules of black manganese nodules*			
3.2	Peak = UTP	3.1–3.3	CL: Silty CLAY with minor coarse sand: orange, streaked red. High plasticity. (Pakiri Formation)	M to W	VSt	HA
3.6	Peak = UTP	3.3–4.1	ML: Sandy SILT: orange/red/black. Low plasticity. Sand is medium grained. (Pakiri Formation)	M	VSt	HA
4.0	Peak = 197+					
4.4	Peak = 197+	4.1–4.4	CL: Silty CLAY with some fine sand: pink/orange/red/light grey. Low plasticity. (Pakiri Formation)	W	VSt	HA
		4.4–4.8	ML: Clayey SILT: orange/red. Low plasticity. With minor limonite nodules throughout. (Pakiri Formation)	M to W	VSt	HA
4.8	Peak = 141kPa Residual = 28kPa	4.8–5.0	ML: Sandy SILT: red/dark orange. Low plasticity. Sand is medium to coarse grained. Limonite stained throughout. (Pakiri Formation)	M to W	VSt	HA
		5.0	Borehole terminated at 5.0 m			

Termination reason: Target Depth Reached

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA07-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

CMW Geosciences

1:25

Logged by: JW	Position: E.1748547.0m N.5972587.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
			OL: TOPSOIL	M	VSt	HA
0.4	Peak = 145kPa Residual = 87kPa		CH: CLAY: orange/brown. High plasticity. Trace rootlets/ organics. (Pakiri Formation)	M	VSt	HA
0.8	Peak = 116kPa Residual = 81kPa		CH: CLAY with trace silt and trace fine grained sand: orange/brown, streaked red. High plasticity. (Pakiri Formation)	M	VSt	HA
		1	CH: CLAY with minor silt and trace fine to medium grained sand: orange/brown, streaked red and mottled black High plasticity. (Pakiri Formation)	M	VSt	HA
1.2	Peak = 160kPa Residual = 44kPa		CH: CLAY with trace silt: light grey, streaked orange. High plasticity. Interbedded with Sandy CLAY with some silt: orange/brown mottled grey. (Pakiri Formation)	M	VSt	HA
1.6	Peak = 145kPa Residual = 41kPa					
2.0	Peak = >200kPa	2	MH: Sandy SILT with minor clay: orange/brown, streaked grey. Low plasticity. Sand is fine grained. (Pakiri Formation) *... at 2.00m, becoming wet with trace nodules of medium gravel sized angular siltstone* *... at 2.10m, limonite staining and minor angular, medium to coarse grained gravel size clasts* *... at 2.20m, trace dark grey, completely weathered mudstone clasts with 20mm bed of limonite stained clayey silt*	M to W / W	VSt / H	HA
2.4	Peak = UTP		CL: Silty CLAY with minor fine to medium grained sand and trace coarse gravel sized mudstone clasts: dark reddish orange. Low plasticity. Mudstone clasts are angular and crumbly. (Pakiri Formation)	M to W	H	HA
2.8	Peak = UTP					
		3				
3.2	Peak = UTP					
3.6	Peak = UTP					
4.0	Peak = UTP	4	MUDSTONE: completely weathered, dark greenish/ grey mudstone. Extremely weak. Low plasticity. (Pakiri Formation)			
			Borehole terminated at 4.0 m			
		5				

Groundwater: ▼ at approx. 3.7 m

Termination reason: Unable to penetrate due to hard ground.

Remarks: Groundwater encountered at 3.70m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA08-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

1:25 Sheet 1 of 1

Logged by: RD | Position: E.1748306.0m N.5971919.0m | Elevation: | Hole Diameter: 50mm
Checked by: RD | Survey Source: Hand Held GPS | Datum: NZTM

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
	▼ (0.2m)						OL: TOPSOIL						
		0.4	Peak = 56kPa Residual = 7kPa				CH: CLAY: light grey, streaked brown. High plasticity. Decaying bark and rootlets throughout. (Alluvium)	W	St		HA		
		0.8	Peak = 70kPa Residual = 15kPa										
		1.2	Peak = 70kPa Residual = 56kPa		1								
		1.6	Peak = 101kPa Residual = 56kPa				CH: CLAY with minor silt, with minor fine sand.: light greyish white. High plasticity. With trace rootlets. (Alluvium)	M to W	VSt				
		2.0	Peak = 124kPa Residual = 49kPa		2								
		2.4	Peak = UTP				ML: Sandy SILT: greyish white. Low plasticity. Sand is medium grained. With completely weathered mudstone clasts. Texture is blocky. (Alluvium)		H				
		2.8	Peak = UTP										
					3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Unable to penetrate due to hard ground.

Remarks: Groundwater encountered at 0.2m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA09-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

1:25

Logged by: JW	Position: E.1748268.0m N.5972005.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Depth (m)	Sample Depth	Type & Results	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
0.0			OL: TOPSOIL	M	VSt	HA
0.1			CH: CLAY with trace fine grained sand: greyish/brown. High plasticity. Trace rootlets.			
0.3			CH: CLAY: brown, streaked orange. High plasticity.			
	0.4	Peak = 113kPa Residual = 73kPa				
0.7			... *at 0.70m, streaked grey*			
	0.8	Peak = 102kPa Residual = 76kPa				
1.0			... *at 1.00m, becoming grey mottled brownish orange*			
	1.2	Peak = 145kPa Residual = 58kPa				
1.3			CH: CLAY with trace silt: grey, streaked orange and light grey. High plasticity. (Mangakahia Complex)			
1.6	1.6	Peak = 169kPa Residual = 64kPa	... *at 1.60m, becoming streaked greenish grey*			
2.0	2.0	Peak = UTP	CL: CLAY with minor medium to coarse gravel sized mudstone clasts. : brownish-grey streaked grey, low plasticity. Mudstone clasts are angular. (Mangakahia Complex)		H	
2.1			... *at 2.10m, becoming dark brownish grey, streaked black/ grey*			
	2.4	Peak = UTP				
2.6			... *at 2.60m, streaked greenish grey*			
	2.8	Peak = UTP				
3.1			... *at 3.10m, streaked reddish brown*			
	3.2	Peak = UTP				
3.6	3.6	Peak = UTP	Borehole terminated at 3.6 m			

Columns not used: Well, Groundwater, RL (m), Recovery, Dynamic Cone Penetrometer (Blows/100mm) 5 10 15, Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks).

Termination reason: Unable to penetrate due to hard ground.

Remarks: Groundwater not encountered.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA10-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

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1:25 | Sheet 1 of 1

Logged by: JW	Position: E.1748465.0m N.5972104.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description (Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit) Rock: Colour; fabric; rock name; additional comments. (origin/geological unit))	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)
							OL: TOPSOIL						
							CH: CLAY with minor silt: orange/brown. High plasticity. With trace rootlets.		St				
		0.4	Peak = 87kPa Residual = 49kPa										
							CH: CLAY with trace fine sand and trace silt: orange/ brown, mottled grey/orange. High plasticity.						
		0.8	Peak = 174kPa Residual = 87kPa				CH: CLAY with trace fine sand: orange/grey. High plasticity.						
					1								
		1.2	Peak = 160kPa Residual = 87kPa										
		1.6	Peak = 174kPa Residual = 93kPa										
		2.0	Peak = 131kPa Residual = 102kPa		2			M					
							CH: CLAY: light grey, mottled orange/red. High plasticity.						
		2.4	Peak = 145kPa Residual = 116kPa								HA		
							... at 2.60m, with minor fine sand						
		2.8	Peak = 142kPa Residual = 100kPa						VSt				
					3		*... at 3.00m, with trace fine sand*						
		3.2	Peak = 131kPa Residual = 87kPa										
							CH: CLAY with minor fine sand and trace silt: grey, streaked orange/red. High plasticity.						
		3.6	Peak = 116kPa Residual = 76kPa										
	▼	4.0	Peak = 105kPa Residual = 64kPa		4		*... at 4.00m, becoming saturated*						
							... at 4.30m, with trace fine sand						
		4.4	Peak = 102kPa Residual = 76kPa					S					
		4.8	Peak = 72kPa Residual = 58kPa										
					5		Borehole terminated at 5.0 m						

Termination reason: Target Depth Reached

Remarks: Groundwater encountered at 4.0m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA11-18

Client: LJ Partnership NZ Ltd
Project: Clayden Road
Site Location: Warkworth
Project No.: AKL2018-0105
Date: 23/08/2018
Borehole Location: Refer to site plan

1:25 Sheet 1 of 1

Logged by: JW/RD	Position: E.1748542.0m N.5972071.0m	Elevation:	Hole Diameter: 50mm
Checked by: RD	Survey Source: Hand Held GPS	Datum: NZTM	Angle from horizontal: 90°

Sample Depth	Type & Results	Depth (m)	Material Description	Moisture Condition	Consistency/ Relative Density	Drilling Method/ Support
			OL: TOPSOIL			HA
0.4	Peak = 134kPa Residual = 61kPa		CH: CLAY with some silt and minor fine grained sand : light brown, streaked orange. High plasticity. (Mangakahia Complex)	M to W	VSt	
0.8	Peak = 148kPa Residual = 76kPa	1	CH: CLAY with minor silt and minor fine grained sand : light grey, streaked orange and light brown. High plasticity. Trace limonite (Mangakahia Complex) *... at 1.10m, with trace silt and trace fine grained sand*	M	VSt	
1.2	Peak = 96kPa Residual = 41kPa		CL: CLAY with some silt and minor fine grained sand: light brown, streaked orange. Low plasticity. Trace limonite. (Mangakahia Complex) *... at 1.30m, becoming light grey, streaked orange*	M	St	
1.6	Peak = 125kPa Residual = 20kPa		MH: Clayey SILT: light grey, streaked orange. Low plasticity. (Mangakahia Complex)	M	VSt	
2.0	Peak = >200kPa	2		M	H	
2.4	Peak = >200kPa		MH: Clayey SILT with some fine to medium grained sand: light brownish grey, streaked orange. Low plasticity. Limestone clasts are angular shaped. Becoming blocky. (Mangakahia Complex)	M	H	
2.8	Peak = 195kPa Residual = 67kPa			M	VSt	
3.2	Peak = 174kPa Residual = 55kPa	3		M	VSt	
3.6	Peak = 145kPa Residual = 41kPa		CL: CLAY with some silt: light brownish grey, streaked orange. Low plasticity. (Mangakahia Complex)	M to W	VSt	
			CL: CLAY with some fine to medium grained sand and minor silt: light brownish grey to grey. Low plasticity. (Mangakahia Complex)	W	VSt	
4.0	Peak = 134kPa Residual = 32kPa	4	CL: Sandy CLAY : orange. Low plasticity. Limonite stained throughout. Blocky texture. (Mangakahia Complex)	W to S	VSt	
4.4	Peak = 160kPa Residual = 73kPa		CL: CLAY with some silt and fine to medium grained sand: light brownish grey, streaked orange. Low plasticity. Blocky texture. (Mangakahia Complex)	W to S	VSt	
4.8	Peak = 189kPa Residual = 87kPa			W to S	VSt	
		5	CL: Silty CLAY: dark grey. Low plasticity. (Mangakahia Complex)	M	VSt	

Borehole terminated at 5.0 m

Groundwater: ▼ at 4.20m

Other columns: Well; Groundwater; RL (m); Graphic Log; Recovery; Dynamic Cone Penetrometer (Blows/100mm) 5 10 15; Structure & Other Observations (Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks)

Termination reason: Target Depth Reached.

Remarks: Groundwater encountered at 4.20m.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

ATTACHMENT J

GEOTECHNICAL ASSESSMENT BY GEOSCIENCES – 245 MATAKANA ROAD

14 October 2019 Document Ref: AKL2018-0228AE Rev 1

Warkworth Land Company Limited
c/o Development Advisory Services Limited
PO Box 5908
Wellesley Street
Auckland 1141

Attention: Cormac Tague

Dear Sir

RE: PLAN CHANGE SUBMISSION – GEOTECHNICAL ASSESSMENT
245 MATAKANA ROAD, WARKWORTH

1 INTRODUCTION

CMW Geosciences (CMW) have been engaged by Warkworth Land Company Limited to undertake a preliminary geotechnical assessment for the proposed plan change of 245 Matakana Road, Warkworth, legally described as Lot 1 DP 101758.

This letter presents the results of our geotechnical assessment of the proposed scheme plan.

2 RELATED REPORTS

The following documents have been referred to during the development of this assessment:

- CMW, Geotechnical Letter for Structure Plan Submission for Stevensons Land and Clayden Road Land in Warkworth (ref. AKL2018-0105AD Rev0) dated 3 September 2018;
- CMW, Plan Change Submission – Geotechnical Assessment, Clayden Road, Warkworth (re. AKL2018-0228AC Rev2) dated 17 July 2019;
- Jacobs, SH1 to Matakana Link Road Ground Investigation, Geotechnical Factual Report (red. IZ093400-SG-R-01, Rev1) dated 3 November 2017;
- Jacobs, SH1 to Matakana Link Road, Geotechnical Interpretative Report (ref. IZ093400-SG-R-02, Rev1) dated 3 November 2017;
- Aecom – factual data including drill holes, test pits and hand auger borehole records;
- Aecom, Matakana Link Road Detailed Design, 90% Geotechnical Design Report (ref. 60591585-RPT-GT-005-0) dated 21 June 2019.

3 GEOLOGY

Published Geological Maps[1,2] indicate the site is predominantly underlain by Pakiri Formation of the Waitemata Group. This geological unit is widespread, of early Miocene age and occurs from the north of Hatfields Beach, west to the Kaipara Harbour and north to Mangawhai. Pakiri Formation is dominated by 10-30m thick, graded medium to coarse grained sandstones alternating with thinner, laminated, siltstones and finer sandstones. This material is generally regarded as competent for subdivision purposes.

Portions on the north-eastern end of the site are also shown to be underlain with Mahurangi Limestones of the Northland Allochthon. The Mahurangi Limestone is represented by blue-grey to white, muddy limestone and weathered clayey residual soils. However, geological investigations undertaken by various consultancies as part of the Matakana Link Road project have not encountered any Northland Allochthon deposits within the site which indicates the deposits may not be as widespread as the geology map shows. This will require further geotechnical investigations to confirm.

The geology plan for the site is appended as ***Drawing 01***.

4 GEOMORPHOLOGY

Based on published geological maps[1,2], a potential inactive thrust fault may extend into the site boundaries. Immediately south of the site, an inactive reverse fault is also inferred to be present.

An incised gully is present within the western portion of the site extending to the north.

Steep slopes are present grading into the gully, with the remaining eastern portion of the site situated across gently to moderately sloping topography.

No soil creep or evidence of instability is present across the site based on a review of historical aerials and reports undertaken for the MLR project. There is the possibility that some soil creep may be present adjacent to the gully.

5 DEVELOPMENT PROPOSAL

Based on the documents received from Aecom, the Matakana Link Road (MLR) is to be located through the central section of the site.

The existing stream environment present within the incised gully in the western portion of the site is to remain and is to be bridged across as part of the MLR project. A wetland is proposed to be constructed as part of the MLR works within the eastern portion of the site adjacent to Matakana Road.

As part of the Plan Change submission prepared by Warkworth Land Company Ltd, the subject site is classified as a “Future Urban Zone”.

Draft development plans provided by Maven Associates and Development Advisory Services Ltd (DASL) associated with the adjacent Warkworth North 2 project are appended.

6 GEOTECHNICAL INVESTIGATIONS

Both Jacobs and Aecom have undertaken a series of investigations across the site in order to define the ground model as part of the MLR project. These include:

---

[1] Edbrooke, S.W. (complier) 2001, Geology of the Auckland Area, 1:250,000 Geological Map 3, GNS Science

[2] Markham, G.S. and Crippen. T.F. 1981: “Mangawhai-Warkworth” NZMS 290 Sheet R08/09, 1:100 000. New Zealand Inventory, Rock Types. Department of Lands and Survey, Wellington, New Zealand.

- Eight machine boreholes to depths of up to 20.5m;
- Three hand auger boreholes to depths of up to 3m;
- Two test pits to depths of up to 5m; and
- 11 Cone Penetration Tests (CPTs) to depths of up to 23m.

Copies of the investigation records are appended and presented on the Aecom Site Investigation Plan (Drawing 30591585_01_013_003).

7 GEOTECHNICAL ASSESSMENT

7.1 Slope Stability

Although no development plans have been provided to date, based on the geology present beneath the site, slope stability is likely to be a moderate geotechnical risk for any proposed development. The principal drivers for instability include the potential Northland Allochthon geology in the northeast corner, and steeper contour and groundwater pressures within the Pakiri Formation residual soils. These will need to be addressed by a combination of re-grading and re-working of any existing instability features as part of development earthworks including the possible provision of shear keys, piles, deep groundwater drainage and other standard geotechnical solutions.

Any potential development will also need to consider the MLR alignment which will run through the site and to ensure slope stability assessment accounts for the earthworks design and traffic loading as a result of the MLR project.

Depending on final site gradients and earthworks regrading, retaining walls may be required between lot boundaries on portions of the site to account for any site gradients and accommodate the development of typical dwellings.

7.2 Matakana Link Road

The MLR alignment is depicted on the scheme plans and it is understood that construction of that road will precede the development of this site into a Future Urban Zone.

Economies of geotechnical remediation are best achieved by designing and developing these two projects concurrently to minimise the required remedial works. Significant cost savings may be achieved by this integration.

7.3 Liquefaction and Settlement

CPT analysis undertaken by Jacobs and Aecom as part of the MLR project indicates there is no significant liquefaction risk across the site. Only the alluvial deposits present within the gullies would be considered susceptible to liquefaction based on the geological age of the deposits. Further analysis is required to quantify this risk, however based on our geological review it is considered unlikely that there is any significant risk of liquefaction on this project.

Residual soils of the Pakiri Formation and Mahurangi Limestone deposits across the majority of this site are not typically prone to excessive settlement under load. Conversely, the alluvial soils that may be present in the western site extremities may be prone to more significant settlement that will require further assessment once development plans are known.

The presence of very stiff and hard soils adjacent to the gullies is expected to provide appropriate founding conditions for any foundations at comparatively shallow depths and will limit the amount of potential settlement induced by the associated fill loads. Accordingly, settlement is not considered to be a high risk hazard for the majority of this site, but where significant depths of filling are to be placed, they will need to be properly benched out, drained and filled. Settlement monitoring will also be required during construction to monitor any settlement that may occur.

During a site walkover of the adjacent property, we noted the presence of sinkholes or tomos in some of the gullies. These features are not uncommon in residual soils and slope colluvium derived from either limestone terrain or in the often sandy / silty soils of Pakiri Formation, where water is able to create underground channels and streams, typically where water flows are high. Care will need to be taken during earthworks operations to identify and remedy any such tomos encountered within the works areas.

7.4 Summary

Consideration should be given to the points above when undertaking further scheme design.

However, based on a review of the data available it is considered that a proposed residential subdivision is geotechnically feasible assuming the full range of remedial earthworks solutions such as development earthwork contouring, shear keys, buttress fills, ground water drainage and similar are available for use on the site.

8 LIMITATIONS

This report has been prepared for use by our client Warkworth Land Company Limited and their consultants for feasibility purposes.

Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

For and on behalf of CMW Geosciences

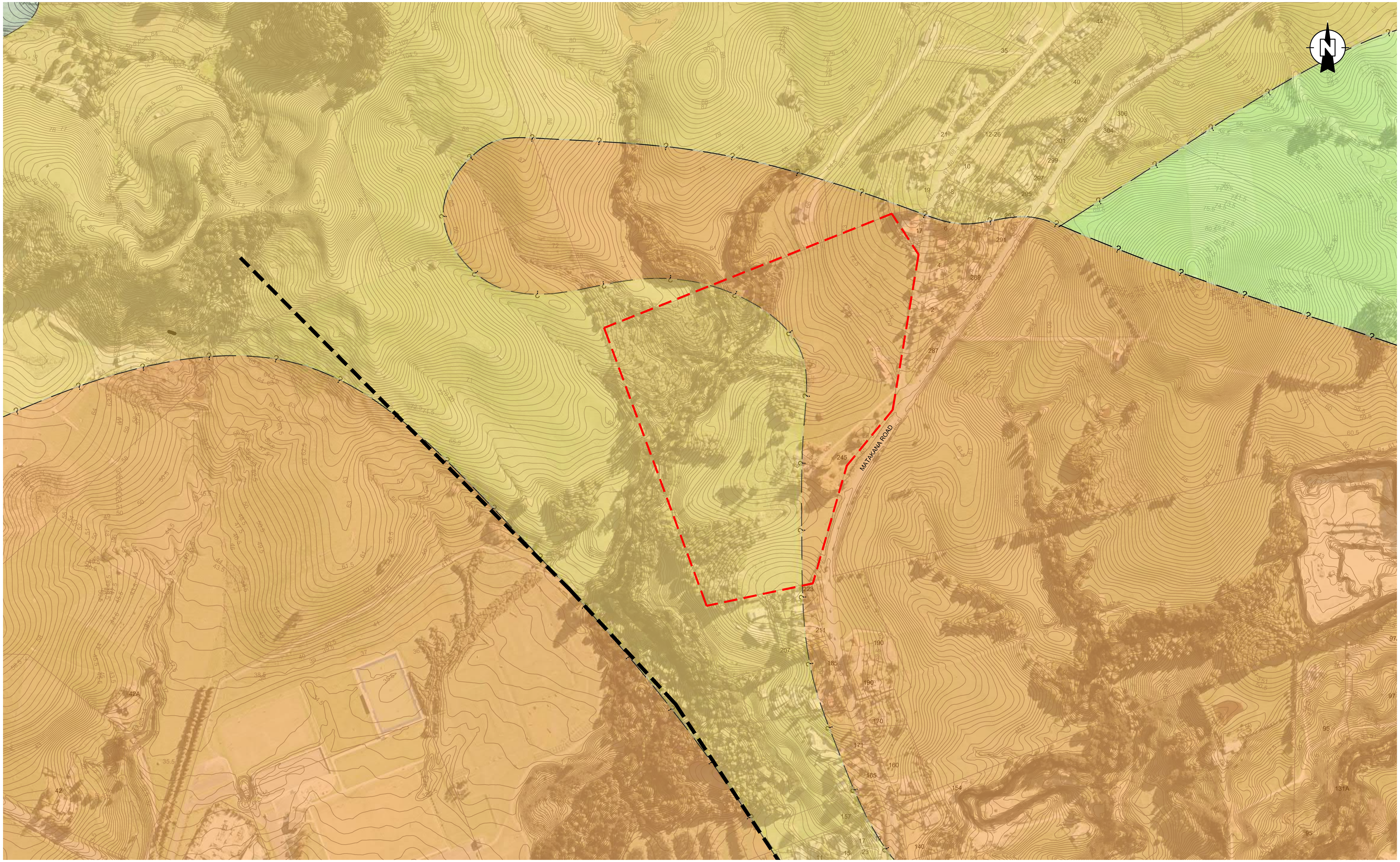
Prepared by:	Reviewed and authorised by:
Olivia Gill	Andrew Linton
Project Geotechnical Engineer	Principal Geotechnical Engineer

Distribution: 1 electronic copy to Warkworth Land Company Ltd via email
Original held at CMW Geosciences

Attachments: Drawings
Investigation Records

Appendix A:

Drawings



LEGEND:

- APPROX. EXTENT
- FAULT
- ? GEOLOGICAL BOUNDARIES
- PAKIRI FORMATION (WAITEMATA GROUP)
- MAHURANGI LIMESTONE (NORTHLAND ALLOCHTHON)
- UNDIFFERENTIATED MANGAKAHIA COMPLEX (NORTHLAND ALLOCHTHON)

NOTES:

1. BASE PLAN ADAPTED FROM: AUCKLAND COUNCIL GIS
2. ALL GEOLOGY HATCHES ARE BASED ON GNS SCIENCE STANDARD.
3. CONTOUR LEVELS ARE IN 0.5m INTERVAL.

0 50 100 150 200 250 m

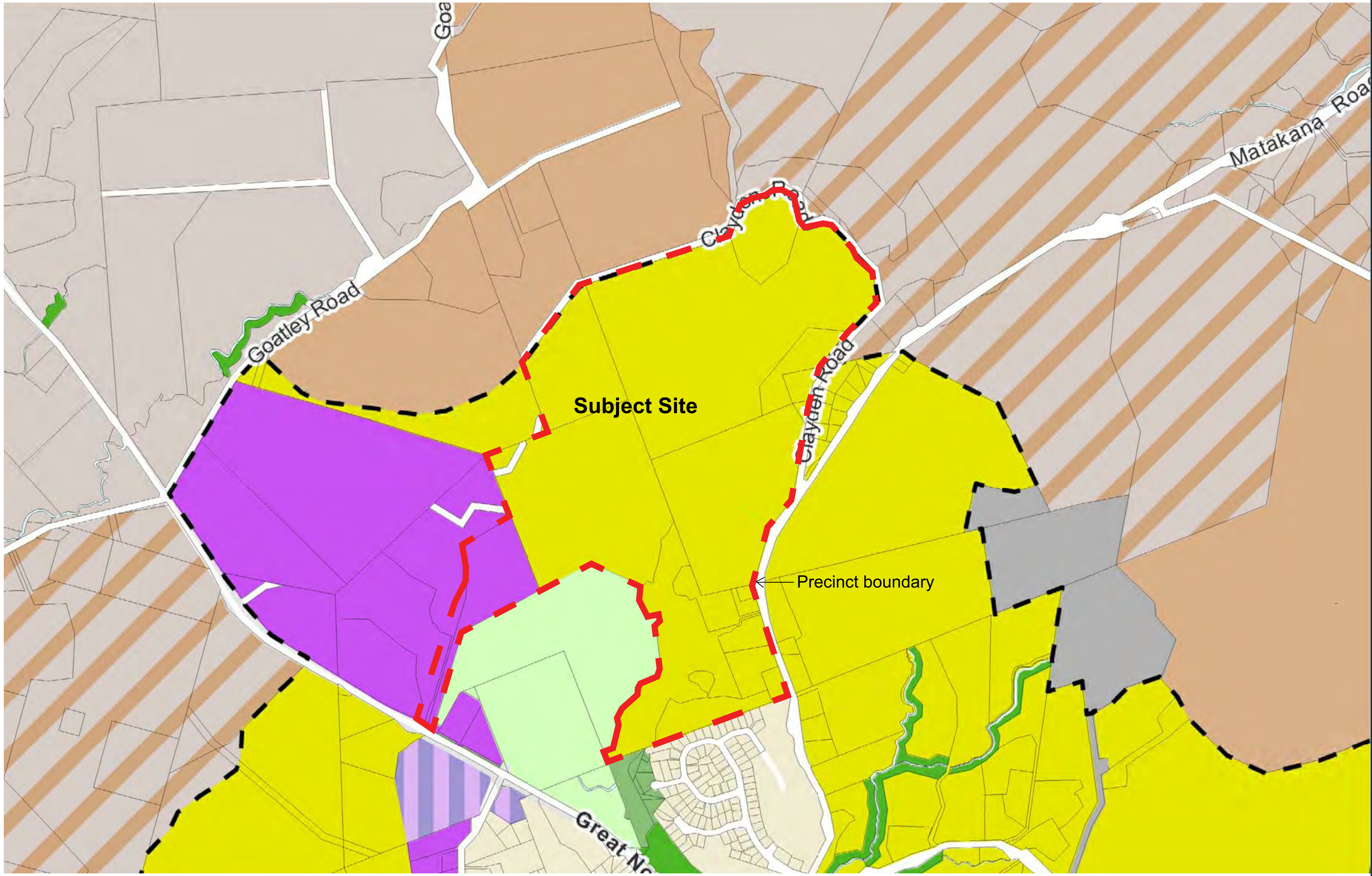
1:5000

CMW Geosciences

CLIENT:	WARKWORTH LAND DEVELOPMENT COMPANY	DRAWN:	FMS	PROJECT:	AKL2018-0228
PROJECT:	STEVENSONS LAND & CLAYDEN ROAD LAND, WARKWORTH	CHECKED:	OMG	DRAWING:	01
		REVISION:	0	SCALE:	1:5000
TITLE:	GEOLOGY PLAN	DATE:	25/07/2019	SHEET:	A3

Zoning Plan

Current Context



Zoning Key

- Country Side Living
- Business - Light Industry Zone
- Future Urban Zone
- Rural - Rural Production Zone
- Rural - Mixed Rural Zone
- Business - General Business Zone
- Special Purpose Zone
- Open Space - Sport and Active Recreation Zone
- Open Space - Informal Recreation Zone
- Open Space - Conservation Zone

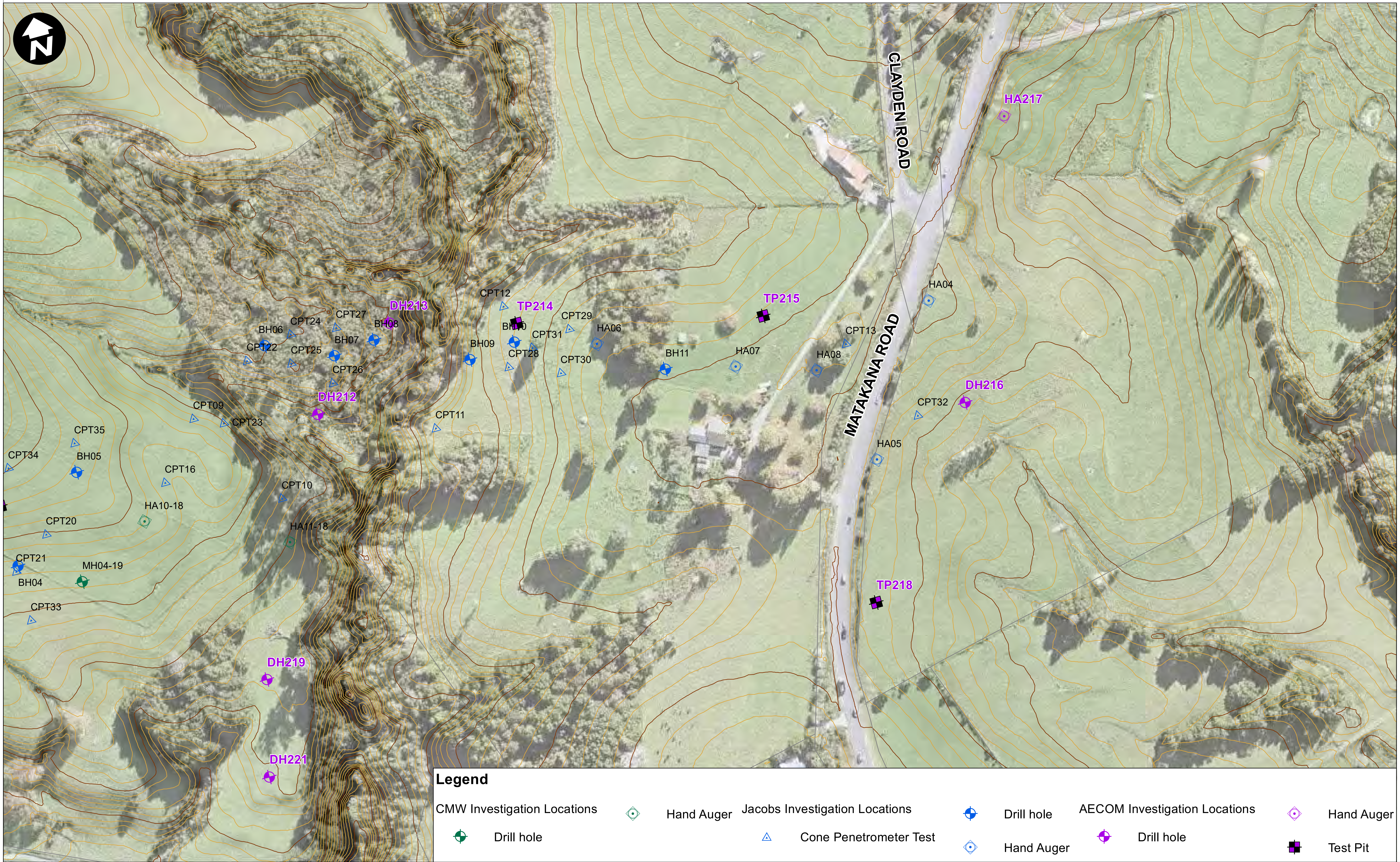
Note:
Layout shown is sketch design only, and is subject to further consultant design work, town planning consents, building consents, other council and regulatory body approvals. Layout and lot yield is subject to change as concept design is progressed and further co-ordinated with civil engineering design is undertaken.

A Studio Architects takes no responsibility for information provided by others. We note that there are minor discrepancies between stream positions provided by consultants and have locations.

Appendix B:

Investigation Records

ISO A3 297mm x 420mm



AECOM

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PROJECT

MATAKANA LINK ROAD (TE HONOHONO KI TAI) DETAILED DESIGN

CLIENT

Auckland Transport
An Auckland Council Organisation

KEY PLAN

889

SPATIAL REFERENCE

Scale: 1:2,000 (A3 size)

20 10 0 20 40 Meters

Map features depicted in terms of NZTM 2000 projection.

Data Sources:
Cadastral Boundaries – LINZ NZ Cadastral Dataset 2016

PROJECT MANAGEMENT

Approved		Date	
Checked	R. Garton	Date	10/04/2019
Designed	M. Bryant	Date	10/04/2019
Drawn	M. Bryant	Date	10/04/2019

ISSUE/REVISION

Rev	Date	Description
A	99.99.99	Xxxxx Xxxxx Xxxxx

PROJECT NUMBER

60591585

SHEET TITLE

Existing Geotechnical Investigation

MAP NUMBER

60591585_01_013_003

Last saved by: BRYANTM (2019-04-10) Last Plotted: 2016-04-15
Filename: P:\605X\60591585\900_CAD_GIS\920_GIS\02_Maps\60591585_01_013_Geotechnical_Investigation_Plan_20190410.mxd

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH212**

Client Auckland Transport
Project Matakana Link Road
Project number 60591585

Co-ordinates 1748576.2mE 5972137.33mN
Orientation -90° Elevation 54.38m
Location Warkworth, Auckland
Feature Proposed bridge embankment

Unit	GEOLOGICAL DESCRIPTION (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc))	Test Records	Drilling Method	TCR [SCR] RQD (%)	SOIL PROPERTIES / DEFECT DESCRIPTION
ALLUVIAL DEPOSITS	0m: ALLUVIUM comprising silt, clayey silt and sandy clay with trace organics throughout.		HA	100	0m: SILT with some sand and minor clay; light brown mottled orange. Firm, dry, low plasticity. Sand is fine. 0.33m: SILT with some clay and trace sand; greyish brown mottled orange. Stiff, moist, medium plasticity. Sand is fine. 1m: Minor fine to coarse, gravel. Gravel is subrounded, very weak, sandstone. 1.2m: Clayey SILT with minor gravel, trace sand and organics; greyish brown mottled orange. Stiff, moist, high plasticity. Sand is fine. Gravel is fine to coarse, subrounded, very weak, sandstone.
		ss 1,1,1, 1,1,0 N=3	SPT	100	
			HQ3	100	1.95m: Sandy CLAY with minor silt, trace gravel and organics; light greyish brown mottled orange. Soft, moist, high plasticity. Sand is fine. Gravel is fine to medium, subrounded, very weak, sandstone.
		15/12	PT	100	3.5 to 3.7m: Very soft.
			HQ3	100	
PAKIRI FORMATION	4.1m: Completely weathered, brown grey, SANDSTONE, extremely weak.				4.1m: Sandy SILT with minor clay; brown grey. Soft, moist, low plasticity. Sand is fine.
		ss 0,1,0, 1,1,1 N=3	HQ3	100	
			HQ3	76	5.75 to 6m: Core loss - infer extremely weak core washed away by drilling.

For explanation of symbols and observations, see key sheet

Date Time (m)

RELATIVE STRENGTH	WEATHERING
VS - Very strong	UW - Unweathered
S - Strong	SW - Slightly weathered
MS - Moderately strong	MW - Moderately weathered
W - Weak	HW - Highly weathered
VW - Very weak	CW - Completely weathered
EW - Extremely weak	RW - Residually weathered

Date logged 20/02/2019
Logged JL
Checked SBS

Driller McMillan
Started 19/02/2019
Finished 20/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 5

Remarks
50mm standpipe piezometer installed upon completion of drilling.
Piezometer developed by air lift.
SPT safety auto trip hammer #N111 used (energy ratio 97%).

NZGD2000 / Mount Eden 2000

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 01/04/19

1/04/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH212**

Client	Auckland Transport	Co-ordinates	1748576.2mE 5972137.33mN
Project	Matakana Link Road	Orientation	-90° Elevation 54.38m
Project number	60591585	Location	Warkworth, Auckland
		Feature	Proposed bridge embankment

GEOLOGICAL DESCRIPTION (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc)) | Test Records | N Values 0 - 50 | Drilling Method (Casing remarks) | Core Loss/Lift (0 - 100%) | Relative Strength (S MS W VW) | Rock Weathering (SW MW HW) | Depth | Graphic Log | TCR [SCR] RQD (%) | Spacing of Natural Defects (mm) (500 100 50 10) | SOIL PROPERTIES (Subordinate MAJOR minor; colour; structure. Strength; moisture condition; grading; bedding; plasticity; sensitivity; major fraction description; subordinate fraction description; minor fraction description etc) / DEFECT DESCRIPTION (Joints, Bedding Seams, Shatter, Shear and Crush Zones, Foliation, Schistosity, Attitude, Spacing, continuity, roughness, infilling, etc.) | Instrumentation

Formation: PAKIRI FORMATION

Geological description:
- 8.51m: Highly weathered, brown grey, fine SANDSTONE, extremely weak.
- 8.7m: Moderately weathered, dark brown grey, fine SANDSTONE, weak.
- 9.11m: Slightly weathered, dark brown grey, interbedded fine SANDSTONE and SILTSTONE, weak.

Test records:
- 79/17
- 125/34; ss 1,2,5, 4,4,5 N=18
- ss 19,31 for 40mm N>50
- sc 20,30 for 35mm N>50

Drilling method / TCR [SCR] RQD:

Drilling Method	TCR [SCR] RQD (%)
PT	100
HQ3	100
SPT	100
HQ3	100
SPT	100
HQ3	100 [35] 0
SPT	100
HQ3	86 [4] 0

Depth: 7, 8, 9, 10, 11

Soil properties / Defect description:

6.25m: Clayey SILT with minor sand; brown grey. Soft, moist, high plasticity. Sand is fine.

6.5m: Dark green staining along relict defects.

6.97m: Silty fine SAND with trace clay, Loose, moist.

7.2m: Sandy SILT with trace clay; brown grey. Stiff, moist, low plasticity. Sand is fine.

7.5 to 7.65m: Very stiff.

7.95m: SILT with some sand and clay; brown grey. Firm, moist, low plasticity. Sand is fine.

8.31m: Soft.

8.51m: Sandy SILT with some clay; brown grey. Hard. moist, low plasticity. Sand is fine.

8.7 to 9.3m: SZ, 5° & angular, fine to coarse gravel. Possibly extremely closely spaced joints disturbed by drilling and handling.

9.11 to 9.4m: J, 85°, Ud, Ro & drilling disturbed

9.25 to 9.7m: SZ & angular, medium to coarse gravel. Possibly very closely spaced joints disturbed by drilling and handling.
9.26 to 9.38m: J, 55°, Ud, Ro, VN, Vn, Fe & x2
9.5 to 9.72m: J, 85°, Pl, Sm, VN, Vn & dark orange Slt Fe
9.7 to 10.7m: SZ & angular, fine to coarse gravel. Possibly extremely closely spaced joints disturbed by drilling and handling.
9.93 to 10.02m: J, 60°, Ud, Ro, VN, Vn & dark orange Slt Fe
10.1m: J, 75°, Ud, Ro, VN, Vn & dark orange Slt Fe, 2x perpendicular, drilling disturbed

10.7 to 11.84m: J, 55°, Ud, Ro, VN, Vn, Slt

10.84 to 12.23m: SZ & angular, fine to coarse gravel. Possibly extremely closely spaced joints disturbed by drilling and handling.

11.8 to 12m: Core Loss.

For explanation of symbols and observations, see key sheet

Date Time (m)

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

RELATIVE STRENGTH	WEATHERING
VS - Very strong	UW - Unweathered
S - Strong	SW - Slightly weathered
MS - Moderately strong	MW - Moderately weathered
W - Weak	HW - Highly weathered
VW - Very weak	CW - Completely weathered
EW - Extremely weak	RW - Residually weathered

Date logged 20/02/2019
Logged JL
Checked SBS

Driller McMillan
Started 19/02/2019
Finished 20/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 5

Remarks
50mm standpipe piezometer installed upon completion of drilling.
Piezometer developed by air lift.
SPT safety auto trip hammer #N111 used (energy ratio 97%).

