



TAURIKO WEST - TUPENGA

Construction Water Assessment Report

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QUALIFICATIONS AND EXPERIENCE

My name is Campbell Ross Stewart. I am an environmental consultant, and a Director at Southern Skies Environmental Limited (SSEL), a company of consulting environmental and erosion and sediment control (ESC) specialists and planners based in Auckland and Kapiti Coast. I was a founding Director of SSEL when it was established in 2003.

My qualifications are Bachelor of Resource Studies (Lincoln University) and a Certified Professional in Erosion and Sediment Control (CPESC – No 7630). I have 30 years of professional land management and ESC experience, and I am a Member of the International Erosion Control association (IESC).

My experience relevant to this Application is as follows;

- Takitimu North Link Stage 2 (TNL2): Technical Specialist, prepared Construction Water Assessment Report for the FTAA substantive application.
- Waikato Expressway – Huntly Section: Erosion and Sediment Control Designer and Technical Advisor for the 15.5km Huntly Section of the Waikato Expressway. I designed and developed the erosion and sediment control plans for the project, led the internal ESC audit program and provided the ESC training to the project team and general ESC management and advice. The project achieved industry-leading environmental compliance scores, which led to winning the Waikato Regional Council Earthworks Site of the Year 2016 and 2017.
- Manawatu Tararua Highway: Manager Erosion and Sediment Control, designing, advising the project team and scheduling ESC and environmental construction related issues during the design and consenting phase. Prepared the ESC AEE and Construction Report, Environment Court Evidence. and Expert Conferencing. I designed and developed the ESC plans for the project moving into the construction phase.

The role required the development of the ESC planning and assessment of effects documentation with the Alliance planning team to obtain approvals through the Environmental Council in short timeframe, in parallel with obtaining a number of ESC and Construction related enabling consents through the Regional Council, and preparing all construction related management plans and ESCPs to allow for a “fast start”.

- Harapaki Windfarm: Erosion and sediment Control Technical Lead. I produced all ESC Plans (8 x separate construction zones) and the Construction Environmental Management Plan for the project, and advised and supported the construction team, including providing internal ESC audits during the construction phase.

I led and advised the environmental methodology for this complex and significant earthwork project, in steep and inhospitable terrain, in an isolated location with difficult access. I worked closely with the construction team to develop practical ESC solutions for the significant earthwork operations. I developed ESCPs that provided flexibility for the construction team, incorporating project design iterations and amendments that were inevitable on the project of this size and complexity. The project was viewed by the Hawkes Bay Regional Council as raising the standard of ESC in the region.

- In 2016 I was the Technical Lead Author of Auckland Council Guideline Document 2016/005 Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region (GD05), which won the NZRMLA 2016 Technical Publication of the Year Award. 2025 and 2026, I am currently the Lead Technical Author for Auckland Council associated with the update of GD05.

Although this Application is not before the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses as contained in section 9 of the Environment Court Practice Note 2023. I agree to comply with that Code. My qualifications as an expert are set out above. I am satisfied that the matters which I address in this Assessment Report are within my area of expertise, except where I state that I am relying on information provided by another person or expert. I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Signed:

s9(2)(a)

Date: 28/07/2026

EXECUTIVE SUMMARY

This Construction Water Assessment Report supports the substantive application for the Tauriko West – Tupenga Project (the Project). It assesses the potential sedimentation effects relating to earthworks and stream works during the construction phase of the Project.

The Project includes the construction of new offline four-lane corridors for SH29 and SH29A and the widening of the Takitimu Drive Toll Road to four lanes, together with associated grade-separated interchanges (Redwood Lane, Takitimu Drive and Belk Road), local road connections (Ōmanawa Road, Tauriko Village and Cambridge Road). The Project traverses two main catchments including the Wairoa River catchment and Kōpūrererua Stream catchment.

The objectives of the erosion and sediment control (ESC) management of the Project are to:

- a. Minimise the potential for sediment generation and sediment yield by maximising the effectiveness of ESC measures associated with earthworks; and
- b. Minimise potential adverse effects on freshwater environments within or beyond the Project area that may arise from the discharge of sediment during the construction of the Project.

This report includes a discussion on concept erosion and sediment control plans (drawings) and sets out an approach for ESC that could be implemented for the Project. The approach is based on the Bay of Plenty Regional Council (BOPRC) Guideline 2010/01 “Erosion and Sediment Control Guideline for Land Disturbing Activities (TG 2010/01). This concept ESC approach represents current industry best practice and also informs the Universal Soil Loss Equation (USLE) completed for the Project.

The assessment of potential effects from the discharge of treated sediment laden runoff to the freshwater receiving environments has been based on estimates of sediment yield for various parts of the Project Area, using the USLE. USLE estimates undertaken for other NZTA infrastructure and land development projects have been compared with recorded Sediment Retention Pond (SRP) performance within those other sites, which confirms that the sediment yield estimates undertaken for the Project are realistic.

The sediment yield estimates have been further validated by an analysis of the responsiveness of various soils along the alignment to chemical treatment, which will maximise treatment device efficiency by enhancing settlement rates. Generally, the sediment loads predicted as a result of Project construction are only a minor contributor of the overall load that will enter a given catchment during a rain event, as the Project earthworks footprint is only a relatively small proportion of the Wairoa and Kōpūrererua catchment systems.

Approximately 40.7ha of earthworks is proposed in the total Wairoa River catchment of approximately 45,000ha. This represents 0.09% of the catchment. The USLE calculation indicates a sediment load increase of approximately 10 tonnes / yr or an approximate 0.11% increase in load.

Approximately 34.9ha of earthworks is proposed in the total Kōpūrererua Stream catchment of approximately 7,400ha. This represents 0.47% of the catchment. The USLE calculation indicates a sediment load increase of approximately 9 tonnes / yr or an approximate 1.2% increase in load.

The implementation of and maintenance of ESC will be driven by the Contractor's team, including a dedicated Environmental Team. The Project Environmental and Construction Management Teams will work closely with BOPRC compliance monitoring inspectors for the duration of the Project, to ensure a high standard of compliance and a no-surprises approach to any design changes and site management.

The preparation and implementation of ESCPs, the implementation of the requirements of those plans and ESC management as described in this report form the basis of my assessment. Based on a review of the existing design information, and experience from other similar roading projects of this scale in New Zealand and the nearby Takitimu North Link Stage 1 (TNL1) project, it is considered that management of ESC in accordance with current best practice can be successfully implemented and will minimise actual and potential adverse effects to ensure that they are temporary and minor in nature.

1 INTRODUCTION

1.1 Purpose and Scope of Assessment

This Report supports the substantive application lodged by NZTA for the Tauriko West – Tupenga SH29 Project.

This report provides an assessment of the potential erosion and sediment related effects of Project construction that are likely to occur, alongside an Erosion and Sediment Control (ESC) methodology. It accounts for concept ESCP drawings contained in **Appendix C**.

The effects associated with the proposed construction works that are assessed in this report are those of land disturbing activities and potential sediment contaminated discharges to the environment. Land disturbing activities do not cause ongoing adverse effects once the Project is operational.

This report includes:

- a. a description of the Project works and understanding of the receiving environment as relevant to the assessment;
- b. identification and recommendation of ESC design principles, methods, practices, and standards to be implemented during construction;
- c. an investigation and assessment of the potential sediment yields and sediment yield determining factors;
- d. an assessment of the construction water effects that are likely to occur with the implementation of the matters covered by b. above; and
- e. development of the Chemical Analysis and Reactivity Test (CART) Report to ground truth assumptions for device performance.

2 DESCRIPTION OF WORKS

A detailed description of the Project is contained in the Substantive Application Report (SAR). A summary of the project works relating to ground disturbance and potential sediment generation is provided below.

2.1 Earthworks

The Project earthworks relate to:

- Enabling works, including geotechnical investigations (including formation of access for geotechnical investigations), establishing construction yards, offices, access points and fencing, constructing site access roads, relocation of services, demolition or removal works and establishing mitigation measures such as ESC measures, earth bunds and planting.
- Bulk earthworks, general cut to fill and cut to waste earthworks.
- Retaining wall construction and associated excavation of footings.
- Bridge construction and associated excavation of abutments and piling.
- Services installation, general trenching activities and the installation of stormwater treatment devices.
- Stream realignments (Kōpūrererua Stream, Nanako Stream, Belk Road Stream).
- Replacement and installation of new culverts.

Earthworks for the Project are anticipated to include the following (approximate volumes only) over an area of approximately 76ha:

- Total cut – 2,300,000 m³
 - Cut to waste – 800,000 m³
- Total fill – 3,300,000 m³
 - Re-use of cut – 1,500,000m³
 - Imported fill – 1,800,000 m³.

It is expected that the Project could be completed within an approximate timeframe of 6-8 years from commencement.

2.2 Stream Works

Construction of the Project will require the installation of a number of bridges and culverts to convey various watercourses and existing drainage channels through the alignment, along with diversions of a number of sections of stream channel.

General principles for the culvert works include managing the works programme so that flows from upstream catchments can be conveyed through the works areas, and any stream realignments are sufficiently stabilised and/or planted before becoming live. Where possible, proposed new culverts will be constructed and made operational prior to the disestablishment of existing culverts.

The construction methodology of stream realignments and culvert installations will be prepared as part of the detailed design phase and once the Contractor has been appointed. Final construction methodologies will be included in the ESCPs that will be certified by BOPRC prior to construction commencement. A particular focus of this methodology is the conveyance of clean water flows from catchments upstream of the works through the work site until such time as the flows can be diverted into their new channels and culverts. In some cases, this may require temporary culverts through the work site.

3 EXISTING ENVIRONMENT – SITE DESCRIPTION

The following is an overview of the existing environment and site description. A detailed overview of the existing environment can be found in the SAR and supporting technical reports.

3.1 Topography

Site investigations have shown the landform along the Project corridor as:

- Comprising undulating elevated terraces, rolling hill topography, board gullies floors and localised incised gullies.
- In some areas, the landform has been extensively modified as a result of urbanisation.

Furthermore, the landforms can be classified into four zones, described as follows:

- Terrace Deposits – undulating, elevated topography, with typical elevations of between RL30m to RL60m.
- Gully Deposits – low-lying (typically RL5m to RL15m), board gully floors associated with the Omanawa Stream, Wairoa River and Kōpūrerua Stream and localised incised gullies at the toe of natural escarpments. Open drains typically present within these areas suggesting presence of shallow groundwater.
- Transition Zones – transitions between terraces and gully floors typically comprise moderately steep to steeply graded escarpments, with gradients between approximately 15 to 45 degrees. Numerous relic slip scarps are situated across the steeper escarpments.
- Clean Fill - known clean fill site, located within an incised gully between Marshall Avenue and SH29A, at the eastern end of the alignment.

3.2 Land Use

The Project corridor passes through mixed land uses that include rural and industrial, medium density residential, horticulture, educational, open space in the valley with a transition into the urban periphery of Tauranga.

3.3 Geology and Soils

While site specific geotechnical investigations are still being completed along the project alignment and have not yet been incorporated into the ground model, soil types are based on nearby geotechnical data and experience with adjacent land development and infrastructure projects. Furthermore, representative samples of the soils encountered at the Project have been utilised for chemical reactivity testing, refer to **Appendix B**.

3.4 Groundwater

As outlined in the Groundwater Assessment¹, the invert level of all cut faces remain above the regional groundwater table. Perched aquifers may be encountered in certain locations due to localised geological conditions. If necessary, and accounting for further design and investigations, dewatering during excavations will be managed through standard construction methodologies, outlined in the ESCP.

3.5 Freshwater Environment

Descriptions of the freshwater receiving environments of the Project are provided in the Ecological Impact Assessment² and are adopted herein.

As described in the ecology assessment, the Project traverses the significant catchments of the Wairoa River (approximately 45,000ha) and Kōpūrerua Stream (approximately 7,500ha). Both catchments include multiple networks of natural and artificial watercourses that drain into the Wairoa River and the main stem of the Kōpūrerua Stream.

¹ Preliminary Groundwater Assessment, WWLA, July 2026

² Ecological Impact Assessment, Boffa Miskell, July 2026

Because the Project traverses multiple catchments and a wide range of watercourse types, from large, natural river systems to artificial drainage channels, the existing environment has been summarised by Boffa Miskell using a grouped approach that reflects shared physical characteristics, hydrological behaviour, ecological function, and faunal patterns (Table 1). The Project watercourses have been grouped into; high value receiving environments, moderate to high-value natural streams and negligible to low value watercourses including highly modified and artificial.

The classification of the receiving environment for each ESC device outlined in the preliminary concept ESC drawings (**Appendix C**) is included in this Report in **Appendix D**.

A small section of the ties in works at the eastern end of SH29A lies with the Waiorohi Stream catchment (the pink catchment in Figure 3-1 below). No bulk earthworks are proposed in this catchment.

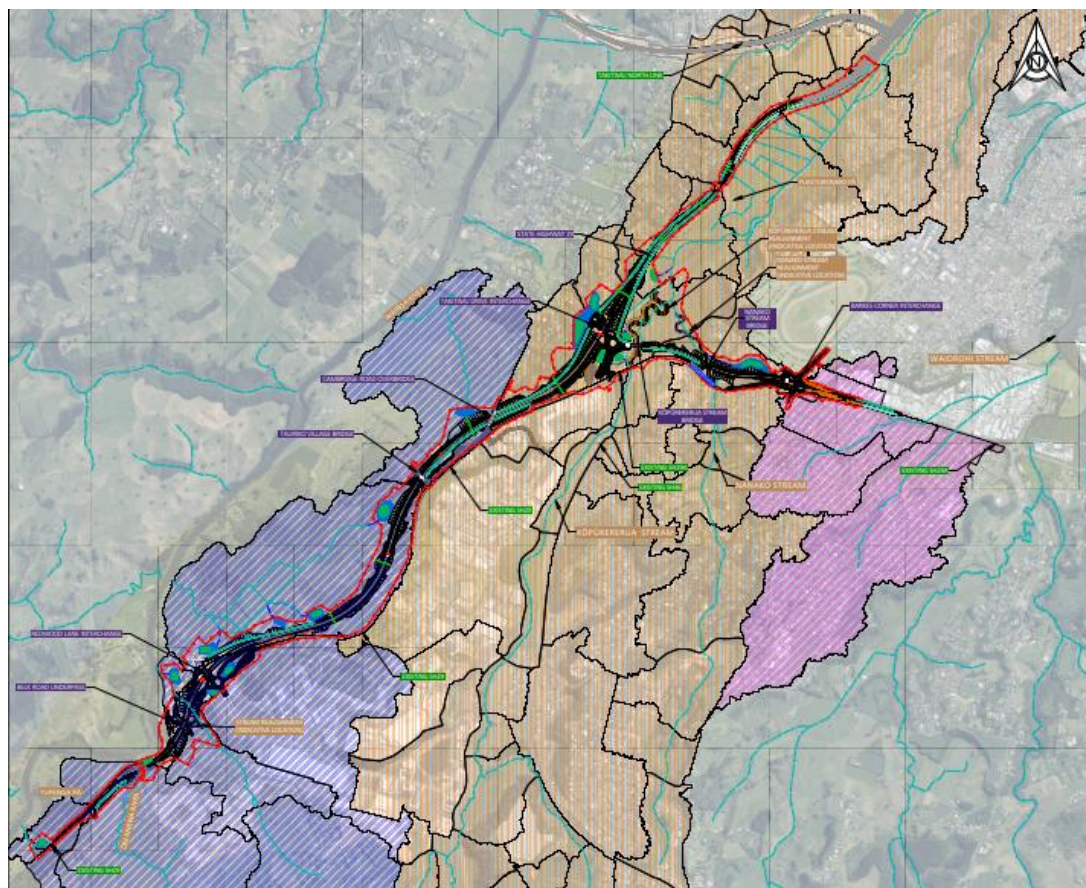


Figure 3-1: Stormwater Catchment Overview Plan, (Source: Bloxam, Burnett & Olliver)

4 ESCP MEASURES

The purpose of this section is to outline ESC measures that can be implemented throughout the works area to ensure that any potential erosion and sediment control effects are minimised to ensure that they are temporary and minor in nature.