NZGD2000 / Mount Eden 2000

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 01/04/19

1/04/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH212**

Client Auckland Transport
Project Matakana Link Road
Project number 60591585

Co-ordinates 1748576.2mE 5972137.33mN
Orientation -90° Elevation 54.38m
Location Warkworth, Auckland
Feature Proposed bridge embankment

GEOLOGICAL DESCRIPTION (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc))	Test Records / N Values 0 - 50	Drilling Method (Casing remarks)	Depth	TCR [SCR] RQD (%)	SOIL PROPERTIES / DEFECT DESCRIPTION
PAKIRI FORMATION: 9.11m: Slightly weathered, dark brown grey, interbedded fine SANDSTONE and SILTSTONE, weak.	sc 17,22,31, 19 for 5mm N>50	SPT		100	12.23 to 12.4m: Crush zone (Inferred as disturbance by drilling). Core recovered as SILT with some sand and gravel; brown. Soft, moist, low plasticity. Sand is fine to coarse. Gravel is fine to medium, angular to subangular sandstone. 12.4 to 13m: SZ & angular, coarse gravel. Possibly very closely spaced joints disturbed by drilling and handling. 12.72 to 12.82m: J, 70°, Ud, Slk & drilling disturbed 12.87m: J, 60°, Ud, Ro, VN, Vn & dark orange Slt Fe
		HQ3	13	100 [46] 27	13m: Trace subangular to rounded, coarse sand to fine gravel sized carbonaceous fragments. 13.1m: Corebound. 13.3m: J, 45°, Ud, Ro, VN, Vn & yellow clay
PAKIRI FORMATION: 13m: Slightly weathered, dark brown grey, medium SANDSTONE, moderately strong.	sc 11,17,18, 28,4 for 4mm N>50	SPT		100	13.5 to 14.65m: SZ & angular, fine to coarse gravel. Possibly extremely closely spaced joints disturbed by drilling and handling.
		HQ3	14	100 [53] 22	14.36 to 14.6m: J, 85°, Ud, Ro, VN, Vn & yellow clay, drilling disturbed 14.41m: HJ, 55° & drilling disturbed 14.53m: HJ, 50° 14.6 to 14.67m: J, 70°, Ud, Ro, VN, Vn & yellow clay, drilling disturbed 14.9m: HJ, 45° & drilling disturbed 14.7m: Minor irregular to subangular, coarse sand to fine gravel sized carbonaceous fragments. 14.8m: Coarse gravel sized, irregular, carbonaceous clast.
	sc 21,29 for 55mm N>50	SPT	15	100	14.94m: J, 60°, Ud, Ro, VN, Vn & br Slt
			16		DH212 terminated at 15.13m Depth Criteria Achieved
			17		

For explanation of symbols and observations, see key sheet

Date Time (m)

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

RELATIVE STRENGTH	WEATHERING
VS - Very strong	UW - Unweathered
S - Strong	SW - Slightly weathered
MS - Moderately strong	MW - Moderately weathered
W - Weak	HW - Highly weathered
VW - Very weak	CW - Completely weathered
EW - Extremely weak	RW - Residually weathered

Date logged 20/02/2019
Logged JL
Checked SBS

Remarks
50mm standpipe piezometer installed upon completion of drilling.
Piezometer developed by air lift.
SPT safety auto trip hammer #N111 used (energy ratio 97%).

NZGD2000 / Mount Eden 2000

Driller McMillan
Started 19/02/2019
Finished 20/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 5

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 01/04/19

1/04/2019

Box: 1 of 5 - Depth: 0.00m to 3.50m of 15.13m

Date Drilled 19/02/2019 to 20/02/2019

Box: 2 of 5 - Depth: 3.50m to 7.31m of 15.13m

Date Drilled 19/02/2019 to 20/02/2019

Box: 3 of 5 - Depth: 7.31m to 10.33m of 15.13m

Date Drilled 19/02/2019 to 20/02/2019

Box: 4 of 5 - Depth: 10.33m to 13.10m of 15.13m

Date Drilled 19/02/2019 to 20/02/2019

AECOM

PHOTOGRAPHIC LOG OF DRILLHOLE

Project Matakana Link Road

Location Warkworth, Auckland

HOLE IDENTIFICATION **DH212**

Box: 5 of 5 - Depth: 13.10m to 15.13m of 15.13m

Date Drilled 19/02/2019 to 20/02/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH213**

Client Auckland Transport
Project Matakana Link Road
Project number 60591585

Co-ordinates 1748629.06mE 5972176.91mN
Orientation -90° Elevation 54.24m
Location Warkworth, Auckland
Feature Bridge foundations

Unit	Geological Description	Test Records	Drilling Method	TCR [SCR] RQD (%)	Depth	Soil Properties / Defect Description
ALLUVIAL DEPOSITS	0m: TOPSOIL.		HA	100	0	0m: SILT with trace clay, sand and organics; dark brown. Firm, dry, low plasticity. Sand is fine.
	0.1m: ALLUVIUM comprising silt, clay, sand, and organics.					0.1m: SILT with some sand and trace clay; orange brown. Firm, dry to moist, low plasticity. Sand is fine. 0.8 to 1.3m: Some clay and trace fine sand; grey mottled orange.
		ss 1,0,1, 1,1,2 N=5	SPT	100	1.5	1.3m: Silty CLAY with trace sand and organics; grey brown. Firm, moist, high plasticity. Sand is fine.
			HQ3	100		2.02m: Steeply inclined, very thin organic silt bed. 2.03 to 2.22m: Minor organics, brown mottled orange. 2.22 to 3.5m: Trace organics, grey brown.
		43/19 ss 0,0,0, 0,1,1 N=2	SPT	100	3.0	3m: Soft.
			HQ3	100		3.5m: SILT with minor clay, trace sand and organics; green grey. Soft, moist, low plasticity. Sand is fine. 3.85 to 4.5m: Core Loss.
		170/34 ss 1,2,1, 2,3,2 N=8	SPT	100	4.5	4.5 to 5.14m: Some clay, trace organics, grey green. Very stiff.
			HQ3	86		5.5 to 5.73m: Trace weathered, white, coarse pumiceous sand. 5.8 to 7.1m: Core Loss. No SPT sample recovered at 6.0m depth. SPT spoon broke off downhole.
NORTHLAND ALLOCHTHON	6m: Moderately degraded, green grey, totally crushed, SILTSTONE, extremely weak. Slickensided and polished surfaces are visible when the core is broken (NORTHLAND ALLOCHTHON GRADE IV).	ss 4,5,6, 7,6,6 N=25	SPT	100	6.0	6m: Clayey SILT with trace sand and gravel; green grey. Very stiff, moist, low plasticity. Sand fine to coarse. Gravel is fine, subangular, very weak, siltstone.
			HQ3	38		
		UTP sc 3,4,5, 5,6,6 N=22	SPT	100	7.5	

Instrumentation water level marks: 18, 13.5, 25.5

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)

RELATIVE STRENGTH	WEATHERING
VS - Very strong	UW - Unweathered
S - Strong	SW - Slightly weathered
MS - Moderately strong	MW - Moderately weathered
W - Weak	HW - Highly weathered
VW - Very weak	CW - Completely weathered
EW - Extremely weak	RW - Residually weathered

Date logged 27/02/2019
Logged JL
Checked SBS

Driller McMillan
Started 20/02/2019
Finished 27/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 9

Remarks
Hole backfilled upon completion.
SPT safety auto trip hammer #N111 used (energy ratio 97%).
Northland Allochthon grading system as per East and George (2001).

NZGD2000 / Mount Eden 2000

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 05/04/19

5/04/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH213**

Client Auckland Transport
Project Matakana Link Road
Project number 60591585

Co-ordinates 1748629.06mE 5972176.91mN
Orientation -90° Elevation 54.24m
Location Warkworth, Auckland
Feature Bridge foundations

Geological Description	Test Records (N Values 0 - 50)	Drilling Method	Depth	TCR [SCR] RQD (%)	Soil Properties / Defect Description
NORTHLAND ALLOCHTHON		HQ3		54	8.3 to 8.6m: Core Loss. Infer extremely weak material lost when drill string became corebound.
		HQ3		100	
	sc 5,6,8, 8,8,7 N=31	SPT	9	100	9.45 to 9.55m: Clayey SILT; light green grey. Soft, moist, high plasticity. Possibly disturbed by SPT.
		HQ3	10	100	
	sc 5,9,8, 8,8,9 N=33	SPT		100	
		HQ3	11	71	11.7 to 12m: Core Loss. Infer extremely weak material washed away during drilling.
	sc 5,7,7, 6,8,7 N=28	SPT	12	100	
		HQ3		100	
		HQ3	13	100	13.34 to 13.5m: Silty CLAY, high plasticity.
	sc 5,8,10, 12,12,14 N=48	SPT		100	
		HQ3	14	81	14.8 to 15m: Core Loss - infer extremely weak material washed away during drilling.
15m: Slightly weathered, green grey, totally crushed, SILTSTONE, extremely weak (NORTHLAND ALLOCHTHON GRADE II). Slickensided and polished surfaces are visible when the core is broken.	sc 9,14,21, 29 for 75mm N>50	SPT	15	100	
		HQ3		78	

Instrumentation: N/A

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)
25/02/2019 11:00	13.50	-	0.9

RELATIVE STRENGTH
VS - Very strong
S - Strong
MS - Moderately strong
W - Weak
VW - Very weak
EW - Extremely weak

WEATHERING
UW - Unweathered
SW - Slightly weathered
MW - Moderately weathered
HW - Highly weathered
CW - Completely weathered
RW - Residually weathered

Date logged 27/02/2019
Logged JL
Checked SBS

Driller McMillan
Started 20/02/2019
Finished 27/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 9

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

Remarks
Hole backfilled upon completion.
SPT safety auto trip hammer #N111 used (energy ratio 97%).
Northland Allochthon grading system as per East and George (2001).

NZGD2000 / Mount Eden 2000

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 05/04/19

5/04/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH213**

Client Auckland Transport
Project Matakana Link Road
Project number 60591585

Co-ordinates 1748629.06mE 5972176.91mN
Orientation -90° Elevation 54.24m
Location Warkworth, Auckland
Feature Bridge foundations

Unit	GEOLOGICAL DESCRIPTION (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc))	Test Records (N Values 0 - 50)	Drilling Method (Casing remarks)	Depth	TCR [SCR] RQD (%)	SOIL PROPERTIES / DEFECT DESCRIPTION	Instrumentation
NORTHLAND ALLOCHTHON	15m: Slightly weathered, green grey, totally crushed, SILTSTONE, extremely weak (NORTHLAND ALLOCHTHON GRADE II). Slickensided and polished surfaces are visible when the core is broken.		HQ3		100		N/A
		sc 6,10,11, 14,18,7 for 35mm N>50	SPT		100		
			HQ3	17	86	17.6 to 17.85m: Clayey SILT with some sand; greenish grey. Hard, moist, high plasticity. 17.85 to 18m: Core Loss - infer core blocked bit (evidence of core spin on core at end of run).	
		sc 4,11,15, 15,20 for 75mm N>50	SPT	18	100		
			HQ3	19	100		
		sc 5,10,14, 16,20 for 75mm N>50	SPT	20	100		
PAKIRI FORMATION	20.25m: Slightly weathered, dark brown grey, interbedded fine SANDSTONE and SILTSTONE, weak.		HQ3		100 [43] 0	20.25 to 28.5m: Predominant joint set perpendicular with core axis, 3 main joint sets; 1st, 0-10°, very closely to widely; 2nd 40-60°, very close; 3rd, 85°, widely. Most joints are undulating, rough, very narrow to tight with brown clay silt veneer. 20.63m: J, 65°, Ud, Ro, VN, Slt	
		sc 50 for 55mm N>50	SPT	21	100	21.06m: J, 85°, Ud, Ro, N, Vn, Slt	
			HQ3	22	53 [12] 0	20.72m: SZ, angular, fine to coarse gravel. SZ, fine to coarse, angular gravel. Possibly extremely closely spaced joints disturbed by drilling and handling. 21.82 to 22.5m: Core loss - infer shear zone gravel washed away by drilling. 22.9 to 23.1m: HJ, 50° & 22.2, 3x, 5mm spacing 23.2 to 22.5m: SZ & 22.2, angular, fine to coarse gravel. Possibly extremely closely spaced joints disturbed by drilling and handling.	
		sc 50 for 60mm N>50	SPT		100		
			HQ3	23	100 [88] 12		

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)
26/02/2019 09:30	18.00	-	0

RELATIVE STRENGTH
VS - Very strong
S - Strong
MS - Moderately strong
W - Weak
VW - Very weak
EW - Extremely weak

WEATHERING
UW - Unweathered
SW - Slightly weathered
MW - Moderately weathered
HW - Highly weathered
CW - Completely weathered
RW - Residually weathered

Date logged 27/02/2019
Logged JL
Checked SBS

Driller McMillan
Started 20/02/2019
Finished 27/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 9

Remarks
Hole backfilled upon completion.
SPT safety auto trip hammer #N111 used (energy ratio 97%).
Northland Allochthon grading system as per East and George (2001).

NZGD2000 / Mount Eden 2000

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 05/04/19

5/04/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH213**

Client: Auckland Transport
Project: Matakana Link Road
Project number: 60591585

Co-ordinates: 1748629.06mE 5972176.91mN
Orientation: -90° Elevation 54.24m
Location: Warkworth, Auckland
Feature: Bridge foundations

Formation	Geological Description (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc))	Test Records	Drilling Method	Depth	TCR [SCR] RQD (%)	Soil Properties / Defect Description
PAKIRI FORMATION		sc 15,20,50 for 65mm N>50	SPT		100	20.25 to 28.5m: Predominant joint set perpendicular with core axis, 3 main joint sets; 1st, 0-10°, very closely to widely; 2nd 40-60°, very close; 3rd, 85°, widely. Most joints are undulating, rough, very narrow to tight with brown clay silt veneer.
			HQ3		66 [16] 0	24.92 to 25.28m: Corre loss - circulation loss.
				25		
			HQ3		100	26.2 to 26.27m: J, 85°, Ud, Ro, VN, NF & 25.15 26.5 to 26.57m: J, 70°, Ud, Ro, VN, NF & 25.15, Disturbed by drilling 27.4 to 27.5m: J, 85°, Ud, Ro, VN, Vn, Slt & 25.15 27.5 to 27.63m: SZ, 40°, Ud, Ro & 25.15, angular, fine to coarse gravel. Possibly extremely closely spaced sub-horizontal joints and vertical joint disturbed by drilling and handling. 27.74 to 28.13m: J, 83°, Ud, Ro, VN, Vn, Slt & 25.15
	25.65m: Slightly weathered, dark brown grey, fine SANDSTONE, weak.	sc 50 for 50mm N>50	SPT		[66] 0	
			HQ3		100	
				26		
	26.3 to 26.4m: Medium to coarse SANDSTONE bed with trace fine gravel sized carbonaceous fragments.				100 [92] 28	
	26.7m: Slightly weathered, massive, dark brown grey, medium to coarse SANDSTONE, weak. Trace fine gravel sized, rounded siltstone clasts.			27		
			HQ3	28	100 [88] 30	
				29		DH213 terminated at 28.5m Depth Criteria Achieved
				30		
				31		

Instrumentation: N/A

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)
27/02/2019 06:15	25.50	-	2.20

RELATIVE STRENGTH
VS - Very strong
S - Strong
MS - Moderately strong
W - Weak
VW - Very weak
EW - Extremely weak

WEATHERING
UW - Unweathered
SW - Slightly weathered
MW - Moderately weathered
HW - Highly weathered
CW - Completely weathered
RW - Residually weathered

Date logged: 27/02/2019
Logged: JL
Checked: SBS

Driller: McMillan
Started: 20/02/2019
Finished: 27/02/2019
Drill Rig: Hanjin D&B-8D tracked
Core Boxes: 9

Remarks
Hole backfilled upon completion.
SPT safety auto trip hammer #N111 used (energy ratio 97%).
Northland Allochthon grading system as per East and George (2001).

NZGD2000 / Mount Eden 2000

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 05/04/19

5/04/2019

Box: 1 of 9 - Depth: 0.00m to 3.00m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

Box: 2 of 9 - Depth: 3.00m to 7.50m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

PHOTOGRAPHIC LOG OF DRILLHOLE

Project Matakana Link Road

Location Warkworth, Auckland

HOLE IDENTIFICATION **DH213**

Box: 3 of 9 - Depth: 7.50m to 12.45m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

Box: 4 of 9 - Depth: 12.45m to 15.75m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

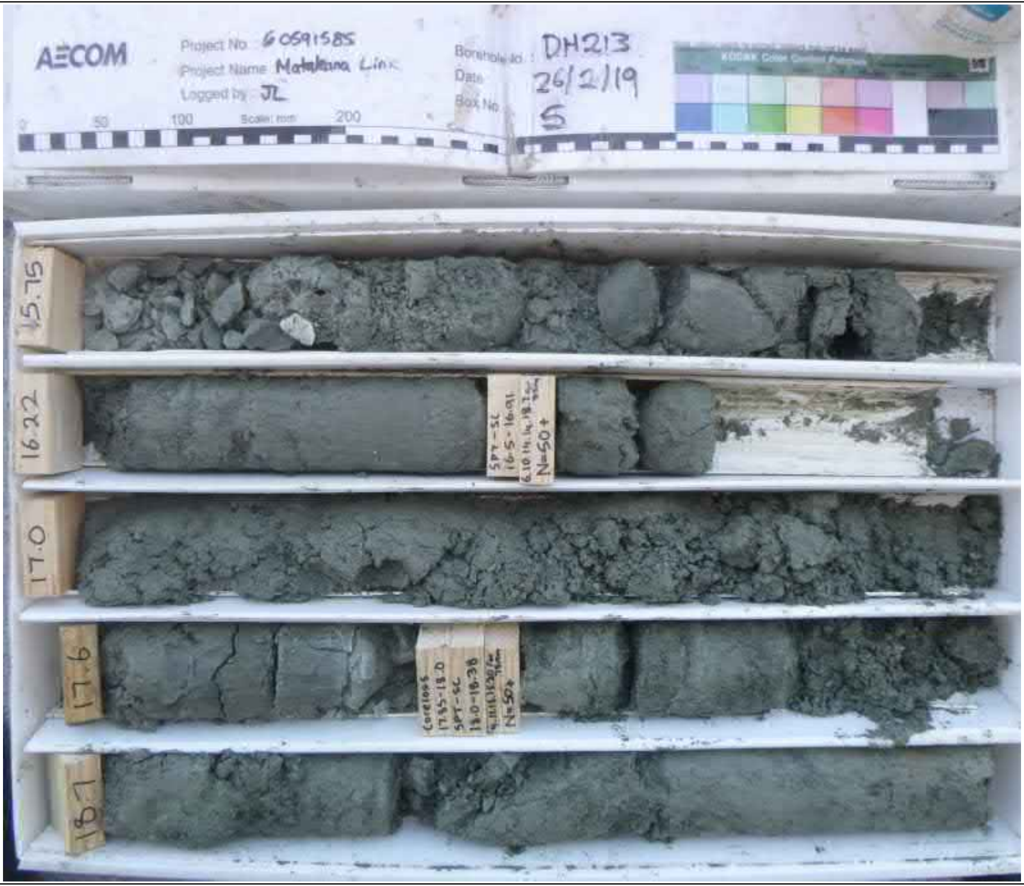
DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 05/04/19

PHOTOGRAPHIC LOG OF DRILLHOLE

Project Matakana Link Road

Location Warkworth, Auckland

HOLE IDENTIFICATION **DH213**



Box: 5 of 9 - Depth: 15.75m to 19.30m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

Box: 6 of 9 - Depth: 19.30m to 21.68m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

PHOTOGRAPHIC LOG OF DRILLHOLE

AECOM

Project Matakana Link Road

Location Warkworth, Auckland

HOLE IDENTIFICATION **DH213**

Box: 7 of 9 - Depth: 21.68m to 25.55m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

Box: 8 of 9 - Depth: 25.55m to 28.18m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

Box: 9 of 9 - Depth: 28.18m to 28.50m of 28.50m

Date Drilled 20/02/2019 to 27/02/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH216**

Client: Auckland Transport
Project: Matakana Link Road
Project number: 60591585

Co-ordinates: 1748934.07mE 5972048.43mN
Orientation: -90° Elevation: 59.77m
Location: Warkworth, Auckland
Feature: Roundabout embankment

Geological Description	Test Records	Drilling Method	Depth (m)	TCR [SCR] RQD (%)	Soil Properties / Defect Description
0m: TOPSOIL		HQ3		100	0m: SILT with minor organics and trace sand; dark brown. Firm, dry to moist, low plasticity. Sand is fine.
0.18m: Completely weathered, orange mottled light grey, SILTSTONE. Extremely weak (NORTHLAND ALLOCHTHON GRADE V-VI).			1		0.18m: SILT with minor clay and trace coarse sand and organics; orange mottled light grey. Stiff, moist, low plasticity. 0.46m: Soft to Firm. 1.3m: Grades to greenish grey.
	26/15 ss 1,1,1, 2,2,3 N=8	SPT		100	
1.95m: Completely weathered, brown mottled light grey, carbonate SILTSTONE. Extremely weak. Corestones of siltstone, extremely weak (NORTHLAND ALLOCHTHON GRADE V-VI). 2.5m: Highly weathered.		HQ3	2	87	1.95m: SILT with minor clay and gravel, and trace sand; greenish grey mottled brown. Firm, moist, low plasticity. Sand is fine, gravel is fine to coarse siltstone clasts. 2.26m: Grades to grey. 2.5m: Very stiff. 2.86 to 3m: Core Loss. Inferred as core washed away during drilling.
2.71m: Moderately weathered, light greenish grey mottled whitish grey, calcareous BRECCIA. Very weak. Breccia is mudstone clasts in silt and sand matrix (NORTHLAND ALLOCHTHON GRADE III).	ss 4,4,12, 15,21,2 for 4mm N>50	SPT	3	100	
		HQ3	4	100	
	sc 8,14,14, 12,9,10 N=45	SPT		100	
		HQ3	5	57	4.95 to 5.4m: Core Loss. Inferred as core washed away during drilling. 5.4 to 5.52m: Likely crushed during drilling.
5.4m: Completely weathered, greenish grey, SILTSTONE. Extremely weak (NORTHLAND ALLOCHTHON GRADE V).					
5.52m: Moderately weathered, light greenish grey mottled whitish grey, calcareous BRECCIA. Very weak. Breccia is mudstone clasts in silt and sand matrix (NORTHLAND ALLOCHTHON GRADE III).	sc 3,9,18, 20,12 for 35mm N>50	SPT	6	100	
		HQ3	7	100	
	sc 6,9,10, 12,12,10 N=44	SPT		100	
			8		DH216 terminated at 7.95m Depth Criteria Achieved
			9		

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

RELATIVE STRENGTH: VS - Very strong; S - Strong; MS - Moderately strong; W - Weak; VW - Very weak; EW - Extremely weak

WEATHERING: UW - Unweathered; SW - Slightly weathered; MW - Moderately weathered; HW - Highly weathered; CW - Completely weathered; RW - Residually weathered

Date logged 4/02/2019
Logged JL
Checked TM

Driller: McMillan
Started: 4/02/2019
Finished: 4/02/2019
Drill Rig: Hanjin D&B-8D tracked
Core Boxes 3

Remarks
50mm standpipe piezometer installed upon completion of drilling. Piezometer developed by air lift.
SPT safety auto trip hammer #N111 used (energy ratio 97%).
Northland Allochthon grading system as per East and George (2001).

NZGD2000 / Mount Eden 2000

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 05/04/19

5/04/2019

Box: 1 of 3 - Depth: 0.00m to 2.86m of 7.95m

Date Drilled 4/02/2019 to 4/02/2019

Box: 2 of 3 - Depth: 2.86m to 6.00m of 7.95m

Date Drilled 4/02/2019 to 4/02/2019

PHOTOGRAPHIC LOG OF DRILLHOLE

Project Matakana Link Road

Location Warkworth, Auckland

HOLE IDENTIFICATION **DH216**

Box: 3 of 3 - Depth: 6.00m to 7.95m of 7.95m

Date Drilled 4/02/2019 to 4/02/2019

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 05/04/19

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH219**

Client: Auckland Transport
Project: Matakana Link Road
Project number: 60591585

Co-ordinates: 1748509.01mE 5971998.83mN
Orientation: -90° Elevation 51.43m
Location: Warkworth, Auckland
Feature: Wetland excavation

GEOLOGICAL DESCRIPTION

(Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc))

ALLUVIAL DEPOSITS

- 0m: TOPSOIL
- 0.31m: ALLUVIUM comprising silt, sand and clay.

PAKIRI FORMATION

- 3.45m: Completely weathered, dark greenish grey, fine SANDSTONE. Extremely weak.
- 3.87m: Highly weathered, dark grey, SANDSTONE. Extremely weak.
- 5.09m: Moderately weathered, dark grey, SANDSTONE. Weak.
- 5.25m: Completely weathered, dark grey, SANDSTONE. Extremely weak.
- 5.5m: Moderately weathered, dark grey, SANDSTONE. Very weak.
  - 5.6 to 6.58m: Joint set, randomly orientated, very closely to closely spaced. Most joints are undulating, rough, with silt veneer infill.
- 6.58m: Slightly weathered, dark grey, SANDSTONE. Weak.

Test Records / Drilling / TCR

Depth interval	Test Records (N Values 0 - 50)	Drilling Method	TCR [SCR] RQD (%)
0 – 1.5m		HA	100
1.5 – 2m	ss 0,0,0, 1,0,1 N=2	SPT	100
2 – 3m		HQ3	81
3 – 3.45m	23/6 ss 0,1,1, 1,2,1 N=5	SPT	100
3.45 – 4.5m		HQ3	62
4.5 – 5m	ss 2,3,4, 3,3,5 N=15	SPT	100
5 – 6m		HQ3	100 [32] 10
6m	sc 37,13 for 9mm N>50	SPT	
6 – 7.5m		HQ3	100 [78] 18
7.5m	sc 23,27 for 30mm N>50	SPT	
7.5 – 9m		HQ3	100 [96] 52
9m	sc 21,29 for 45mm N>50	SPT	
9 – 10m		HQ3	

SOIL PROPERTIES / DEFECT DESCRIPTION

(Subordinate MAJOR minor; colour; structure. Strength; moisture condition; grading; bedding; plasticity; sensitivity; major fraction description; subordinate fraction description; minor fraction description etc)

(Joints, Bedding Seams, Shatter, Shear and Crush Zones, Foliation, Schistosity, Attitude, Spacing, continuity, roughness, infilling, etc.)

- 0m: SILT with some organics and trace fine sand; dark brown. Firm, dry, non plastic.
- 0.31m: SILT with minor clay and trace sand; brownish orange. Very stiff, dry to moist, low plasticity. Sand is fine.
  - 0.61m: Becoming brownish grey mottled orange.
  - 1m: Firm.
- 1.5m: Sandy SILT with minor clay; brown mottled orange and grey. Soft, moist, low plasticity. Sand is fine.
  - 2.8 to 3m: Core Loss. Inferred as soft material washed away during drilling.
- 3.45m: Sandy SILT with trace clay; dark greenish grey. Firm, moist, medium plasticity. Sand is fine.
  - 3.64m: Stiff.
- 3.87m: Sandy SILT; dark greenish grey. Very stiff, moist, low plasticity. Sand is fine to medium.
  - 4.1 to 4.5m: Core Loss. Circulation lost.
- 5.25m: Sandy SILT; dark greenish grey. Hard, moist, low plasticity. Sand is fine to medium.
- 6.58 to 6.93m: J, 80°, Ud, Ro, VN, Vn, Slt
- 6.85 to 7.1m: CZ, Crush Zone
- 7.1 to 7.25m: Joint set, average 45°, very closely to closely spaced. Most joints are undulating, rough with no infill.
  - 7.1 to 7.17m: J, 45°, Ud, Ro, N, NF
- 7.61 to 9m: Joint set, randomly orientated, very closely to closely spaced. Most joints are undulating, smooth with no infill.
  - 7.61 to 7.7m: J, 80°, Ud, Ro, N, NF
  - 7.71 to 8m: J, 45°, Ud, Ro, N, NF
  - 8.64m: J, 85°, Ud, Sm, VN, NF
  - 9.001 to 9.06m: CZ, Crush Zone
  - 9.06 to 9.18m: J, 80°, Pl, Ro, N
- 9.4 to 9.84m: Joint set, average 20°, closely spaced. Most joints are undulating, rough with no infill.
  - 9.84 to 9.87m: CZ, Crush Zone

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)
07/02/2019 09:30	9.00	-	6

RELATIVE STRENGTH	WEATHERING
VS - Very strong	UW - Unweathered
S - Strong	SW - Slightly weathered
MS - Moderately strong	MW - Moderately weathered
W - Weak	HW - Highly weathered
VW - Very weak	CW - Completely weathered
EW - Extremely weak	RW - Residually weathered

Date logged 7/02/2019
Logged JL
Checked SBS

Driller: McMillan
Started: 5/02/2019
Finished: 7/02/2019
Drill Rig: Hanjin D&B-8D tracked
Core Boxes: 5

Remarks
50mm standpipe piezometer installed upon completion of drilling.
Piezometer developed by air lift.
SPT safety auto trip hammer #N111 used (energy ratio 97%).

NZGD2000 / Mount Eden 2000

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 03/04/19

3/04/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH219**

Client Auckland Transport
Project Matakana Link Road
Project number 60591585

Co-ordinates 1748509.01mE 5971998.83mN
Orientation -90° Elevation 51.43m
Location Warkworth, Auckland
Feature Wetland excavation

GEOLOGICAL DESCRIPTION (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc))	Test Records (N Values 0 - 50)	Drilling Method (Casing remarks)	Depth	TCR [SCR] RQD (%)	SOIL PROPERTIES / DEFECT DESCRIPTION
PAKIRI FORMATION: 6.58m: Slightly weathered, dark grey, SANDSTONE. Weak.		HQ3		100 [93] 64	10 to 11.1m: Joint set, average 20°, very closely to closely spaced. Most joints are undulating, rough with no infill.
	sc 30,20 for 5mm N>50	SPT			
		HQ3	11	100 [89] 46	11.1 to 11.23m: J, 75°, Ud, Ro, VN, Vn, Slt 11.23 to 11.45m: J, 75°, Ud, Ro, N 11.53 to 11.66m: CZ, Crush Zone 11.89 to 11.95m: CZ, Crush Zone
	sc 14,12,50 for 50mm N>50	SPT	12		DH219 terminated at 12.05m Depth Criteria Achieved
			13		
			14		
			15		
			16		
			17		
			18		
			19		

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

RELATIVE STRENGTH
VS - Very strong
S - Strong
MS - Moderately strong
W - Weak
VW - Very weak
EW - Extremely weak

WEATHERING
UW - Unweathered
SW - Slightly weathered
MW - Moderately weathered
HW - Highly weathered
CW - Completely weathered
RW - Residually weathered

Date logged 7/02/2019
Logged JL
Checked SBS

Remarks
50mm standpipe piezometer installed upon completion of drilling.
Piezometer developed by air lift.
SPT safety auto trip hammer #N111 used (energy ratio 97%).

NZGD2000 / Mount Eden 2000

Driller McMillan
Started 5/02/2019
Finished 7/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 5

3/04/2019

Box: 1 of 5 - Depth: 0.00m to 3.64m of 12.05m

Date Drilled 5/02/2019 to 7/02/2019

Box: 2 of 5 - Depth: 3.64m to 6.58m of 12.05m

Date Drilled 5/02/2019 to 7/02/2019

PHOTOGRAPHIC LOG OF DRILLHOLE

AECOM

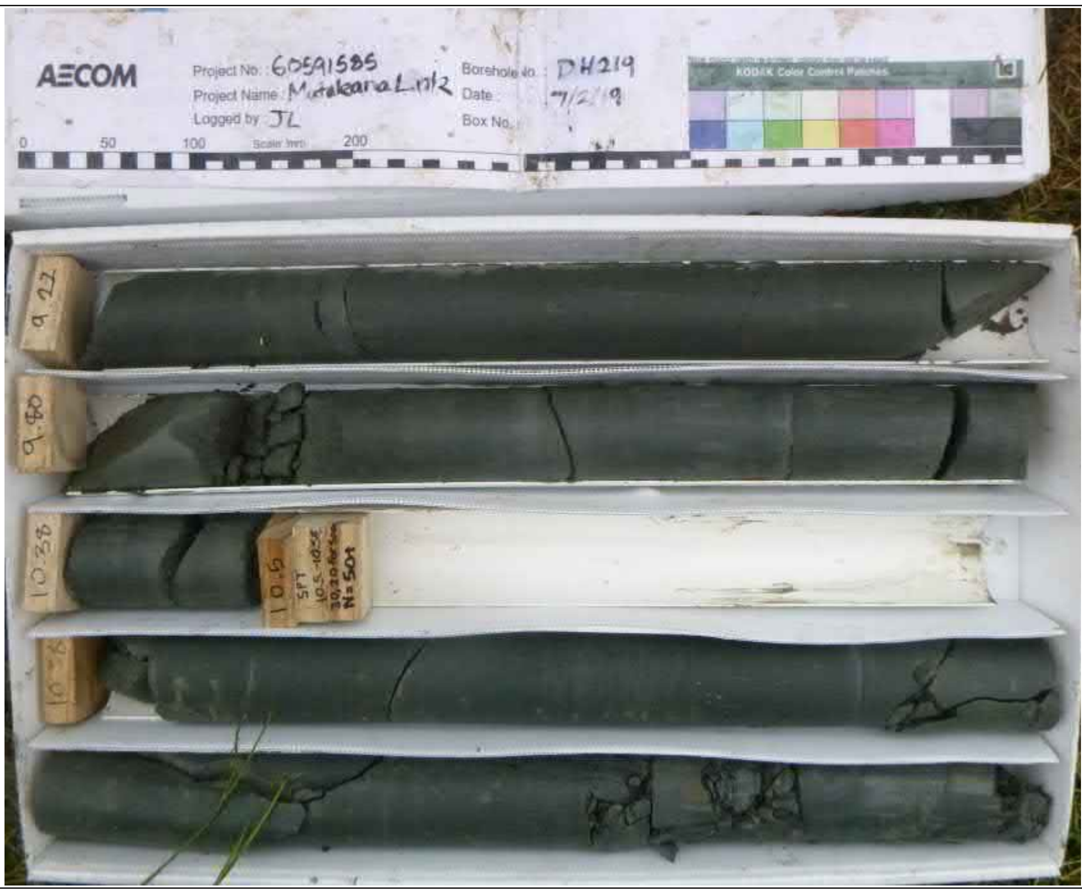
Project Matakana Link Road

Location Warkworth, Auckland

HOLE IDENTIFICATION **DH219**

Box: 3 of 5 - Depth: 6.58m to 9.22m of 12.05m

Date Drilled 5/02/2019 to 7/02/2019



Box: 4 of 5 - Depth: 9.22m to 11.83m of 12.05m

Date Drilled 5/02/2019 to 7/02/2019

Box: 5 of 5 - Depth: 11.83m to 12.05m of 12.05m Date Drilled 5/02/2019 to 7/02/2019

AECOM

LOG OF DRILLHOLE

HOLE IDENTIFICATION **DH221**

Client Auckland Transport
Project Matakana Link Road
Project number 60591585

Co-ordinates 1748496.01mE 5971944.97mN
Orientation -90° Elevation 49.97m
Location Warkworth, Auckland
Feature Wetland excavation

Depth (m)	Geological Description	Test Records (N Values)	Drilling Method	TCR (%)	Soil Properties / Defect Description
0	0m: TOPSOIL		HQ3	100	0m: Sandy SILT; greyish brown. Soft, dry, low plasticity. Sand is fine.
0.1					0.1m: Organic sandy SILT; dark brown. Soft, moist, low plasticity. Rootlets up to 1 mm wide. Organics are amorphous and spongy.
0.24	0.24m: COLLUVIUM comprising silt, clay, sand, organics and gravel. (COLLUVIUM)				0.24m: Clayey SILT with some gravel; brown. Firm, moist, low plasticity. Gravel is coarse, subangular to subrounded, siltstone. 0.6m: Stiff. 0.9m: Iron stained bands.
0.75–1.5		84/15; 105/62	HQ3	71	1.28 to 1.5m: Core Loss. Inferred as very soft clay washed away by driller.
1.5–2.0			PT	100	1.75m: Clayey SILT with trace fine sand; brownish grey. Very soft, wet, low plasticity.
2.0–3.0			HQ3	30	2.16m: Firm. 2.3 to 3m: Core Loss. Soil caught in catcher.
3.0–4.5		54/31	HQ3	67	3m: Silty CLAY with trace fine sand; brownish grey. Very soft, wet, high plasticity. 3.11m: SILT with some clay, minor fine sand and trace organics; grey mottled orange. Soft, moist, low plasticity. Organics are granular and iron stained. 3.6m: Firm. 4 to 4.5m: Core Loss. Inferred as soft silt washed away during drilling.
4.5–5.0	4.75m: Completely weathered, grey, SILTSTONE. Extremely weak. (PAKIRI FORMATION)		PT	100	4.75m: Clayey SILT with trace sand; grey. Stiff, moist, low plasticity. Sand is fine. Carboniferous material up to 20mm in size.
5.0–6.0			HQ3	100	5.77m: Stiff.
6.0–6.5		70/25	PT	100	6.25m: Sandy SILT with minor clay; dark grey mottled brown. Stiff, moist, low plasticity. Sand is fine. Carboniferous material up to 20mm in size.

Groundwater: 7.5

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)

RELATIVE STRENGTH
VS - Very strong
S - Strong
MS - Moderately strong
W - Weak
VW - Very weak
EW - Extremely weak

WEATHERING
UW - Unweathered
SW - Slightly weathered
MW - Moderately weathered
HW - Highly weathered
CW - Completely weathered
RW - Residually weathered

Date logged 28/02/2019
Logged JL
Checked TM

Driller McMillan
Started 27/02/2019
Finished 28/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 3

Remarks
Hole backfilled upon completion.
SPT safety auto trip hammer #N111 used (energy ratio 97%).