Industry accepted practice is that the Contractor, once the project is confirmed for construction, will develop ESCPs to account for the Project's specific construction methodology.

Therefore, the detail provided within this section and in the concept drawings is an Indicative Design. The ESCP drawings in **Appendix C** represent an example of the layout of erosion and sediment control devices based on the high-level constructability and staging information.

ESCPs will be completed by the Contractor prior to works commencing and be certified by the Bay of Plenty Regional Council (BOPRC). Conditions of consent (included in the SAR) impose the necessary requirements to be included in the ESCPs.

Best practice erosion and sediment controls, methodologies and management will be implemented throughout the works in general accordance with the BOPRC Environmental Guideline 2010/01 "Erosion and Sediment Control Guidelines for Land Disturbing Activities" (TG 2010/01).

4.1 Enabling Works

Prior to the installation of the main ESC measures and commencement of bulk earthmoving activities, enabling works are likely to establish site access, facilities and construction areas to a state where the bulk construction works can occur.

The specific details of the enabling activities will be subject to the specific design and programme yet to be developed by the chosen site contractor and thus specific plans of these works are yet to be produced. However, a general summary of the types of enabling activities expected to be required on site are described as follows.

4.1.1 Utility Relocations

The project includes the relocation of high-pressure gas main and high voltage transmission lines. These works could be undertaken in advance of the main construction works in order to advance the overall programme. Typically, these works would not require significant earthworks, nevertheless, ESCPs will be prepared to ensure appropriate management of physical works.

4.1.2 Stream Realignments

It is likely that undertaking the Kōpūrererua and Nanako Stream realignments as enabling works will provide for overall programme benefits. Both realignments are adjacent to areas of significant earthworks, and undertaking the realignments in advance of the main works will have advantages for the stabilisation of the new stream realignments, early commencement of habitat restoration and flexibility for ESC implementation.

Stream realignment works will be addressed via specific stream works methodologies included in a Stream Management and Monitoring Plan, and specific ESC methodologies and ESCPs will also be developed.

4.1.3 Access Tracks/Haul Roads

The chosen site contractor will want to establish early construction access throughout the site to allow for early commencement of site clearance and construction activity. In particular, early access to culvert construction sites will be needed, along with access to cut areas to provide a source of material for fill. Hence, establishment of access tracks/haul routes is likely to be required throughout the site as part of the site enabling works within each construction zone.

Where possible, access tracks/haul roads will be established through upgrade of existing access roads and driveways. However, through parts of the site, new lengths of tracking will be required within the highway designation

although not necessarily along the permanent expressway alignment. Access tracks/haul routes will need to be of a standard to support heavy construction machinery.

4.1.4 Temporary Culverts

In addition to the permanent culvert crossing works, temporary culverts will be required in association with establishment of initial access tracks and haul routes. Temporary culverts may be installed in locations of the permanent culvert crossings to enable early access through the site however will comprise much shorter length crossings and may be formed from lower specification materials such as steel pile casings, storm boss pipes or recycled concreted pipes. These temporary crossings would be removed upon completion of the permanent crossings.

Methodologies for the culvert construction will be confirmed post-detailed design and will be included in the ESCPs.

4.1.5 Construction Yards

Construction yards are expected to be installed along the alignment to allow for establishment of site offices, staff carparking, soil testing facilities and secure storage of construction materials. Site compounds will likely be established through the creation of an aggregate platform, perimeter security fencing, portacom offices and container storage facilities.

4.1.6 Vegetation Clearance

Vegetation clearance will be required across the majority of the designated area to provide a clear corridor to allow bulk earthworks activities to proceed. In general, this will include the clearance of the existing residential and horticultural operations (e.g. pasture, avocados, kiwifruit and ornamental gardens) with few notable stands of native vegetation located within the alignment.

Where required, vegetation clearance will be undertaken, and felled vegetation may be mulched on site for use in stabilisation of landscape batters and fill areas.

4.2 Erosion and Sediment Control Methods

Best practice ESCs, methodologies and management will be implemented throughout the works in general accordance with TG 2010/01, except where an alternative control system has been designed and certified as part of an ESCP. ESC methods and devices will be implemented on the site over the course of the construction earthworks activities to ensure that potential soil erosion and sediment discharge effects are appropriately managed.

In general, the site presents a medium risk of potential erosion and sediment effects based upon the rolling topography, soil types, the large scale of earthworks and the sensitive receiving environment at some locations of higher value watercourses and wetlands.

Areas of increased risk include the clean water diversions required for stream realignments, the isolation of upstream cleanwater flows from the works areas, and works within the Kōpūrurerua floodplain and wetland area.

Staging of the required bulk fills and associated impact on traffic management during construction are likely to include construction techniques such as staging of cuts/ fill and ESC devices placed mid-slope or mid-carriageway. Staging will enable the significant earthworks programmes to be completed while ensuring satisfactory traffic flows throughout the construction works programme.

A concept layout of site ESCs is outlined on the drawings included as **Appendix C**. As described in Section 3 above, these plans are concept only. The ESC methodologies and ESCPs will be subject to further refinement and detail by the construction team (once the contract has been awarded) through the detailed ESCP development and BOPRC submission process.

It should also be noted that the concept ESC drawings are based upon the preliminary bulk cut to fill layout as depicted on the plans, whereas in reality, the works will often require a series of phases of enabling activities prior to

achieving the main bulk earthworks catchments as outlined on these plans. Again, the finalised details of all ESC measures for all phases of the works will be confirmed in the construction ESCPs.

4.3 Erosion and Sediment Control Personnel

Based on experience with similar NZTA Projects, in addition to the structural ESC measures to be implemented on site, benefits are gained by taking a team approach to the implementation, on-going operation, and the monitoring of the controls throughout the duration of the works. The specialised requirements to implement and manage a large-scale ESC operation over multiple years is a key delivery input to the successful ESC outcome.

The construction contractor will appoint an Environmental Manager who will have overall responsibility for ESC development, implementation and maintenance across the site throughout the duration of the Project. The Environmental Manager will set up an Environmental Team (or similar) which will be established at the commencement of the Project and will be vested with the responsibility for implementation of the approved ESCPs throughout the site. Specific details of key personnel would be confirmed through the finalised ESCPs and introduced to BOPRC compliance staff during project preconstruction meetings.

Copies of the certified ESCPs will be made available and a copy should be held with the relevant Construction Managers at all times. The Environmental Team will maintain daily on-the-ground supervision of the ESC measures across the Project, supported by the construction teams.

4.4 Monitoring and Maintenance

The monitoring and maintenance of all on-site erosion and sediment control methods and devices will ensure the success of the ESCP programme to minimise sediment discharge effects.

Current and long-term weather forecasts will be monitored by site management to ensure that construction activities are planned and resourced to address any changing weather conditions. Proactive site monitoring will be undertaken regularly and prior to forecasted trigger events. Monitoring of ESC measures are set out in Table 4.1 below:

Table 4.1. Monitoring methods.

Work Phase	Frequency	Monitoring actions
Enabling Stage	Daily	- Inspect all structures - Visual monitoring of discharge water quality
	Prior to a forecast trigger event	Inspect all erosion and sediment control measures, devices and chemical treatment systems
Bulk Earthworks stage	Daily	- Inspect all structures - Visual monitoring of discharge water quality
	Prior to a forecast trigger event	Inspect all erosion and sediment control measures, devices and chemical treatment systems
Pavement Preparation Stage	Weekly	- Inspect all structures - Visual monitoring of discharge water quality
	Prior to forecast trigger event	Inspect all erosion and sediment control measures, devices and chemical treatment systems

Should monitoring of ESC devices identify the need for maintenance of devices (e.g., de-sludging of sediment controls, repair of devices etc) that maintenance will be implemented by the contractor as soon as site conditions allow.

Material removed from sediment control devices (sediment sludges) will be placed within a contained (bund) area, outside any concentrated flow paths but within the sediment control device catchment. During dry conditions the material will be removed to a fill site and spread to dry, prior to blending into the fill surface.

4.4.1 Water Quality Monitoring

Monitoring of the sediment control devices and site discharges (via the sediment control devices) provides direct feedback to the construction team on the site's performance. The management of ESC for a Project's duration is dynamic and the earthwork contributing catchments of the devices can be changing daily with a large cut and fill operation. Different soils profiles as cut and fill operations progress can also rapidly change ESC performance with different suspension and settlement rates, affecting chemical dose rates. A comprehensive and proactive monitoring approach is considered to be a critical element to a successful large scale earthworks operation minimising the effects of sediment discharges on the receiving environment.

Sediment control device water quality, discharge water quality and the receiving environment water quality will be closely monitored through visual inspection over the life of the Project to determine ESC performance and potential downstream effects. This will occur through direct observation of the devices and can also include the use of Secchi discs or clarity tubes to provide an immediate measure of water clarity.

Should the visual monitoring identify poor discharge quality occurring from the sediment control devices, water quality monitoring should be implemented to quantify the quality of the discharges and any effects upon water quality within the receiving environment. The proposed water quality monitoring includes:

- Collection of samples from the identified devices after any Trigger Event within the proceeding 24 hours at the following points:
 - Directly upstream of the discharge outlet;
 - At the discharge outlet;
 - Downstream of the discharge outlet at a location which is no more than three times the width of the river or stream.
- Analysis of all samples for suspended solids and turbidity.

The sample results will be reviewed to determine the quality of the discharge, and to assist in informing the post event actions, for example, the need for maintenance, upgrade or additional works to improve treatment efficiencies and discharge outcomes. In the event that sediment control device discharge quality causes adverse downstream water quality, the contractor will implement one or multiple contingency measures as outlined within Section 4.4.2 below.

4.4.2 Contingency Measures

Should monitoring of devices identify poor performance, a number of contingencies can be implemented to ensure that treatment efficiencies improve. These include:

- The addition of chemical flocculant batch dosing in accordance with the approved ESCP;
- Lifting T-Bar decants to allow for prolonged retention of runoff and increased settlement with decants only being dropped to discharge level once pond water quality has improved;
- Increasing device storage volumes;
- Stabilisation of areas with hay mulch;
- Installation of sediment pits, hay bale barriers, contour drains and other erosion control measures within device catchment areas;
- Stabilisation of diversion drains with rock/geotextile or check dams;
- Installation of silt fence baffles across SRPs to enhance treatment function;
- Grading of SRP inverts backward towards the forebay to maximise sediment accumulation within the initial pond lengths and enhance discharge quality.

4.4.3 Record Keeping

Each sediment control device will be labelled as identified within the approved ESCP.

Records will be kept for each device by the site contractor responsible for operation and maintenance of sediment control devices of the following details:

- Construction date for each structure;
- Inspection comments;
- Details of maintenance required and date completed;
- Audit comments and date completed;
- Council inspection date;
- Request for decommissioning date;
- Date structure decommissioned;
- Final inspection date.

These records will be kept on site and can be made available to BOPRC upon request.

4.4.4 Decommissioning of Structures

Pursuant to BOPRC standard requirements, no ESC structures can be decommissioned until approval has been received from the BOPRC. There is set criteria that needs to be met before a structure can be removed which will typically comprise the following steps:

1. Establish a suitable vegetation cover to minimise erosion/sediment discharge effects (typically a minimum 80% grass cover);
2. Obtain written approval from BOPRC for the removal of the structures (request approval to be provided through either email, letter or site inspection sheet);
3. Once approval has been provided, identify a fine weather window for works to be carried out;
4. Remove structure and fully stabilise the area with suitable vegetation. Mulch/slash may be utilised to provide temporary protection of areas until the permanent vegetation has established.

5 ASSESSMENT OF EFFECTS

The following sections outline the methodology utilised to assess the effects, discusses the potential impacts of the Project work from sediment related discharges from construction water, and outlines recommended mitigation measures.

5.1 Methodology

5.1.1 Erosion and Sediment Control Processes

Erosion occurs when the surface of the land is worn away (eroded) by the action of water, wind, ice, or geological processes. Through the erosion process, soil particles are dislodged, generally by rainfall and surface water flow. As rain falls, water droplets concentrate and form small flows. As this flow moves down a slope, the combined energy of the rain droplets and the concentration of flows has the potential to dislodge soil particles from the surface of the land. The amount of sediment generated through erosion depends on the erodibility of the soil, the energy created by the intensity of the rain event, the site conditions (for example, the slope and the slope length) and the area of bare earth or unstabilised ground open to rainfall (referred to as "open" areas).

Sedimentation occurs when these soil particles are deposited. This occurs when runoff velocities become low enough for sediments to fall out of suspension. With the exception of filter socks and filter bags, sediment retention devices act as low velocity depositional environments by holding water back long enough for sediments to fall out of suspension.

The following terms represent the key aspects of ESC:

- (a) Sediment generation – the process whereby erosion dislodges and mobilises soil particles. It is influenced by slope gradient, slope length, soils, rainfall, surface condition and erosion control factors; and
- (b) Sediment yield – the amount of sediment that leaves the site and enters the receiving environment. It is influenced by the amount of sediment generated on site, the efficiency of the sediment control devices and the supporting management protocols.

The purpose of ESC is to minimise sediment yield to appropriately minimise off-site water quality and ecological effects during the earthworks phase of a project. ESC must be implemented together to achieve these outcomes.

Erosion control is based on the practical prevention of dislodging and mobilising sediment in the first instance. If erosion control measures and practices are effective, then sediment generation will be minimised and the primary reliance on the sediment control measures is reduced, with the overall efficiency of the ESC management system maximised.

Sediment control refers to the management of the sediment after it has been generated. It is inevitable that sediment will be generated through land disturbance activities, even with industry best practice erosion control measures in place. Sediment control measures are designed to capture this sediment to minimise any resultant sediment-laden discharges to waterways. No sediment control measures are 100% efficient i.e., there is always a residual discharge of treated sediment-laden water. Hence, erosion control is critical to minimise the amount of sediment generated that needs to be captured and retained within the sediment controls. Reducing the sediment load reaching the sediment controls also allows them to service more rain events between cleanouts and reduces maintenance costs.

The overall effectiveness of the ESC management measures will have a direct effect on the sediment yield that discharges from the site and into the receiving environment.

5.1.2 Sediment Yield Assessment

5.1.2.1 Approaches to Estimating Sediment Yield

For consenting purposes, the requirement to estimate sediment yield from earthworks projects has varied throughout New Zealand. The practice of forecasting likely sediment yield from construction sites began in the Auckland region

during the 1990s and was used to assist in the design of ESC measures within a particular project. This approach allowed potential variability in sediment yield across a site to be identified, as well as informing the construction industry of the indicative volumes of sediment that could be generated and discharged during earthworks if not appropriately managed.

With respect to more recent NZTA projects, various approaches to estimating sediment yield and associated effects have been applied. These have ranged from assessments based on typical earthworks catchments within a project area, to project-wide modelling and estimates using various assessment tools.

The most commonly used estimating tool has been the Universal Soil Loss Equation (USLE³). More sophisticated modelling tools have also been used, including the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model, which was applied to the Puhoi to Warkworth (P2WK) project, in conjunction with the USLE.

P2WK invested significant time and cost to derive estimates of sediment yield to a high degree of resolution, albeit subject to the uncertainty associated with the assumption inputs applied to the modelling.

For the recently consented Te Ara o Te Ara - Mt Messenger Bypass, the NZTA project team adopted the estimated hill country annual sediment yield value derived from the P2WK modelling, based on an assumption of sufficiently similar soil types and topography.

For the Huntly Section of the Waikato Expressway, the NZTA project team provided USLE calculations for three typical SRP catchments within the alignment (being steep (2.17ha), moderate (2.1ha) and low gradient (2.08ha)) as representative of the project without any further project-wide extrapolation.

For the Te Ahu a Turanga and recent Otaki to North of Levin (O2NL) and Takitimu North Link Stage 2 (TNL2) Projects, the NZTA project teams provided USLE calculations for several typical SRP catchments within the alignment located across representative areas of the project. Calculations from the representative catchments were then used for project-wide extrapolation.