NZGD2000 / Mount Eden 2000

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 09/04/19

LOG OF DRILLHOLE

AECOM

HOLE IDENTIFICATION **DH221**

Client: Auckland Transport
Project: Matakana Link Road
Project number: 60591585

Co-ordinates: 1748496.01mE 5971944.97mN
Orientation: -90° Elevation: 49.97m
Location: Warkworth, Auckland
Feature: Wetland excavation

Formation	Geological Description	Test Records (N Values)	Drilling Method	Depth (m)	TCR [SCR] RQD (%)	Soil Properties / Defect Description
PAKIRI FORMATION	6.91m: Completely weathered, blue grey, fine to coarse, SANDSTONE. Extremely weak.		HQ3		100	6.91m: Silty fine to coarse SAND with minor clay; blue grey. Medium dense, moist, uniformly graded.
	7.43m: Highly weathered, dark greenish grey, fine SANDSTONE. Extremely weak.	ss 3,2,2, 3,3,5 N=13	SPT			7.43m: Fine to coarse SAND with some silt; greenish grey. Medium dense, moist, uniformly graded.
	7.72m: Highly weathered, greenish grey, SILTSTONE. Extremely weak.			8	100	7.72m: SILT with some fine sand and minor clay; greenish grey. Stiff, moist, low plasticity. Fine clasts of sandstone up to 10mm.
	8.23m: Moderately weathered, grey, fine SANDSTONE. Very weak.		HQ3		100 [43] 26	8.27 to 8.38m: Joint set, average 20°, very closely spaced. Most joints are undulating, rough with iron staining.
	8.44m: Moderately weathered, blueish dark grey, fine SANDSTONE. Weak.					8.7 to 8.88m: Joint set, average 20°, very closely spaced. Most joints are undulating, smooth with iron staining and sand veneer.
		sc 15,35 for 60mm N>50	SPT	9		9.11m: J, 65°, Ud, Ro, N, Sn, Fe 9.11 to 9.35m: Joint set, average 40°, closely spaced. Most joints undulating and steeped, rough with silt veneer. 9.4 to 9.57m: HJ, 70°, Ud, Sm, VN, C, Fe, 8mm wide 9.54m: SZ, 60°, Ud, Sm, VN, Cg, Cl
	9.72m: Slightly weathered, dark grey, fine SANDSTONE. Weak to moderately strong.		HQ3	10	100 [79] 0	9.62 to 9.98m: Joint set, average 45°, very closely to closely spaced. Most joints are undulating, smooth with clay veneer. 9.57 to 9.6m: SZ, 30°, Ud, Sm, Cg, Cl & Fe
		sc 35,15 for 13mm N>50	SPT			
				11		DH221 terminated at 10.63m Depth Criteria Achieved
				12		
				13		

Column headings: GEOLOGICAL DESCRIPTION (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc)); Test Records; N Values 0 - 50; Drilling Method (Casing remarks); Core Loss/Lift (0 - 100%); Relative Strength (S MS W VW); Rock Weathering (SW MW HW); Depth; Graphic Log; TCR [SCR] RQD (%); Spacing of Natural Defects (mm) (500 100 50 10); SOIL PROPERTIES (Subordinate MAJOR minor; colour; structure. Strength; moisture condition; grading; bedding; plasticity; sensitivity; major fraction description; subordinate fraction description; minor fraction description etc); DEFECT DESCRIPTION (Joints, Bedding Seams, Shatter, Shear and Crush Zones, Foliation, Schistosity, Attitude, Spacing, continuity, roughness, infilling, etc.); Instrumentation

For explanation of symbols and observations, see key sheet

FLUID DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)
28/02/2019 07:00	7.50	-	2.2

RELATIVE STRENGTH
VS - Very strong
S - Strong
MS - Moderately strong
W - Weak
VW - Very weak
EW - Extremely weak

WEATHERING
UW - Unweathered
SW - Slightly weathered
MW - Moderately weathered
HW - Highly weathered
CW - Completely weathered
RW - Residually weathered

Date logged 28/02/2019
Logged JL
Checked TM

Driller McMillan
Started 27/02/2019
Finished 28/02/2019
Drill Rig Hanjin D&B-8D tracked
Core Boxes 3

Remarks
Hole backfilled upon completion.
SPT safety auto trip hammer #N111 used (energy ratio 97%).

NZGD2000 / Mount Eden 2000

Hand Held Shear Vane
GEOVANE1347: 19mm blade: Correction Factor: 1.549
vane shear strength per NZGS guideline

DRILLHOLE LOG 60591585_MLR_MASTER.GPJ BASE.GDT 27/03/19

27/03/2019

Box: 1 of 3 - Depth: 0.00m to 05.00m of 10.63m

Date Drilled 27/02/2019 to 28/02/2019

Box: 2 of 3 - Depth: 5.00m to 08.55m of 10.63m

Date Drilled 27/02/2019 to 28/02/2019

Box: 3 of 3 - Depth: 8.55m to 10.63m of 10.63m

Date Drilled 27/02/2019 to 28/02/2019

AECOM

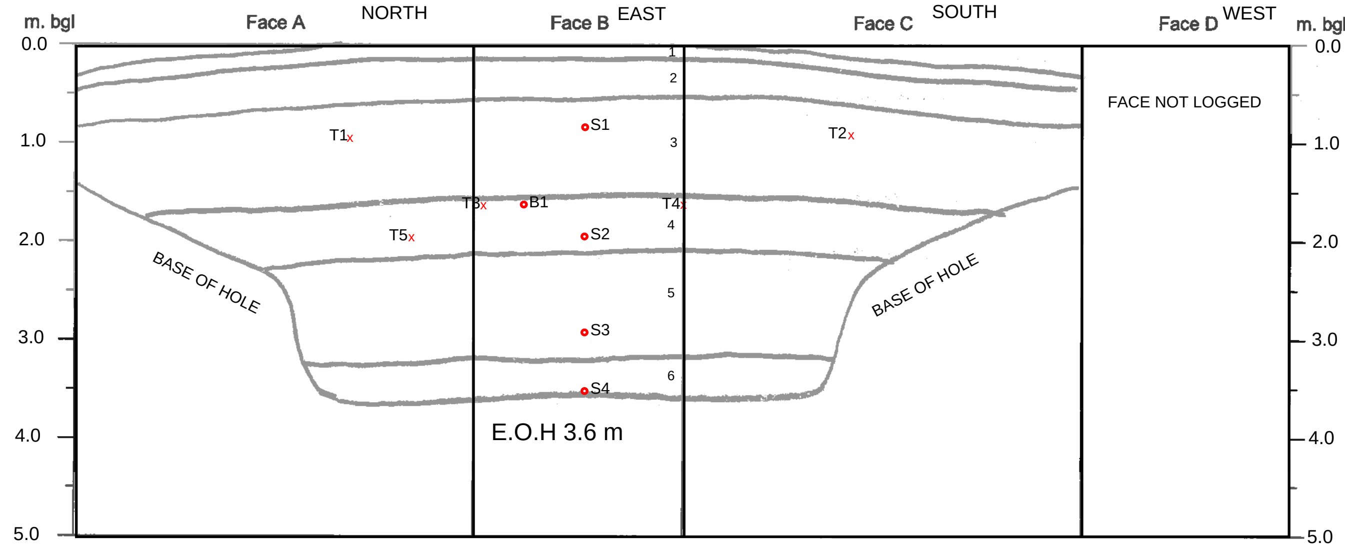
LOG OF INSPECTION PIT

INSPECTION PIT IDENTIFICATION **TP214**

Client Auckland Transport
Project Matakana Link Road
Project number 60591585

Co-ordinates 1748699.06mE 5972158.03mN
Orientation -90° Elevation 58.31m
Location Warkworth, Auckland
Feature Proposed shear

Face Sketch (Includes Stratum Boundaries, Stratum Reference Numbers and face(s) sketched.



Depth	GEOLOGICAL DESCRIPTION (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc)	Test Records	Sampling	DCP (Blows per mm) 2 4 6 8	SOIL DESCRIPTION (Subordinate MAJOR minor; colour; structure. Strength; moisture condition; grading; bedding; plasticity; sensitivity; major fraction description; subordinate fraction description; minor fraction description etc) / Depth Related Remarks / DEFECT DESCRIPTION (Joints, Bedding Seams, Shatter, Shear and Crush Zones, Foliation, Schistosity, Attitude, Spacing, continuity, roughness, infilling, etc.)	Graphic Log	Instrumentation
	0m: TOPSOIL				0m: Silty CLAY with some rootlets; greyish brown. Hard, dry. (1)		
	0.15m: SUBSOIL				0.15m: Orange brown, blocky structure due to dessication cracks. (2)		
1	PAKIRI FORMATION — 0.6m: Residual soil of PAKIRI FORMATION	174* 156/67	BAGS1		0.6m: CLAY with trace silt; brownish orange. Very stiff, moist, high plasticity. (3)		
2		116/58 116/58 104/29 UTP	BAGB1 BAGS2		1.6m: CLAY with some silt and sand; brownish orange, mottled light grey. Very stiff, moist, high plasticity. Sand is fine and in light grey lenses. (4)		
3	2.2m: Completely to highly weathered, brownish orange, iron stained, SILTSTONE, with fine sand lenses; extremely weak. Highly decomposed, completely discoloured [PAKIRI FORMATION].		BAGS3		2.2m: CLAY with some silt and sand; brownish orange, mottled light grey. Very stiff, moist, high plasticity. Sand is fine and in light grey lenses. (5) 2.7m: Pink staining, wet. Completely decomposed to soil strength.		
	3.2m: RESIDUAL SANDSTONE		BAGS4		3.2m: Sandy SILT with minor clay; light grey. Soft, wet, low plasticity. Sand is fine. (6)		
4	3.5m: Completely weathered, light grey, sandy SILTSTONE. Extremely weak [PAKIRI FORMATION]				3.5m: Soft to firm. TP214 terminated at 3.6m Target Depth		

For explanation of symbols and observations, see key sheet

DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)

Hand Held Shear Vane
GEOVANE734: 19mm blade (A): Correction Factor: 1.449
Vane shear strength per NZGS guideline

Length 3.3m
Width 2.1m
Stability Stable
Excavation Method 20t excavator
Orientation B 130°

Remarks
Hole backfilled upon completion.
T = HandShear Vane Test
S = Disturbed Samples
B = Bulk Samples
No groundwater encountered.
174 kPa is the shear vane limit
NZGD2000 / Mount Eden 2000

Started 26/02/2019
Finished 26/02/2019
Date logged 26/02/2019
Logged AM
Checked GMP

Page 1 of 1

INSPECTION PIT 60591585_MLR_MASTER.GPJ BASE.GDT 28/03/19

28/03/2019

PHOTOGRAPHIC LOG OF TEST PIT

Project	Matakana Link Road
Location	Warkworth, Auckland
Date excavated	26/02/2019

Hole Identification **TP214**

TP214 - Site

TP214 – Spoil pile

PHOTOGRAPHIC LOG OF TEST PIT

Project	Matakana Link Road
Location	Warkworth, Auckland
Date excavated	26/02/2019

Hole Identification **TP214**

TP214 – Face B

TP214 – Face A

TP214 – Face C

AECOM

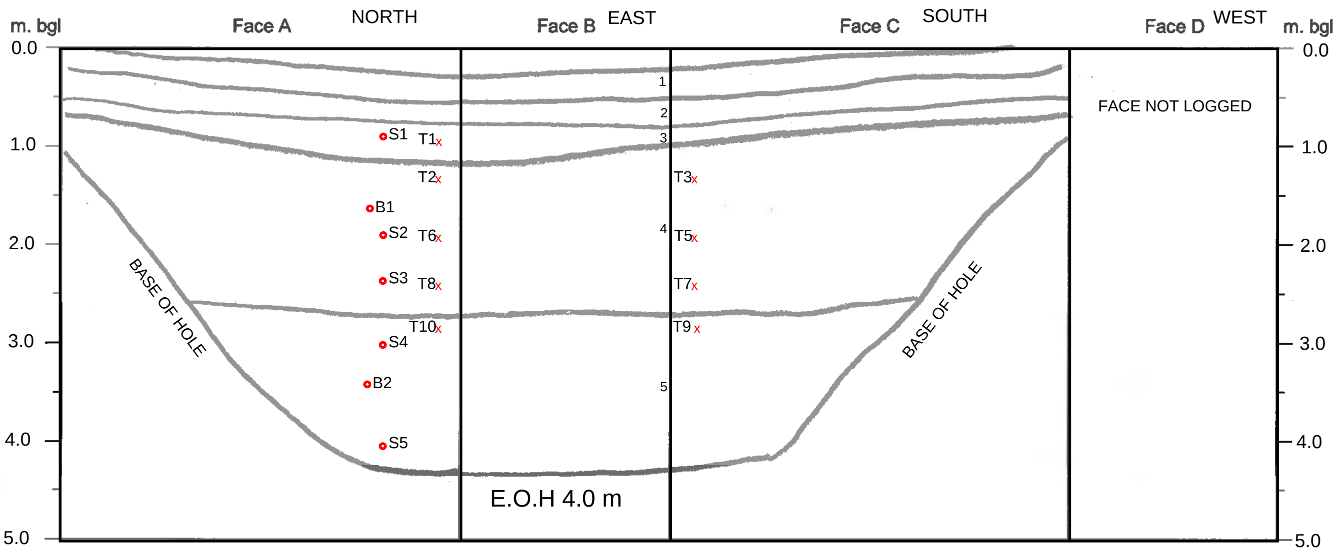
LOG OF INSPECTION PIT

INSPECTION PIT IDENTIFICATION **TP215**

Client	Auckland Transport
Project	Matakana Link Road
Project number	60591585

Co-ordinates	1748835.69mE 5972125.86mN
Orientation	-90° Elevation 64.61m
Location	Warkworth, Auckland
Feature	Drainage pond

Face Sketch (Includes Stratum Boundaries, Stratum Reference Numbers and face(s) sketched.



Depth	GEOLOGICAL DESCRIPTION (Weathering, Colour, Fabric, Rock Name, Strength, Discontinuities, Lithological Features (bedding, foliation, mineralogy, cement, etc))	Test Records	Sampling	DCP (Blows per mm)	SOIL DESCRIPTION (Subordinate MAJOR minor; colour; structure. Strength; moisture condition; grading; bedding; plasticity; sensitivity; major fraction description; subordinate fraction description; minor fraction description etc) / Depth Related Remarks / DEFECT DESCRIPTION (Joints, Bedding Seams, Shatter, Shear and Crush Zones, Foliation, Schistosity, Attitude, Spacing, continuity, roughness, infilling, etc.)	Graphic Log	Instrumentation
	0m: TOPSOIL				0m: Silty CLAY with some rootlets; greyish brown. Hard to very stiff, dry to moist, friable. (1)		
	0.25m: SUBSOIL				0.25m: Silty CLAY, light brown. Very stiff, dry to moist with columnar structure of desiccation cracks. (2)		
	PAKIRI FORMATION: 0.5m: Residual soil of PAKIRI FORMATION	84/29	BAGS1		0.5m: Silty CLAY; light brownish grey with orange mottles. Stiff, moist, high plasticity. (3)		
1		58/30 62/35 59/29			0.95m: Silty CLAY; light greyish orange brown. Stiff, moist, high plasticity. (4)		
		52/32 64/29	BAGB1 BAGS2				
2		61/38 78/29	BAGS3		2m: Becoming more silty with orange streaks.		
	2.5m: Completely weathered bluish grey SILTSTONE as very stiff clayey SILT [PAKIRI FORMATION]	61/32 116/36			2.5m: Clayey SILT with trace organic flecks, bluish grey with dark red iron oxide staining. Stiff to very stiff, moist, low plasticity, residual blocky rock structure. (5)		
3			BAGS4 BAGB2		3m: Streaked light grey.		
			BAGS5				
4					TP215 terminated at 4m Unable to advance as too difficult to excavate		

DCP scale: 2 4 6 8

For explanation of symbols and observations, see key sheet

DEPTHS DURING DRILLING

Date Time	Drilled Depth (m)	Casing Depth (m)	Fluid Depth (m)

Hand Held Shear Vane

GEOVANE734: 19mm blade (A): Correction Factor: 1.449

Vane shear strength per NZGS guideline

Length	3.3m
Width	2.1m
Stability	Stable
Excavation Method	20t excavator
Orientation	B 90°

Remarks

Hole backfilled upon completion.
T = HandShear Vane Test
S = Disturbed Samples
B = Bulk Samples
No groundwater encountered.

NZGD2000 / Mount Eden 2000

Started 26/02/2019
Finished 26/02/2019
Date logged 26/02/2019
Logged AM
Checked GMP

PHOTOGRAPHIC LOG OF TEST PIT

Project	Matakana Link Road
Location	Warkworth, Auckland
Date excavated	26/02/2019

Hole Identification **TP215**

TP215 - Site

TP215 – Spoil pile

PHOTOGRAPHIC LOG OF TEST PIT

Project	Matakana Link Road
Location	Warkworth, Auckland
Date excavated	26/02/2019

Hole Identification **TP215**

TP215 – Face B

TP215 – Face C

TP215 – Face D

R.L. (m)	Depth (m)	Drilling Method / Flush Return (%)	TCR (RQD) (%)	In-Situ Testing	Sampling
60.27–58.77	0.00–1.50	OB	100		
58.77–58.27	1.50–2.00	SPT	100	I_{vp}102/I_{vr}47 SPT$_s$=3,2,4 N=6	SPTLS
58.27–57.77	2.00–2.50	PT	100		U
57.77–57.27	2.50–3.00	OB	100		
57.27–56.77	3.00–3.50	SPT	100	I_{vp}60/I_{vr}19 SPT$_s$=1,0,1 N=1	SPTLS
56.77–56.27	3.50–4.00	OB	100		
56.27–55.77	4.00–4.50	PT	100		U
55.77–55.27	4.50–5.00	SPT	100	SPT$_s$=0,0,0 N=0	SPTLS
55.27–54.27	5.00–6.00	OB	100		
54.27–53.77	6.00–6.50	SPT	100	I_{vp}47/I_{vr}28 SPT$_s$=0,0,1 N=1	SPTLS
53.77–53.27	6.50–7.00	OB	100		
53.27–52.77	7.00–7.50	PT	100		U
52.77–52.27	7.50–8.00	SPT	0	SPT$_s$=0,0,0 N=0	SPTLS

Depth (m)	Description of Strata	Defect Description	Geological Unit
0.00–0.30	Clayey SILT; dark brown. Stiff, dry, slightly plastic.		TOPSOIL
0.30–0.50	Clayey SILT; light grey, mottled orange. Hard, dry, slightly plastic.		ALLUVIUM
0.50–3.50	Silty CLAY; light grey mottled orange. Stiff, moist, highly plastic. *1.50m: minor rootlets* *2.50m: some organics (wood fragments, rootlets), stiff*		ALLUVIUM
3.50–4.70	Clayey SILT with some sand and minor organics; light yellowish brown. Stiff, moist, slightly plastic.		ALLUVIUM
4.70–5.00	Sandy CLAY with some organics; dark grey, streaked orange and mottled black. Firm to stiff, wet, slightly to moderately plastic, sand is medium, organics contain wood fragments and peat.		ALLUVIUM
5.00–	Clayey SILT with minor sand; dark grey. Firm, moist, slightly plastic, sand is fine to medium. *7.00m: becoming stiff*		PAKIRI FORMATION

Backfill / Installation: BH06

Driller:	Prodrill	**Easting:**	5972183.3	**Elevation:**	60.27	**Started:**	03/04/2018
Plant:	Track mounted	**Northing:**	1748556.7	**Datum:**	Auckland 1946	**Finished:**	04/03/2018
Logged by:	CR	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

Project: SH1 to Matakana Road Geotechnical Investigation
Client: Auckland Transport
Location: Warkworth, New Zealand
Hole ID: BH06
Project No: IZ093400

Depth (m)	Drilling Method	TCR (RQD) (%)	In-Situ Testing	Sampling	Description of Strata	Defect Description	Geological Unit
to 9.00	OB	100			Silty medium SAND, minor clay, dark grey. Loose, wet.		PAKIRI FORMATION
9.00–9.50	SPT	100	SPT_s=1,2,1 N=3	SPTLS	*9.00m: some silt clasts (fine gravel sized 2-3mm), crushes to SILT (relic siltstone).*		
9.50	OB	100			Sandy SILT; grey. Stiff, moist, low plasticity. Sand is medium, poorly graded, 30mm sand beds 10mm siltstone beds (COMPLETELY WEATHERED INTERBEDDED SILTSTONE AND SANDSTONE).		
	PT	100	I_{vp}47/I_{vr}16	U			
	SPT	100	SPT_s=2,1,3 N=4				
10.95	OB	47			CORE LOSS		
11.50					Sandy SILT; darkgrey. Stiff, moist, low plasticity. Sand is medium, poorly graded, sand is in 30mm bands. (COMPLETELY WEATHERED INTERBEDDED SILTSTONE AND SANDSTONE).		
	SPT	100	SPT_s=2,2,3 N=5				
			I_{vp}63/I_{vr}16				
		100					
		100	SPT_s=2,2,4 N=6				
14.60					Completely weathered, dark bluish grey, thinly bedded SILTSTONE. Extremely weak, very thin sandstone beds spaced 50 mm apart. Recovered as: Clayey SILT with some fine sand; grey. Hard, moist, slightly plastic.		
		100	SPT_s=12,16,34 Nc=50				
15.45					Slightly weathered, dark grey, massive SILTSTONE. Weak.	**15.45 - 15.56m**: JT, 75 - 85°, clean, PR, RF **15.57 - m**: B, 10 - 15°, clean, PR, RF **15.67 - 15.8m**: JT, 49 - 59°, clean, PR, RF	

Driller:	Prodrill	**Easting:**	5972183.3	**Elevation:**	60.27
Plant:	Track mounted	**Northing:**	1748556.7	**Datum:**	Auckland 1946
Logged by:	CR	**Grid:**	NZTM2000	**Inclination:**	-90
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**	

Started: 03/04/2018
Finished: 04/03/2018
Standard: NZS 4402:1986
Status: Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

R.L. (m)	Depth (m)	Drilling Method Flush Return (%) 25 50 75	TCR (RQD) (%) 25 50 75	Spacing of Natural Defects (mm) 500 100 50 10	In-Situ Testing	Sampling	Rock Strength EW VW W MS S VS	Weathering Grade RS CW HW MW SW	Geology Legend	Groundwater	Description of Strata	Defect Description	Geological Unit	Backfill / Installation
44			100(10)								16.50	**16.1 - 16.5m**: JT, 80 - 90°, clean, UN, RF, 3x J parallel in core, crushed by drilling and handling		

SPT$_s$=50

Hole Terminated at 16.50 m
Target depth

Driller:	Prodrill	**Easting:**	5972183.3	**Elevation:**	60.27	**Started:**	03/04/2018
Plant:	Track mounted	**Northing:**	1748556.7	**Datum:**	Auckland 1946	**Finished:**	04/03/2018
Logged by:	CR	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

BH06 Depth Range 0.00m - 3.00m

BH06 Depth Range 3.00m - 6.90m

Title	Core Photo BH06	*Project*	Matakana Link	*Client*	Auckland Transport
Scale	Not to scale	*Rev*	Revision 0		

BH06 Depth Range 6.90m - 10.95m

BH06 Depth Range 10.95m - 14.40m

Title	Core Photo BH06	*Project*	Matakana Link	*Client*	Auckland Transport
Scale	Not to scale	*Rev*	Revision 0		

BH06 Depth Range 14.40m - 16.50m

Title	Core Photo BH06	*Project*	Matakana Link	*Client*	Auckland Transport
Scale	Not to scale	*Rev*	Revision 0		

JACOBS

Borehole log

Project: SH1 to Matakana Road Geotechnical Investigation
Client: Auckland Transport
Location: Warkworth, New Zealand

Hole ID: BH07
Project No: IZ093400

R.L. (m)	Depth (m)	Drilling Method	TCR (RQD) (%)	In-Situ Testing	Sampling	Depth marker	Description of Strata
							Silty fine SAND; grey. Loose, moist, poorly graded. *0.10m: Becomes dark brown and with minor organics.*
57	1	OB	100	I_{vp}125/I_{vr}16		0.3	Clayey SILT with minor sand; greyish brown mottled orange. Very stiff, moist, slightly plastic. *0.50m: Becomes pale grey mottled orange.*
56		SPT	100	I_{vp}85/I_{vr}23 SPT$_s$=1,2,3 N=5	SPTLS		*1.50m: Becomes stiff and with trace rootlets.*
	2	OB	55			2	Sandy SILT with trace clay and organics (wood); grey, mottled orange. Firm, moist, slightly plastic. Sand is fine, poorly graded.
55						2.55	CORE LOSS
	3	SPT	33	SPT$_s$=2,2,1 N=3	SPTLS	3	Sandy SILT with trace clay and organics (wood); grey, mottled orange. Firm, moist, slightly plastic. Sand is fine, poorly graded.
54		OB	80		U	3.6	200mm of wood fragments encountered
	4		100			3.8	SILT with some organics and sand; dark brown, thinly bedded. Firm, wet, slightly plastic. Sand is fine to medium, poorly graded, organics contain wood fragments and peat. *4.10m: Becomes grey, with minor sand and lamination ceases.* *4.50m: Becomes dark brown mottled black.*
53		OB SPT	100	I_{vp}91/I_{vr}13 SPT$_s$=2,2,2 N=4	SPTLS	4.9	CLAY with some organics; grey. Stiff, wet, moderately plastic. Organics contain peat.
	5	OB	100			5.1	Sandy clayey SILT with some organics; grey mottled black. Firm to stiff, wet, slightly plastic. Sand is fine to medium, poorly graded. Organics are peat with trace wood.
52	6	PT	100	I_{vp}50/I_{vr}10	U		
		SPT	100	SPT$_s$=0,1,3 N=4	SPTLS		*6.00m: Becomes with some sand, sand is fine to coarse, well graded.*
51	7	OB	90			7.2	Clayey SILT with minor fine sand; bluish grey. Stiff, moist, slightly plastic.
50	8	SPT	91	I_{vp}81/I_{vr}13 SPT$_s$=1,3,4 N=7	SPTLS		

Geological Unit: ALLUVIUM

Driller:	Prodrill	**Easting:**	5972167.5	**Elevation:**	57.90	**Started:**	29/03/2018
Plant:	Track Mounted	**Northing:**	1748593.6	**Datum:**	Auckland 1946	**Finished:**	03/04/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

R.L. (m)	Depth (m)	Drilling Method / Flush Return (%)	TCR (RQD) (%)	In-Situ Testing	Sampling
			100		
49	9	PT	100		U
		SPT	100	SPT_s=3,4,5 N=9	SPTLS
48	10	OB	100		
47	11	SPT	100	I_{vp}76+ SPT_s=5,9,11 N=20	
		OB	100		
46	12	HQ3	100(20)		
45		SPT	0	SPT_s=31,50/90mm Nc=50/90mm	
44	13	HQ3	100(16)		
	14	SPT	0	SPT_s=50/75mm	
43	15	HQ3	100(32)		
42		SPT	0	SPT_s=50/85mm	
	16				

Description of Strata

9.00m: Becomes grey mottled dark grey and with some fine sand, clay ceases.

9.5 — Clayey SILT with some sand; dark grey. Hard, moist, low plasticity. Sand is fine to medium, poorly graded (COMPLETELY WEATHERED THINLY BEDDED INTERBEDDED SILTSTONE AND SANDSTONE.).

10.50m: Becomes stiff

11.40m: Clasts of very weak siltstone and relic fracturing encountered.

11.6 — Slightly weathered, greenish grey SILTSTONE. Extremely weak to very weak.

12.30-12.50m: Highly fractured from drilling and handling

12.8 — Slightly weathered, grey, thinly bedded, INTERBEDDED SANDSTONE AND SILTSTONE. Very weak, 80% sandstone and 20% siltstone.
13.05-13.20m: Core appears crushed due to drilling and handling

13.5 — *13.50-14.00m: Core appears crushed due to drilling and handling*
Slightly weathered, dark grey, thinly bedded INTERBEDDED SILTSTONE AND SANDSTONE. Very weak to weak, 80% siltstone and 20% sandstone.

14.40-14.60m: Sandstone becomes coarse grained with clasts of mudstone up to 30 mm in diameter.

14.70-14.90m: Core appears crushed due to drilling and handling

15 — Slightly weathered, grey, coarse grained SANDSTONE. Extremely weak to very weak with clasts of siltstone up to 30 mm in diameter.
15.35-15.45m: Core appears crushed due to drilling and handling

15.85 — Slightly weathered, grey, SILTSTONE. Weak.
15.9 — *15.58-17.00m: Core appears crushed due to drilling and handling*

Geological Unit: PAKIRI FORMATION

Driller:	Prodrill	**Easting:**	5972167.5	**Elevation:**	57.90	**Started:**	29/03/2018
Plant:	Track Mounted	**Northing:**	1748593.6	**Datum:**	Auckland 1946	**Finished:**	03/04/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

R.L. (m)	Depth (m)	Drilling Method Flush Return (%)	TCR (RQD) (%)	Spacing of Natural Defects (mm)	In-Situ Testing	Sampling	Fine Soil Consistency / Granular Soil Density / Rock Strength	Weathering Grade	Geology Legend	Groundwater	Description of Strata	Geological Unit	Backfill / Installation
		HQ3	100(40)								16.2 Slightly weathered, grey, thinly bedded INTERBEDDED SILTSTONE AND SANDSTONE. Weak, 50% siltstone and 50% sandstone.	PAKIRI FORMATION	
41	17										Slightly weathered, greenish grey, massive, coarse grained SANDSTONE. Weak. 17		

Hole Terminated at 17.00 m
Target depth

Driller:	Prodrill	**Easting:**	5972167.5	**Elevation:**	57.90	**Started:**	29/03/2018
Plant:	Track Mounted	**Northing:**	1748593.6	**Datum:**	Auckland 1946	**Finished:**	03/04/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

BH07 Depth Range 0.00m - 3.50m

BH07 Depth Range 3.50m - 6.70m

Title	**Core Photo BH07**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

BH07 Depth Range 6.70m - 10.10m

BH07 Depth Range 10.10m - 13.10m

Title	**Core Photo BH07**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

BH07 Depth Range 13.10m - 16.20m

BH07 Depth Range 16.20m - 17.00m

Title	**Core Photo BH07**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

JACOBS Borehole log

Project:	SH1 to Matakana Road Geotechnical Investigation	**Hole ID:**	BH08
Client:	Auckland Transport	**Project No:**	IZ093400
Location:	Warkworth, New Zealand	**Page:**	1 of 4

Depth (m)	Drilling Method	TCR (%)	In-Situ Testing	Sampling	Description of Strata	Geological Unit
0.00–0.20	OB	94			Sandy SILT with trace rootlets; drak brown. Very stiff, moist, slightly plastic.	TOPSOIL
0.20–1.60	OB	94	I_{vp}133/I_{vr}28		Clayey SILT; pale grey mottled orange and black. Very stiff, moist, slightly plastic. *1.00m: Becomes with minor fine sand, poorly graded.* *1.50-1.60m: core loss*	ALLUVIUM
1.60–3.10	SPT / OB / PT	100 / 100 / 100	I_{vp}128/I_{vr}28 SPT$_s$=2,1,3 N=4; I_{vp}78/I_{vr}31	SPTLS; U	Sandy SILT; brownish grey. Soft to firm, moist, slightly plastic. Sand is fine to medium, poorly graded. *2.10m: Becomes brownish grey.* *2.50m: Becomes stiff.*	ALLUVIUM
3.10–3.90	SPT / OB	100 / 66	SPT$_s$=0,0,2 N=2	SPTLS	Silty CLAY with trace sand and organics; brownish grey. Firm, moist, moderately plastic. Sand is fine, poorly graded.	ALLUVIUM
3.90–4.20	OB	66			Sandy SILT with minor clay and organics; dark brown. Firm, moist, slightly plastic. Sand is fine, poorly graded.	ALLUVIUM
4.20–4.50	OB	66			CORE LOSS	
4.50–5.60	SPT / OB	100 / 90	I_{vp}47/I_{vr}13 SPT$_s$=0,0,0 N=0		Sandy CLAY with some silt; grey. Firm, moist, slightly plastic. Sand is fine, poorly graded. *5.00m: Becomes with trace organics (rootlets and wood).* *5.10m: Becomes with medium sand, poorly graded.* *5.40-5.50m: core loss*	ALLUVIUM
5.60–6.50	PT / SPT	30 / 80	SPT$_s$=0,0,2 N=2	U; SPTLS	SILT with some organics; dark brown. Firm, moist, slightly plastic. Organics are peat and wood fragments. *6.00m: Becomes bluish grey streaked dark brown.*	ALLUVIUM
6.50–6.70	OB	90			CORE LOSS	
6.70–7.00	OB	90			SILT with some organics; dark brown. Firm, moist, slightly plastic. Organics are peat and wood fragments.	ALLUVIUM
7.00–8.00	OB / SPT	90 / 100	I_{vp}125/I_{vr}16 SPT$_s$=0,1,4 N=5	SPTLS	Clayey SILT with some organics and trace sand; pale brown. Very stiff, moist, slightly plastic. *7.50m: Becomes bluish grey and wood encountered.*	ALLUVIUM

R.L. (m): 56 to 48 (ground level 56.23). Backfill / Installation: BH08.

Driller:	Prodrill	**Easting:**	5972170.5	**Elevation:**	56.23	**Started:**	26/03/2018
Plant:	Track Mounted	**Northing:**	1748618.0	**Datum:**	Auckland 1946	**Finished:**	29/03/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

Depth (m)	Drilling Method	TCR (%)	In-Situ Testing	Sampling	Description of Strata	Geological Unit
8.0–9.0	OB	100			Sandy SILT with trace clay; grey streaked brown. Stiff to very stiff, moist, slightly plastic. Sand is medium, poorly graded.	PAKIRI FORMATION
9.0–9.45	SPT	90	I_{vp}70+ SPT$_s$=5,10,15 N=25	SPTLS		
9.45–10.5	OB	100				
10.5–10.95	SPT	60	I_{vp}210+ SPT$_s$=8,8,12 N=20	SPTLS		
10.80					SILT with minor fine sand and trace clay; grey. Thinly bedded, very stiff, dry to moist, slightly plastic (COMPLETELY WEATHERED SILTSTONE).	
10.95–11.75	OB	100				
11.75–12.55	HQ3	100				
12.55–13.0	SPT	0	SPT$_s$=14,23,23 Nc=46		*12.50m: Becomes hard.*	
13.0–14.05	HQ3	100				
14.05–14.5	SPT	0	SPT$_s$=11,15,17 Nc=32			
14.60					CORE LOSS	
14.70					SILT with minor fine sand and trace clay; grey. Thinly bedded, very stiff, dry to moist, slightly plastic (COMPLETELY WEATHERED SILTSTONE). *14.70m: Becomes very thinly bedded.*	
14.5–15.55	HQ3	105				
15.50					Sandy CLAY with minor silt; grey. Very stiff, saturated, slightly plastic. *15.50m: Complete water loss at 15.5m.*	
15.55–16.0	SPT	0	SPT$_s$=21,23,15 Nc=38			
15.80					SILT with minor fine sand and trace	

Driller:	Prodrill	**Easting:**	5972170.5	**Elevation:**	56.23	**Started:**	26/03/2018
Plant:	Track Mounted	**Northing:**	1748618.0	**Datum:**	Auckland 1946	**Finished:**	29/03/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

R.L. (m)	Depth (m)	Drilling Method / Flush Return (%)	TCR (RQD) (%)	In-Situ Testing	Description of Strata	Defect Description	Geological Unit
32					*zone. Recovered as: Sandy GRAVEL with some silt.* *24.20-24.60m: Recovered as gravel, completely fractured.*	PR, RF	
		SPT	0	SPT_s=50/50mm			
	24.60				Slightly weathered, grey, medium grained, subhorizontally interbedded SANDSTONE and SILTSTONE. Weak, beds are moderately thin to moderately thick, 80% sandstone, 20% siltstone. *24.60-26.00m: Highly fractured zone.* *24.70m: Becomes fine grained.*	**24.6 - m**: B, 0°, clean, PR, RF **24.7 - m**: B, 5°, Mudstone infill, PR, RF **24.7 - 24.75m**: JT, 60°, clean, PR, RF **24.8 - m**: B, 5°, clean, PR, S **24.9 - 24.95m**: B, 5°, Mudstone infill, PR, S **25.1 - m**: JT, 45°, clean, UN, RF	PAKIRI FORMATION
31	25	HQ3	58(13)				
	25.40				Slightly weathered, grey, laminated, fine grained, SANDSTONE. Weak, bedding is gently inclined. *25.40m: Recovered as cobbles, completely fractured.* *25.50m: Becomes massive, fine to coarse, well graded.* *25.70-26.00m: Recovered as gravel, completely fractured.*	**25.45 - m**: JT, 0°, clean, UN, RF **25.55 - 25.65m**: JT, 60°, CA mineral coating, PR, RF	
	26 / 26.00	SPT		SPT_s=50/75mm	Hole Terminated at 26.00 m Target depth		

Column scales: Drilling Method / TCR 25 50 75; Spacing of Natural Defects (mm) 500 100 50 10; Rock Strength EW VW W MS S VS; Weathering Grade RS CW HW MW SW. Other columns: Sampling, Geology Legend, Groundwater, Backfill / Installation.

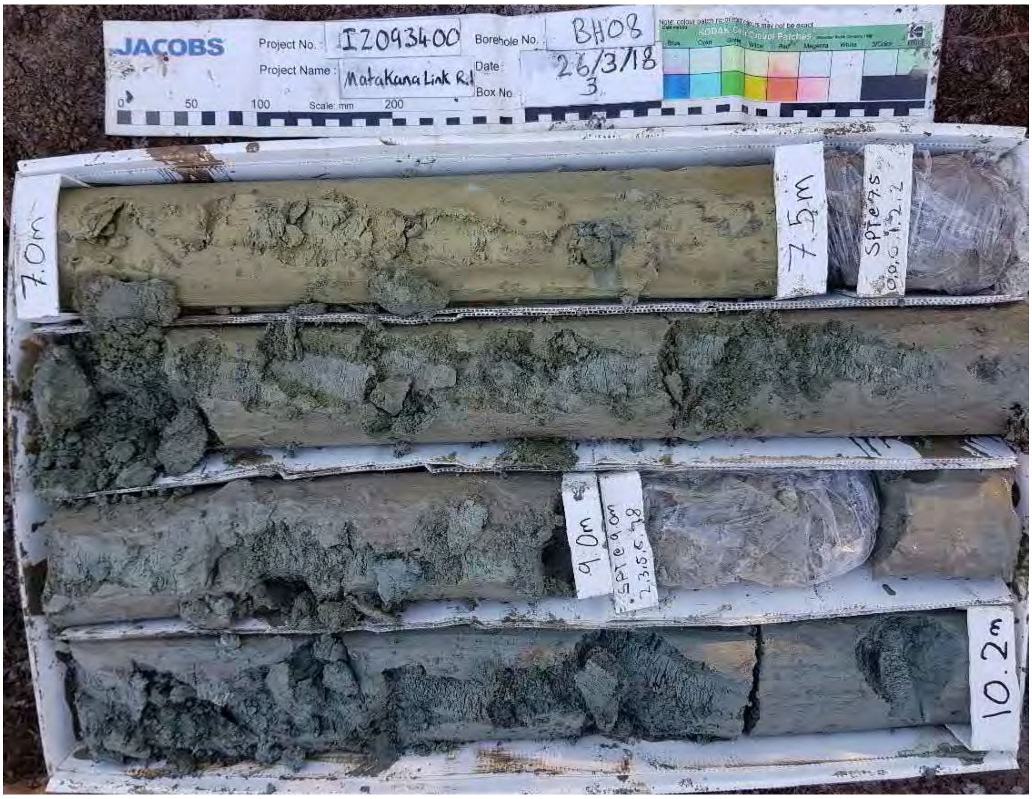
Driller: Prodrill	**Easting:** 5972170.5	**Elevation:** 56.23	**Started:** 26/03/2018
Plant: Track Mounted	**Northing:** 1748618.0	**Datum:** Auckland 1946	**Finished:** 29/03/2018
Logged by: LJ	**Grid:** NZTM2000	**Inclination:** -90	**Standard:** NZS 4402:1986
Checked by: SKA	**Accuracy:** dGPS0.1	**Orientation:**	**Status:** Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

BH08 Depth Range 0.00m - 2.40m

BH08 Depth Range 2.40m - 7.00m

Title	Core Photo BH08	*Project*	Matakana Link	*Client*	Auckland Transport
Scale	Not to scale	*Rev*	Revision 0		



BH08 Depth Range 7.00m - 10.20m

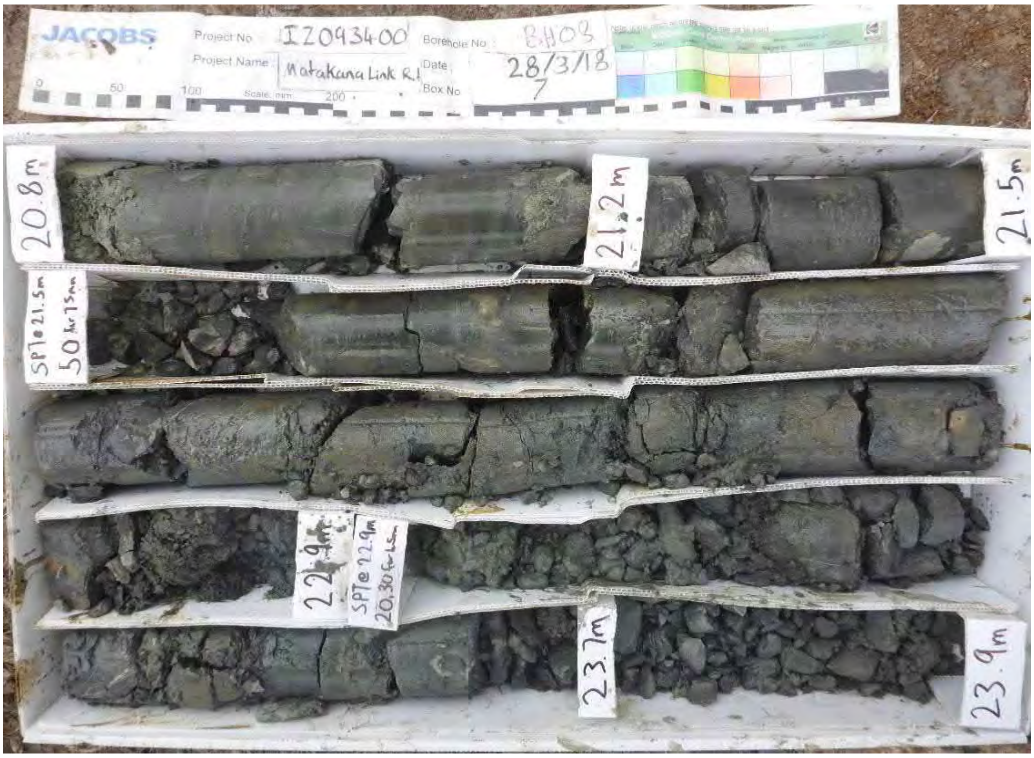
BH08 Depth Range 10.20m - 13.80m

Title	Core Photo BH08	*Project*	Matakana Link	*Client*	Auckland Transport
Scale	Not to scale	*Rev*	Revision 0		

BH08 Depth Range 13.80m - 18.00m

BH08 Depth Range 18.00m - 20.80m

Title	Core Photo BH08	*Project*	Matakana Link	*Client*	Auckland Transport
Scale	Not to scale	*Rev*	Revision 0		



BH08 Depth Range 20.80m - 23.90m

BH08 Depth Range 23.90m - 26.00m

Title	Core Photo BH08	*Project*	Matakana Link	*Client*	Auckland Transport
Scale	Not to scale	*Rev*	Revision 0		

JACOBS Borehole log

Project:	SH1 to Matakana Road Geotechnical Investigation	**Hole ID:**	BH09
Client:	Auckland Transport	**Project No:**	IZ093400
Location:	Warkworth, New Zealand	**Page:**	1 of 3

Depth (m)	R.L. (m)	Drilling Method	TCR (RQD) (%)	In-Situ Testing	Sampling	Depth to base (m)	Description of Strata	Geological Unit
0.00–0.30		OB	100			0.30	SILT with trace rootlets; dark brown. Firm, moist, slightly plastic (TOPSOIL).	TOPSOIL
0.30–2.00	53	OB	100	I_{vp}63/I_{vr}16; I_{vp}110/I_{vr}31		2.00	SILT with some clay; yellowish brown mottled orange. Stiff, moist, slightly plastic. *1.00m: Becomes very stiff.* *1.30m: becoming sandy SILT with trace clay; pale grey with orange laminations. Horizontally laminated, stiff, moist, slightly plastic. Sand is fine to medium, poorly graded.* *1.70m: SILT with minor sand and trace clay; pale grey with orange laminations. Horizontally laminated, stiff, moist, slightly plastic. Sand is fine to medium, poorly graded.*	PAKIRI FORMATION
1.50–1.95	52	SPT	100	I_{vp}63/I_{vr}14; SPT_s=2,2,3 N=5	SPTLS			
2.00–2.15		OB	70			2.15	CORE LOSS	
2.15–2.35						2.35		
2.35–3.10	51	PT	100	I_{vp}25/I_{vr}3	U	3.10	Sandy CLAY with trace silt; pale grey with orange laminations. Horizontally laminated, soft to firm, moist, low plasticity. Sand is medium, poorly graded.	
3.10–3.70		SPT	100	SPT_s=0,1,1 N=2	SPTLS	3.70	SILT with minor sand and trace clay; pale grey mottled orange. Firm, moist, slightly plastic. Sand is fine, poorly graded.	
3.70–4.70	50	HQ3	100			4.70	Sandy CLAY with trace silt; pale yellowish grey mottled orange. Soft, wet, moderately plastic. Sand is medium, poorly graded. *4.20m: Becomes with trace fine gravel. Gravel is mudstone, grey, subangular, poorly graded.* *4.40m: Becomes dark grey.*	
4.70–6.10	49, 48	SPT / PT	100 / 100	I_{vp}38/I_{vr}8; SPT_s=1,1,3 N=4	SPTLS / U	6.10	SILT with trace clay; dark grey. Firm, moist, slightly plastic. *5.20m: Becomes with trace fine sand, poorly graded.*	
6.10–6.50		HQ3	100			6.50	Sandy CLAY with minor silt; dark grey. Firm, wet, slightly plastic. Sand is fine to medium, poorly graded	
6.50–7.20	47	SPT	100	I_{vp}28/I_{vr}2; SPT_s=2,2,3 N=5	SPTLS	7.20	SILT with minor sand and trace clay; dark grey. Firm, wet, slightly plastic. Sand is fine, poorly graded. Mudstone lenses present, 20 mm in diameter.	
7.20–7.90	46	HQ3	100			7.90	Sandy CLAY with minor silt and gravel; grey. Firm, wet, slightly plastic. Sand is fine to medium, poorly graded. Gravel is greenish grey mudstone, fine to medium, subangular, poorly graded.	
7.90–							SILT with trace clay and sand; grey.	