As a result, NZTA now has broad experience with ESC management tools derived from monitoring undertaken on various roading projects. This information allows confidence in estimating sediment yields and confirming the relevance (or otherwise) of the available prediction tools.

5.1.2.2 Estimate of Sediment Yield for the Project

Eight USLE estimates of sediment yield have been undertaken for typical SRP catchments within the Project based on the Concept ESC Drawings (**Appendix C**), located across representative grades and catchments. The USLE calculations are provided in **Appendix A**.

Applying an estimate that best reflects the topography or soil type of a given section of earthworks within the Project, the USLE estimates have been applied to the footprint of earthworks within the two main stream catchments crossing the alignment. They derive an estimate of sediment load in tonnes from the Project for one year, being the first year of works within each given area.

To the greatest extent practicable, earthworks areas, including gully fills, will be treated by chemically treated SRPs, which are the most efficient sediment retention device. Areas of restricted space or small isolated catchment areas will be the main reasons where it might not be practical to install a SRP. In these circumstances, DEBs and silt fences will be used. Areas treated by DEBs and silt fences will be minimised as far as practicable and will not be a significant component of the overall treatment system within the Project and is evident in the Concept ESC Drawings (**Appendix C**).

³ The USLE is a relatively simple model suitable as a sediment yield estimation tool for a range of land disturbing activities including earthworks. The USLE method can be used to identify variation in potential sediment yield across a site rather than providing a numerically accurate estimate of actual total sediment yield. While the overall estimate of the yield is indicative of the magnitude of sediment likely to be discharged, the range of assumption required in the USLE calculation means that it should not be relied on as an accurate assessment of the actual total yield.

The USLE values reported below include the following assumptions:

- (a) Soil composition based on geotechnical investigations.
 - 40% clay, 50% silt, and 10% sand.
 - This is considered to be a general average assumption for the site on the basis of available data. Both the ash and tephra units vary throughout the Project, but generally within these ranges with a more dominant silt %.
- (b) The SRP catchment will be fully exposed for the full twelve months of the earthworks period each year. In practice, full exposure for the year is unlikely as various areas will be progressively stabilised, such as cut and fill batters and completed works areas. Winter works earthwork operations are also likely to restrict the open areas throughout the winter period.
- (c) No use of contour drains. In practice contour drains will be implemented to break up flow path lengths and correspondingly reduce sediment generation. Contour drains have a significant sediment yield reduction effect on the USLE model.
- (d) Assumed 95% average treatment efficiency for chemically treated SRPs⁴, and 80% average treatment efficiency for chemically treated DEB. These values have been generally accepted for NZTA and other earthworks projects throughout New Zealand and is supported by real-time automated monitoring of ponds within various projects⁵. As detailed in the CART, bench testing of soils from the Project Area has shown a good response to chemical treatment.

These assessed values are based on the design and installation of guideline compliant controls, and proactively managed and operated in accordance with the guidelines. NZTA projects, with their specialised environmental team management structures, proactive chemical treatment management, and rigorous monitoring and maintenance provisions, will be at or near these efficiency levels. Table 4-2 below provides a summary of the estimated sediment yields (t/ha/yr) and loads (t/yr) derived from the USLE. It presents the sediment yield estimated for the initial year of works in each SRP catchment plus 1 DEB catchment based on the approximate footprint of earthworks within the catchment, a corresponding estimate of sediment yield for that same footprint under the existing land use and presents the additional load that will result from the earthworks over that period. Average sediment load values of the devices in each catchment was used.

In addition, for comparative purposes, the existing land use estimated sediment yields have been extrapolated to include the area of each catchment for the Wairoa and Kōpūrerua catchments using an average pre-earthworks sediment load value of the corresponding device catchment areas. The extrapolation is derived by using the SRP pre-development footprint values and multiplying by the total catchment.

A small section of the tie-in works at the eastern end of SH29A lies with the Waiorohi Stream catchment. No USLE assessments have been made for this catchment as limited earthworks are proposed in this catchment and silt fencing and/or rapid stabilisation of pavement widening works in this location is appropriate.

⁴ Auckland Regional Council Technical Publication 227 – *The Use of Flocculants and Coagulants to Aid the Settlement of Suspended Sediment in Earthworks Runoff: Trials, Methodology and Design, June 2004*.

⁵ P2WK; Milldale Development Stages 1 and 2.

Table 4-2: Estimated sediment yields and loads for the Project for the initial phase of works within the Wairoa and Kōpurererua catchments

Stream	Earthworks area total (ha)	Indicative USLE Catchments	Sediment yield earthworks (t/ha/yr)	Sediment load earthworks (t/yr)	Sediment yield from existing land within earthworks footprint (t/ha/yr) (using same indicative USLE catchment)	Sediment load from existing land within Project earthworks footprint (t/yr)	Sediment load difference: earthworks minus existing (t/yr)	Stream Catchment (ha)	Catchment Sediment Load Before (t/yr) (based on USLE existing land assumptions)	Catchment sediment load during earthworks (t/yr) (catchment sediment load + sediment load difference)	Catchment Sediment Load Increase (t/yr)	% catchment increase	Earthworks area as % of catchment
Wairoa Catchment		SRP-K (3.52ha)	0.61	24.83	0.27	10.99	13.84	45000					
		SRP-D2 (1.32ha)	0.52	21.16	0.23	9.36	11.80						
		SRP-P (5.18ha)	0.49	19.94	0.22	8.95	10.99						
		SRP-Q2 (1.03ha)	0.17	6.92	0.08	3.26	3.66						
		SRP-Q3 (3.39ha)	0.45	18.32	0.2	8.14	10.18						
Total Wairoa Catchment Average USLE Calculation	40.7	40.7ha	0.45	18.23	0.200	8.14	10.09	45,000	9000	9010	10.09	0.11%	0.09%
Kopurererua Catchment		SRP-Y (1.91ha)	0.21	7.32	0.09	3.14	4.19	7400					
		DEB-F (0.44ha)	0.53	18.49	0.06	2.09	16.39						
		SRP-AC (2.53ha)	0.34	11.86	0.15	5.23	6.63						
Total Kopurererua Catchment Average USLE Calculation	34.88	30.88ha	0.36	12.56	0.100	3.49	9.07	7,400	740	749	9.07	1.21%	0.47%

5.2 Potential Adverse Effects

The potential adverse effects of sediment laden discharges from the Project during the construction phase include direct impacts on water quality, freshwater biodiversity, and values of specific interest to mana whenua. These potential impacts of accelerated erosion and sediment discharge are well documented.

Where appropriate ESCs are not implemented, there is potential for potential adverse effects on:

- Ecological values associated with direct and indirect impacts on flora and fauna on land and in adjacent freshwater and marine waterbodies, such as:
 - Smothering.
 - Deterioration of habitat from discharge of sediment and pollutants and sedimentation (e.g. stream blockage, reduced light levels, weed growth).
 - Abrasion and direct impact to fish, stream insects, shellfish and other bottom-dwelling organisms.
- Water quality for consumable water resources.
- Aesthetic and recreational values of land and waterbodies.
- Property and public utilities.
- Cultural matters of significance to mana whenua, including the mauri of water, mahinga kai, customary rights and kaitiaki initiatives.

The Project traverses the catchments of the Wairoa River catchment and Kōpūrererua Stream catchment. Both catchments include multiple networks of natural and artificial watercourses that drain into the Wairoa River and the main stem of the Kōpūrererua Stream.

In general, and as illustrated in Table 4-2 above, the sediment loads predicted as a result of the Project construction, are a small proportion of the overall load that will enter the Wairoa and Kōpūrererua catchments during a rain event, as the Project earthworks footprint is only a small proportion of most of the Wairoa and Kōpūrererua catchment systems.

The Wairoa River catchment is significant (approximately 45,000ha in area) with a large area of horticulture and areas of lifestyle and pastoral farming. Industrial land use is developing in the catchment in the vicinity of the SH29 /Kaweroa Drive area. Approximately 40.7ha of earthworks is proposed in this catchment and represents 0.09% of the total catchment area. The USLE calculation indicates a sediment load increase of approximately 10 tonnes / yr or an approximate 0.11% increase in load from the baseline assumption (runoff from existing land use, stream bank and bed erosion and potential periodic land slips).

The Kōpūrererua Stream catchment is also significant (approximately 7,400ha in area) with a large area of horticulture and areas of lifestyle and pastoral farming in the upper catchment. Industrial land use, urban area and the Kōpūrererua Stream reserve dominate the central and lower parts of the catchment adjacent to SH29. Approximately 34.9ha of earthworks is proposed in this catchment and represents 0.47% of the total catchment area. The USLE calculation indicates a sediment load increase of approximately 9 tonnes / yr or an approximate 1.2% increase in load from the baseline assumption (runoff from existing land use, stream bank and bed erosion and potential periodic land slips).

While both catchments include forest and regenerating forest in the upper catchments, both include significant areas of horticulture and areas of lifestyle and pastoral farming. Sediment sources within those catchments will include sediment laden runoff from existing horticulture, pasture, forest, stream bank and stream bed erosion, land slips, farm tracking, and sundry other sources. Hence, for most of the catchments, the Project represents a small percentage of the USLE calculated estimated sediment load of their overall catchment.

The potential adverse effects of the predicted sediment yield from the Project on the freshwater receiving environments are assessed and reported on in the Ecological Impact Assessment.

With the implementation and proactive management of best-practice ESC design and methodologies that are constructed, operated, and maintained to a high standard (in accordance with the requirements of TG2010/01),

subject to chemical treatment, and a proactive and responsive monitoring and maintenance programme as summarised above, construction of the Project is unlikely to result in significant sediment-related adverse effects downstream of the Project area. Adverse effects are anticipated to be temporary and minor. This conclusion is based on:

- my observation of the performance of roading and other large-scale earthworks projects that have implemented the same standard of ESC practice and dedicated environmental team and management structures;
- my observation of the performance of large-scale earthworks projects implementing proactive chemical treatment management on all sediment control devices;
- my observation of the performance of projects that emphasis proactive monitoring to maintain the performance of all ESC devices; and
- the small relative proportion of each catchment in relation to the earthworks footprint as noted above.

6 PROPOSED MITIGATION MEASURES

Mitigation of the potential sedimentation effects as a result of the Project earthworks are described in the sections below.

6.1 Erosion and Sediment Control Management

Ensuring dedicated management and specialist personnel have overall responsibility for ensuring that the ESCPs are complied with in terms of design, site operations, the installation and management of the devices, chemical management and monitoring is a critical success factor.

6.2 Best Practice Erosion and Sediment Control

All ESC measures will be designed, constructed, and maintained in accordance with TG 2010/01, being the industry best-practice guidelines for the region.

Furthermore, NZTA has demonstrated a successful track record⁶ with respect to ESC associated with large infrastructure projects and the implementation and maintenance of ESC and methodologies in challenging terrain. A key aspect of that success is through implementing dedicated ESC environmental management team structure, comprehensive and integrated chemical management planning, operations and management and extensive ESC monitoring and maintenance.

ESCPs will be prepared that focus on the management of specific works areas throughout the Project construction phase. This approach enables specific areas of high construction complexity to be identified, staged, and managed effectively.

6.3 Key Erosion and Sediment Control Measures

ESC measures will be undertaken and implemented with a hierarchy and priority order as follows:

- Erosion control in all circumstances by minimising sediment generation through a range of structural (physical measures) and non-structural (methodologies and construction sequencing) measures.
- Sediment control implemented for all sediment laden discharges by prioritising the most efficient devices and minimising the extent of works that are treated by less efficient devices. On this basis, priority will be given to chemically treated SRPs that should be rationalised within the Project area to ensure they are fully utilised, centralised, effective and do not create unnecessary earthworks in themselves.

The development of ESCPs, in accordance with the direction and principles of TG 2010/01, will allow for future flexibility and practicality of approach to ESC and will allow the ability to adapt appropriately to changing conditions.

Progressive and rapid stabilisation of disturbed areas using mulch, aggregate and geotextiles should be ongoing during the construction phase. Forms of temporary stabilisation should be used for stockpiles, ground improvement in locations where topsoil has been removed, concentrated flow paths, and cut batters. Permanent stabilisation should be carried out in accordance with the final design parameters and will comprise the stabilised road surface and rock lined swales, establishing vegetation (e.g. topsoil and planting), mulch and exposed rock surfaces if they occur.

Vegetative stabilisation will need to be appropriate to the soil type, geology, and time of year with the intent of achieving at least 80% vegetative cover or another non-erodible surface. Stabilisation is designed for both rainfall and wind erosion control (dust minimisation) and will be progressively implemented.

All SRPs and DEBs will be chemically treated. A Chemical Analysis and Reactivity Test (CART) has been completed (**Appendix B**) and reports on bench testing undertaken for a range of soil samples taken along the Project's alignment. The CART confirms the effectiveness of chemical treatment for the soils found in the Project area and informs the assessment of effects. Chemical treatment procedures will need to be prepared that provides a management framework for the implementation of flocculation within the Project area. A schedule within the ESCPs

⁶ Good compliance records, several projects winning both environmental and ESC awards locally and internationally.

will be progressively updated as bench testing is undertaken throughout the Project to correspond with construction progress. The bench testing assesses the specific soil type against different approved chemicals and dose rates to determine the optimum dose rate to provide the best water quality outcome. The ongoing bench testing will establish the dose rate and set-up details for the dosing systems within each catchment.

Stream works will need to be undertaken in a manner that recognises the higher risk of this activity and the sensitivity of the receiving environments. Works within active stream channels and any associated works will be undertaken subject to specific construction methodologies (e.g., diversion of flows around the area of works or undertaking construction 'offline') and where practicable during times of forecasted weather windows.

6.4 Monitoring

Monitoring and maintenance provisions will be included in the ESCPs and include a methodology to ensure that ESC measures have been designed, installed, and managed in accordance with an ESC management structure described above or similar, and to monitor the effectiveness of ESC for the duration of the construction phases of the Project.

Compliance and performance will be achieved through appropriate location, design, installation, as-built certification, maintenance, and monitoring of ESC devices. ESC management in this context is not restricted to physical structures but also includes work practices and methodologies.

As-built certification of devices is an important element of effective site management as it confirms compliance of the installed controls in accordance with the guidelines and the ESCP. As-built checklists and/or drawings should be prepared for all controls to ensure that they have been installed as designed. Works within the catchment of an ESC device should not commence until the as-built document for the device (or devices) has been certified by a suitably experienced ESC practitioner.

Regular monitoring underpins the successful implementation of the ESC management system.

The monitoring will also provide continual feedback to ensure successful ESC performance and early detection of activities or problems that have the potential to result in an adverse environmental effect.

The frequency of the device monitoring will vary throughout the construction programme and reflect areas of changing activity and risk within the Project Area. During the active construction phase in a given area, monitoring will be undertaken daily as well as pre- and post-rainfall events. Monitoring will report any repairs or issues that need to be addressed and the timeframe for completion of those actions.

The regular monitoring will need to be supported by monitoring of the chemical treatment systems, weather, rainfall trigger events, and will include wet weather responses and contingencies.

6.4.1 Weather forecasting, recording and responses

Weather forecast monitoring is an important part of a project's ESC management and should initiate pre-rainfall event inspections as well as inform the timing of undertaking higher risk activities such as stream works.

Monitoring weather forecasts is important in identifying trigger events (rain events of certain intensities) and prompting site preparation for the event. The Project should utilise readily available forecast methodologies including metvw.com and metservice.com. Forecast maps should be reviewed daily and assessed for periods of wet weather as required.

Rainfall should be recorded by a telemetered rainfall monitoring station installed on site to provide real-time continuous rainfall intensity and volume data. That real-time data can be available via a range of platforms including mobile phone apps. Email and text notifications can be programmed to ensure relevant staff, including the Environmental Management Team, are alerted when rainfall trigger events occur.

Recorded rainfall can be compared to forecasts to assist with more accurate rainfall prediction as the Project progresses.