Column headings: R.L. (m); Depth (m); Drilling Method / Flush Return (%) 25 50 75; TCR (RQD) (%) 25 50 75; Spacing of Natural Defects (mm) 500 100 50 10; In-Situ Testing; Sampling; Rock Strength EW VW W MS S VS; Weathering Grade RS CW HW MW SW; Geology Legend; Groundwater; Description of Strata; Defect Description; Geological Unit; Backfill / Installation (BH09)

Driller:	Prodrill	**Easting:**	5972144.9	**Elevation:**	53.90	**Started:**	21/03/2018
Plant:	Track Mounted	**Northing:**	1748668.3	**Datum:**	Auckland 1946	**Finished:**	22/03/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

R.L. (m)	Depth (m)	Drilling Method / Flush Return (%)	TCR (RQD) (%)	In-Situ Testing	Sampling	Description of Strata	Defect Description	Geological Unit
		SPT	66	SPT$_s$=2,4,4 N=8	SPTLS	Firm to stiff, moist, slightly plastic. Sand is fine, poorly graded.		PAKIRI FORMATION
45		PT	80		U			
	9	HQ3	100			8.80 SILT with trace clay; grey. Very stiff to hard, moist, slightly plastic (COMPLETELY WEATHERED SILTSTONE).		
44		SPT	100	SPT$_s$=11,22,28/35mm N=50/185mm	SPTLS	9.40 Fine to medium SAND with trace silt, grey mottled dark grey. Very dense, moist, poorly graded (COMPLETELY WEATHERED SANDSTONE).		
43	10	HQ3	100(7)			10.05 Slightly weathered, grey, fine to medium grained SANDSTONE with siltstone inclusions. Weak.	**10.1 - m**: JT, 0°, clean, PR, RF **10.15 - m**: JT, 50°, clean, PR, RF **10.3 - m**: JT, 30°, clean, PR, S **10.4 - m**: CZ, 45°, Gravel infill, PR, RF **10.6 - m**: CZ, 0°, Silty Gravel infill, PR, RF **10.7 - m**: JT, 20°, clean, UN, RF **10.75 - m**: JT, 50°, clean, PR, RF **10.8 - m**: JT, 90°, clean, UN, RF	
	11	SPT	0	SPT$_s$=50/120mm			**10.85 - m**: JT, 20°, clean, PR, RF **11.1 - m**: JT, 35°, clean, PR, RF **11.2 - m**: JT, 20°, Sand infill, PR, S **11.3 - m**: JT, 30°, clean, UN, RF **11.55 - m**: JT, 30°, clean, PR, RF	
42	12	HQ3	100(33)				**11.85 - m**: JT, 5°, clean, UN, RF **11.85 - 11.9m**: JT, 60°, clean, UN, RF **12 - m**: JT, 30°, clean, UN, RF **12.1 - m**: JT, 40°, CA surface staining, PR, RF **12.12 - m**: JT, 40°, CA surface staining, UN, RF **12.2 - m**: JT, 20°, clean, PR, RF **12.3 - m**: JT, 65°, clean, UN, RF **12.4 - m**: JT, 50°, clean, UN, RF	
41		SPT	0	SPT$_s$=50/85mm		*12.50-12.70m: Completely fractured due to drilling and handling.*	**12.75 - m**: JT, 15°, clean, UN, RF **12.95 - m**: JT, 0°, Fe surface staining, PR, S	
40	13	HQ3	100(51)				**13.05 - m**: JT, 5°, clean, ST, RF **13.1 - m**: JT, 0°, clean, ST, RF **13.3 - m**: JT, 55°, clean, UN, RF **13.4 - m**: JT, 10°, clean, ST, RF **13.5 - m**: JT, 20°, clean, PR, RF **13.6 - m**: JT, 20°, clean, PR, RF	
39	14	HQ3	94(30)			*14.00-14.60m: Highly fractured zone.*	**14.05 - m**: JT, 15°, clean, PR, RF **14.1 - m**: JT, 25°, Fe surface staining, UN, RF **14.15 - m**: JT, 40°, clean, PR, RF **14.15 - 14.2m**: JT, 70°, Fe surface staining, UN, S **14.35 - m**: JT, 0°, clean, PR, RF **14.35 - 14.4m**: JT, 70°, Fe surface staining, PR, S **14.45 - m**: JT, 20°, clean, UN, RF **14.5 - 14.6m**: JT, 60°, CA surface staining, UN, RF **14.7 - m**: JT, 30°, clean, UN, RF **14.75 - m**: JT, 10°, Fe surface staining, UN, RF **14.9 - m**: JT, 30°, Fe surface staining, UN, RF	
38	15						**14.92 - m**: JT, 30°, clean, PR, RF **15 - m**: JT, 40°, clean, ST, S **15.1 - m**: JT, 10°, clean, PR, RF **15.2 - m**: JT, 5°, clean, UN, RF **15.25 - m**: JT, 5°, clean, UN, RF	
	16							

Other column headings: Spacing of Natural Defects (mm); Rock Strength (EW VW W MS S VS); Weathering Grade (RS CW HW MW SW); Geology Legend; Groundwater; Backfill / Installation.

Driller:	Prodrill	**Easting:**	5972144.9	**Elevation:**	53.90	**Started:**	21/03/2018
Plant:	Track Mounted	**Northing:**	1748668.3	**Datum:**	Auckland 1946	**Finished:**	22/03/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

R.L. (m)	Depth (m)	Drilling Method Flush Return (%)	TCR (RQD) (%)	Spacing of Natural Defects (mm)	In-Situ Testing	Sampling	Rock Strength	Weathering Grade	Geology Legend	Groundwater	Description of Strata	Defect Description	Geological Unit	Backfill / Installation
		HQ3	100(46)									15.3 - m: JT, 45°, clean, UN, RF, 0 mm 15.4 - m: JT, 50°, clean, UN, RF 15.95 - m: JT, 45°, clean, UN, S 16 - m: JT, 0°, clean, PR, RF 16.1 - m: JT, 45°, clean, ST, RF 16.2 - m: JT, 45°, clean, UN, RF 16.6 - m: JT, 30°, clean, ST, RF 16.65 - m: JT, 45°, clean, PR, S 16.7 - m: JT, 30°, CA surface staining, UN, RF	PAKIRI FORMATION	
37	17											16.75 - m: JT, 45°, clean, UN, S 16.8 - m: JT, 5°, clean, PR, RF 16.85 - 16.9m: JT, 45°, clean, UN, RF 17.6 - m: JT, 40°, Gravel soil infilling, PR, RF		
36	18	HQ3	100(67)								18.50	17.95 - m: JT, 0°, clean, ST, RF 18.05 - 18.1m: CZ, 5°, Gravel soil infilling, PR, RF 18.15 - m: JT, 5°, Black Mineral Alteration other, PR, RF 18.3 - m: JT, 30°, clean, PR, RF 18.4 - m: CZ, 5°, Gravel soil infilling, UN, RF 18.5 - m: CZ, 30°, Gravel soil infilling, UN, RF		

Hole Terminated at 18.50 m
Target depth

Driller:	Prodrill	**Easting:**	5972144.9	**Elevation:**	53.90	**Started:**	21/03/2018
Plant:	Track Mounted	**Northing:**	1748668.3	**Datum:**	Auckland 1946	**Finished:**	22/03/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

BH09 Depth Range 0.00m - 3.90m

BH09 Depth Range 3.90m - 8.50m

Title	**Core Photo BH09**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

BH09 Depth Range 8.50m - 12.20m

BH09 Depth Range 12.20m - 15.00m

Title	**Core Photo BH09**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

<u>**BH09 Depth Range 15.00m - 17.60m**</u>

<u>**BH09 Depth Range 17.60m - 18.50m**</u>

Title	**Core Photo BH09**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

Columns: R.L. (m) | Depth (m) | Drilling Method Flush Return (%) 25 50 75 | TCR (RQD) (%) 25 50 75 | Spacing of Natural Defects (mm) 500 100 50 10 | In-Situ Testing | Sampling | Rock Strength EW VW W MS S VS | Weathering Grade RS CW HW MW SW | Geology Legend | Groundwater | Description of Strata | Defect Description | Geological Unit | Backfill / Installation

Drilling Method	TCR (RQD) (%)	In-Situ Testing	Sampling
OB	100	I_{vp}172/I_{vr}66; I_{vp}110/I_{vr}44	
SPT	100	I_{vp}117/I_{vr}31; SPT_s=1,1,1 N=2	SPTLS
OB	100		
PT	100	I_{vp}47/I_{vr}31	U
SPT	100	SPT_s=0,0,2 N=2	SPTLS
OB	100		
SPT	100	I_{vp}54/I_{vr}19; SPT_s=0,0,0 N=0	
HQ3	90		
PT	100	I_{vp}31/I_{vr}16	U
SPT	100	SPT_s=0,0,1 N=1	SPTLS
HQ3	100		

R.L. (m): 58, 57, 56, 55, 54, 53, 52, 51

Depth (m): 1, 2, 3, 4, 5, 6, 7, 8

Description of Strata

0.15 SILT; dark brown. Stiff, dry, slightly plastic.

Clayey SILT; light brown with bands of orange and brown. Very stiff, moist, moderately plastic.

0.80m: Becomes with some fine sand.

2.40m: Becomes light grey mottled brown and orange, firm and medium to high plasticity.

3.70m: Becomes Sandy SILT with some clay; light brown. Firm, wet, moderately plastic. Sand is fine to medium, poorly grade

4.00 Sandy SILT with some clay; dark grey with faint light brown bands. Firm, wet, moderately plastic. Sand is fine to medium, poorly graded (COMPLETELY WEATHERED SILTSTONE)

7.00 Silty CLAY with some sand; dark grey. Stiff, wet, slightly plastic (COMPLETELY WEATHERED SILTSTONE).

Geological Unit: TOPSOIL; PAKIRI FORMATION

Backfill / Installation: BH10

Driller:	Prodrill	**Easting:**	5972147.8	**Elevation:**	58.37	**Started:**	19/03/2018
Plant:	Track mounted	**Northing:**	1748695.4	**Datum:**	Auckland 1946	**Finished:**	20/03/2018
Logged by:	CR/LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

Columns: R.L. (m) | Depth (m) | Drilling Method / Flush Return (%) (25 50 75) | TCR (RQD) (%) (25 50 75) | Spacing of Natural Defects (mm) (500 100 50 10) | In-Situ Testing | Sampling | Rock Strength (EW VW W MS S VS) | Weathering Grade (RS CW HW MW SW) | Geology Legend | Groundwater | Description of Strata | Defect Description | Geological Unit | Backfill / Installation

R.L. (m): 50, 49, 48, 47, 46, 45, 44, 43
Depth (m): 9, 10, 11, 12, 13, 14, 15, 16

Drilling Method	TCR (RQD) (%)	In-Situ Testing	Sampling
SPT	100	SPT_s=0,0,0 N=0	SPTLS
HQ3	100		
SPT	100	I_{vp}172/I_{vr}47 SPT_s=3,5,6 N=11	SPTLS
HQ3	100		
SPT	100	SPT_s=6,8,12 N=20	SPTLS
HQ3	100		
SPT	100	SPT_s=8,10,33 N=43	SPTLS
HQ3	100(48)		
SPT	0	SPT_s=50/85mm	
HQ3	100(69)		
SPT	0	SPT_s=50/70mm	
HQ3			

Description of Strata

8.00m: 30 - 40 mm thick bands of silty CLAY of medium plasticity encountered.

8.50

Clayey SILT with some sand; dark grey. Firm, wet, moderately plastic. Bands of medium sand present, 20-30 mm in thickness spaced 50 mm (COMPLETELY WEATHERED INTERBEDDED SILTSTONE AND SANDSTONE).

10.00m: Bands of medium grained SAND become 100 - 150 mm thick.

12.50

Completely weathered, grey, INTERBEDDED SILTSTONE AND SANDSTONE. Extremely weak, 75% siltstone and 25% sandstone. Siltstone recovered as: SILT; grey. 300 mm thick bands, hard, moist, slightly plastic. Sandstone recovered as: Clayey fine to medium SAND; grey. 100 mm thick bands, dense, moist, poorly graded.

13.20

Slightly weathered, dark grey, massive, coarse grained SANDSTONE. Weak.

15.50m: Becomes moderately strong and fine to medium grained.
15.55-15.85m: Becomes sub-horizontally laminated.

Defect Description

- **10.6 - m**: JT, 60°, clean, PR, RF
- **13.2 - 13.4m**: B, 20°, clean, UN, RF
- **13.4 - 13.5m**: JT, 65°, clean, PR, RF
- **13.55 - 13.6m**: JT, 35°, clean, PR, RF
- **13.7 - m**: JT, 45°, clean, PR, RF
- **14.25 - 14.35m**: B, 20°, clean, UN, RF
- **14.56 - 14.58m**: JT, 50°, clean, UN, RF
- **15 - m**: VN, 35°, CA infill, UN, RF
- **15.3 - m**: JT, 55°, clean, UN, RF
- **15.7 - m**: JT, 20°, clean, UN, S
- **15.9 - m**: JT, 10°, clean, UN, RF

Geological Unit: PAKIRI FORMATION

Driller:	Prodrill	**Easting:**	5972147.8	**Elevation:**	58.37	**Started:**	19/03/2018
Plant:	Track mounted	**Northing:**	1748695.4	**Datum:**	Auckland 1946	**Finished:**	20/03/2018
Logged by:	CR/LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

R.L. (m)	Depth (m)	Drilling Method / Flush Return (%)	TCR (RQD) (%)	Spacing of Natural Defects (mm)	In-Situ Testing	Sampling	Rock Strength	Weathering Grade	Geology Legend	Groundwater	Description of Strata	Defect Description	Geological Unit	Backfill / Installation
42		HQ3	100(73)									**15.95 - m**: JT, 50°, clean, UN, RF **16.4 - m**: JT, 50°, clean, PR, RF **16.55 - m**: CZ, 40°, Gravel soil infilling, PR, RF **16.7 - m**: JT, 30°, clean, UN, S	PAKIRI FORMATION	
	17	SPT	0		SPT_s=50/50mm						*16.90-17.00m: 3x calcite veins stained orange, closed.* *17.00-17.60m: Becomes steeply inclined thinly bedded, interbedded with siltstone.*	**17.2 - m**: CZ, 45°, Gravel soil infilling, UN, RF		
41		HQ3	100(63)									**17.45 - m**: JT, 45°, clean, UN, RF **17.6 - m**: JT, 45°, clean, PR, RF **17.62 - m**: VN, 45°, CA infill, UN, RF **17.7 - m**: JT, 25°, clean, PR, RF **17.8 - m**: JT, 20°, clean, UN, RF **17.95 - m**: JT, 45°, clean, PR, RF **17.98 - m**: JT, 0°, Fe surface staining, ST, RF		
40	18											**18.1 - m**: JT, 45°, CA infill, UN, S **18.2 - m**: JT, 25°, clean, UN, RF **18.3 - m**: JT, 50°, clean, UN, RF **18.4 - m**: JT, 50°, clean, PR, RF		
											18.50-19.05m: Becomes steeply inclined thinly bedded.	**18.6 - m**: JT, 20°, Gravel soil infilling, UN, RF **18.7 - m**: JT, 35°, clean, UN, RF **18.8 - m**: JT, 25°, clean, UN, RF		
39	19	HQ3	100(56)								*19.10m: Becomes sub-horizontally, very thinly bedded.*	**19 - m**: JT, 25°, clean, UN, RF **19.1 - m**: JT, 0°, clean, UN, RF **19.15 - m**: JT, 60°, clean, UN, RF **19.25 - m**: JT, 25°, clean, PR, RF **19.5 - m**: JT, 85°, clean, UN, S **19.55 - m**: JT, 45°, clean, PR, S **19.8 - m**: JT, 65°, clean, UN, S **19.9 - m**: JT, 50°, clean, PR, RF		
	20										20.00			

Hole Terminated at 20.00 m
Target depth

Driller:	Prodrill	**Easting:**	5972147.8	**Elevation:**	58.37	**Started:**	19/03/2018
Plant:	Track mounted	**Northing:**	1748695.4	**Datum:**	Auckland 1946	**Finished:**	20/03/2018
Logged by:	CR/LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.

BH10 Depth Range 0.00m - 3.45m

BH10 Depth Range 3.45m - 6.10m

Title	**Core Photo BH10**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

BH10 Depth Range 6.10m - 10.40m

BH10 Depth Range 10.40m - 13.80m

Title	**Core Photo BH10**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

BH10 Depth Range 13.80m - 16.50m

BH10 Depth Range 16.50m - 19.30m

Title	**Core Photo BH10**	*Project*	**Matakana Link**	*Client*	**Auckland Transport**
Scale	**Not to scale**	*Rev*	**Revision 0**		

BH10 Depth Range 19.30m - 20.00m

Title **Core Photo BH10** *Project* **Matakana Link** *Client* **Auckland Transport**

Scale **Not to scale** *Rev* **Revision 0**

JACOBS

Borehole log

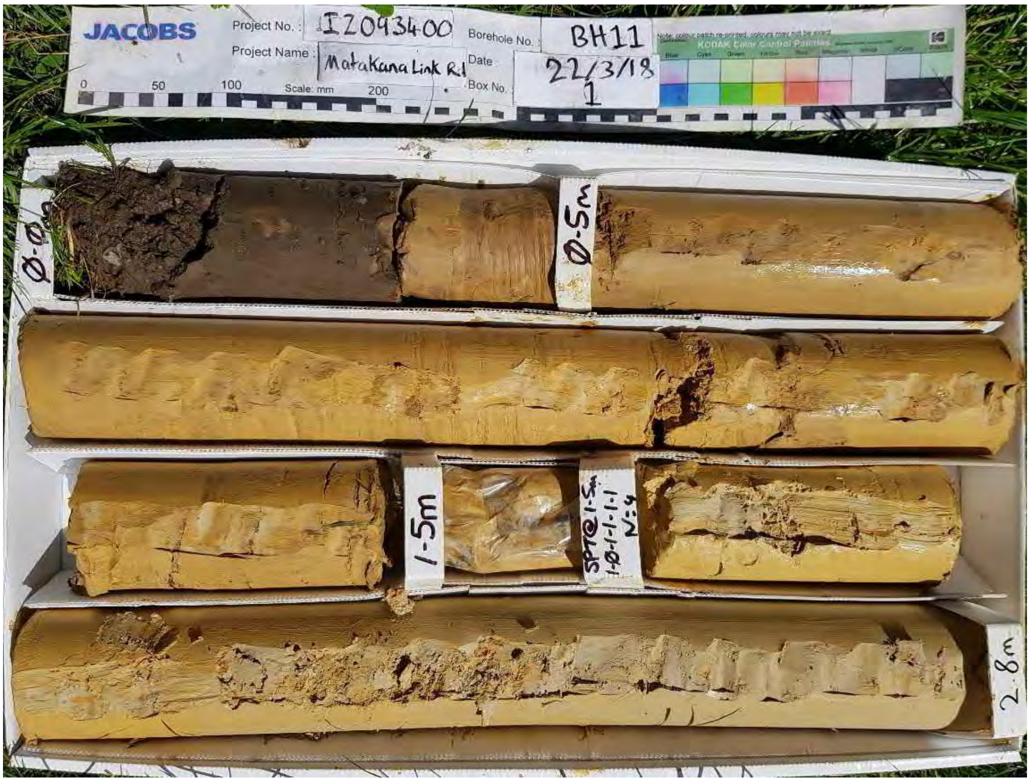
Project:	SH1 to Matakana Road Geotechnical Investigation	**Hole ID:**	BH11
Client:	Auckland Transport	**Project No:**	IZ093400
Location:	Warkworth, New Zealand	**Page:**	1 of 1

R.L. (m)	Depth (m)	Drilling Method / Flush Return (%)	TCR (RQD) (%)	In-Situ Testing	Sampling	Description of Strata	Geological Unit
65	0.20	OB	100			SILT with trace rootlets; dark brown. Soft, moist, slightly plastic.	TOPSOIL
				I_{vp}141/I_{vr}18		Clayey SILT; orangey brown. Very stiff, moist, slightly to moderately plastic.	PAKIRI FORMATION
64	1	OB	100			*0.80m: Becomes pale grey mottled orange.*	
		SPT	100	I_{vp}75/I_{vr}23 SPT$_s$=1,2,2 N=4	SPTLS	*1.50m: Becomes stiff.*	
63	2	OB	100				
62	3.00	SPT	100	I_{vp}47/I_{vr}22 SPT$_s$=1,1,3 N=4	SPTLS	Sandy SILT with trace clay; yellowish brown. Firm, moist, slightly plastic. Sand is fine to medium, poorly graded. *3.30m: Becomes grey.*	
	3.50	OB	65			Clayey SILT with trace fine sand; grey. Stiff, moist, slightly plastic.	
61	4.15					CORE LOSS	
	4.50	SPT	100	I_{vp}53/I_{vr}14 SPT$_s$=2,3,3 N=6	SPTLS	Sandy SILT with trace clay; grey. Stiff, moist, slightly plastic. Sand is fine to medium, poorly graded.	
	5.00					Hole Terminated at 5.00 m Target depth	

Other columns: Spacing of Natural Defects (mm); Rock Strength (EW VW W MS S VS); Weathering Grade (RS CW HW MW SW); Geology Legend; Groundwater; Defect Description; Backfill / Installation.

Driller:	Prodrill	**Easting:**	5972110.7	**Elevation:**	65.10	**Started:**	22/03/2018
Plant:	Track mounted	**Northing:**	1748774.0	**Datum:**	Auckland 1946	**Finished:**	22/03/2018
Logged by:	LJ	**Grid:**	NZTM2000	**Inclination:**	-90	**Standard:**	NZS 4402:1986
Checked by:	SKA	**Accuracy:**	dGPS0.1	**Orientation:**		**Status:**	Final

Remarks:
Shear vane calibrated DR2722
Uncorrected N value SPT
Hole location determined by dGPS0.1.



BH11 Depth Range 0.00m - 2.80m

BH11 Depth Range 2.80m - 5.00m

Title	Core Photo BH11	*Project*	Matakana Link	*Client*	Auckland Transport
Scale	Not to scale	*Rev*	Revision 0		

ATTACHMENT K1

TRAFFIC TPC

TRAFFIC PLANNING CONSULTANTS LTD

Warkworth: Clayden Road

Plan Change Request
to
Auckland Unitary Plan

Transport Assessment

Prepared By:
Todd Langwell

February 2020
Reference: 18161
Issue F – Updated Final

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Project Information:

Client	Warkworth Land Company Ltd
Job Number	18161
Title	Warkworth: Clayden Road - Plan Change Request to Auckland Unitary Plan - Transport Assessment
Prepared By	Todd Langwell
Date	February 2020

Document History and Status

Revision	Date Issued	Reviewed By	Approved By	Date Approved	Status
A	17/07/2019	P Kelly	T Langwell	17/07/2019	Draft
B	19/07/2019		T Langwell	19/07/2019	Final
C	09/08/2019		T Langwell	09/08/2019	Updated Final
D	07/10/2019		T Langwell	08/10/2019	Updated Final
E	14/10/2019		T Langwell	14/10/2019	Updated Final
F	07/02/2020		T Langwell	10/02/2020	Updated Final

TABLE OF CONTENTS

1.0 INTRODUCTION

The purpose of this report is to provide a Transport Assessment of a request to rezone blocks of land from Future Urban/Light Industry to a mix of residential zones. The plan change seeks rezoning land from Future Urban/Light Industry to a mix of residential zones. The plan change request includes the creation of a new precinct to be called "Warkworth: Clayden Road".

The overall land area is in an area between State Highway 1 and Matakana Road immediately north of the Warkworth Showgrounds. The area is generally rural in use with a small proportion of light industrial and is located within the Warkworth Structure Plan Area and a Future Urban Zone. The location of the site in relation to the road network is set out in other documents within the application. It basically consists of the following land holdings:

- Warkworth Land Company being the owner of two blocks of land known as the Stevenson and Clayden blocks;
- White Light Family Trust at 245 Matakana Road; and
- 21 Clayden Road and 35 Clayden Road.

Figure 1: General Site Location

This report describes the location of the site in relation to the adjacent transport environment; describes the form of a potential development and its connections to the road network; assesses the likely impacts of the rezoning on the transport environment; and assesses the proposal in terms of the relevant objectives and policies in the Auckland Unitary Plan (Operative in Part) (AUP). A focus of the assessment is on the largest of the land owners being the Warkworth Land Company as the planning for this site is further advanced, however the development of the other parcels of land are anticipated to be similar and consistent with the proposed zoning.

2.0 EXISTING TRANSPORT ENVIRONMENT

2.1 Road Network

The current access options for the site are limited to State Highway 1 near its western boundary, Clayden Road and Matakana Road, both near its eastern boundary.

<u>Clayden Road</u>
Clayden Road is a local road and is predominantly unsealed and narrow and connects to Matakana Road. Two-way flow is permitted however there are sections where unobstructed two-way flow is not possible. Traffic flows on Clayden Road are estimated to be no more than 200-300 vehicles per day.

<u>State Highway 1</u>
State Highway 1 (SH1) forms the transport corridor through the Warkworth area connecting Auckland to northern New Zealand and Warkworth's arterial and collector roads. SH1 is classified as Strategic Arterial Road and is a high-volume State Highway in the New Zealand Transport Agency's (NZTA's) One Network Road Classification. SH1 currently carries an estimated 22,000 vehicles per day near the proposed site. Currently, it is typically one traffic lane in each direction with localised widening near intersections and built up urban areas.

<u>Matakana Road</u>
Matakana Road is classified as an Arterial Road and connects with SH1 to the south of the site. It has dual functions of moving traffic and providing access to abutting properties. Matakana Road predominantly has a two-lane carriageway about 7.5 metres wide where one traffic lane is provided in each direction. Average daily traffic volumes on Matakana Road were measured to be 9,200 vehicles per day as of March 2018.

2.2 Future Transport Context

The Warkworth Structure Plan sets out the transport infrastructure anticipated to support future development in Warkworth including the site and the Future Urban Zones. Several conceptual networks have been evaluated and the following preferred and indicative projects have been identified. ***Figure 2*** illustrates the location of these projects in relation to the site. New road corridors are planned for:

- Matakana Link Road (MLR);
- Future Matakana Road extension to Sandspit Road;
- Western Collector – Northern and southern connection to SH1; and
- Ara Tūhono – Pūhoi to Warkworth, Road of National Significance (P2Wk).

Most critical to the accessibility of the site is the Matakana Link Road (MLR) which passes through the subject site and provides a high-quality connection to the wider network. Further discussion on the MLR and access options for the site are discussed below.

The site's improved connectively to other modes such as public transport, walking, and cycling are also identified in the Warkworth Structure Plan and will provide choice of travel mode and a higher level of accessibility to the wider network.

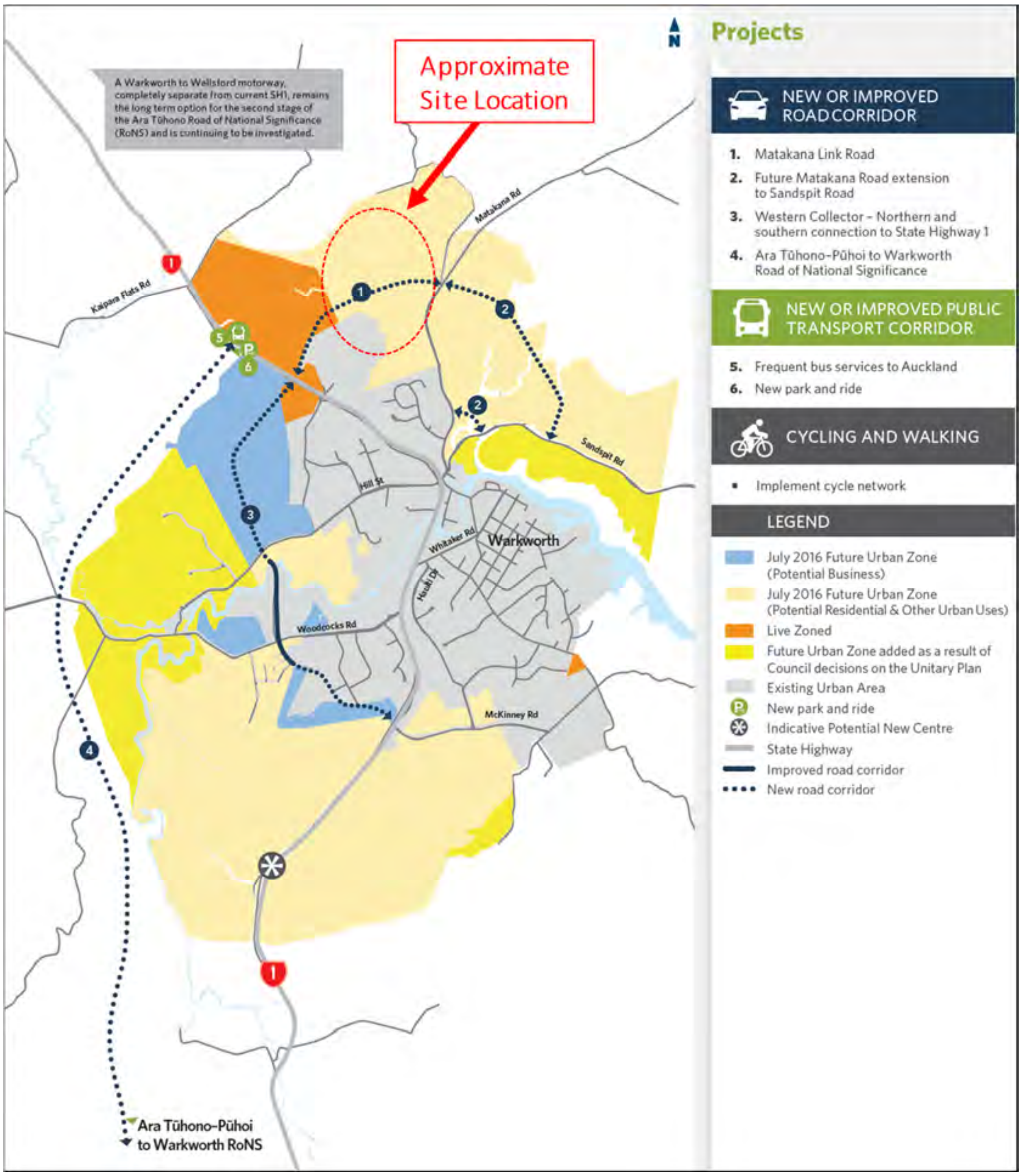


Figure 2: Supporting Growth Preferred Transport Network
Source: New Zealand Transport Agency/Auckland Transport

The following other projects are anticipated to be progressed through an alliance with Auckland Transport and NZTA to address the transport network issues in Warkworth:

- Short term strategies for managing network demands and improving safety, such as introducing smart technologies or improving efficiency of intersections along the existing SH1 will continue to be implemented while new roading infrastructure is developed in the medium to long term.

- Auckland Transport and NZTA has begun the investigation for upgrading the SH1/Hill Street intersection, which involves assessing possible improvements to the layout and increased capacity.

- Stage One of the Western Link route, connecting Mansel Drive to Falls Road, was opened to the public in March 2017. The exact route of the remaining two stages has yet to be determined but is likely to connect to SH1 in the vicinity of McKinney Road in the south and the MLR in the north.

- A new road network will also be investigated in the wider southern growth area when this area begins to develop, providing more local road options for north-south travel and east-west movements connecting back into SH1.

2.3 Existing Public Transport Accessibility

There are currently limited public transport services accessible to the site and within the Warkworth area. The nearest bus terminus where all services connect, is located within the town centre of Warkworth, about 25-30 minutes' walk from the site.

- Warkworth is now connected to the Hibiscus Coast Station in Silverdale (Route 995) with a service operating every 30 minutes ,7 days per week.

- There are also bus routes that connect Warkworth with Algies Bay and Snells Beach (Route 996) and Omaha, Matakana and Point Wells (Route 997) that operate hourly, 7 days per week.

- Regional bus services also operate daily between Auckland, Warkworth, Whangarei, and Kerikeri.

Future public transport is planned for Warkworth to support the planned population growth in the area. In the longer term, regional transport is planned to be provided between Auckland and Warkworth with an express bus service along P2Wk, supported by local bus services in Warkworth. There is plans to provide a park and ride bus station facility located near the P2Wk interchange on SH1, providing a high level of accessibility for the express service to the motorway. If implemented, this facility is expected to function as a public transport hub for north Warkworth and surrounding residential developments.

2.4 Pedestrian and Cyclist Facilities

There is limited walking and cycling opportunities near the site. No cycle facilities are provided on Clayden Road, or Matakana Road. To the south of the site, SH1 has a shared path between Hudson Road and Hill Street. The shared path connects with a cycle trail between Hudson Road and Matakana Road through the Warkworth Showgrounds.

In line with the Structure Plan aspirations for Warkworth, a cycle network is planned that connects Warkworth town centre with residential suburbs and commercial areas. This network will provide integrated walking and cycling infrastructure to facilitate active transport mode choices for residents and businesses throughout Warkworth.

2.5 Matakana Link Road (MLR)

The MLR is proposed to connect SH1 and Matakana Road with a new four-lane arterial road. Combined with the new Ara Tūhono – Pūhoi to Warkworth Motorway, 50% of traffic that uses SH1 to the south of Warkworth is anticipated to bypass the busy Hill Street intersection to the south of the site, relieving congestion in central Warkworth and improving traffic flow particularly around the Hill Street intersection.

MLR is also being provided to improve access to new growth areas and the eastern beach destinations and provide separate cycling and walking facilities.

Approximately 1.3 kms long with a road reserve width of 29.5 metres, the new road includes walking and cycling facilities on each side of the road. The road has been designed for a posted speed limit of 50km/hr.

Where the road intersects with SH1, a signalised intersection is proposed. Where the road intersects with Matakana Road a roundabout is proposed. Its indicative alignment and layout are shown in ***Figure 3*** and typical cross sections in ***Figure 4*** and ***Figure 5***.

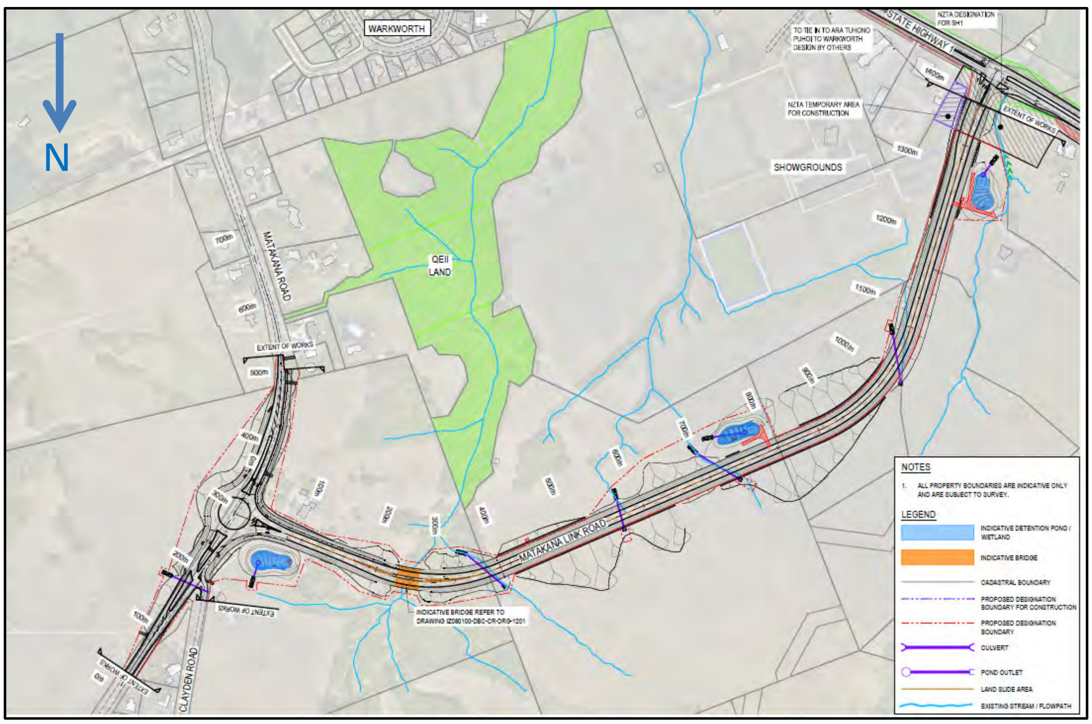


Figure 3: MLR – Indicative Alignment

Source: Auckland Transport Assessment – Jacobs – August 2018

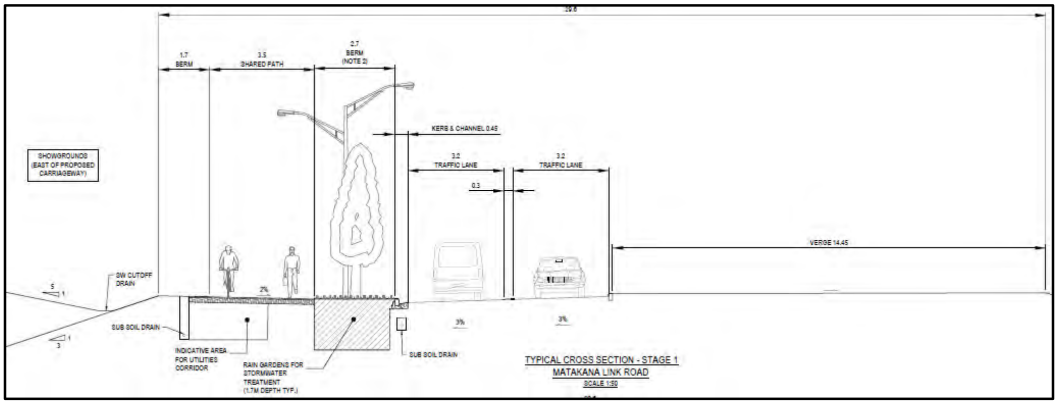


Figure 4: Proposed MLR Cross Section (Stage 1)
Source: Auckland Transport – Jacobs – August 2018

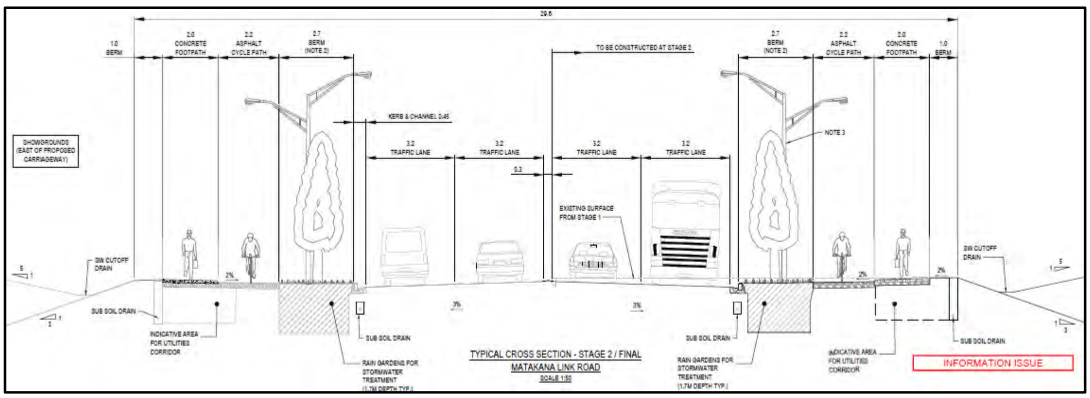


Figure 5: Proposed MLR Cross Section (Stage 2 and Final)
Source: Auckland Transport – Jacobs – August 2018

Based on the traffic modelling that informed the Transport Assessment of effects of the MLR (prepared by Jacobs), the future traffic flows for MLR have been identified. The modelling involved forecasting and modelling the future transport network, including the MLR Project, for the years 2026 and 2036.

The modelled traffic flow demands assume that MLR Project will be constructed and development will occur around it, and therefore already includes traffic flow demands for the Future Urban zones and the subject site. The MLR is modelled as a four-lane arterial road connecting SH1 and Matakana Road, with four roundabouts along its length for accessing development including the subject site. There is no information as to the number of dwellings or scale of development for each site, but the model assumes full development of the Future Urban Zone.

The modelling anticipated average daily flows along MLR to be 11,500 vehicles per day in 2026 and 22,700 vehicles per day by 2036. Peak hour flows have also been anticipated to be in the order of about 985 vehicles per hour (vph) in 2026 and about 2,000 vph in 2036.

Following discussions with Auckland Transport, some key points to note regarding the MLR project:

- The project recently gained approval for a Notice of Requirement to designate the necessary land for construction, although it is current subject to an appeal by a number of parties;

- The road is anticipated to be constructed in two stages, initially as a two-lane road (one-lane in each direction) anticipated to be open by September 2021 to align with the completion of the Ara Tūhono – Pūhoi to Warkworth Motorway. Stage 2 will complete the final cross section of four traffic lanes, and is anticipated to be required by 2036 depending on traffic growth in the area;

- Local access roads are anticipated along the alignment to support future development with up to four connections points. These connections are anticipated to be controlled by traffic signals or roundabouts, or "left in/left out" priority control intersections depending on the anticipated demands;

- The spacing of these intersections are anticipated to be about 200 metres apart to provide optimal and safe operation of each, however this will be subject to a more detailed assessment and design at the time of any subdivision or land use consenting;

- Developers will be required to vest additional land to create these intersections and provide the necessary turning lanes and supporting infrastructure to mitigate and manage any effects; and

- Final approval of each intersection form and location will be subject to Auckland Transport agreement in consultation with NZTA.

2.6 The Warkworth Structure Plan – Supporting Growth ITA

In February 2019, the Supporting Growth Alliance prepare an Integrated Transport Assessment (ITA). The purpose of the ITA was to identify at a high level the proposed arterial and collector road network, the public transport network and active mode network to support the future growth of Warkworth in line with the Warkworth Structure Plan.

The ITA also identified the anticipated trip generation for the various structure plan zoning and land uses, provided high level traffic modelling outputs, and recommended intersection treatments and road cross sections for the key roads.

An addendum was also prepared in July 2019 to account for changes to the Warkworth Structure Plan following consultation with the public. The changes relevant to this proposal included an increased in residential density within the Warkworth Land Company site and other areas.

The proposal is located within Stage 1 of the Future Urban Land Supply Strategy (FULSS) that includes the Warkworth North Plan Change area (PC25) to the southwest of the site. The ITA has assumed a total of 2,300 households and about 1500 jobs within Stage 1.

Figure 6 below illustrates the proposed zoning and areas proposed under the Warkworth Structure Plan for the Warkworth: Clayden Road PPC area. It identifies various zones and estimated number of dwellings as follows within the proposed plan change area:

Ref:	Zone Type	Area (m²)	No. Dwellings
10	Mixed Housing Suburban	215,623	288
12	Mixed Housing Suburban	89,849	62
19	Mixed Housing Urban	418,527	561
24	Large Lot Size	235,583	23
27	Business – Neighbourhood Centre	3,000	5
Totals		**962,582**	**939**

As can be seen the Warkworth Structure Plan is anticipated a slightly higher yield than what is proposed. ***Figure 6*** also outlines the approximate boundaries for the Warkworth Clayden PPC in relation to each zone. A small portion of Zone 24 sits outside of the PPC area. However, this zone is only expected to yield 23 dwellings overall, therefore it is negligible in the context of the overall yield for the PPC area.

With regards to employment numbers, the Warkworth Structure Plan is estimating Zone 27 will have 10 employment jobs. The PPC also includes Business Neighbourhood Centre, however the number of employment jobs is not identified. Nevertheless, the different in job numbers are considered negligible in the context of the PPC area.

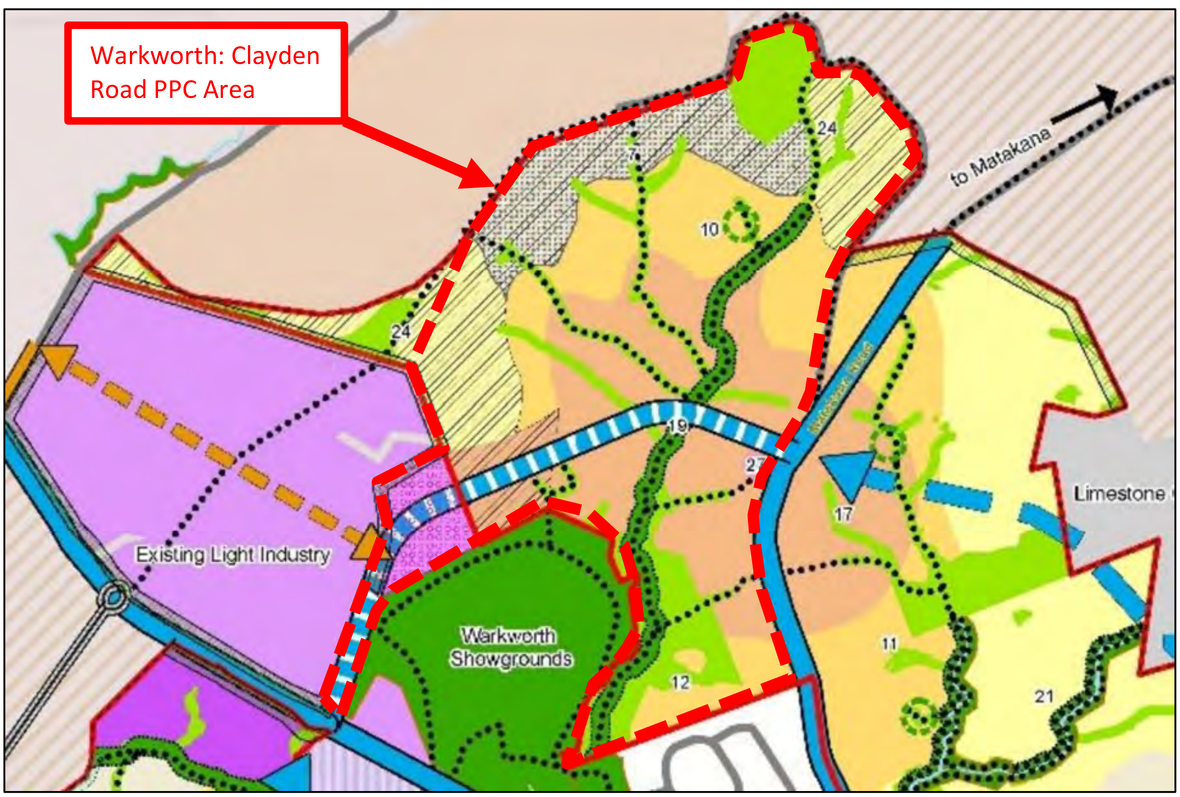


Figure 6 – Warkworth Structure Plan – Proposed Zoning (June 2019)

3.0 THE PROPOSAL

3.1 General Description

The plan change seeks rezoning land from Future Urban/Light Industry to a mix of residential zones. The plan change request includes the creation of a new precinct to be called "Warkworth: Clayden Road". The intention is to provide higher density adjacent to the MLR and the parklands, low density buffering the rural area, and medium density in between.

The proposed general zoning is illustrated in ***Figure 7*** and the anticipated transport provisions in ***Figure 8***.

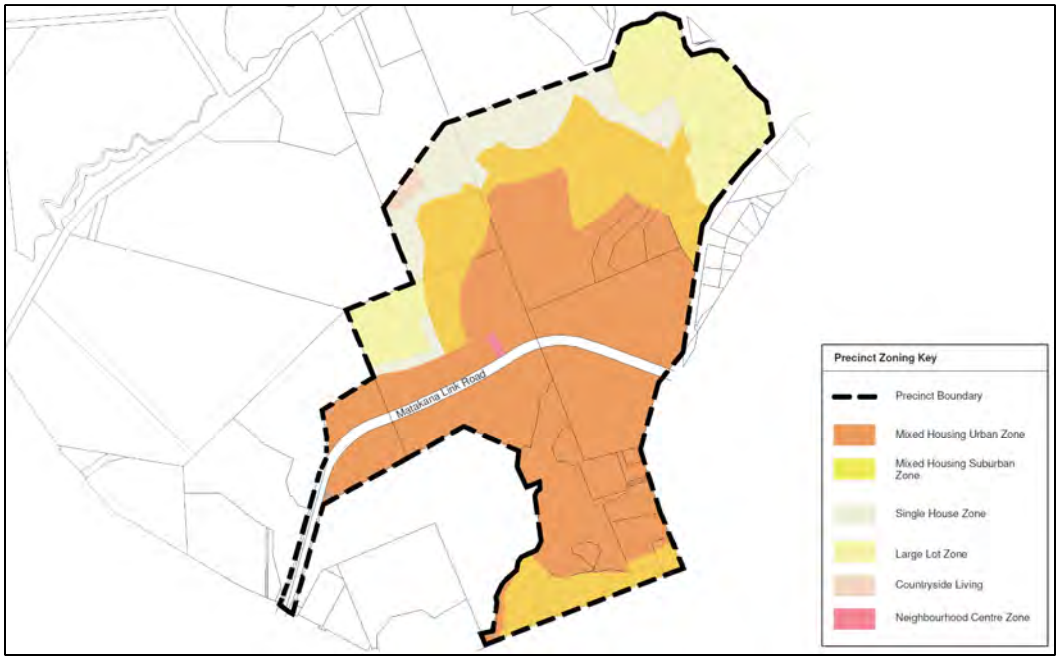


Figure 7: Proposed General Zoning Layout
Source: A Studio Architects

The key transport outcomes of the proposal are:

- To support the MLR including its alignment, as a vital link in the transport network for Warkworth and Mahurangi;
- To provide quality connected residential neighbourhoods to support the growth of Warkworth;
- To rezone a small area of light industry land to residential, recognising the unsuitability of this land for industrial activity given access constraints resulting from the MLR;
- Creating a network of walkways and cycleways through the plan change area with a series of roads and greenway routes; and
- Identifying key intersection on the MLR to provide access to the adjacent land for development.

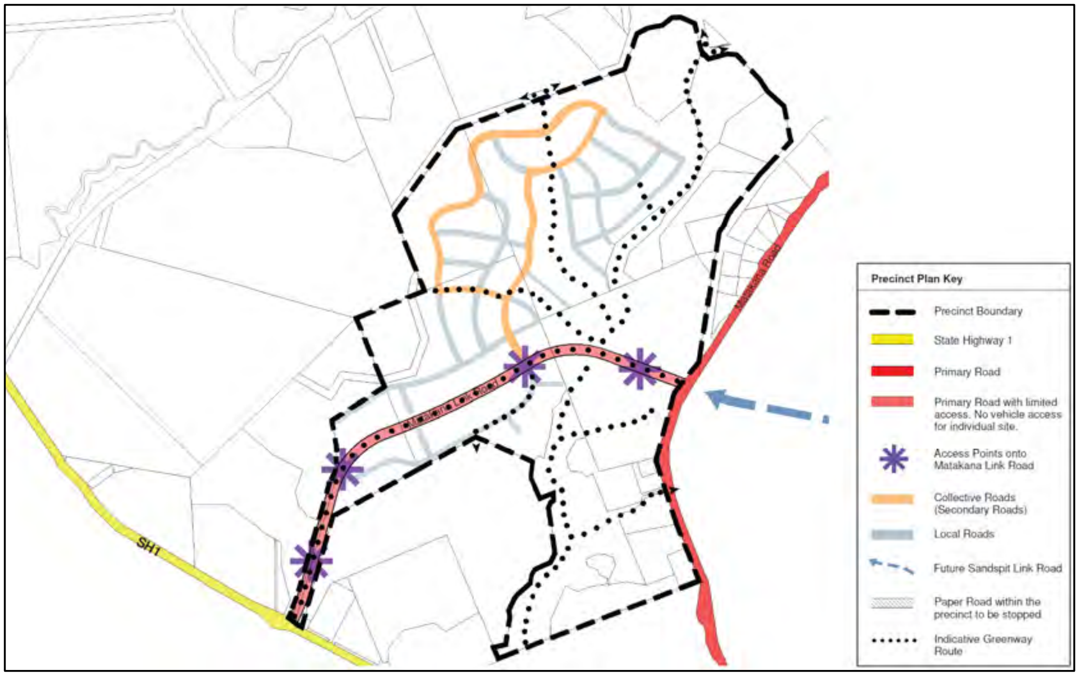


Figure 8: Proposed Transport Provisions
Source: A Studio Architects

The MLR provides the best opportunity for most of the plan change area to access the wider road network. It is intended to provide access to the Future Urban Zone (including the site) and create a section of an arterial road network which will enable access to the wider road network.

The MLR will provide certainty for developers on land accessibility. It will be a limited access road, which means there will be no driveways from adjoining properties on to the road in the long term however recognising that accesses to properties will be provided through certain points under a controlled environment.

It is anticipated that there will be up to four controlled intersections along MLR to provide access to neighbouring land (subject to Geotechnical, Ecology, and Civil requirements) as illustrated in ***Figure 8***. Two of the intersection locations can facilitate access to the live industrial zoned land, two intersection can support access to the Stevenson-Clayden land and one intersection location for the White Light Trust land. Their location and spacing has been agreed following discussions between Auckland Transport, NZTA and landowners.

These intersections need to be controlled by either traffic signals or roundabouts or limited to left turns only to support the safety and performance of the MLR. All locations will have the ability to be either "T" or Crossroad junctions to support development on land to the north and south of the MLR.

Further traffic modelling and assessment will be necessary to verify the intended layout of the intersections and their suitability to accommodate the anticipated flows as land use occurs.

3.2 Stevenson / Claydon

The potential masterplan for the Stevenson Claydon site is shown in ***Figure 8***. The location and alignment of all roads within the masterplan area have been designed to take account of topography and ecological features of the site as well as stormwater and geotechnical requirements and the alignment of MLR.

The Masterplan includes the ability for a special purpose sporting facility to be accommodated alongside the Warkworth Showgrounds. The facility is anticipated to be a facility like the Northern Arena in Silverdale that accommodates swimming and fitness activities for the local community. A small neighbourhood centre is also proposed to accommodate locally focused commercial and retail activities.

This masterplan is an example of the type of development this plan change will enable. It is not necessarily the final detailed form of development but represents likely development for the site.

Figure 8: Potential Masterplan Layout
Source: A Studio Architects

Figure 10 illustrates the potential mix of indicative lots sizes to match the proposed zoning. From a transport perspective, this provides enough information in order to quantify the potential trip generation that may occur from the site. A total of 691 lots were identified, with most ranging in size between 200 m² and 1,000 m². Approximately 50 lots have a size over 1,000m².

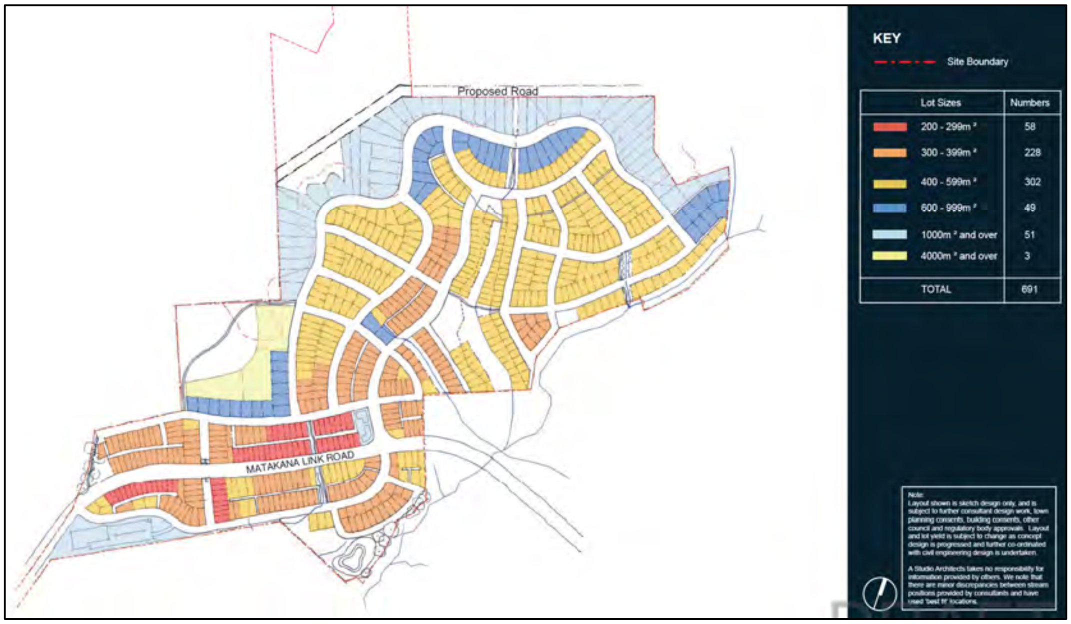


Figure 10: Indicative Lot Sizes
Source: A Studio Architects

3.2.1 Road Hierarchy

Figure 11 illustrates the potential road hierarchy for the site. The most significant road within the study area is the MLR which will provide the primary function of moving traffic and providing accessibility to the future growth areas including the Masterplan area. Full design details of this road have been provided above and its design has anticipated the development of the site and growth within the wider Warkworth area.

Figure 11: Potential Road Hierarchy
Source: A Studio Architects

A secondary "Collector" type road running in a north-south alignment will provide the primary access to most lots with the Masterplan area. The traffic volume anticipated on the secondary road will be in the order of about 3,500 to 5,000 vehicle movements per day depending on the future extension of the road. This level of traffic flow falls within the usual thresholds for classification as a Collector Road and would be capable of performing collector-type functions such as distributing traffic, accommodating pedestrian and cycling facilities. It is intended that this road will be designed for these functions and will likely have slightly wider road reserve as a result.

The balance of the Masterplan involved a network of local and recreational edge roads that will provide access to most lots. These roads are anticipated to carry no more than 500 vehicle movements per day in line with local road functions.

3.2.2 Walking and Cycling Strategy

Figure 12 illustrates the potential walking and cycling routes through the Masterplan area. The masterplan will provide high quality walking and cycling infrastructure to minimise the need to use private vehicles for the trips within the site. For instance, all collector roads will provide protected cycleways and footpaths, and recreational routes will be provided along the green corridors.

By providing a high standard of pedestrian and cycle facilities, pedestrians and cyclists of all ages can move safely through the area with minimal risk. This will be an important function of any future development.

Figure 12: Proposed Masterplan & Road Hierarchy
Source: A Studio Architects

3.2.3 Road Design Principles

Best-practice residential area design aims to produce liveable residential neighbourhoods that contribute to safety, good health, efficiency, and sustainability while having good levels of amenity.

Street patterns that allow good access through and around the area and to local services by walking and cycling are beneficial, and guidelines generally talk about connectivity and permeability as being desirable attributes. Legibility is another desirable attribute and the creation of self-explaining roads.

It is desirable for residents to be within easy walking distance of public transport services and local service centres to assist in reducing demand for private vehicle travel. Pedestrian walkability catchments are generally based on good access being provided within 400 metres or about 5-minutes' walk with lesser access being provided within 800 metres or 10-minute walk.

In terms of intersection design, crossroads on streets where traffic volumes are higher have been shown to have poorer crash records. In general, where traffic volumes are higher than 1000 vehicles per day consideration should be given to controlling conflict at cross-roads. Roundabouts can be effective at controlling conflict and moderating speeds, although busy roundabouts can be difficult for pedestrians and cyclists to negotiate. Many guidelines refer to the desirability of avoiding crossroads by shifting roads to produce a series of "T" intersections instead.

The proposed Masterplan area is designed to make the most of opportunities to promote walking and cycling. It aims to provide for the daily needs of pedestrian and cyclist movements by:

- Connecting new footpaths with the proposed footpath network immediately outside the site;
- Creating opportunities for recreational walking and cycling through the area; and
- Providing a low speed street network that allows cyclists and vehicles to share the same carriageway on an equal basis.

3.3 White Light Family Trust – 245 Matakana Road

The White Light Family Trust block of land lies on the western side of Matakana Road and it has existing road frontage onto Matakana Link Road and Clayden Road. The future MLR divides the site into two land parcels to the north and south of MLR.

The proposed zoning for this land holding is Mixed Housing Urban zone consistent with the Warkworth Structure Plan 2019. About 210 medium density residential lots are with an approximate lot size of 300m². These are likely to be split evenly between both land parcels north and south of the MLR.

No masterplan is currently available; however, it is intended that the access provisions will be intended onto MLR, Clayden Road and Matakana Road.

Although subject to approval from Auckland Transport and NZTA, it is intended to have a "Left In – Left Out" intersection for both the northern and southern land parcels both connecting to MLR.

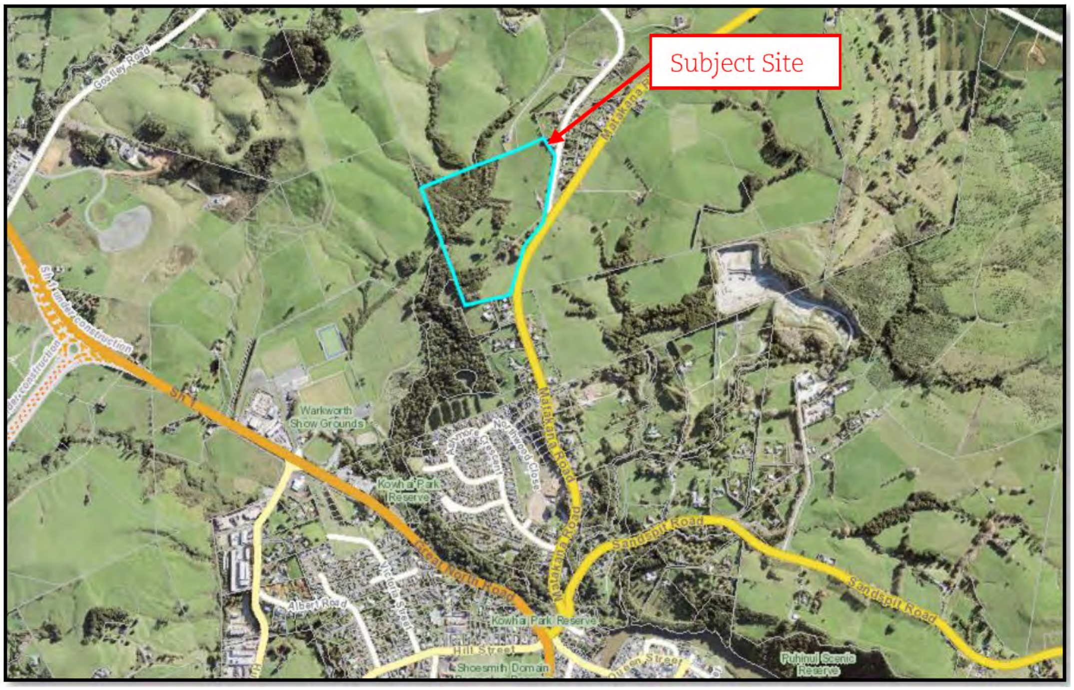


Figure 13: 245 Matakana Road
Source: Harrison Grierson

3.4 21 Clayden Road & 35 Clayden Road

These two properties are small land holdings both with direct access to Clayden Road. With the proposed plan change these sites are also intended to be consistent with the Warkworth Structure Plan as Mixed Housing Urban. Access to these lots are intended to continue via Clayden Road.

No details of potential yield are available, however given the size of the existing land parcels, the potential number of residential lots is intended to be negligible.

3.5 Overall Trip Generation

3.5.1 Residential

An indication of the trip generation for the site can be derived from survey data set out in the Roads and Traffic Authority (RTA), New South Wales – 'Guide to Traffic Generating Developments' publication.

The vehicle trip generation rates of residential dwellings can vary depending on the type of unit and location of the development. The RTA publication provides trip generation rates for single dwelling houses. It indicates daily and peak hour vehicle generation rates as set out in ***Table 1.***

Table 1: Estimated Trip Generation Rates

Lot Type	Daily Trip Rates (vpd)	Peak Hour Trip Rates (vph)
Low Density	9.0	0.85
Medium Density	6.5	0.65

Based on these adopted rates, the estimated number of trips for the total potential residential development for the plan change area is shown in ***Table 2***.

Table 2: Estimated Masterplan Area Trip Generation

Lot Type	No Lots	Daily Trip (vpd)	Peak Hour Trip (vph)
Low Density	405	3,645	344
Medium Density	496	3,224	322
Totals	**901**	**6,869**	**666**

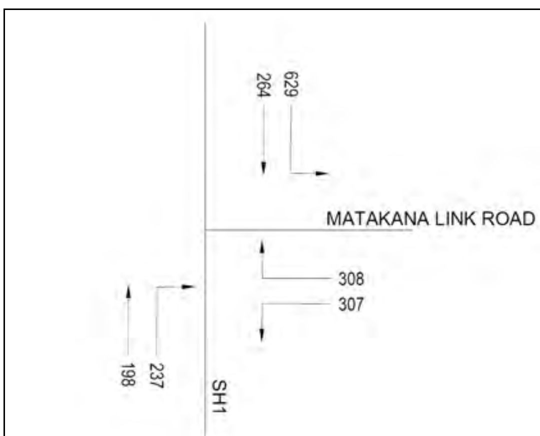
Based on a potential yield of about 900 dwellings and a mixture of low and medium density housing, the expected trip generation for the site is about 6,900 vehicle movements per day (vpd) and about 670 vehicle movements per hour (vph) during the two peak commuter periods.

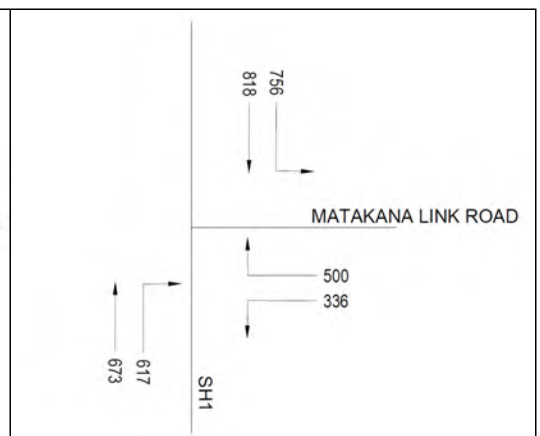
As a comparison, Section 7.4.6 of the Integrated Transport Assessment prepared by the Supporting Growth Alliance (SGA) and dated 13 February 2019 was prepared for the Warkworth Structure Plan sets out predicted vehicle trip generation rates used in that assessment as follows:

- 0.48 trips per dwelling in the morning peak hour;
- 0.36 trips per dwelling in the interpeak hour;
- 0.56 trips per dwelling in the evening peak hour, and
- 5.95 trips per dwelling per day.

In each instance the trip rates utilised by the SGA are lower than those rates used in our assessment. The lower rates are due to "discounts" that have been predicted by SGA for increases in public transport use, increases in use of other modes such as walking and cycling and car sharing, reduction in household sizes and occupations plus the reduction in the parking requirements set out in the Auckland Unitary Plan.

To provide some further comfort, ***Figure 13*** provides a comparison between the PM peak turning volumes predicted by the Warkworth Structure Plan (2046 volumes) and the TPC assessment (2036 volumes) for the MLR and SH1 approaches.





Warkworth Structure Plan (2046)	TPC Assesment (2036)

Figure 2 – Warkworth Structure Plan – Proposed Zoning (June 2019)

There are some differences in the through volumes shown on SH1 and the respective right turn movements from both roads. The difference in through movements is a result of our assessment utilising current volumes on SH1 where the SGA is predicting a reduction in the future. A large proportion of the right turn movements are flows assigned to the light industrial zone alongside the precinct. Some assumptions were made on their trip distribution as at the time of assessment nothing was available.

Given the predictions in the SGA assessment, NZTA and Auckland Transport appear to be comfortable with the proposed vehicle trip generation for future years. It can therefore be considered that our assessment of vehicle trip generation can be considered conservative. There is certainly the potential for the actual vehicle trip generation to be closer or even consistent with those predicted by the SGA. This will reduce the overall effects and can only be considered a positive.

3.5.2 Special Purpose Activity

The proposed Masterplan for the Stevenson Clayden Block also includes the ability to accommodate a special purpose sporting facility adjacent to the Warkworth Showgrounds. It is anticipated that such a facility could accommodate community focused swimming and fitness activity. For the purposes of this assessment, a trip generation rate like a fitness gym has been applied to a nominal gross floor area (GFA) of 1,500m². Based on a peak trip generation rate of 6vph/100m² GFA, the resulting trip generation during the peak commute times will be about 90 vph.

3.5.3 Neighbourhood Centre Zone

The proposal also allows for a small parcel of land to be zoned Business – Neighbourhood Centre zone to accommodate locally commercial and retail activities. As this will be a small and locally focused zone, it is anticipated to generate a negligible number of trips external to the precinct.

3.5.4 Light Industrial (Goatley Holdings)

Although not part of the plan change application (and still subject to resource consent), the trip generation relating to the Goatley Holdings Limited subdivision consent has been included in this assessment to understand the overall trip generation effects on the Matakana Link Road and its intersections with State Highway 1 and Matakana Road.

The ITA prepared by Stantec does not provide any details around predicted trip generation or distribution. The ITA states:

> *"Traffic modelling has been able to be included in this ITA report due to the lack of availability of existing traffic models by NZTA……..As travel patterns within the local area are likely to be fundamentally changed with these new roads, this modelling information is required in order to accurately determine the traffic effects associated with Stage Two of the subject development. An addendum report will be completed once this modelling information has been received."*

At the time of writing this report Stantec have begun their trip generation and modelling process and preliminary trip generation predictions have been provided to Traffic Planning Consultants Ltd regarding the proposed industrial subdivision indicated that a trip generation assessment. The following information has been provided and utilised for this assessment:

- The overall site has a estimated effective GFA of 206,908 m² based on a building coverage of 49%.

- Trip generation is based on a peak hour trip rate of 1.04vph per 100m² of GFA for general light industrial activities. A 30% trip reduction factor has then been applied to account for trips between activities within the subdivision; and

- A 75% inbound and 25% outbound split in the AM peak and reversed in the PM Peak will be applied to external trips. Most trips are expected to go to and from Sandspit, Warkworth Town Centre and Warkworth south.

It is noted that these predictions are preliminary and Stantec are reviewing their trip generation methodology and will be relying on the network modelling they are preparing to get more detailed information on trip distribution and assignments.

3.6 Trip Distribution

The expected trip distribution through the nearby intersections used for this assessment has been based on the information provided by Stantec (with some assumptions) and has been derived based on a gravity assessment of the potential lot layout to the wider road network derived from the distribution used for the traffic modelling assumed by Jacobs in their assessment of the MLR. The resulting traffic distributions of potential future traffic has been shown in ***Figure 14 and Figure 15***. This includes all predicted trips from the plan change area and the proposed industrial subdivision on the Goatley Limited block of land.

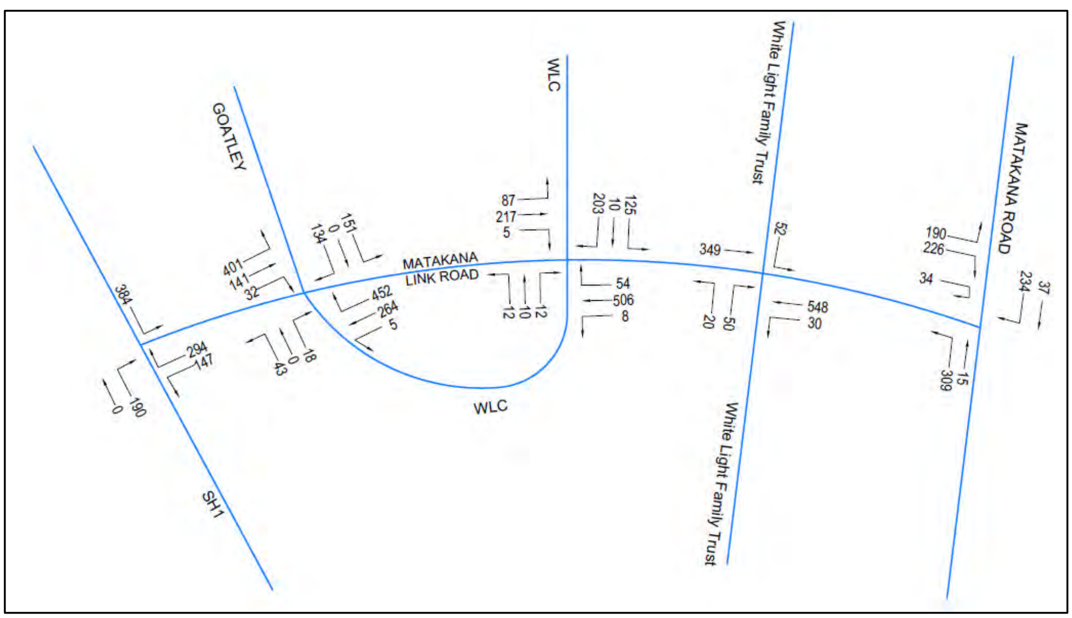


Figure 14: Predicted Trip Distribution – AM Peak

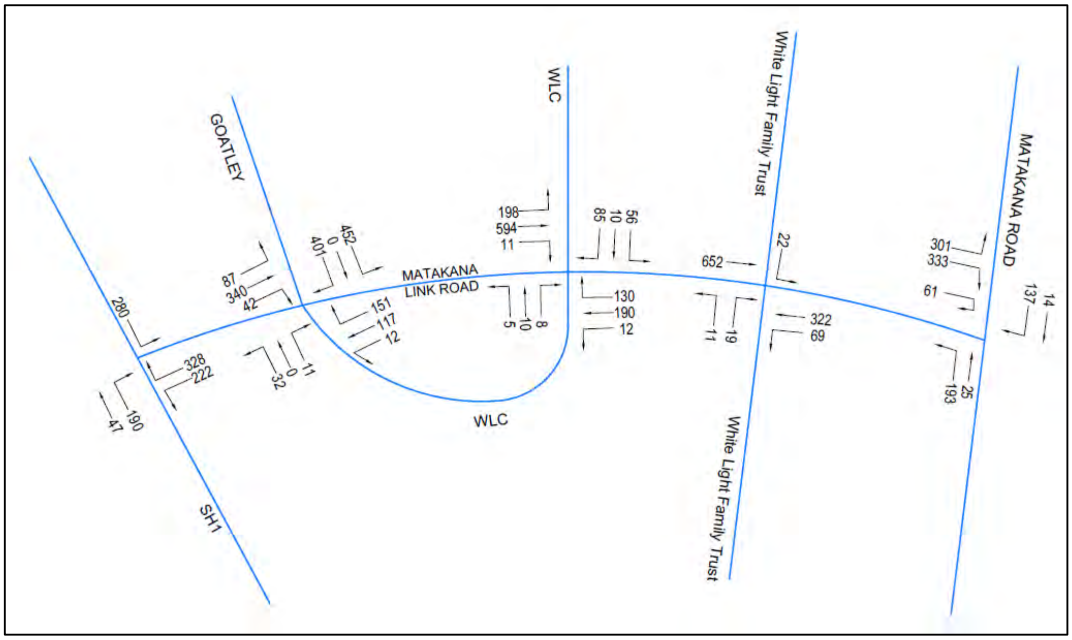


Figure 15: Predicted Trip Distribution – PM Peak

4.0 TRANSPORT ASSESSMENT

4.1 Intersection Capacity Effects

To test the likely effects of the generated traffic from plan change area, the two key intersections where Matakana Link Road connects with State Highway 1 and Matakana Road have been modelled using a SIDRA-8 traffic model. The models were created based on the following parameters:

- The models have been run for an AM and a PM peak hour for a design year of 2036. This is expected to be when the site will be fully developed, if not sooner.