Where more significant rainfall events are forecast, including trigger events (refer to Section 6.4.3 below), additional site inspections will be undertaken by the Project Environmental Team to ensure all ESC measures are fully

operational and identify any additional measures that could be installed, such as additional sediment sumps or contour drains.

6.4.2 Chemical Treatment Monitoring

A core part of chemical treatment management is monitoring to check that the systems are all working as anticipated and to provide information to facilitate ongoing maintenance and improvements to the chemical treatment systems.

Monitoring and maintenance of the chemical treatment systems should be undertaken in accordance with the ESCP. It will include a visual inspection of the chemical treatment system at least weekly and pre- and post-rainfall, and inspection of clarity of impounded water and discharges from SRPs and DEBs. All components of the treatment system should be checked, including the catch trays, inlet and outlet hoses, and chemical discharge location. The pH of the discharge will be checked to ensure that it is within the 5.5 to 8.5 range⁷.

Where clarity is less than anticipated, a suitably experienced ESC specialist should be contacted and the ESC system for that device be reviewed. This may include re-testing of soils and adjustment of the dose rate.

6.4.3 Trigger Event Monitoring

The objective of trigger event monitoring is to understand the performance of the Project's ESCs through a range of larger (but still relatively frequent) storm events, using water visual clarity as a proxy for pond performance and overall ESC performance indicator.

Consistent with other projects of comparable scale (including the nearby TNL Stages 1 and 2), a rainfall response trigger of 25mm in 24 hours will be adopted. This trigger has been adopted as intensities and durations above which, a range of more significant outflows will occur from SRPs and DEBs.

The ESCP (and proposed Conditions) sets out that when a trigger event is forecast, a pre-rain inspection will be undertaken by the Environmental Management Team in conjunction with the Construction Team. The purpose of the inspection will be to ensure that the site is fully prepared for the higher intensity and/or duration rainfall event and identify any additional measures that could be adopted to further minimise the risk of sediment discharges.

When a rainfall trigger event occurs, Environmental Management Team members and key construction team members will be notified via the telemetered rainfall monitoring stations and site monitoring will be initiated. Inflow and outflow clarity will be recorded manually at each SRP and DEB that is discharging (subject to health and safety restrictions such as limitations on night access). This data will be used to confirm SRP and DEB performance, including trends or variability between devices. This will in turn allow ongoing identification of issues and adjustments to maximise performance across the site.

6.4.4 Audits and Reporting

Details of proposed auditing and reporting on device and Project performance will be provided in the Project ESCPs. For programmed BOPRC inspections, a member of the Environmental Management Team will accompany the Council inspector in all audits. All ESC maintenance actions identified by the BOPRC inspector would be recorded into the Environmental Management System. Work Instructions with details and timeframes will be issued to the responsible staff by the Environmental Manager or Environmental Technical Specialist or similar, based on the Council's instruction. The staff would report back the completion of those actions to be inspected and confirmed by the Environmental Manager or Environmental Technical Specialist. Confirmation will then be emailed to the Council inspector.

Following a rainfall trigger event, a report will be provided to BOPRC within 10 days of the event which will include a summary of the performance of SRPs, DEBs and overall ESC system observed during the rainfall event.

⁷ pH range of between 5.5 to 8.5 is generally accepted as presenting little threat of toxicity, reference from discussion paragraphs in TG 2010/01.

7 RECOMMENDATIONS

Based on the assessment of potential adverse effects resulting from construction water impacts identified in Section 5, and the mitigation measures described in Section 6, my recommendations are as follows.

- All earthworks and land disturbance activities should be undertaken in general accordance with TG 2010/01.
- The approach to managing construction water discharges for each stage of works will be confirmed by the Contractor prior to works commencing through the preparation (and certification by Council) of ESCPs for activities within the Project area.
- The ESCPs should include a project Environmental Management Team that includes dedicated management and specialist personnel responsible for ensuring that ESCP compliance.
- The ESCPs should include procedures for chemical treatment, be prepared for the Project and submitted to Council prior to commencement of works. This will confirm the chemical treatment set up and including all relevant batch dosing information, procedures and protocols. The procedures should be in accordance with therefore Auckland Council's Guideline Document 2016/005 '*Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region, Incorporating Amendment 1*'⁸
- The ESCPs should confirm the ongoing monitoring and maintenance of ESC measures that will be implemented on the Project throughout the construction period. The ESCP should include, but not necessarily be limited to, the following matters:
 - The key purpose and objectives of the monitoring;
 - General erosion and sediment control monitoring and maintenance procedures that will be implemented to detect and prevent any adverse sediment effects;
 - How specific water quality monitoring for the implementation of specific site management actions will be achieved;
 - Specific water quality monitoring procedures based on the water quality expectations and including procedures to comply with any construction earthworks conditions;
 - Specific management responses that will be undertaken in response of the water quality triggers and any other adverse sediment effect that is identified; and
 - Recording and reporting procedures.
- Prior to any stream works and culvert extensions (and/or culvert replacements) commencing on the site, a final construction methodology should be included within a Stream Management and Monitoring Plan. Details to be provided should include, but should not be limited to timing, staging and sequencing of stream works, and the erosion sediment control measures to be employed to mitigate the effects on waterbodies.

Through the implementation of the recommended key mitigation measures above, any construction water discharges will be subject to best practice management and proven management conditions, which will ensure any potential effects from the Project works to be temporary and minor in nature.

⁸ Chemical treatment is currently absent from the Bay of Plenty Regional Council's (BoPRC) erosion and sediment control guidelines and therefore Auckland Council's Guideline Document 2016/005 '*Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region, Incorporating Amendment 1*' should be adopted.

8 CONCLUSION

This report assesses the construction water (sediment) related effects of the Project.

The potential adverse effects of sediment laden discharges from the Project include direct impacts on water quality, freshwater biodiversity and values of specific interest to mana whenua. These effects are well understood from experience with NZTA linear infrastructure projects over many years.

Best practice ESC is based on key management principles, minimising the area exposed to erosion at any given time, implementing best-practice ESC measures, comprehensive chemical treatment and management of devices, and an effective monitoring and management programme undertaken by a dedicated site team. The assessment of effects described in this report assumes this best practice ESC approach will be implemented.

The estimated increase of sediment yield over and above the existing land use scenario will vary between the two main catchments between 0.1% to 1.2%.

Best-practice ESC can be successfully implemented and can provide certainty in mitigating any actual and potential adverse effects. This conclusion is based on a review of the existing design information, and experience from other similar roading projects that include significant earthworks that have implemented and best practice ESC approach as described above.

Ongoing monitoring, and the ability to amend or improve ESC performance and practices during the construction of the Project to directly address any identified issues over the construction period is essential. The proposed ESCPs will provide further certainty that the construction water management can be effectively managed throughout.

Conditions of consent are recommended that will ensure the implementation of ESC measures on site, including monitoring and management requirements.

It is concluded that any change in water quality associated with the construction runoff during the construction phase can be managed to ensure that it will be temporary and minor in nature.

APPENDICES

APPENDIX A – USLE CALCULATION SHEETS

USLA Calculations – pre-development and Year 1 development

Catchment SRP-K

Universal Soil Loss Equation		Project Tauriko - SRP-K						Total Estimated Sediment Yield		3.1552	
								Total Catchment Area (ha)		7.04	
Sub-Catchment	R	USLE Parameters	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Catchment A pre development	147	0.34	0.92	0.02	1.00	3.52	1.00	3.2361	0.30	0%	0.9708
Catchment A Year 1	147	0.34	0.92	1.00	0.90	3.52	1.00	145.6234	0.30	95%	2.1844

Sub-Catchment Description		Catchment K pre development Subcatchments must be named to be included in summary									
Exposed Catchment Area (ha)		Exposed Area (ha)								3.520	
Average Catchment Slope (%)		Average Slope %								3.70	
Rainfall Erosion index		Tauriko (107)								147	
Soil Erodibility Factor		K Topsoil 40%Clay, 50%Silt, 10%Sand								0.34	
Slope Length and Steepness Factor		LS User defined Slope length								0.92	
Ground Cover Factor		C Pasture - undisturbed								0.02	
Roughness Factor		P Pasture - undisturbed								1.00	
Sediment Delivery Ratio										0.30	
Sediment Control Measure Efficiency		pre earthworks								0%	
Duration of Exposure		Months								12.00	