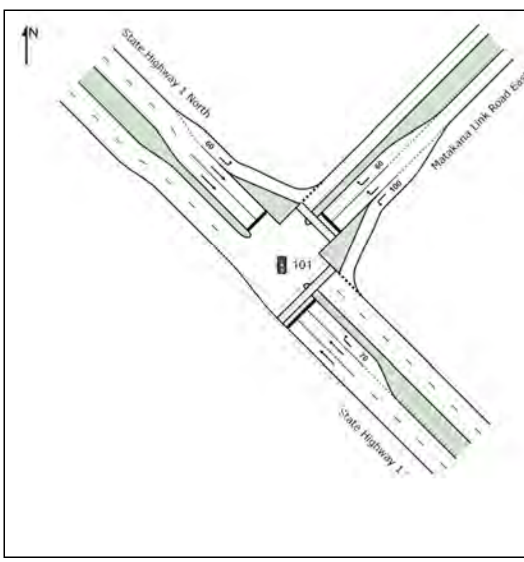
- Predicted base traffic volumes for the Matakana Link Road, State Highway 1 and Matakana Road have been extracted from the Transport Assessment and Saturn models prepared by Jacobs for the Matakana Link Road dated October 2018. The Saturn model included vehicle trips based on the development of the future urban and industrial zones adjacent to the MLR that are anticipated to have access to the it.

- A total of 1,028 vph in the AM peak and 1,409 vph in the PM peak were assigned to the subject sites (including the Goatley parcel) in the Saturn model. These trips and their distribution have been extracted from the model and replaced with those predicted trips and distribution shown in ***Figure 14*** and ***Figure 15*** above. This would anticipate full build out of the entire plan change area, establishment of a Northern Arena Complex and full development of the Goatley industrial subdivision.

- Intersection layouts are also consistent with the layouts and phasing presented in the Jacobs report and with what is expected to be constructed for Stage 1 of the Matakana Link Road; A signalised intersection at SH1 and a single lane roundabout at Matakana Road.

- In general, SIDRA-8 default values are used in both instances.

The layouts for each intersection are shown in ***Figure 16*** and the model results are provided in ***Figures 17-20***.



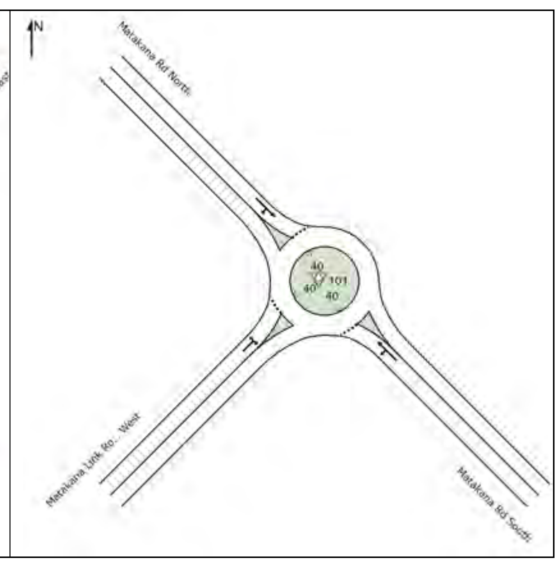


Figure 15: MLR Intersection Layouts (Stage 1)

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: Matakana Rd South												
1	L2	473	2.0	0.566	4.3	LOS A	5.0	35.8	0.73	0.60	0.75	47.2
2	T1	189	2.0	0.566	3.6	LOS A	5.0	35.8	0.73	0.60	0.75	48.8
Approach		662	2.0	0.566	4.1	LOS A	5.0	35.8	0.73	0.60	0.75	47.6
NorthWest: Matakana Rd North												
8	T1	283	2.0	0.499	3.2	LOS A	4.0	28.3	0.66	0.57	0.66	47.6
9	R2	313	2.0	0.499	9.5	LOS A	4.0	28.3	0.66	0.57	0.66	48.6
Approach		596	2.0	0.499	6.5	LOS A	4.0	28.3	0.66	0.57	0.66	48.1
SouthWest: Matakana Link Road West												
10	L2	239	2.0	0.424	2.9	LOS A	3.4	24.1	0.51	0.55	0.51	46.2
12	R2	294	2.0	0.424	8.5	LOS A	3.4	24.1	0.51	0.55	0.51	48.7
12u	U	36	2.0	0.424	10.6	LOS B	3.4	24.1	0.51	0.55	0.51	50.4
Approach		569	2.0	0.424	6.3	LOS A	3.4	24.1	0.51	0.55	0.51	47.7
All Vehicles		1827	2.0	0.566	5.6	LOS A	5.0	35.8	0.64	0.57	0.64	47.8

Movement Performance - Vehicles

Figure 17: SIDRA 8 Results – Matakana Road / Matakana Link Road – Roundabout (AM Peak)

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
SouthEast: Matakana Rd South												
1	L2	292	2.0	0.365	3.5	LOS A	2.7	19.2	0.61	0.47	0.61	47.6
2	T1	130	2.0	0.365	2.8	LOS A	2.7	19.2	0.61	0.47	0.61	49.2
Approach		422	2.0	0.365	3.3	LOS A	2.7	19.2	0.61	0.47	0.61	48.1
NorthWest: Matakana Rd North												
8	T1	265	2.0	0.663	10.3	LOS B	8.0	56.7	1.00	1.10	1.32	44.5
9	R2	255	2.0	0.663	16.6	LOS B	8.0	56.7	1.00	1.10	1.32	45.3
Approach		520	2.0	0.663	13.4	LOS B	8.0	56.7	1.00	1.10	1.32	44.9
SouthWest: Matakana Link Road West												
10	L2	515	2.0	0.833	3.5	LOS A	13.8	98.5	0.80	0.56	0.80	45.5
12	R2	648	2.0	0.833	9.1	LOS A	13.8	98.5	0.80	0.56	0.80	48.0
12u	U	64	0.0	0.833	11.1	LOS B	13.8	98.5	0.80	0.56	0.80	49.6
Approach		1227	1.9	0.833	6.8	LOS A	13.8	98.5	0.80	0.56	0.80	47.0
All Vehicles		2169	1.9	0.833	7.7	LOS A	13.8	98.5	0.81	0.67	0.89	46.7

Movement Performance - Vehicles

Figure 18: SIDRA 8 Results – Matakana Road / Matakana Link Road – Roundabout (PM Peak)

The modelling results for the Matakana Road / Matakana Link Road intersection show that the single lane roundabout will operate safely and efficiently during both periods, with minimal delay and queuing.

Saturation levels for all approaches remain well be capacity. A Level of Service (LOS) of A is expected in the AM peak for most approaches and the average delay for the overall intersection of 5.6 seconds. During the PM, similar performances are expected with an overall average delay of 7.7 seconds. The LOS remains at A for most approaches but reduces to LOS B for the Matakana Road (north) approach.

The results show that the new proposed roundabout intersection will continue to operate satisfactorily during all periods with the full development of plan change area.

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
Movement Performance - Vehicles												
SouthEast: State Highway 1 South												
2	T1	523	5.0	0.252	5.2	LOS A	2.7	19.8	0.55	0.46	0.55	46.7
3	R2	273	2.0	0.745	24.0	LOS C	5.8	41.4	0.99	0.95	1.25	37.5
Approach		796	4.0	0.745	11.6	LOS B	5.8	41.4	0.70	0.63	0.79	43.1
NorthEast: Matakana Link Road East												
4	L2	220	2.0	0.196	7.1	LOS A	1.4	10.2	0.49	0.65	0.49	45.6
6	R2	447	2.0	0.814	27.4	LOS C	5.1	36.6	1.00	1.02	1.48	36.1
Approach		667	2.0	0.814	20.7	LOS C	5.1	36.6	0.83	0.89	1.15	38.8
NorthWest: State Highway 1 North												
7	L2	405	2.0	0.361	7.3	LOS A	2.9	20.6	0.54	0.67	0.54	45.4
8	T1	585	5.0	0.774	20.1	LOS C	6.4	46.5	1.00	0.98	1.31	39.2
Approach		990	3.8	0.774	14.9	LOS B	6.4	46.5	0.81	0.85	0.99	41.5
All Vehicles		2453	3.4	0.814	15.4	LOS B	6.4	46.5	0.78	0.79	0.97	41.2

Figure 19: SIDRA 8 Results – State Highway 1 / Matakana Link Road – Traffic Signals (AM Peak)

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed km/h
Movement Performance - Vehicles												
SouthEast: State Highway 1 South												
2	T1	673	5.0	0.274	4.8	LOS A	4.2	30.6	0.45	0.39	0.45	46.9
3	R2	617	2.0	1.023	84.6	LOS F	37.0	263.4	1.00	1.48	2.21	23.1
Approach		1290	3.6	1.023	43.0	LOS D	37.0	263.4	0.72	0.91	1.30	31.4
NorthEast: Matakana Link Road East												
4	L2	336	2.0	0.276	7.8	LOS A	3.3	23.6	0.45	0.64	0.45	45.2
6	R2	500	2.0	0.910	44.6	LOS D	9.4	67.0	1.00	1.15	1.68	30.9
Approach		836	2.0	0.910	29.8	LOS C	9.4	67.0	0.78	0.94	1.18	35.4
NorthWest: State Highway 1 North												
7	L2	756	2.0	0.753	16.8	LOS B	13.8	98.5	0.83	0.93	1.11	40.8
8	T1	818	5.0	1.000	66.9	LOS E	21.2	154.9	1.00	1.54	2.12	26.1
Approach		1574	3.6	1.000	42.8	LOS D	21.2	154.9	0.92	1.25	1.63	31.6
All Vehicles		3700	3.2	1.023	40.0	LOS D	37.0	263.4	0.81	1.06	1.41	32.3

Figure 20: SIDRA 8 Results – State Highway 1 / Matakana Link Road – Traffic Signals (PM Peak)

The modelling results for the State Highway 1 / Matakana Link Road intersection show that the proposed traffic signals will also operate safely and efficiently during AM Peak period. An overall LOS of B is expected in the AM peak and the overall average delay for intersection of 15.4 seconds. The worst movement is anticipated to be the right turn movement from MLR with a LOS of C and average delay of 27.4 seconds.

During the PM, an overall average delay of 40.0 seconds. An overall LOS is expected to be LOS D. In general, an average LOS D or better for an intersection during the peak hours is considered appropriate for an urban area. It must be acknowledged that this level of service is only occurring for what is a short time of the day, with the balance of the day experiencing must better levels of service.

The worst movement is also anticipated to be the right turn movement from SH1 (south) with a LOS of F and average delay of 84.6 seconds. It is also noted that saturation levels for this movement are exceeding the allowable thresholds as well as the opposing southbound through movement on SH1. It is not unexpected given that these two movement are competing for the same green time.

Given the conservative analysis that comes with fixed time modelling that SIDRA-8 provides, it is anticipated that the intersection will experience a better performance and will be able to adjust green times and cycle time to meet demand. It is also acknowledged that further assessment and modelling may be necessary once the trip generation of the Goatley industrial subdivision is finalised.

As can be seen in Figure 2 above, and as discussed above, the future flows anticipated by Auckland Transport and NZTA are expected to be much lower for the right turn movements at the intersection. I therefore anticipate the intersection to operate at a much higher level of service than our assessment currently predicted.

Furthermore, it must be noted that the 260-metre-long queue that our SIDRA modelling is predicting is the 95% Back queue. This suggests that this length queue will only occur for a very short period during the busier hour of the day and for the most part queues will be much less than this. It is more appropriate to consider the 50% queue when determining effects on upstream intersection. In this case, our model predicts the 50% queue for the right turn into MLR to be no longer than 80 metres. For comparison, the SGA SIDRA modelling of the WSP has predicted a 95% back of queue to also be 80 metres long in 2046.

4.2 Future Intersection Upgrades

The two major intersection at either end of the MLR are also anticipated in the WSP to be upgrades in crossroad intersections with the completion of the Western Collector Road and the extension of Matakana Road to Snells Beach.

To illustrate the potential future operation of these intersections ***Figure 21*** and ***Figure 22*** provide the predicted intersection performance during the PM peak period for both intersections. As can be seen both intersections are anticipated to operate within their capacity in 2046.

MOVEMENT SUMMARY

Site: 125PM [125 SH1/ Western Link/ MLR]

2046 PM Peak Hour - Full Build Out
Signals - Fixed Time Isolated Cycle Time = 100 seconds (User-Given Cycle Time)
Variable Sequence Analysis applied. The results are given for the selected output sequence.

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop Queued	Effective Stop Rate per veh	Average Speed km/h
South: Western Link											
1	L2	535	10.2	0.726	22.7	LOS C	19.9	149.7	0.84	0.91	43.9
2	T1	392	3.8	0.726	33.8	LOS C	19.9	149.7	0.94	0.89	38.1
3	R2	83	2.5	0.217	41.3	LOS D	3.4	24.3	0.87	0.75	35.8
Approach		1009	7.1	0.726	28.5	LOS C	19.9	149.7	0.88	0.89	40.7
East: SH1											
4	L2	34	6.3	0.033	11.2	LOS B	0.5	4.0	0.38	0.63	49.9
5	T1	198	23.4	0.329	40.3	LOS D	4.5	38.1	0.92	0.73	36.3
6	R2	237	11.6	0.552	41.5	LOS D	10.2	78.7	0.92	0.82	35.5
Approach		468	16.2	0.552	38.8	LOS D	10.2	78.7	0.88	0.77	36.6
North: Matakana Link Road											
7	L2	307	6.8	0.717	25.7	LOS C	12.6	92.6	0.92	0.89	42.8
8	T1	425	3.2	0.717	33.6	LOS C	12.6	92.6	0.96	0.88	38.2
9	R2	308	4.8	0.818	52.2	LOS D	15.9	115.9	1.00	0.94	32.4
Approach		1041	4.8	0.818	36.8	LOS D	15.9	115.9	0.96	0.90	37.4
West: SH1											
10	L2	629	3.7	0.600	17.5	LOS B	16.8	121.5	0.69	0.83	46.1
11	T1	264	14.7	0.418	40.9	LOS D	6.1	48.4	0.94	0.75	36.0
12	R2	356	10.7	0.824	50.3	LOS D	18.3	139.9	1.00	0.94	32.8
Approach		1249	8.0	0.824	31.8	LOS C	18.3	139.9	0.83	0.85	39.2
All Vehicles		3768	7.9	0.824	33.2	LOS C	19.9	149.7	0.89	0.86	38.7

Figure 21: SIDRA Results – State Highway 1 / Matakana Link Road / Western Collector - (PM Peak 2046)
Source: SGA – WSP Integrated Transport Assessment

MOVEMENT SUMMARY

Site: 268PM [268 Matakana/ MLR/ SLR]

2046 PM Peak Hour - Full Build Out
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop Queued	Effective Stop Rate per veh	Average Speed km/h
South: Matakana Rd											
1	L2	139	6.1	0.355	4.6	LOS A	1.6	12.0	0.48	0.57	46.5
2	T1	167	13.2	0.355	4.5	LOS A	1.6	12.0	0.48	0.57	47.9
3	R2	44	0.0	0.355	9.0	LOS A	1.6	12.0	0.48	0.57	48.1
Approach		351	8.7	0.355	5.1	LOS A	1.6	12.0	0.48	0.57	47.4
East: Sandspit Link Rd											
4	L2	65	1.6	0.403	5.4	LOS A	1.9	14.8	0.60	0.68	46.2
5	T1	244	22.0	0.403	5.7	LOS A	1.9	14.8	0.60	0.68	47.5
6	R2	20	0.0	0.403	9.9	LOS A	1.9	14.8	0.60	0.68	47.8
Approach		329	16.6	0.403	5.9	LOS A	1.9	14.8	0.60	0.68	47.2
North: Matakana Rd											
7	L2	40	39.5	0.369	7.6	LOS A	2.2	18.5	0.73	0.75	45.5
8	T1	260	21.5	0.369	6.7	LOS A	2.2	18.5	0.73	0.75	47.1
9	R2	163	0.0	0.220	11.1	LOS B	1.2	8.1	0.67	0.82	45.3
Approach		463	15.5	0.369	8.3	LOS A	2.2	18.5	0.71	0.77	46.3
West: Matakana Link Rd											
10	L2	377	6.4	0.354	4.2	LOS A	1.6	11.9	0.38	0.52	47.0
11	T1	431	3.7	0.548	3.7	LOS A	3.4	24.0	0.44	0.53	47.4
12	R2	324	0.0	0.548	8.3	LOS A	3.4	24.0	0.44	0.53	47.6
Approach		1132	3.5	0.548	5.2	LOS A	3.4	24.0	0.42	0.53	47.3
All Vehicles		2275	8.7	0.548	5.9	LOS A	3.4	24.0	0.52	0.60	47.1

Figure 22: SIDRA Results – Matakana Rd / Matakana Link Road / Snells Beach Link Road - (PM Peak 2046)
Source: SGA – WSP Integrated Transport Assessment

5.0 AUCKLAND UNITARY PLAN CONSIDERATIONS

5.1 Section E27 – Objectives and Policies

Section E27.2 Objectives includes the following:

(1) Land use and all modes of transport are integrated in a manner that enables:

(a) the benefits of an integrated transport network to be realised; and

(b) the adverse effects of traffic generation on the transport network to be managed.

The proposed residential rezoning is suitably located for future access to public transport along State Highway 1 and Matakana Link Road. The future proposal to provide a Park and Ride facility to the west of the site will also provide good opportunities to promote public transport use. Provisions for introducing bus services through the site has been allowed for and will enable a high standard of access.

The proposed masterplan has also considered the provision of walking and cycling facilities that will connect to the wider road network. Provisions for walking and cycling have also been proposed on the MLR and the surrounding road network, which will provide a fully integrated network when completed.

As demonstrated in this report, any adverse effects of generated traffic on the transport network are expected to be accommodated through the proposed Matakana Link Road and proposed intersections.

Section E27.3 Policies includes the following:

(1) Require subdivision, use and development which:

(a) generate trips resulting in potentially more than minor adverse effects on the safe, efficient and effective operation of the transport network;

(b) are proposed outside of the following zones:

(i) the Business – City Centre Zone, Business – Metropolitan Centre Zone, Business – Town Centre Zone;

(ii) Residential – Terrace Housing and Apartment Buildings Zone;

(iii) the Centre Fringe Office Control as shown on the planning maps; or

(c) do not already require an integrated transport assessment or have been approved based on an integrated transport assessment to manage adverse effects on and integrate with the transport network by measures such as travel planning, providing alternatives to private vehicle trips, staging development or undertaking improvements to the local transport network.

The assessment contained in this report is considered appropriate for such a scale of development. Any potential minor adverse effects can be managed and mitigated through the provision of suitable intersections along Matakana Link Road.

5.2 Section E27 – Transport Standards

Section E27.6 Standards sets out the transport related standards for development. These standards are considered suitable to be applied to activities and any future development of the site.

Compliance with these standards would be assessed as part of any future resource consent application.

The site is to gain access directly from Matakana Link Road in the future, which is going to be a Limited Access Road. Resource consent is required for any new access onto limited access roads, and the effects will need to be assessed in detail at that time.

5.3 Section E27 – Assessment Criteria

These assessment criteria will need to be considered at the time of a future resource consent application. Notwithstanding that, this report demonstrates that access to the site can be provided safely and efficiently from the wider road network.

6.0 CONCLUSIONS

The following conclusions can be made in respect of the proposal to rezone the Warkworth: Clayden Road area in Warkworth:

- The potential residential development for the site is feasible in terms of the transportation perspective and has been anticipated in the future planning for the MLR and the Warkworth Structure Plan;
- Stage 1 of the MLR is anticipated to be completed in September 2021, with a future Stage 2 to be completed by 2036 (or as traffic flows dictate);
- As part of planning for the MLR, new intersections are anticipated to facilitate access to the site which will be required to be controlled by either a roundabout, traffic signal or priority control intersections with limited to left turns. These types of intersection are expected to be determined at the time of any subsequent resource consent applications;
- Developers will be required to vest additional land to create these intersections and provide the necessary turning lanes and supporting infrastructure;
- Final approval of each intersection form and location will be subject to Auckland Transport agreement in consultation with NZTA;
- Following the completion of the MLR, the site is considered to have a high level of accessibility to public transportation, walking, and cycling;
- The estimated traffic generation of the proposal is likely to be about 6,900 traffic movements per day with peak hour traffic generation of about 670 traffic movements per hour based on 901 residential lots within the subject site; and
- The estimated traffic generated by the proposal can be accommodated on the nearby road network.

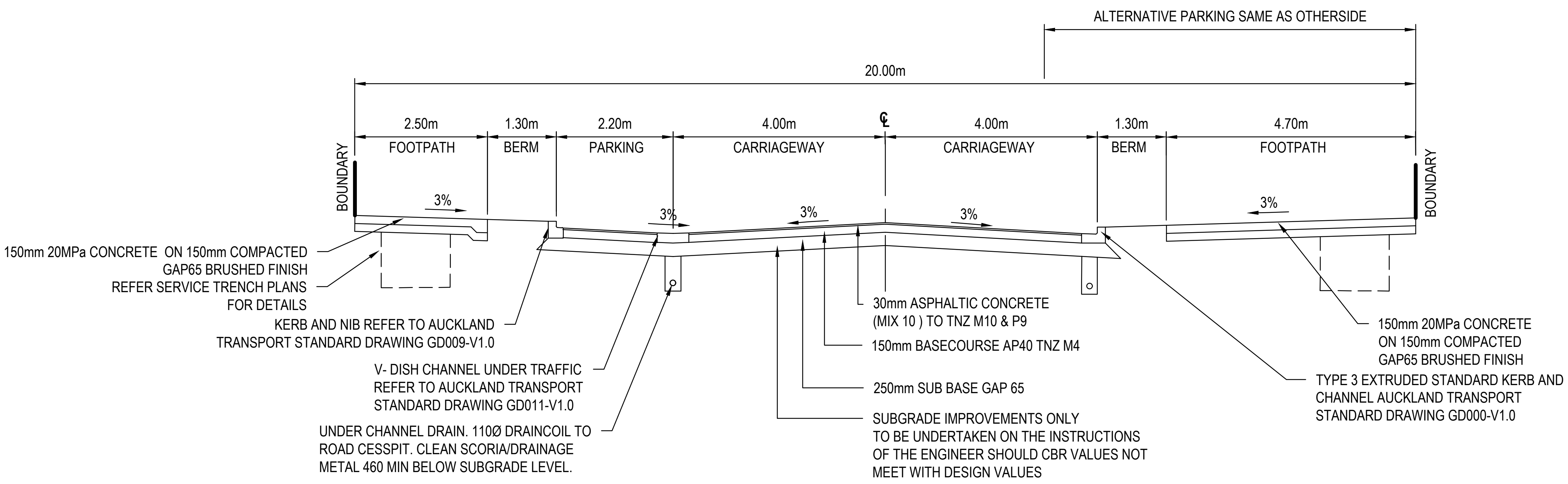
Prepared by,

Todd Langwell

ATTACHMENT K2

ROAD CROSS SECTION

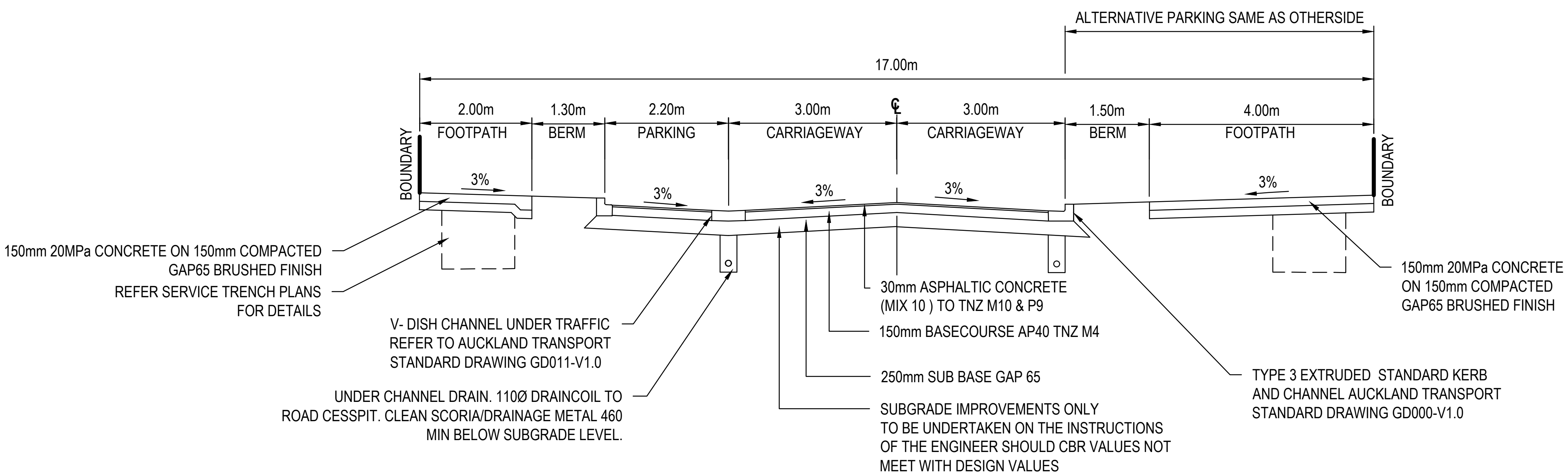
DRAFT



A
-
PROPOSED ROAD - SECTION A

SCALE 1:100 @ A3

DESIGN BASED ON MINIMUM CBR OF 5.0
(AT STANDARD COLLECTOR ROAD GD003)



B
PROPOSED ROAD - SECTION B

SCALE 1:100 @ A3

DESIGN BASED ON MINIMUM CBR OF 5.0
(AT STANDARD LOCAL ROAD GD004)

Notes

1. All works to be in accordance with Auckland Council standards.
2. Contractor is to avoid using GPS for set out of the kerb levels where gradients less than 1%.
3. It is the contractors responsibility to locate all services that may be affected by his operations.
4. The contractor shall comply with all relevant OSH and Health and Safety requirements.
5. The contractor shall obtain all necessary approval from utility operators before commencing work under or near their services.
6. Final pavement design subject to CBR/Beam tests on subgrade material.
7. Setout schedule with co-ordinates of chainage points along road centreline to be supplied to the contractor prior to construction.
8. Refer to long section for finished centreline levels. Refer to typical cross sections to obtain levels for other locations
9. All ducts shall have locations marked on kerb lines in accordance with specification.
10. Pram crossings are to be flush to the channel with no lip.
11. All kerb and channel to have sawcuts at max. 4m centres.
12. All kerbing, channels and edge beams shall have 4kg black oxide.
13. All signage and pavement markings to be in accordance with NZTA MOTSAM standards and the ATCOP TCDM.
14. All street name signs shall follow ATCOP guidelines in terms of layout, clearances, and construction details.
15. All line markings to be reflectorised in accordance with MOTSAM standards.
16. The minimum vertical and lateral clearances for signage shall be in accordance with MOTSAM standards.
17. Street lighting shall be designed in accordance with all applicable New Zealand Standards including but not restricted to the current version of AS/NZS 1158 Lighting for Roads and Public Spaces series of standards.
18. All new, modified or upgraded pram crossings must be in accordance with RTS 14 Guidelines for Facilities for Blind and Vision-impaired Pedestrians and NZS/AS 1428.4 and must comply with the details provided in AT's Standard Plan No.FP009.

Ref	Revisions	By	Date

	By	Date
Survey	-	-
Design	GB	12/18
Drawn	JW	12/18
Checked	GB	12/18

M A V E N
Maven Associates
09 571 0050
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www.maven.co.nz
12-14 Walls Road, Penrose

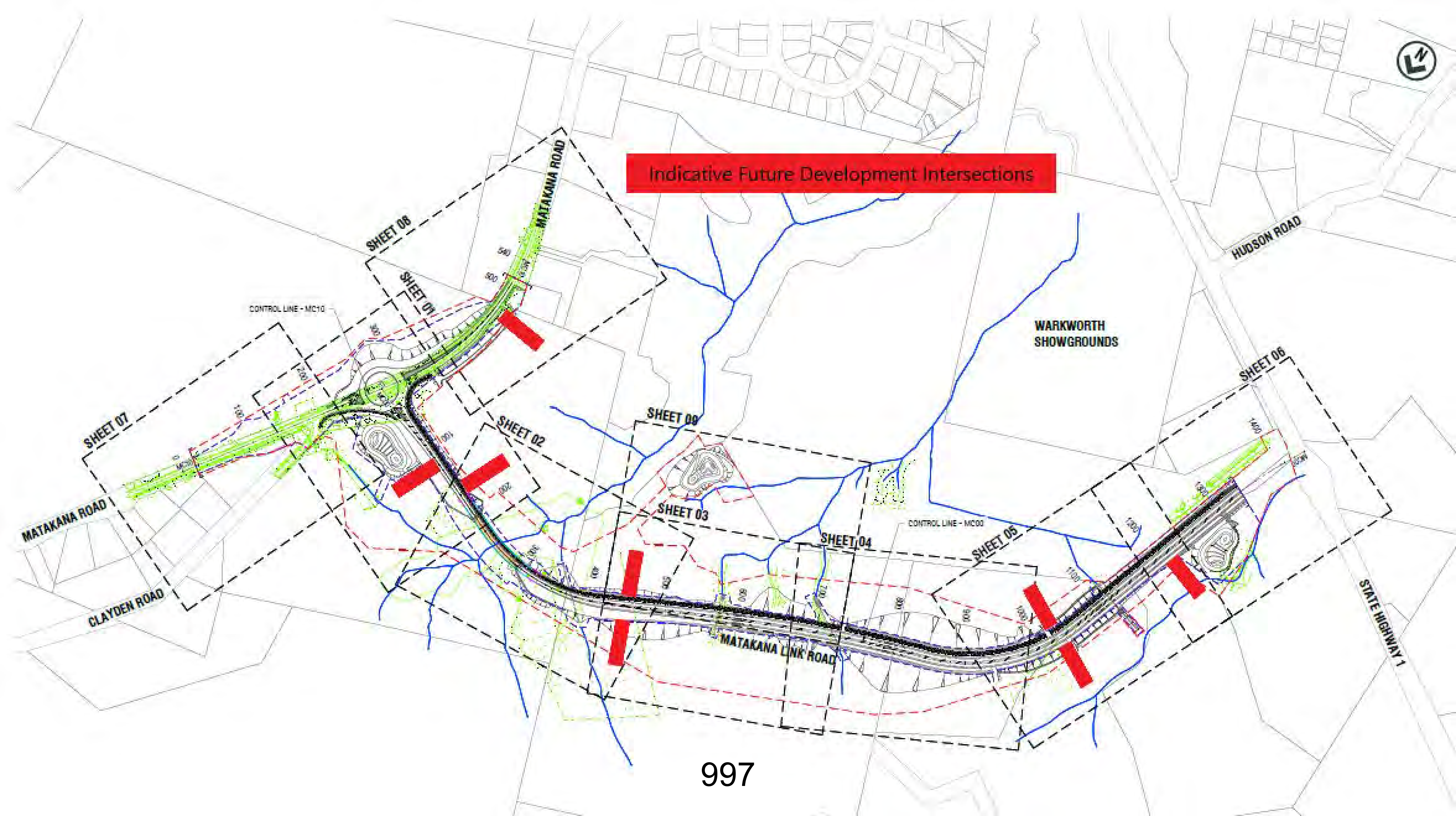
Project
GOATLEY ROAD & CLAYDEN ROAD WARKWORTH FOR L.J. PARTNERSHIP LTD.

Title
ROADING TYPICAL SECTION

Project no.	102008
Scale	AS MENTIONED
Cad file	ROAD SECTIONS
Drawing no.	C310 Rev A

ATTACHMENT K3

AT PLAN OF MATAKANA LINK ROAD INTERSECTIONS


Indicative Future Development Intersections
MATAKANA ROAD
SHEET 08
SHEET 01
CONTROL LINE - MC10
SHEET 07
MATAKANA ROAD
CLAYDEN ROAD
SHEET 02
SHEET 09
SHEET 03
SHEET 04
CONTROL LINE - MC00
SHEET 05
SHEET 06
WARKWORTH
SHOWGROUNDS
HUDSON ROAD
MATAKANA LINK ROAD
STATE HIGHWAY 1

ATTACHMENT L

LAND SUPPLY ASSESSMENT BY COLLIERS

Colliers INTERNATIONAL

Accelerating success.

Warkworth

Market Analysis
September 2018

Prepared for:
Warkworth Land Company Limited
c/o Development Advisory Services
Limited

Prepared by:
Colliers International

TABLE OF CONTENTS

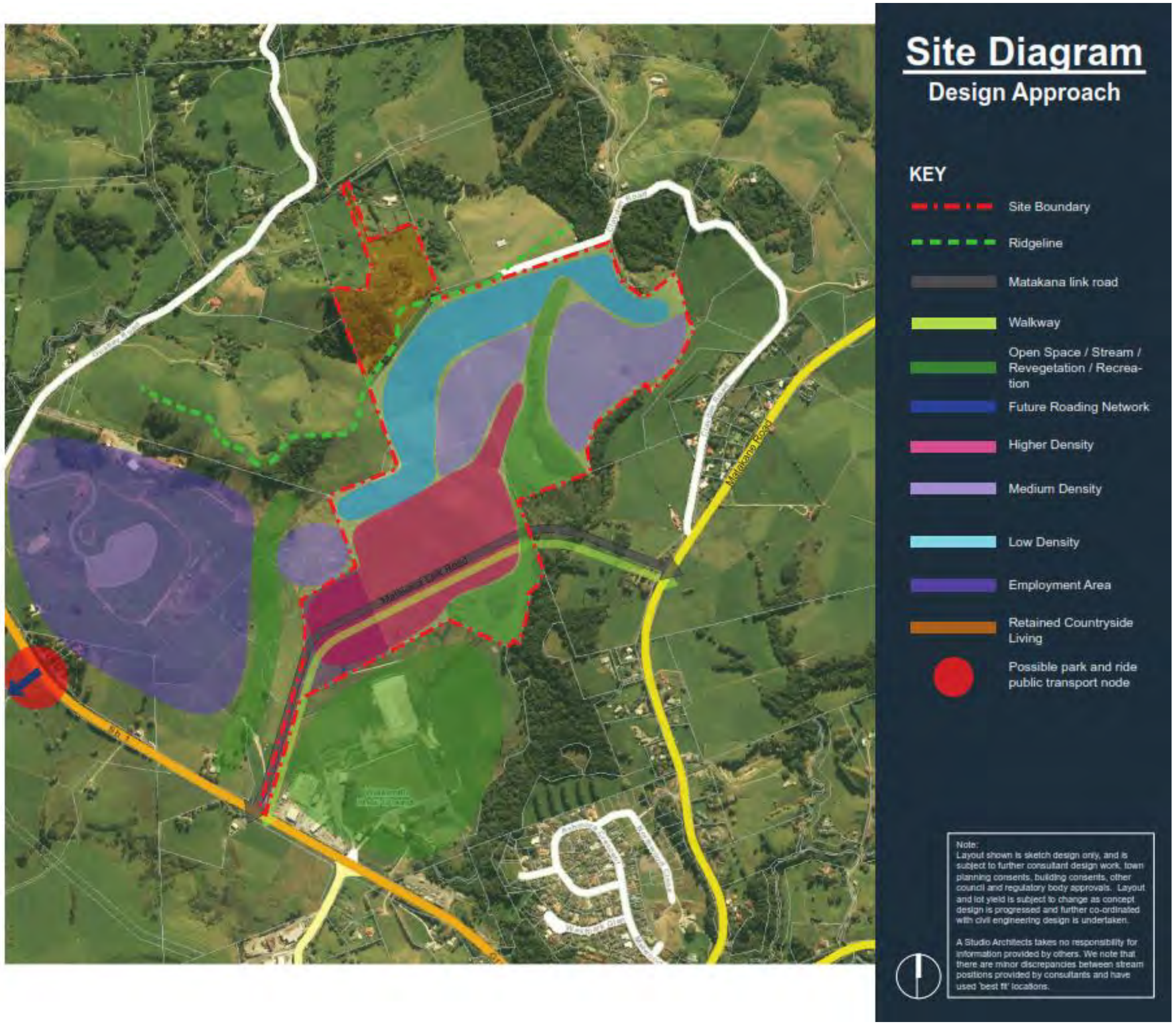
TABLE OF FIGURES

PURPOSE

Warkworth Land Company Limited c/o Development Advisory Services Limited has requested Colliers International to undertake research on the following matters:

- The demand for growth within the Warkworth area, and in Warkworth North in particular.
- An analysis of a logical distribution of growth across Warkworth.
- An analysis of the economic stimulation that this development will give to the Warkworth economy.

Figure 1: Warkworth Site



Source: Development Advisory Services Limited

KEY FINDINGS

Economic Profile and Growth

The industrial sector is Rodney Ward's highest producing sector in terms of gross domestic profit, however it is the lowest growth industry. Office is the second highest producing sector and the highest growth industry.

In Rodney Ward, in the two years to June 2018 a total of **1,787** residential dwellings have been consented (an average of **894** per annum). Commercial consents average only **45** per annum in the same period but the trend is upwards.

Industries employing the most people in the Rodney Ward are Construction, Health Care and Social Assistance, Retail Trade, and Accommodation and Food Services and are also the top growth industries.

In Rodney Ward, it is estimated that there will be **2,000** new jobs by 2023. If each of the 2,000 new jobs in Rodney was in a separate household, then that would be 2,000 potential new mortgage applicants and owner-occupier households by 2023.

Demographic Analysis

Cape Rodney South's population (the census area unit where the development is situated) is projected to grow by **84%** by 2038, meaning that around **992** homes (2.5 per household) are needed to meet population demand.

Warkworth's population is projected to grow by **79%** by 2038, meaning that around **1,292** homes (2.4 per household) are needed to meet population demand. Of those, **35%** are needed in the next 10 years (2018-2028).

In Rodney Local Board area there is growth forecast in all household arrangements, the largest proportionately being a **95%** increase in one-person households, suggesting that there is a demand for one-bedroom or studio accommodation, and also potential for sharing of larger homes.

Residential Demand

The majority of residential sales in Warkworth are three and four-bedroom dwelling sales.

Household growth forecasts estimate **456** homes will be needed in Warkworth area unit and **424** in Cape Rodney South, the other most relevant area unit, an average of **88** per annum to accommodate one household per dwelling, in each of the next 10 years (2018-2028).

Using REINZ data, North Shore's median of $1.048m in the last six months, compared to Warkworth's equivalent of $745,000, offers a compelling incentive for households to locate in Warkworth particularly as the increasing population will trigger amenity improvements over time.

Absorption: In order to sell 100 to 150 units (homes or sections) per annum, which we think is a reasonable target, sales at this site will have to capture a mix of the existing market activity in the immediately adjacent Warkworth area units, the wider catchment, and Auckland's North Shore.

An example of the proportions required to reach 150 units is:

- **Warkworth**, 20% of current annual sales activity (26) plus 20% of new house requirement (14) – total of **40.**
- **Target Catchment**, 5% of current annual sales activity (14) plus 5% of new house requirement (23) – total **37**, excluding Warkworth sales.
- **North Shore**, 2% of current annual sales activity – total of **74.**

It is likely that the majority of sales will be completed homes rather than sections. A more conservative forecast, halving the proportion of Warkworth and North Shore market capture to 10% and 1% respectively, still amount to 94 units per annum. Given the high quality of the location, local environment and masterplan, we would anticipate that 100-150 units per annum could be sold. One of the keys to an accelerated sales rate, or absorption, will be attracting buyers from North Shore. Even capturing 1% or 2% of North Shore's annual sales will require professional marketing, which we assume will be in place, and a maintenance of the financial incentive expressed above, in terms of the relative median prices.

KEY FINDINGS

Locational Benefits

Future infrastructure projects that will impact this development are significantly positive for demand. They are Ara Tūhono – the Warkworth to Wellsford road upgrade, SH1 Dome Valley safety improvements, Ara Tūhono – Pūhoi to Warkworth road upgrade (north of Warkworth), and the Pūhoi to Wellford (south of Pūhoi) road upgrade.

The Puhoi motorway extension will meet the existing SH1 at a roundabout around halfway between Hudson Road and Kaipara Flats Road, very close to one of the entrances to the subject site by the Warkworth showgrounds.

The new road, effectively also acting as a Warkworth bypass, will allow drivers to avoid the SH1/Hill Road/ Matakana Rd junction which is notoriously congested at times. Even those heading north to Matakana and the coast beyond can use the proposed Matakana Link Road shown as part of the development of the subject site, to avoid that junction.

The establishment of the new road will open up the north-west of the town which has so far seen very little development. Development of this site will, in comparison to development in other parts of the town, trigger less travel through the town as both the new motorway and Matakana Road will be immediately accessible from the subject site.

Warkworth North is in our view clearly the most logical part of the town to concentrate development.

There will inevitably be competing developments in and around Warkworth in the next few years as the attractiveness of the town improves. It is desirable that development and sales activity is encouraged at the most logical locations, those that will maximise efficiency and minimise traffic effects.

If this site could be developed relatively quickly and the house-buying public were aware that it was consented and virtually certain to proceed, then a greater proportion of new residents of Warkworth could be attracted to this site, with positive benefits in terms of efficiency.

Economic Stimulation

We have no information on land development or building construction costs, but the sums to be expended will clearly be very substantial. As a minimum, 600 sections will cost over $60m to develop at $100,000 per section and the construction of the houses, of say 100sqm each, will be at least $170m, a total development spend of say $230m.

Economic benefits can be categorised as direct, indirect and induced (or downstream). The calculations are based on New Zealand's input-output tables and suggest that each $1 of base construction investment will produce $2.51 (ignoring induced or downstream benefits) in economic activity.

Even basing the calculations on a conservative land and buildings spend, and assessing direct and indirect benefits only, the economic activity stimulated by the Warkworth development is likely to trigger some $577m of economic activity.

The downstream or induced impact takes account, for example, of the increase in spending as a result of increased household income and expenditure. Much of that increase will be spent in the local area in which it is activated, as of course that is where the workers and their households will be based.

The induced spend is estimated at 66 to 73 cents for each construction dollar. On that basis the entire downstream activity generated would be at least $150m. Therefore say $727m of economic stimulation would be activated. However much of that will be felt outside of the local economy.

If 25% of the direct and indirect activity was experienced in the locality, and also 50% of the additional induced activity was earned or spent in the locality, that would amount to $220m of economic stimulation for the local area.

ECONOMIC PROFILE AND GROWTH

RODNEY LOCAL BOARD - OVERVIEW

Auckland's northernmost local board, Rodney includes Kawau Island and Kumeu/Huapai, Helensville, Warkworth, Matakana and Wellsford.

Rodney Local Board covers an extensive area in the north of the region. The main townships are Kumeu/Huapai, Helensville, Warkworth, Matakana and Wellsford.

Dairying, horticulture, winemaking, tourism and forestry are key parts of the rural economy. As a result of proximity to Auckland, lifestyle blocks, retirement housing and holiday homes are also very popular.

At the southern end of the board area is the Kaipara Harbour, the largest enclosed harbour in the southern hemisphere.

Ngati Whatua Nga Rima o Kaipara has five marae in this area.

Note Rodney Local Board area and Rodney Ward area are the same. Appendix One highlights the area on a map.

RODNEY LOCAL BOARD - OUTCOMES

Outcome: We can get around easily and safely. Our transport infrastructure keeps pace with the needs of our communities. Our growing townships have the same choices for quality public transport as the rest of Auckland.

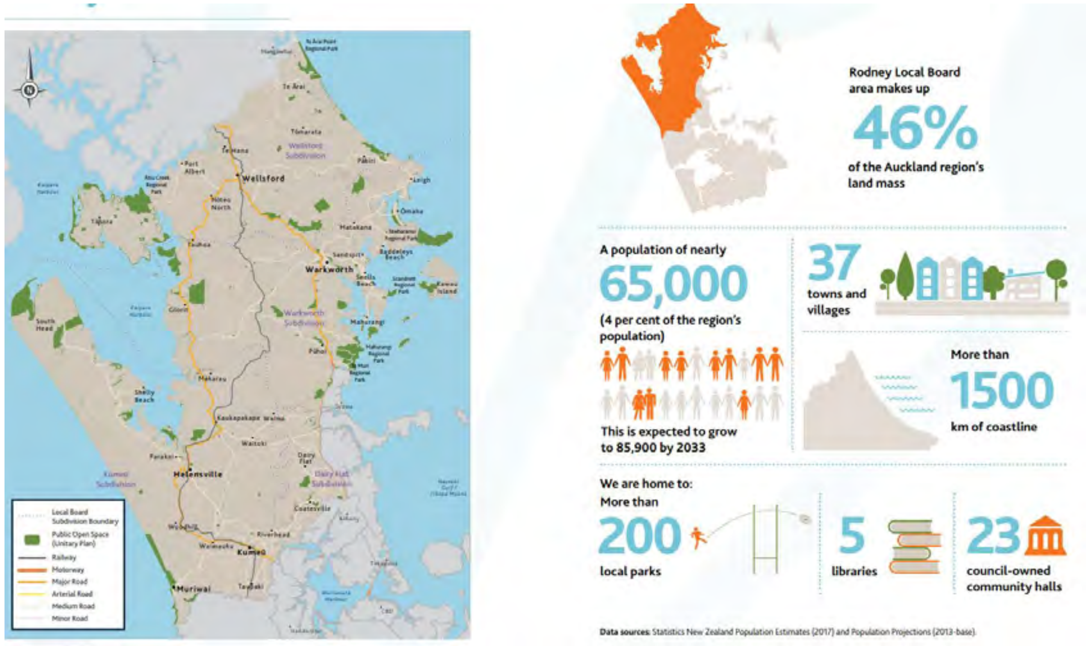
Outcome: Communities are influential and empowered. Our communities influence local decision-making. They are empowered and enabled to act and take the lead on community projects and in the planning for their areas.

Outcome: Parks and sports facilities that everyone can enjoy. Our local parks and sports facilities cater to a wide range of sporting and recreational interests. They are easily accessible, connecting our towns, villages and growth areas.

Outcome: Our harbours, waterways and environment are cared for, protected and healthy. Our harbours and the rivers and streams that feed them are healthy and thriving natural marine environments. Our stormwater and wastewater services are reliable, well maintained and environmentally friendly, minimising downstream environmental impacts.

Outcome: Arts and culture is vibrant and strong. Local facilities are the heart of our communities. They are well used and cared for by communities that manage them.

Figure 2: Rodney Local Board



Source: Auckland Council

RODNEY WARD - GROSS DOMESTIC PRODUCT

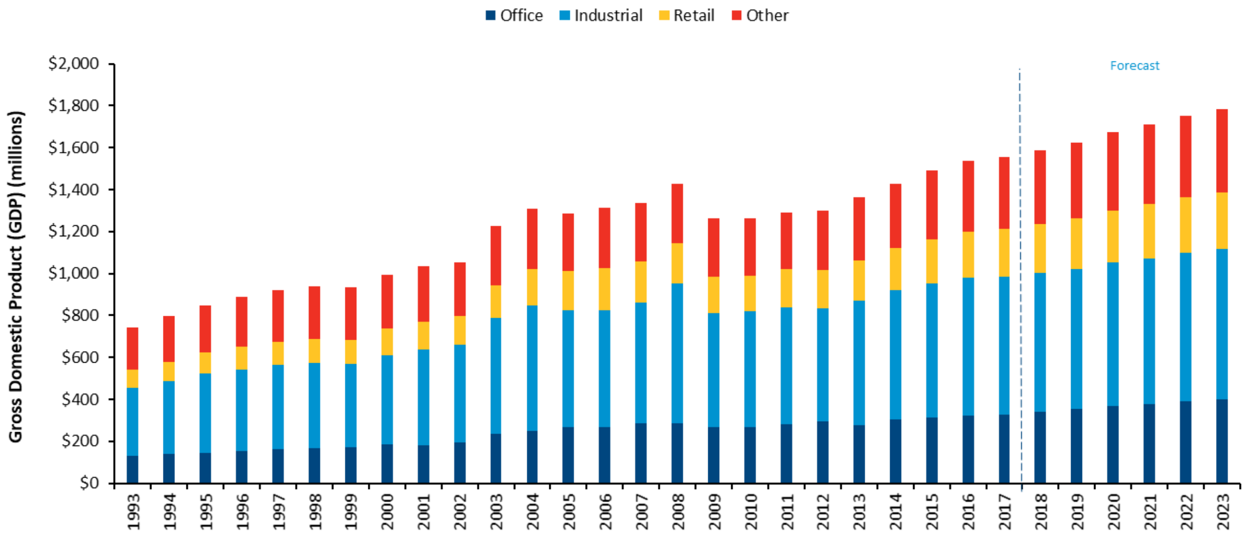
The table to the right uses Australian and New Zealand Standard Industrial Classification (ANZSIC) coding to identify the property sectors. A list of what industries fall under each property sector can be found in the appendix.

Data at this level should be treated as indicating local trends rather than being relied upon as statistically robust in the context of the site.

With that caveat we note that most GDP growth is forecast to occur in industries using retail and office property.

The industrial sector is the highest producing sector but the lowest growth industry. Office is the second highest producing sector and the highest growth industry.

Figure 3: Rodney Ward Gross Domestic Product by Sector



	Office	Industrial	Retail	Other	All Industries
2017P	$329	$657	$227	$343	$1,556
2018F	$342	$662	$232	$353	$1,589
2019F	$352	$671	$241	$361	$1,625
2020F	$366	$687	$249	$371	$1,672
2021F	$376	$697	$258	$381	$1,712
2022F	$390	$709	$264	$389	$1,751
2023F	$399	$716	$273	$397	$1,785
Percentage Growth (6 Years)	21%	9%	21%	16%	15%
GDP Growth (6 Years)	$70	$59	$47	$54	$229

Source: NZIER, Colliers International Research
Note: GDP numbers are in millions of dollars.

ECONOMIC PROFILE AND GROWTH

RODNEY WARD - BUILDING CONSENTS

This data set is annual to June. The residential building consent figures shows that most of the annual building consents are for houses (stand-alone dwellings) but in recent years there has been an increase in townhouses (& other dwellings such as units and flats) and retirement village units suggesting a changing demographic in the Rodney Ward area.

In the two years to June 2018 a total of 1,787 residential dwellings have been consented (an average of 894 per annum).

Apartments are virtually absent from the data, with only one apartment complex consented in 2018.

Commercial unit numbers are low, but higher in the last two years than in earlier years. In the two years to June 2018 a total of 90 commercial units have been consented (an average of 45 per annum).

The more significant categories in the last two years have been industrial, storage and educational. Educational consents (schools and research facilities), are helpful in terms of satisfying future residential demand.

Figure 4: Rodney Ward Residential Building Consent

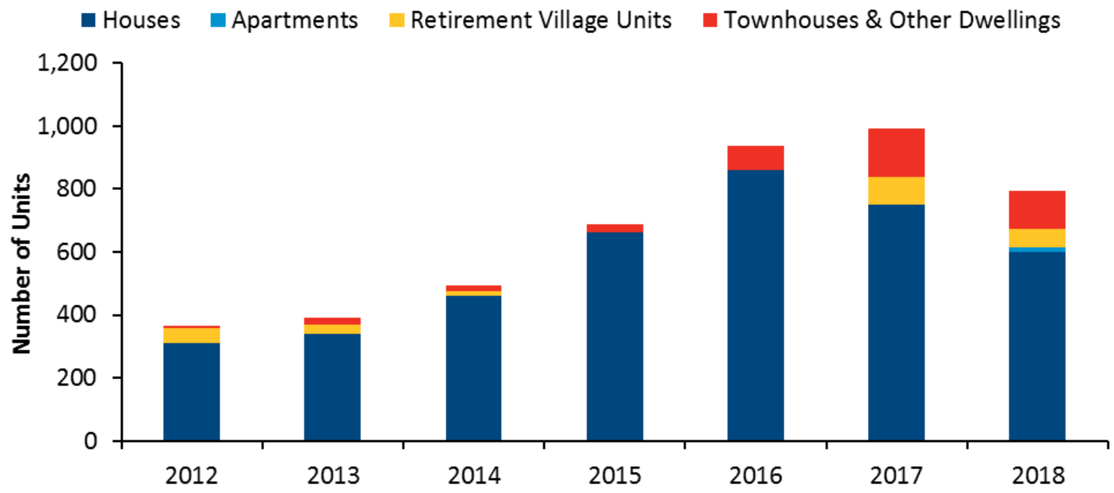
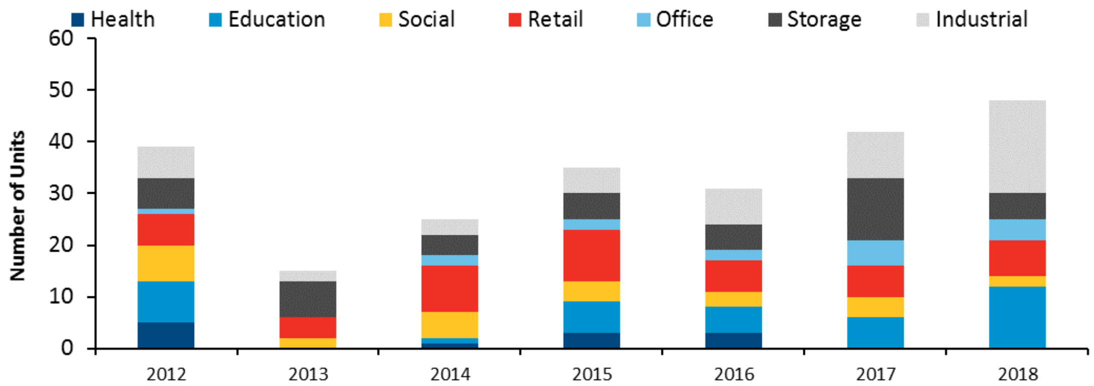


Figure 5: Rodney Ward Commercial Building Consent



Source: Stats NZ, Colliers International Research (Annual to June)

TARGET CATCHMENT – DEMOGRAPHIC ANALYSIS

We have identified a Target Catchment, highlighted in the yellow on the right. This Target Catchment is based on Statistics New Zealand's Area Units.

These areas have been selected based on the potential buyer demographics for Warkworth. The circle denotes a 10 km radius, from which one would expect most buyers to be sourced for urban residential developments. However, for this development, we anticipate buyers will come from a wider area, due to the scale of the development and the low population density of the surrounding country. The highlighted areas are generally within 20km of the site.

Later in the report we analyse likely buying activity from Auckland's North Shore (not shown), which we anticipate will be significant provider of buyer interest despite its distance from the subject site.

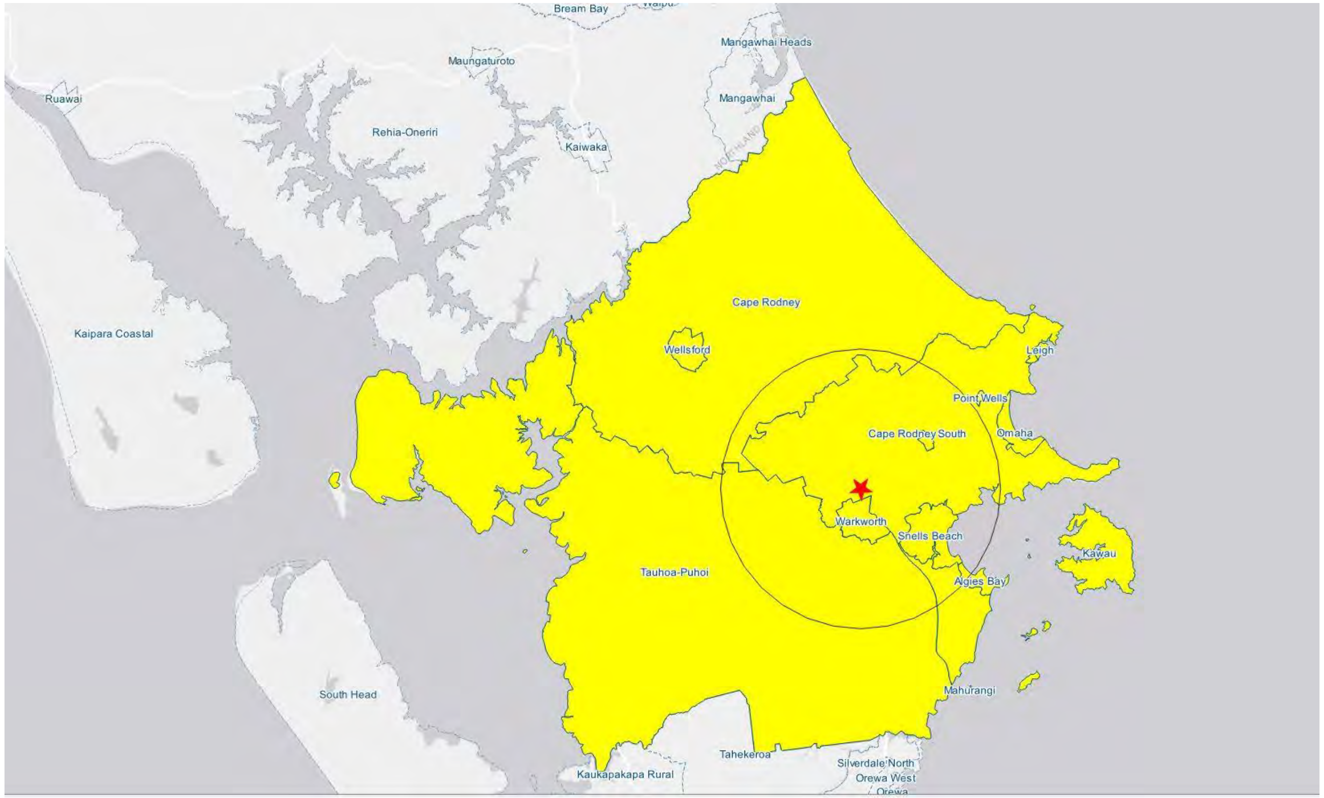
The site falls under the area unit Cape Rodney South but is very close to the area unit Warkworth, so both area units will be analysed, forming as the immediate locality.

The Target Catchment falls under the Rodney Ward and Rodney Local Board areas, which are the same area.

The tables in the demographic section provides a review of the population and household profile for the Target Catchment, while the population and household projections provide a high-level understanding of the likely dwelling demand in the target catchment and local board areas.

This information is sourced from the 2013 Census area units.

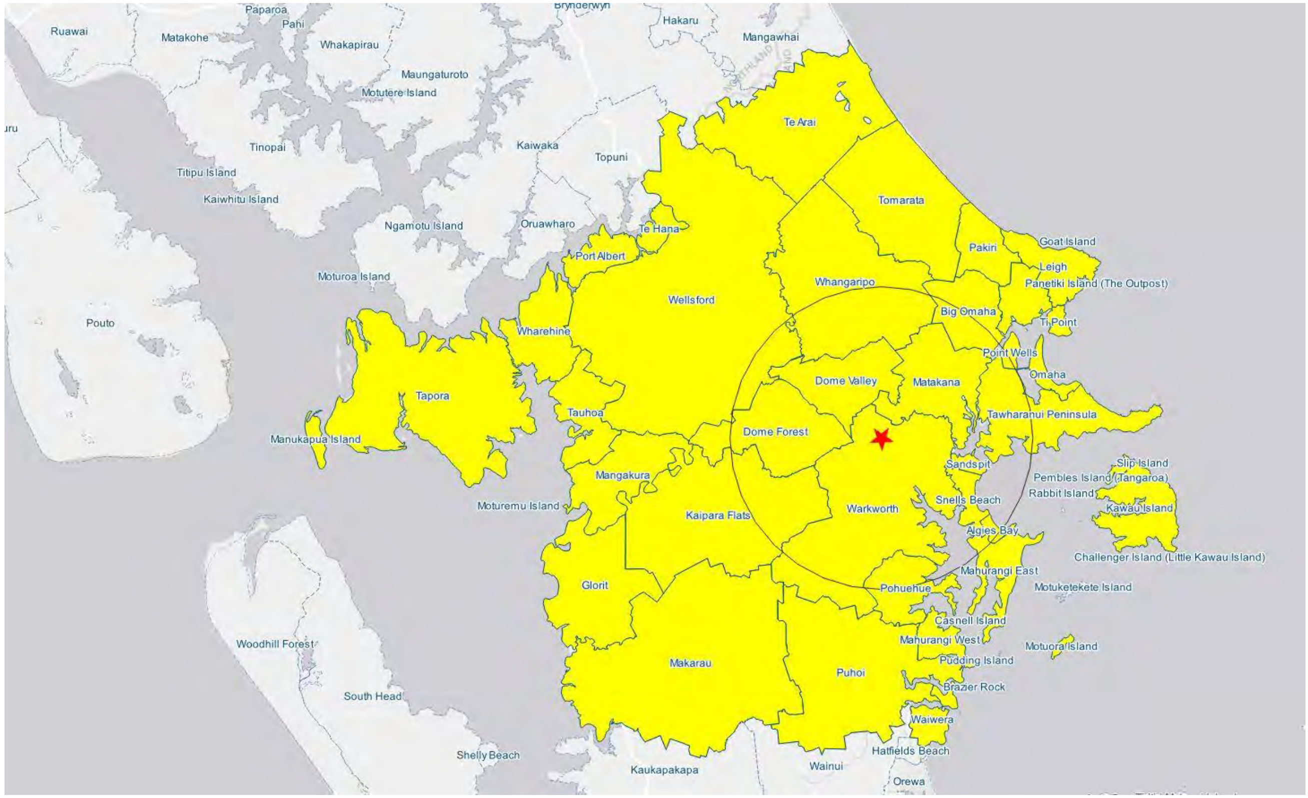
Figure 6: Target Catchment Map - Demographic Analysis



Source: Stats NZ, QGIS, Colliers International Research
A list of area units that are included in the target catchment can be found in the appendix.

In order to analyse sales, we can't use the same area unit area, as the data source for sales, Corelogic, uses suburb areas, based on Fire Service definitions, rather than area units. The closest we can get to the area units based catchment is shown in Figure 7. It is similar to, but not identical to Figure 6.

Figure 7: Target Catchment Map - Residential Sales Analysis



Source: NZFS, QGIS, Colliers International Research
A list of area units that are included in the target catchment can be found in the appendix.

POPULATION AND HOUSEHOLD PROJECTIONS

These population and household projections are a useful high-level indicator of likely dwelling demand. This information, including the projections, is sourced from Stats NZ. Updated data from the 2018 census is unlikely to be available until next year.

We look at the immediate locality Cape Rodney South and Warkworth area units; the target catchment of approximately 20km radius; the whole of Rodney Ward or Local Board Area (which are the same thing); and finally, all of Auckland.

The data highlights:

- Population projections for all areas are relatively similar at 8% to 11% per 5-year period in percentage terms, except Rodney which is around 8% to 16% per period, contributing to the total household growth project of 90% (2013-2038).
- Cape Rodney South's population is projected to grow by 84% by 2038, meaning that around 992 homes (2.5 per household) are needed to meet population demand.
- Warkworth's population is projected to grow by 79% by 2038, meaning that around 1,292 homes (2.4 per household) are needed to meet population demand. Of those, 35% are needed in the next 10 years (2018-2028).
- The Target Catchment's population is projected to grow by 62% by 2038, meaning that around 6,122 homes (2.4 per household) are needed to meet population demand. Of these, 2,393 are needed in the next 10 years (2018 to 2028). These include the 456 required in Warkworth and 420 required in Cape Rodney South.

Figure 8: Population and Household Growth Projections (2013-2038)

Population Projections	2013	2018	2023	2028	2033	2038	Number Increase (Between 2013 & 2038)
Cape Rodney South Area Unit	2,950	3,620	4,240	4,680	5,080	5,430	2,480
Warkworth Area Unit	4,090	5,090	5,650	6,230	6,790	7,320	3,230
Target Catchment	23,410	27,170	30,050	32,810	35,400	37,840	14,430
Rodney Local Board Area	57,300	66,800	76,200	84,600	92,900	100,600	43,300
Auckland	1,493,200	1,699,900	1,859,300	1,990,100	2,112,000	2,222,700	729,500

Household Projections	2013	2018	2023	2028	2033	2038
Cape Rodney South Area Unit	1,180	1,448	1,696	1,872	2,032	2,172
Warkworth Area Unit	1,636	2,036	2,260	2,492	2,716	2,928
Target Catchment	9,932	11,527	12,748	13,919	15,018	16,053
Rodney Local Board Area	21,222	25,692	29,308	33,840	37,160	40,240
Auckland	514,897	586,172	664,036	710,750	754,286	793,821

Household 5-Year Growth in each period	2018	2023	2028	2033	2038	Number Increase (Between 2013 & 2038)	% Increase (Between 2013 & 2038)
Cape Rodney South Area Unit	23%	17%	10%	9%	7%	992	84%
Warkworth Area Unit	24%	11%	10%	9%	8%	1,292	79%
Target Catchment	16%	11%	9%	8%	7%	6,122	62%
Rodney Local Board Area	21%	14%	15%	10%	8%	19,018	90%
Auckland	14%	13%	7%	6%	5%	278,925	54%

Source: Stats NZ, Colliers International Research.

Population and household growth are based on medium projections. 2018 figures are estimates.

POPULATION PROJECTIONS – AGE GROUP

The data highlights:

- In all areas except Warkworth area unit (AU), from 2013 to 2038, growth in the 65+ years old cohort is by far the highest. The growth in 65+ population raises the prospect of demand for aged care property.
- In Warkworth AU, 15-39 and 40-64 cohorts are expected to grow equally rapidly, at a much higher rate than the over 65's.
- Growth in 0-14 years is the lowest in all areas, with the exception of Cape Rodney South whose lowest growth is in the 40-64 year olds.
- This table refers to individuals, not households.

Figure 9: Population Growth Projections by Age Group (2013-2038)

Area	Age	2013	2018	2023	2028	2033	2038	% Increase (Between 2013 & 2038)
Cape Rodney South Area Unit	0-14 years	530	570	650	760	840	860	62%
	15-39 years	650	970	1,230	1,280	1,240	1,220	88%
	40-64 years	1,220	1,310	1,360	1,410	1,570	1,770	45%
	65 years and over	550	780	1,000	1,230	1,430	1,570	185%
	Total	**2,950**	**3,620**	**4,240**	**4,680**	**5,080**	**5,430**	**84%**
Warkworth Area Unit	0-14 years	810	870	980	1,110	1,230	1,260	56%
	15-39 years	1,030	1,680	1,900	1,990	1,930	2,020	96%
	40-64 years	1,200	1,330	1,460	1,700	2,070	2,320	93%
	65 years and over	1,050	1,210	1,310	1,430	1,560	1,710	63%
	Total	**4,090**	**5,090**	**5,650**	**6,230**	**6,790**	**7,320**	**79%**
Target Catchment	0-14 years	4,600	4,740	5,030	5,560	6,120	6,380	39%
	15-39 years	5,500	7,630	8,890	9,450	9,360	9,530	73%
	40-64 years	8,410	8,770	9,180	9,720	10,900	12,090	44%
	65 years and over	4,900	6,030	6,950	8,080	9,020	9,840	101%
	Total	**23,410**	**27,170**	**30,050**	**32,810**	**35,400**	**37,840**	**62%**
Rodney Local Board Area	0-14 years	11,900	12,100	13,100	14,600	16,200	17,000	43%
	15-39 years	14,700	19,900	23,900	25,800	26,100	26,900	83%
	40-64 years	21,700	23,300	25,000	26,700	29,800	32,900	52%
	65 years and over	9,000	11,500	14,200	17,500	20,800	23,800	164%
	Total	**57,300**	**66,800**	**76,100**	**84,600**	**92,900**	**100,700**	**76%**
Auckland	0-14 years	311,500	323,700	345,100	361,400	378,800	377,300	21%
	15-39 years	539,400	666,700	731,500	753,300	728,700	728,800	35%
	40-64 years	472,500	501,500	530,800	571,500	651,000	715,600	51%
	65 years and over	169,800	208,000	252,000	303,900	353,600	401,000	136%
	Total	**1,493,200**	**1,699,900**	**1,859,400**	**1,990,100**	**2,112,100**	**2,222,700**	**49%**

Source: Stats NZ, Colliers International Research. Population are based on medium projections. 2018 figures are estimates. Percentage growth tables can be found in the appendix.

POPULATION PROJECTIONS – ETHNIC GROUP

The data highlights:

- The 2013 ethnicity forecasts are not available by Area Unit and therefore cannot be aggregated into Target Catchment or presented as specific Area Unit forecasts.
- Growth in the Asian cohort is highest in all areas with not much growth in European cohort.
- The Asian cohort's population is estimated to double by 2038 in both the Rodney Local Board and Auckland, compared to 2013, and increases by 310% in Rodney, albeit from a small base.
- European ethnicity will still dominate Rodney at 85% in 2038, compared to Auckland's 48%.

Figure 10: Population Growth Projections by Ethnic Group (2013-2038)

Area	Ethnic Group	2013	2018	2023	2028	2033	2038	% Increase (Between 2013 & 2038)
Rodney Local Board Area	European or Other (including New Zealander)	52,500	59,100	65,800	72,400	79,100	85,600	63%
	Maori	6,080	6,890	7,780	8,750	9,830	11,050	82%
	Asian	2,300	4,450	6,280	7,400	8,440	9,420	310%
	Pacific	1,740	2,200	2,680	3,160	3,640	4,140	138%
	Total	**57,300**	**66,800**	**76,100**	**84,600**	**92,900**	**100,700**	**76%**
Auckland	European or Other (including New Zealander)	886,400	946,700	986,800	1,014,700	1,038,800	1,057,600	19%
	Maori	169,800	188,100	204,900	221,600	239,200	257,600	52%
	Asian	348,900	472,700	567,500	645,200	719,000	788,800	126%
	Pacific	227,000	252,400	279,500	307,800	337,300	367,000	62%
	Total	**1,493,200**	**1,699,900**	**1,859,300**	**1,990,100**	**2,112,000**	**2,222,700**	**49%**

Source: Stats NZ, Colliers International Research. Population are based on medium projections. 2018 figures are estimates. Percentage growth charts can be found in the appendix.

POPULATION PROJECTIONS – HOUSEHOLD ARRANGEMENT

The data highlights:

- In Rodney Local Board area there is growth forecast in all household arrangements, the largest proportionately being a 95% increase in one-person households, suggesting that there is a demand for one-bedroom or studio accommodation, and also potential for sharing of larger homes.
- Over 60% growth in the family household arrangement also suggests strong demand growth for two or more-bedroom accommodation.
- General household arrangement trends from the 2013 New Zealand Census, include:
    - Over two-thirds (68.3 percent) of households contained one family (with or without other people) in 2013 – down slightly from 69.1 percent in 2006.
    - Women were more likely than men to live in one-person households, with women making up 57.4 percent of one-person households.
    - Most people (79.9 percent) in one-person households were aged 45 years and over.
    - Households with one or two usual residents made up over half of New Zealand households, at 57.0 percent.

Figure 11: Population Growth Projections by Household Arrangement (2013-2038)

Area	Household Arrangement	2013	2018	2023	2028	2033	2038	% Increase (Between 2013 & 2038)
Rodney Local Board Area	Family households	16,500	18,900	21,000	23,100	25,100	27,000	64%
	Other multi-person households	500	500	600	600	600	700	40%
	One-person households	4,300	5,100	5,900	6,800	7,600	8,400	95%
	Total	**21,300**	**24,500**	**27,500**	**30,500**	**33,300**	**36,100**	**69%**
	Average household size	*2.7*	*2.6*	*2.6*	*2.5*	*2.5*	*2.5*	
Auckland	Family households	379,600	437,700	486,500	525,000	560,200	591,900	56%
	Other multi-person households	21,900	27,700	29,000	29,300	29,800	30,400	39%
	One-person households	96,400	111,600	126,500	140,900	155,200	168,800	75%
	Total	**498,000**	**577,000**	**642,100**	**695,200**	**745,100**	**791,100**	**59%**
	Average household size	*2.9*	*2.9*	*2.8*	*2.8*	*2.8*	*2.8*	

Source: Stats NZ, Colliers International Research. Population are based on medium projections. 2018 figures are estimates. Percentage growth charts can be found in the appendix.

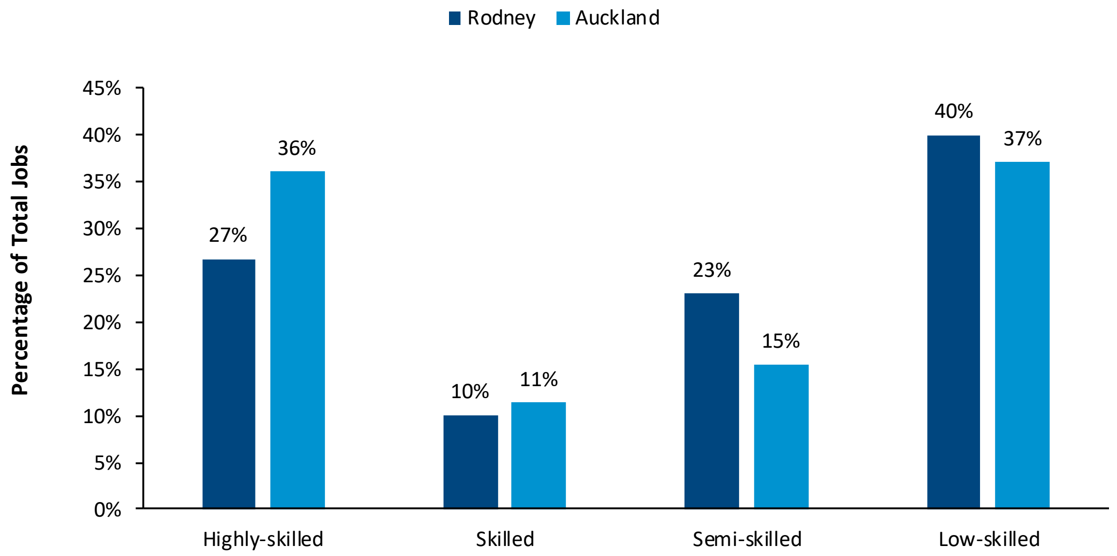
RODNEY WARD EMPLOYMENT PROFILE – SKILL LEVEL

This section uses data sourced principally from economists Infometrics and NZIER, with additional data from Stats NZ. The Infometrics information here is useful as it divides employment by skill levels, which the other data provided does not.

- The majority of jobs in the Rodney are semi-skilled or low-skilled jobs, representing 63%.
- The equivalent figure for Auckland is 52%
- Rodney has 40% of its workforce in low-skilled jobs which has somewhat negative implications for home ownership aspirations, countered by increasing rental demand.

Figure 12: Rodney Ward Employment by Skill Level 2017

	Rodney		Auckland		New Zealand	
	Number of Jobs	% of Total	Number of Jobs	% of Total	Number of Jobs	% of Total
Highly-skilled	5,415	27%	308,014	36%	802,782	33%
Skilled	2,046	10%	97,384	11%	267,788	11%
Semi-skilled	4,663	23%	132,310	15%	421,918	18%
Low -skilled	8,089	40%	316,705	37%	917,673	38%
	20,213	100%	854,413	100%	2,410,161	100%



Source: Infometrics, Colliers International Research

EMPLOYMENT GROWTH

RODNEY WARD EMPLOYMENT PROFILE – GROWTH INDUSTRIES

- Industries are ranked by the actual number of jobs filled rather than percentage growth, between end of 2016 and the end of 2017.
- Industries employing the most people in the Rodney Ward are Construction, Health Care and Social Assistance, Retail Trade, and Accommodation and Food Services.
- Health Care and Social Assistance, Construction, and Accommodation and Food Services are also the top growth industries.
- Social Assistance is a category encompassing care services such as Child Care and Residential Care.

Figure 13: Rodney Ward – Top 15 Industries by Number of Jobs Filled

Industry	2016	2017	Actual Growth	Percentage Growth
Health Care and Social Assistance	1,716	1,790	74	4.3%
Construction	2,308	2,358	51	2.2%
Accommodation and Food Services	1,327	1,365	38	2.8%
Professional, Scientific and Technical Services	863	897	34	3.9%
Transport, Postal and Warehousing	552	585	33	5.9%
Retail Trade	1,626	1,659	32	2.0%
Agriculture	921	951	30	3.2%
Wholesale Trade	610	636	26	4.2%
Rental, Hiring and Real Estate Services	1,022	1,047	25	2.4%
Education and Training	1,154	1,177	22	1.9%
Information Media and Telecommunications	573	594	22	3.8%
Other Services	392	406	15	3.8%
Arts and Recreation Services	306	318	12	3.8%
Financial and Insurance Services	234	243	9	3.9%
Fishing, Aquaculture and Agriculture, Forestry a	152	160	8	5.3%

Source: NZIER, Colliers International Research

EMPLOYMENT GROWTH

RODNEY WARD - EMPLOYMENT GROWTH

For this section we have utilised data supplied by NZIER. Our membership of NZIER allows us to request data for specific projects, which we have done on this occasion.

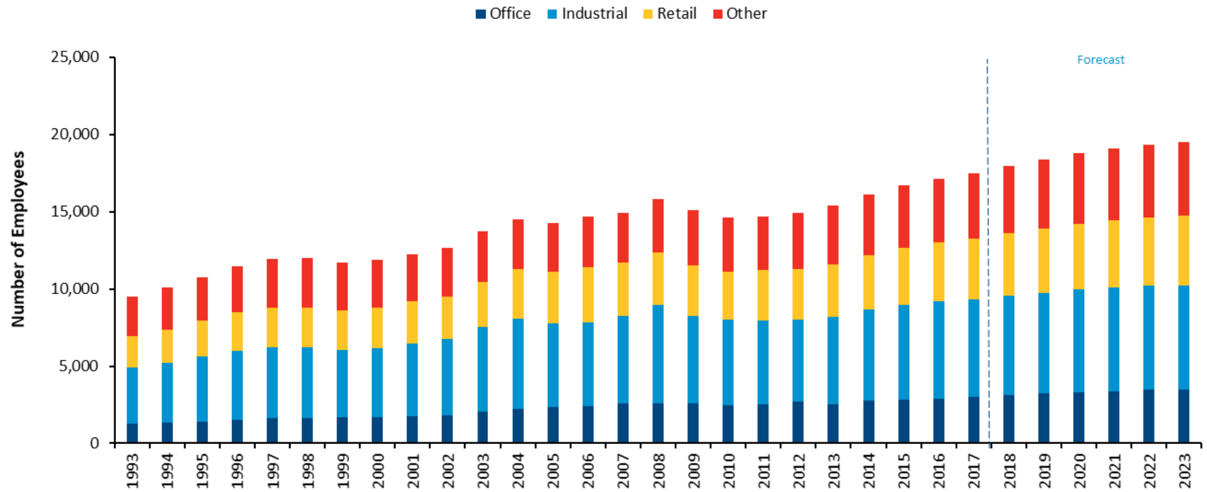
Infometrics and Stats NZ also provide employment data, and their data can differ to the NZIER data. This is illustrated in the difference in employment numbers between figure 14 and figure 12. The data should therefore be treated as indicative.

We have divided the jobs data in to property usage types. These follow closely, but not exactly, the GDP growth numbers in figure 4 divided into property types.

The numbers are important not just to forecast demand for commercial property, but because jobs growth is an indicator of residential demand, for both owner-occupied and rental.

In Rodney Ward, it is estimated that there will be 2,000 new jobs by 2023. If each of the 2,000 new jobs in Rodney was in a separate household, then that would be 2,000 potential new mortgage applicants and owner-occupier households by 2023.

Figure 14: Rodney Ward Employment Growth by Sector



	Office	Industrial	Retail	Other	All Industries
2017P	2,985	6,352	3,900	4,240	17,478
2018F	3,121	6,440	4,027	4,390	17,978
2019F	3,218	6,532	4,159	4,489	18,398
2020F	3,319	6,641	4,255	4,581	18,796
2021F	3,384	6,684	4,356	4,659	19,082
2022F	3,460	6,724	4,411	4,705	19,301
2023F	3,509	6,733	4,488	4,747	19,477
Percentage Growth (6 Years)	18%	6%	15%	12%	11%
Number Growth (6 Years)	524	380	588	508	2,000

Source: NZIER, Colliers International Research

INDUSTRIAL VACANT LAND

INDUSTRIAL VACANT LAND ANALYSIS

We have been asked to comment briefly on demand for, and availability of industrial land locally.

We have completed a detailed review of vacant industrial zoned land each year since 2013. The amount of available land in Rodney District and in Warkworth has remained consistent in recent years.

The increase in the other areas of Auckland in 2017 can be ascribed to a degree by new industrial zoning. Take-up is the key variable, and for Auckland was at a record high level in 2017. There is a low supply of smaller sites however with only 7.2 ha of sites less than 0.5 ha (5,000sqm) in Rodney.

This data is not available by area unit or other small geography, but we note that no industrial land sections are currently advertised for sale on Trade Me in Warkworth.

Figure 15: Industrial Vacant Land Analysis – Auckland vs Rodney

Auckland Region						
Year	Existing Land	New Addition	Full Take-Up	Partial Take-Up	Total Take-Up	Available Land
2013	1,013.8	28.9	20.4	3.6	24.0	1,018.6
2014	1,018.6	26.0	40.6	8.2	48.8	995.8
2015	995.8	20.5	75.9	17.3	93.1	923.2
2016	923.2	112.7	55.9	21.5	77.3	958.5
2017	958.5	279.2	115.6	38.3	153.9	1,083.8
Auckland - Rodney						
Year	Existing Land	New Addition	Full Take-Up	Partial Take-Up	Total Take-Up	Available Land
2013	72.4	1.0	4.4	0.8	5.2	68.2
2014	68.2	7.5	2.9	0.1	3.0	72.8
2015	72.8	4.6	5.2	0.2	5.4	71.9
2016	71.9	13.9	10.3	1.2	11.5	74.3
2017	74.3	6.7	4.9	3.6	8.5	72.5

Figure 16: Industrial Vacant Land – by Rodney Suburb Level

Suburb	Nov-16	Nov-17	Difference
Dairy Flat	0.766	0.000	-0.766
Helensville	5.627	4.458	-1.169
Kumeu	1.433	0.225	-1.208
Riverhead	9.152	5.740	-3.412
Silverdale	20.895	24.196	3.301
Snells Beach	0.329	0.000	-0.329
Stanmore Bay	0.724	0.154	-0.570
Stillwater	12.911	12.911	0.000
Warkworth	8.827	8.827	0.000
Wellsford	13.595	15.962	2.367

Figure 17: Industrial Vacant Land – by Rodney Parcel Size

Parcel Size	Nov-13	Nov-14	Nov-15	Nov-16	Nov-17
<0.5ha	15.391	12.612	11.312	10.192	7.218
0.5-1ha	8.679	10.122	9.000	7.005	5.204
>1.0-5.0ha	17.531	17.531	19.111	18.068	15.201
>5.0ha	26.635	32.491	32.491	38.994	44.850
	68.236	72.757	71.914	74.258	72.473

Source: CoreLogic, Colliers International Research

RESIDENTIAL SALES TRENDS

SALES VOLUME – RESIDENTIAL DWELLING

This section breaks down residential dwelling sales for the Target Market and for Auckland as a whole. Residential dwelling sales include house, apartment, flat, unit and townhouse sales.

Note that these data are based on settlement statements provided by solicitors, to the government.

There were 2,698 sales in the Target Market between 2013 to July 2018, which is around 2% of all of Auckland house sales. These data are illustrated to the right, and by the pie charts which represent the same data for the whole period.

The Target Market's proportion of sales by typology follows a very similar pattern to that of Warkworth's breakdown, with the majority of the house sales being three and four-bedroom homes.

Figure 18: Number of Residential Sales – Warkworth

Typology	2013	2014	2015	2016	2017	2018	Total
1 Bedroom	2	2	NA	1	NA	NA	5
2 Bedrooms	27	24	30	20	20	6	127
3 Bedrooms	87	73	83	59	60	4	366
4 Bedrooms	46	47	39	31	43	3	209
5+ Bedrooms	3	3	6	5	7	1	25
Total	165	149	158	116	130	14	732

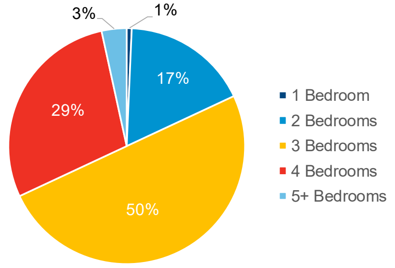


Figure 19: Number of Residential Sales - Target Market

Typology	2013	2014	2015	2016	2017	2018	Total
1 Bedroom	11	13	11	16	3	NA	54
2 Bedrooms	102	83	104	78	65	13	445
3 Bedrooms	309	279	293	235	197	23	1,336
4 Bedrooms	160	144	173	134	127	15	753
5+ Bedrooms	26	16	33	15	19	1	110
Total	608	535	614	478	411	52	2,698

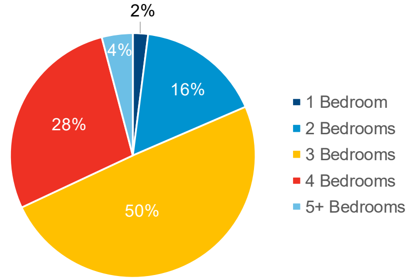
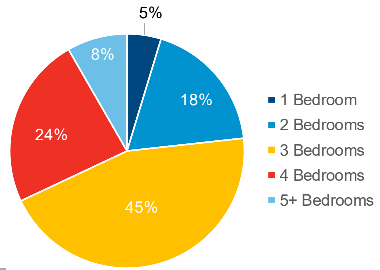


Figure 20: Number of Residential Sales – North Shore

Typology	2013	2014	2015	2016	2017	2018	Total
1 Bedroom	84	80	110	68	63	20	425
2 Bedrooms	891	788	819	599	406	77	3,580
3 Bedrooms	2,648	2,336	2,453	1,946	1,396	159	10,938
4 Bedrooms	1,599	1,491	1,660	1,272	812	83	6,917
5+ Bedrooms	666	617	798	557	400	48	3,086
Total	5,888	5,312	5,840	4,442	3,077	387	24,946



Source: CoreLogic, Colliers International Research
Note: All sales are freehold market sales

FUTURE PROJECTS - ARA TŪHONO – WARKWORTH TO WELLSFORD

The Warkworth to Wellsford project is the second section of Ara Tūhono – Pūhoi to Wellsford project. The project is in an investigation currently.

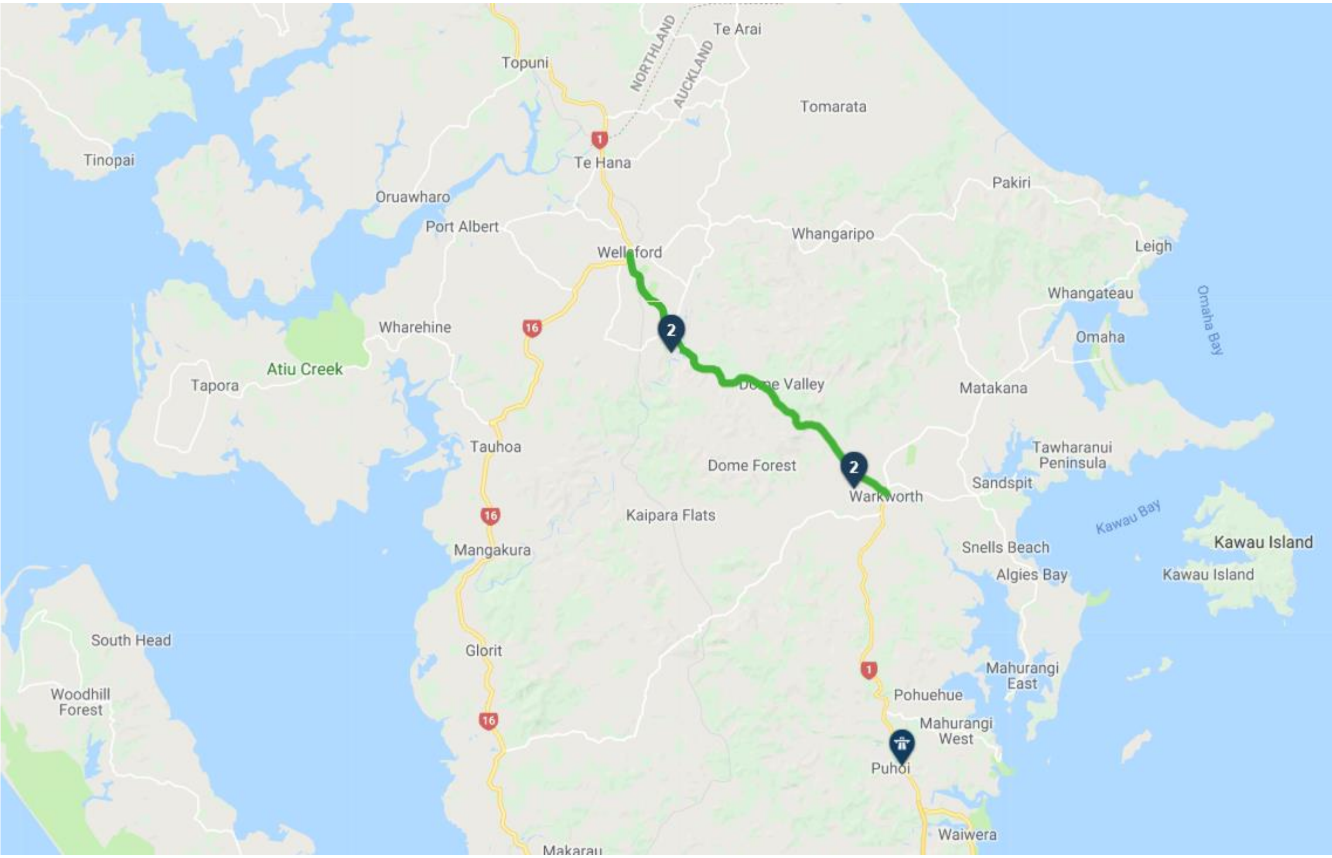
Stage one, between Pūhoi and Warkworth, is currently under construction, with a completion date of late-2021.

An off-line motorway, completely separate from the current SH1 remains the preferred long-term option between Warkworth and Wellsford and the Transport Agency is continuing to investigate this second stage of Ara Tūhono Pūhoi to Wellsford project.

Project type: Roads of National Significance

Project status: Investigation

Figure 21: Pukekohe Station Project



Source: NZTA

FUTURE PROJECTS - SH1 DOME VALLEY

Project overview

This project on SHI through the Dome Valley is part of the government's Safe Roads and Roadsides.

Estimated project cost: $35 million

Project type: Safety improvements

Project status: Design

Timeline: Start late 2018 and finish these stages in 2019.

FUTURE PROJECTS - HILL STREET IMPROVEMENTS

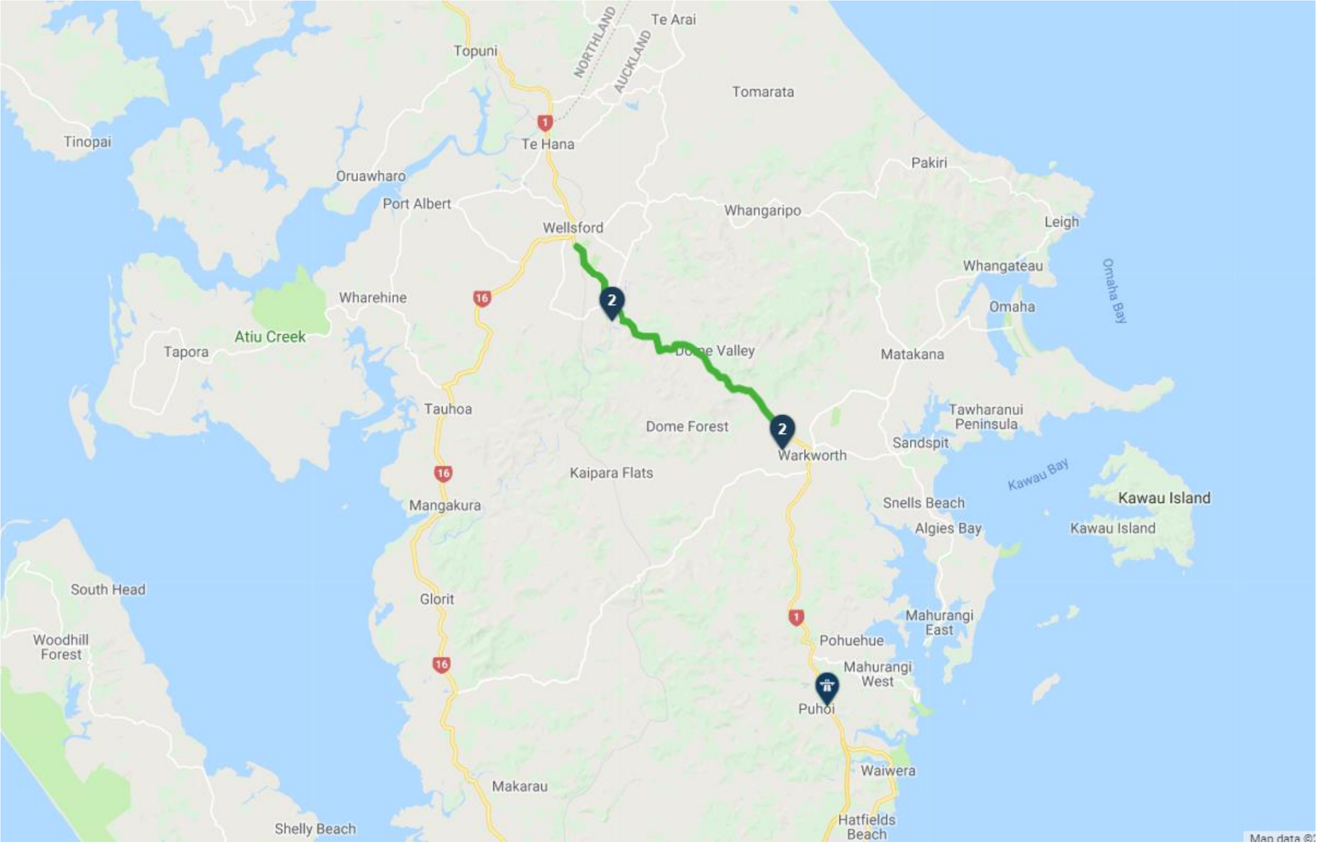
Project overview

The Hill Street Improvements project is a single stage business case for long term improvements to the Hill Street intersection. The business case is being undertaken in partnership with Auckland Transport and is expected to be completed in early-2019.

Project type: Road improvements

Project status: Investigation

Figure 22: SH1 Dome Valley



Source: NZTA

FUTURE PROJECTS - ARA TŪHONO – PŪHOI TO WARKWORTH

Project overview

In November 2016, the Transport Agency awarded a Public Private Partnership (PPP) contract to the Northern Express Group (NX2) for this project. Under the PPP contract, the Northern Express Group will finance, design, construct, manage and maintain the Pūhoi to Warkworth motorway for the 25 years that will follow the expected five-year construction period. Full ownership of the highway will remain with the public sector. The Pūhoi to Warkworth motorway will open to traffic in late 2021.

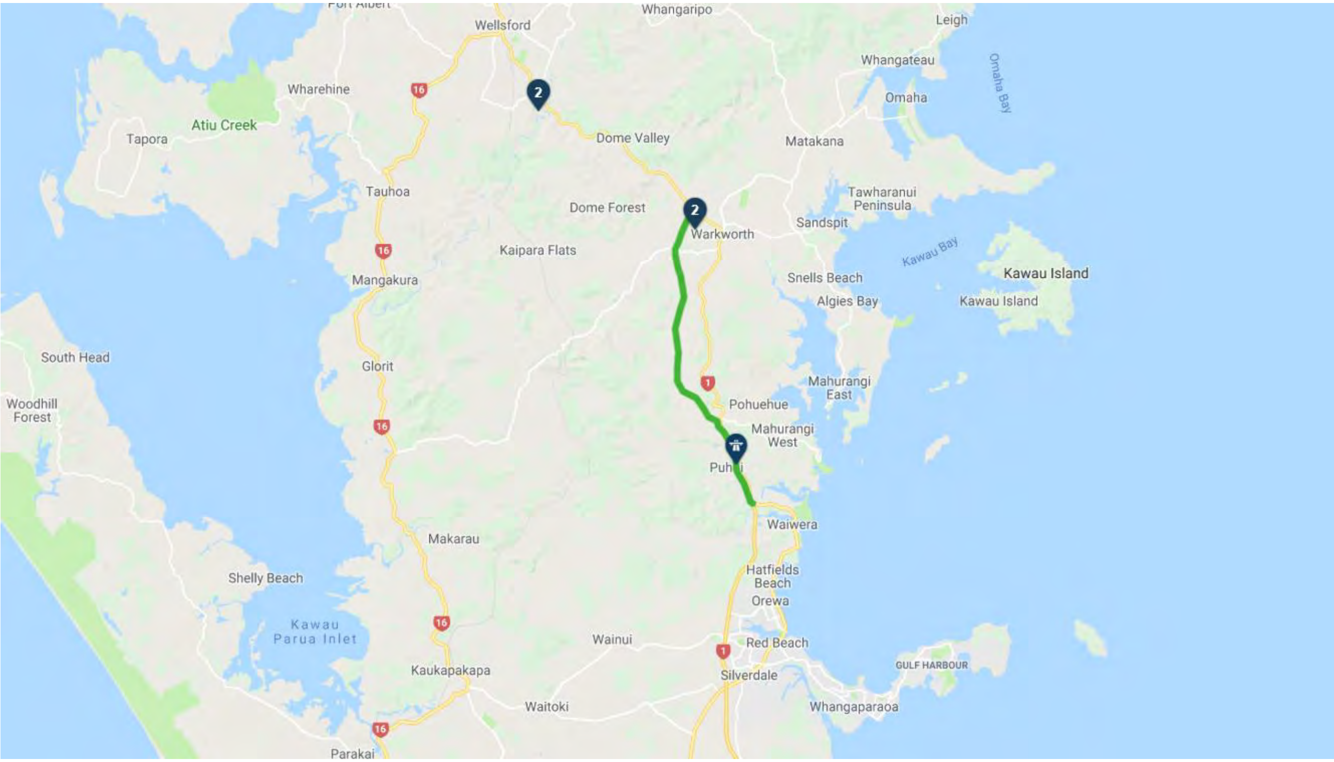
The Pūhoi to Warkworth project will extend the four-lane Northern Motorway (SH1) 18.5km **from the Johnstone's Hill tunnels to just north of Warkworth**. It is the first stage of the Ara Tūhono – Pūhoi to Wellsford Road of National Significance.

Project type: Roads of National Significance

Project status: Construction

This project will be of significance to the development, making access to Warkworth North, from areas south of Warkworth, quicker and safer.

Figure 23: Ara Tūhono – Pūhoi to Warkworth



Source: NZTA

FUTURE PROJECTS - ARA TŪHONO – PŪHOI TO WELLSFORD

Project overview

The Ara Tūhono – Pūhoi to Wellsford road of national significance runs approximately 38 kilometres through the Rodney area north of Auckland on State Highway 1. The project aims to extend the Northern Motorway (SH1) **from the Johnstone's Hill tunnels just south of Pūhoi to a point north of Wellsford.** Existing and anticipated future regional growth will provide opportunities for economic and social development in Northland and provide a better connection to Auckland for freight, tourism and motorists.

Estimated project cost: $100 million +

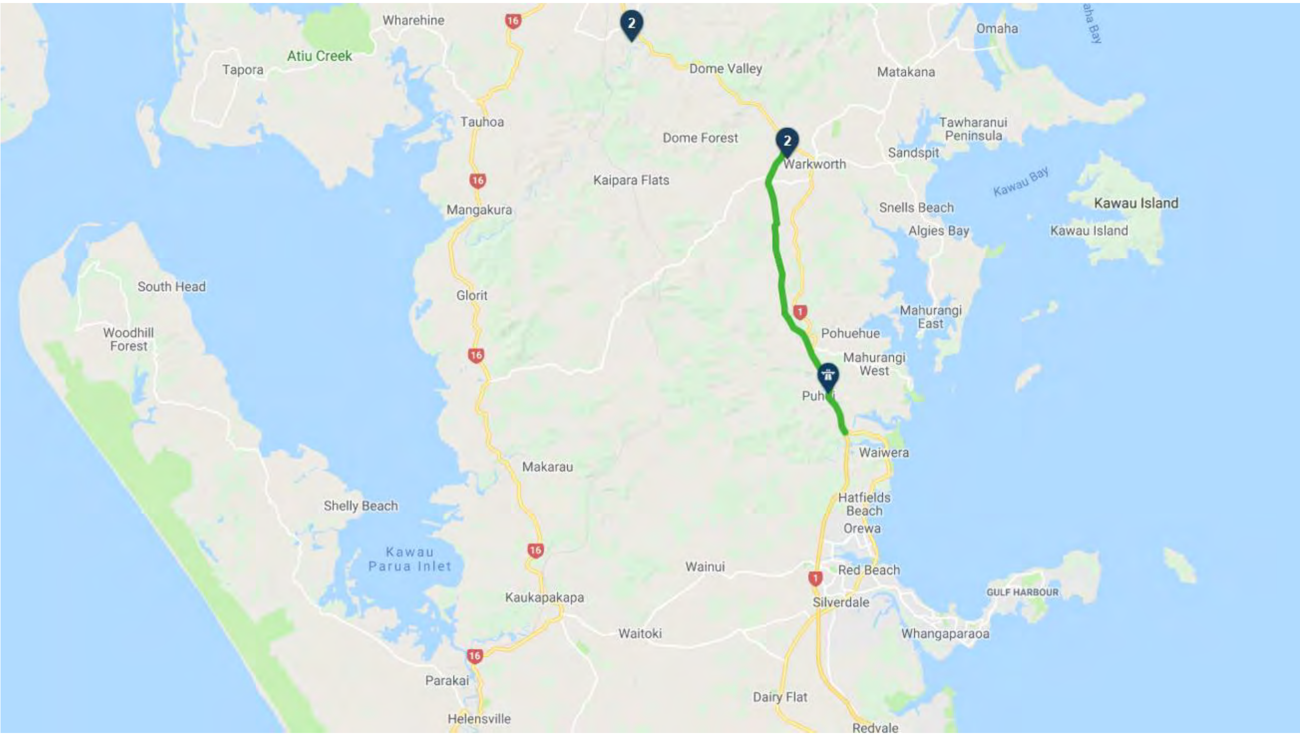
Project type: Roads of National Significance

FUTURE PROJECTS - NEW NETWORK FOR WARKWORTH

Project overview

From Sunday 30 September 2018, Warkworth will be connected to Hibiscus Coast Station in Silverdale with new bus route 995. New bus routes 996 and 997 will replace the Kowhai Connection. These services will operate 7 days a week.

Figure 24: Ara Tūhono – Pūhoi to Wellsford



Source: NZTA

SUMMARY: RESIDENTIAL DEMAND

The preceding analysis demonstrates, by way of dwelling sales history, that for the last full year of data in 2017, 130 homes have been sold in Warkworth and 411 in the wider Target Catchment.

Household growth forecasts estimate 456 homes will be needed in Warkworth area unit and 424 in Cape Rodney South, the other most relevant area unit, an average of 88 per annum to accommodate one household per dwelling, in each of the next 10 years (2018-2028).

The target catchment needs 239 per annum including the 88 noted above.

However, it is also relevant to consider spill-over demand from Auckland, particularly as roading infrastructure improves to make the commute to Auckland practical. The completion of the bypass as part of the Puhoi to Warkworth motorway extension, is now under construction and due for completion in late 2021. According to forecasts, afternoon peak period traffic shows an approximate 7-minute time saving for a motorist travelling north from Pūhoi to north of Warkworth and an approximate 16-minute saving for motorists traveling south from north of Warkworth to Pūhoi.

Using REINZ data, North Shore's median of $1.048m in the last six months, compared to Warkworth's equivalent of $745,000, offers a compelling incentive for households to locate in Warkworth particularly as the increasing population will trigger amenity improvements over time.

Around 3,677 homes were sold on the North Shore in 2017, and 700 in Rodney Ward, including the 411 sold in the Target Catchment.

Absorption:

The proposed development which we understand will consist of 600-650 sections, will, we anticipate, be developed in stages over a period of some years.

In order to sell 100 to 150 units (homes or sections) per annum, which we think is a reasonable target, sales at this site will have to capture a mix of the existing market activity in the immediately adjacent Warkworth area units, the wider catchment, and Auckland's North Shore.

An example of the proportions required to reach 150 units is:

Warkworth, 20% of current annual sales activity (26) plus 20% of new house requirement (14) – total of 40.

Target Catchment, 5% of current annual sales activity (14) plus 5% of new house requirement (23) – total 37, excluding Warkworth sales.

North Shore, 2% of current annual sales activity – total of 74.

In total this matches a target of 150 sales per annum.

It is likely that the majority of sales will be completed homes rather than sections. A more conservative forecast, halving the proportion of Warkworth and North Shore market capture to 10% and 1% respectively, still amount to 94 units per annum. Given the high quality of the location, local environment and masterplan, we would anticipate that 100-150 units per annum could be sold.

One of the keys to an accelerated sales rate, or absorption, will be attracting buyers from North Shore. Even capturing North Shore's annual sales will require professional marketing, which we assume will be in place, and a maintenance of the financial incentive expressed above in terms of the relative median prices.

Warkworth North is particularly well placed to benefit from this activity as it is close to the end of the motorway and bypass, see following section.

SUMMARY: LOCATIONAL BENEFITS

Future infrastructure projects that will impact this development are significantly positive for demand. They are Ara Tūhono – the Warkworth to Wellsford road upgrade, SH1 Dome Valley safety improvements, Ara Tūhono – Pūhoi to Warkworth road upgrade (north of Warkworth), and the Pūhoi to Wellford (south of Pūhoi) road upgrade.

The Puhoi motorway extension will meet the existing SH1 at a roundabout around halfway between Hudson Road and Kaipara Flats Road, very close to one of the entrances to the subject site by the Warkworth showgrounds.

The new road, effectively also acting as a Warkworth bypass, will allow drivers to avoid the SH1/Hill Road/ Matakana Rd junction which is notoriously congested at times. Even those heading north to Matakana and the coast beyond can use the proposed Matakana Link Road shown as part of the development of the subject site, to avoid that junction.

Of course, the Hill Road/SH1 junction will be less busy as a consequence of the improvements and will still be useful for residents of the subject site to access Warkworth town centre either directly along SH1 or via the new Matakana Link Road.

The establishment of the new road will open up the north-west of the town which has so far seen very little development. Development of this site will, in comparison to development in other parts of the town, trigger less travel through the town as both the new motorway and Matakana Road will be immediately accessible from the subject site.

Warkworth North is in our view clearly the most logical part of the town to concentrate development.

There will inevitably be competing developments in and around Warkworth in the next few years as the attractiveness of the town improves. It is desirable that development and sales activity is encouraged at the most logical locations, those that will maximise efficiency and minimise traffic effects.

If this site could be developed relatively quickly and the house-buying public were aware that it was consented and virtually certain to proceed, then a greater proportion of new residents of Warkworth could be attracted to this site, with positive benefits in terms of efficiency.

Figure 25: Pūhoi to Wellsford

Source: NZTA

SUMMARY: ECONOMIC STIMULATION

We have no information on land development or building construction costs, but the sums to be expended will clearly be very substantial. As a minimum, 600 sections will cost over $60m to develop at $100,000 per section and the construction of the houses, of say 100sqm each, will be at least $170m, a total development spend of say $230m.

We are not economists and rely on existing industry benchmarks for our analysis of the economic effects of construction spending.

For example, PWC's 2016 report to the Construction Strategy Group (and others) noted that construction is highly integrated across the economy. The flow-on effects of construction are significant and in the context of this development include significant benefits to retail and wholesale trade, and to professional services.

Economic benefits can be categorised as direct, indirect and induced (or downstream). The calculations are based on New Zealand's input-output tables and suggest that each $1 of base construction investment will produce $2.51 (ignoring induced or downstream benefits) in economic activity.

Even basing the calculations on a conservative land and buildings spend, and assessing direct and indirect benefits only, the economic activity stimulated by the Warkworth development is likely to trigger some $577m of economic activity.

Not all of that will be felt locally, which we address as part of the thinking on induced benefits.

The downstream or induced impact takes account, for example, of the increase in spending as a result of increased household income and expenditure. Much of that increase will be spent in the local area in which it is activated, as of course that is where the workers and their households will be based.

This induced spend is estimated at 66 to 73 cents for each construction dollar. On that basis the entire downstream activity generated would be at least $150m.

In total therefore say $727m of economic stimulation would be activated. However much of that will be felt outside of the local economy.

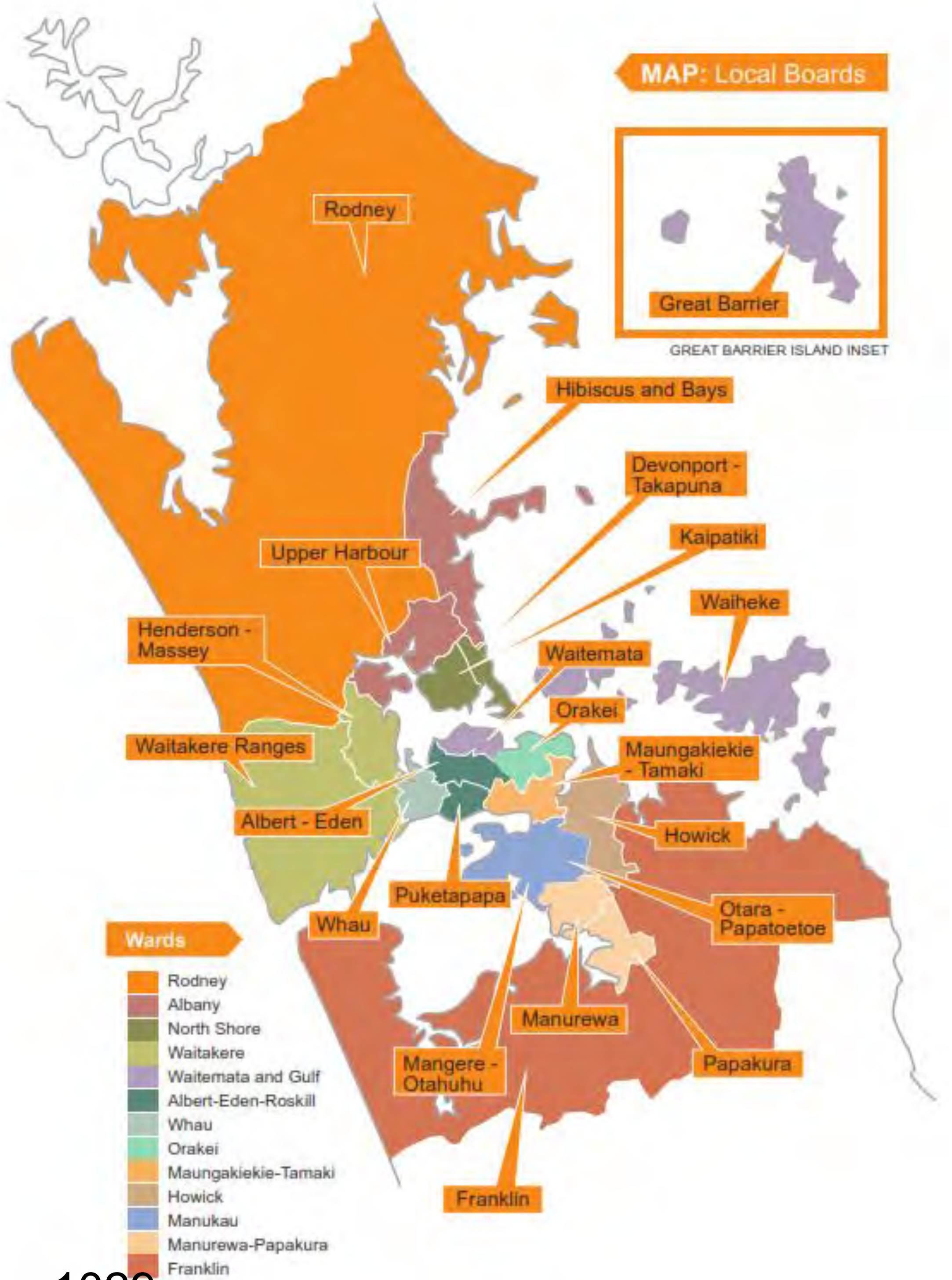
If 25% of the direct and indirect activity was experienced in the locality, and also 50% of the additional induced activity was earned or spent in the locality, that would amount to $220m of economic stimulation for the local area.

APPENDICES

Appendix 1

Auckland Local Board and Ward Area Map

Source: Auckland Transport



Appendix 3

ANZSIC by Property Sector

Source: NZIER, NZ Statistics

Group	Code	Industry group	Detailed industry group
Industrial	BB	Mining	Mining
Industrial	CC	Food, Beverage and Tobacco Product Manufacturing	Beverage and Tobacco Product Manufacturing
Industrial	CC	Food, Beverage and Tobacco Product Manufacturing	Dairy Product Manufacturing
Industrial	CC	Food, Beverage and Tobacco Product Manufacturing	Fruit, Oil, Cereal and Other Food Product Manufacturing
Industrial	CC	Food, Beverage and Tobacco Product Manufacturing	Meat and Meat Product Manufacturing
Industrial	CC	Food, Beverage and Tobacco Product Manufacturing	Seafood Processing
Industrial	CC	Furniture and Other Manufacturing	Furniture and Other Manufacturing
Industrial	CC	Metal Product Manufacturing	Fabricated Metal Product Manufacturing
Industrial	CC	Metal Product Manufacturing	Primary Metal and Metal Product Manufacturing
Industrial	CC	Non-Metallic Mineral Product Manufacturing	Non-Metallic Mineral Product Manufacturing
Industrial	CC	Petroleum, Chemical, Polymer and Rubber Product Manufacturing	Basic Chemical and Chemical Product Manufacturing
Industrial	CC	Petroleum, Chemical, Polymer and Rubber Product Manufacturing	Petroleum and Coal Product Manufacturing
Industrial	CC	Petroleum, Chemical, Polymer and Rubber Product Manufacturing	Polymer Product and Rubber Product Manufacturing
Industrial	CC	Printing	Printing
Industrial	CC	Textile, Leather, Clothing and Footwear Manufacturing	Textile, Leather, Clothing and Footwear Manufacturing
Industrial	CC	Transport Equipment, Machinery and Equipment Manufacturing	Transport Equipment Manufacturing
Industrial	CC	Wood and Paper Products Manufacturing	Pulp, Paper and Converted Paper Product Manufacturing
Industrial	CC	Wood and Paper Products Manufacturing	Wood Product Manufacturing
Industrial	DD	Electricity, Gas, Water and Waste Services	Electricity and Gas Supply
Industrial	DD	Electricity, Gas, Water and Waste Services	Water, Sewerage, Drainage and Waste Services
Industrial	EE	Construction	Building Construction
Industrial	EE	Construction	Construction Services
Industrial	EE	Construction	Heavy and Civil Engineering Construction
Industrial	FF	Wholesale Trade	Wholesale Trade
Industrial	II	Transport, Postal and Warehousing	Postal, Courier Transport Support, and Warehousing Services.
Industrial	II	Transport, Postal and Warehousing	Rail, Water, Air and Other Transport
Industrial	II	Transport, Postal and Warehousing	Road Transport
Office	JJ	Information Media and Telecommunications	Information Media Services
Office	JJ	Information Media and Telecommunications	Telecommunications, Internet and Library Services
Office	KK	Financial and Insurance Services	Auxiliary Finance and Insurance Services
Office	KK	Financial and Insurance Services	Finance
Office	KK	Financial and Insurance Services	Insurance and Superannuation Funds
Office	LL	Rental, Hiring and Real Estate Services	Property Operators and Real Estate Services
Office	MN	Administrative and Support Services	Administrative and Support Services
Office	MN	Professional, Scientific and Technical Services	Professional, Scientific and Technical Services
Office	OO	Central Government Administration, Defence and Public Safety	Central Government Administration, Defence and Public Safety
Office	OO	Local Government Administration	Local Government Administration
Other	AA	Agriculture	Dairy Cattle Farming
Other	AA	Agriculture	Horticulture and Fruit Growing
Other	AA	Agriculture	Poultry, Deer and Other Livestock Farming
Other	AA	Agriculture	Sheep, Beef Cattle and Grain Farming
Other	AA	Fishing, Aquaculture and Agriculture, Forestry and Fishing Support Services	Agriculture, Forestry and Fishing Support Services and Hunting
Other	AA	Fishing, Aquaculture and Agriculture, Forestry and Fishing Support Services	Fishing and Aquaculture
Other	AA	Forestry and Logging	Forestry and Logging
Other	PP	Education and Training	Education and Training
Other	QQ	Health Care and Social Assistance	Health Care and Social Assistance
Retail	GH	Accommodation and Food Services	Accommodation and Food Services
Retail	GH	Retail Trade	Motor Vehicle and Motor Vehicle Parts and Fuel Retailing
Retail	GH	Retail Trade	Other Store-Based Retailing and Non Store Retailing
Retail	GH	Retail Trade	Supermarket, Grocery Stores and Specialised Food Retailing
Retail	LL11	Rental, Hiring and Real Estate Services	Rental and Hiring Services (except Real Estate)
Retail	RS	Arts and Recreation Services	Arts and Recreation Services
Retail	RS	Other Services	Other Services

Appendix 3

Target Catchment – Demographic Analysis

Source: NZ Statistics

Omaha	Cape Rodney South	Kawau
Algies Bay	Tauhoa-Puhoi	Warkworth
Mahurangi	Wellsford	Point Wells
Matakana	Leigh	Snells Beach
Cape Rodney	Matheson Bay	

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Appendix 4

Target Catchment – Residential Analysis

Source: New Zealand Fire Service

Big Omaha	Omaha	Wharehine
Glorit	Tomarata	Manukapua Island
Whangateau	Wellsford	Port Albert
Makarau	Point Wells	Mahurangi East
Pakiri	Ti Point	Whangaripo
Matakana	Leigh	Mangakura
Snells Beach	Sandspit	Waiwera
Warkworth	Tawharanui Peninsula	Motuora Island
Tauhoa	Te Arai	Tapora
Dome Valley	Algies Bay	Puhoi
Mahurangi West	Dome Forest	Te Hana
Pohuehue	Kawau Island	Kaipara Flats

Appendix 5

Population Growth Projections by Age Group (2013-2038) (Percentage)

Source: Stats NZ, Colliers International Research
Population are based on medium projections.
2018 figures are estimates.

Area	Age	2013	2018	2023	2028	2033	2038
Cape Rodney South Area Unit	0-14 years	18%	16%	15%	16%	17%	16%
	15-39 years	22%	27%	29%	27%	24%	22%
	40-64 years	41%	36%	32%	30%	31%	33%
	65 years and over	19%	22%	24%	26%	28%	29%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Cape Rodney South Area Unit	0-14 years	20%	17%	17%	18%	18%	17%
	15-39 years	25%	33%	34%	32%	28%	28%
	40-64 years	29%	26%	26%	27%	30%	32%
	65 years and over	26%	24%	23%	23%	23%	23%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Target Catchment	0-14 years	20%	17%	17%	17%	17%	17%
	15-39 years	23%	28%	30%	29%	26%	25%
	40-64 years	36%	32%	31%	30%	31%	32%
	65 years and over	21%	22%	23%	25%	25%	26%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Rodney Local Board Area	0-14 years	21%	18%	17%	17%	17%	17%
	15-39 years	26%	30%	31%	30%	28%	27%
	40-64 years	38%	35%	33%	32%	32%	33%
	65 years and over	16%	17%	19%	21%	22%	24%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Auckland	0-14 years	21%	19%	19%	18%	18%	17%
	15-39 years	36%	39%	39%	38%	35%	33%
	40-64 years	32%	30%	29%	29%	31%	32%
	65 years and over	11%	12%	14%	15%	17%	18%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

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Appendix 6

Population Growth Projections by Ethnic Group (2013-2038) (Percentage)

Source: Stats NZ, Colliers International Research
Population are based on medium projections.
2018 figures are estimates.

Area	Ethnic Group	2013	2018	2023	2028	2033	2038
Rodney Local Board Area	European or Other (including New Zealander)	92%	88%	86%	86%	85%	85%
	Maori	11%	10%	10%	10%	11%	11%
	Asian	4%	7%	8%	9%	9%	9%
	Pacific	3%	3%	4%	4%	4%	4%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Auckland	European or Other (including New Zealander)	59%	56%	53%	51%	49%	48%
	Maori	11%	11%	11%	11%	11%	12%
	Asian	23%	28%	31%	32%	34%	35%
	Pacific	15%	15%	15%	15%	16%	17%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Appendix 7

Population Growth Projections by Family and Household Arrangement (2013-2038) (Percentage)

Source: Stats NZ, Colliers International Research
Population are based on medium projections.
2018 figures are estimates.

Area	Household Arrangement	2013	2018	2023	2028	2033	2038
Rodney Local Board Area	Family households	77%	77%	76%	76%	75%	75%
	Other multi-person households	2%	2%	2%	2%	2%	2%
	One-person households	20%	21%	21%	22%	23%	23%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	Average household size	*2.7*	*2.6*	*2.6*	*2.5*	*2.5*	*2.5*
Auckland	Family households	76%	76%	76%	76%	75%	75%
	Other multi-person households	4%	5%	5%	4%	4%	4%
	One-person households	19%	19%	20%	20%	21%	21%
	Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
	Average household size	*2.9*	*2.9*	*2.8*	*2.8*	*2.8*	*2.8*