Catchment details	R	USLE Parameters	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Catchment K pre development	147	0.34	0.92	0.02	1.00	3.52	1.00	3.24	0.30	0%	0.9708

Sub-Catchment Description		Catchment K Year 1 Subcatchments must be named to be included in summary									
Exposed Catchment Area (ha)		Exposed Area (ha)								3.520	
Average Catchment Slope (%)		Average Slope %								3.70	
Rainfall Erosion index		Tauriko (107)								147	
Soil Erodibility Factor		K Topsoil 40%Clay, 50%Silt, 10%Sand								0.34	
Slope Length and Steepness Factor		LS User defined Slope length								0.92	
Ground Cover Factor		C Bare Soil - rough irregular surface								1.00	
Roughness Factor		P Bare Soil - rough irregular surface								0.90	
Sediment Delivery Ratio										0.30	
Sediment Control Measure Efficiency		Sediment Retention Pond - Chemical Treatment								95%	
Duration of Exposure		Months								12.00	

Catchment details	R	USLE Parameters	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Catchment K Year 1	147	0.34	0.92	1.00	0.90	3.52	1.00	145.62	0.30	95%	2.1844

Predevelopment: 0.27 T/ha/yr

Year 1: 0.61 T/ha/yr

Assumed no contour drains.

Steep upper terrace slopes with long flat gully floor. Majority of grade gentle.

Catchment SRP-D2

Universal Soil Loss Equation		Project Tauriko - SRP-D2						Total Estimated Sediment Yield			1.0019
								Total Catchment Area (ha)			2.64
		USLE Parameters				Area	Time	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield
Sub-Catchment	R	K	LS	C	P	(ha)	(years)	(tonnes)	Ratio	(%)	(Tonnes)
Catchment A pre development	147	0.34	0.78	0.02	1.00	1.32	1.00	1.0276	0.30	0%	0.3083
Catchment A Year 1	147	0.34	0.78	1.00	0.90	1.32	1.00	46.2431	0.30	95%	0.6936

Sub-Catchment Description		Catchment D2 pre development Subcatchments must be named to be included in summary									
Exposed Catchment Area (ha)									Exposed Area (ha)		1.320
Average Catchment Slope (%)									Average Slope %		4.00
Rainfall Erosion index		R	Tauriko (107)						147	User Defined	
Soil Erodibility Factor		K	Topsoil		40%Clay, 50%Silt, 10%Sand				0.34		
Slope Length and Steepness Factor		LS	User defined Slope length						0.78	160	
Ground Cover Factor		C	Pasture - undisturbed						0.02		
Roughness Factor		P	Pasture - undisturbed						1.00		
Sediment Delivery Ratio										0.30	
Sediment Control Measure Efficiency		pre earthworks								0%	
Duration of Exposure										Months	12.00

		USLE Parameters				Area	Time	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield
Catchment details	R	K	LS	C	P	(ha)	(years)	(tonnes)	Ratio	(%)	(Tonnes)
Catchment D2 pre development	147	0.34	0.78	0.02	1.00	1.32	1.00	1.03	0.30	0%	0.3083

Sub-Catchment Description		Catchment D2 Year 1 Subcatchments must be named to be included in summary									
Exposed Catchment Area (ha)									Exposed Area (ha)		1.320
Average Catchment Slope (%)									Average Slope %		4.00
Rainfall Erosion index		R	Tauriko (107)						147	User Defined	
Soil Erodibility Factor		K	Topsoil		40%Clay, 50%Silt, 10%Sand				0.34		
Slope Length and Steepness Factor		LS	User defined Slope length						0.78	160	
Ground Cover Factor		C	Bare Soil - rough irregular surface						1.00		
Roughness Factor		P	Bare Soil - rough irregular surface						0.90		
Sediment Delivery Ratio										0.30	
Sediment Control Measure Efficiency		Sediment Retention Pond - Chemical Treatment								95%	
Duration of Exposure										Months	12.00

		USLE Parameters				Area	Time	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield
Catchment details	R	K	LS	C	P	(ha)	(years)	(tonnes)	Ratio	(%)	(Tonnes)
Catchment D2 Year 1	147	0.34	0.78	1.00	0.90	1.32	1.00	46.24	0.30	95%	0.6936

Predevelopment: 0.23 T/ha/yr

Year 1: 0.52 T/ha/yr

Assumed no contour drains.

Section of steeper hill slope with majority of catchment grade gentle.

Catchment SRP-P

Universal Soil Loss Equation						Project Tauriko - SRP-P			Total Estimated Sediment Yield			3.6763	
									Total Catchment Area (ha)			10.36	
Sub-Catchment	R	USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield		
		K	LS	C	P			(tonnes)	Ratio	(%)	(Tonnes)		
Catchment A pre development	147	0.34	0.73	0.02	1.00	5.18	1.00	3.7706	0.30	0%	1.1312		
Catchment A Year 1	147	0.34	0.73	1.00	0.90	5.18	1.00	169.6753	0.30	95%	2.5451		
Sub-Catchment Description		Catchment P pre development Subcatchments must be named to be included in summary											
Exposed Catchment Area (ha)									Exposed Area (ha)		5.180		
Average Catchment Slope (%)									Average Slope %		3.50		
Rainfall Erosion index		R		Tauriko (107)					147		User Defined		
Soil Erodibility Factor		K		Topsoil		40%Clay, 50%Silt, 10%Sand				0.34			
Slope Length and Steepness Factor		LS		User defined Slope length						0.73		400	
Ground Cover Factor		C		Pasture - undisturbed						0.02			
Roughness Factor		P		Pasture - undisturbed						1.00			
Sediment Delivery Ratio											0.30		
Sediment Control Measure Efficiency		pre earthworks									0%		
Duration of Exposure									Months		12.00		
Catchment details	R	USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield		
		K	LS	C	P			(tonnes)	Ratio	(%)	(Tonnes)		
Catchment P pre development	147	0.34	0.73	0.02	1.00	5.18	1.00	3.77	0.30	0%	1.1312		
Sub-Catchment Description		Catchment P Year 1 Subcatchments must be named to be included in summary											
Exposed Catchment Area (ha)									Exposed Area (ha)		5.180		
Average Catchment Slope (%)									Average Slope %		3.50		
Rainfall Erosion index		R		Tauriko (107)					147		User Defined		
Soil Erodibility Factor		K		Topsoil		40%Clay, 50%Silt, 10%Sand				0.34			
Slope Length and Steepness Factor		LS		User defined Slope length						0.73		400	
Ground Cover Factor		C		Bare Soil - rough irregular surface						1.00			
Roughness Factor		P		Bare Soil - rough irregular surface						0.90			
Sediment Delivery Ratio											0.30		
Sediment Control Measure Efficiency		Sediment Retention Pond - Chemical Treatment									95%		
Duration of Exposure									Months		12.00		
Catchment details	R	USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield		
		K	LS	C	P			(tonnes)	Ratio	(%)	(Tonnes)		
Catchment P Year 1	147	0.34	0.73	1.00	0.90	5.18	1.00	169.68	0.30	95%	2.5451		

Predevelopment: 0.22 T/ha/yr

Year 1: 0.49 T/yr

Assumed no contour drains.

Steep upper terrace slopes with long flat gully floor. Majority of grade gentle.

Catchment SRP-Q2

Universal Soil Loss Equation				Project Tauriko - SRP-Q2				Total Estimated Sediment Yield			0.2579
								Total Catchment Area (ha)			2.06
								Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Sub-Catchment	R	USLE Parameters			P	Area (ha)	Time (years)				
		K	LS	C							
Catchment A pre development	147	0.34	0.26	0.02	1.00	1.03	1.00	0.2645	0.30	0%	0.0794
Catchment A Year 1	147	0.34	0.26	1.00	0.90	1.03	1.00	11.9045	0.30	95%	0.1786

Sub-Catchment Description		Catchment Q2 pre development Subcatchments must be named to be included in summary									
Exposed Catchment Area (ha)								Exposed Area (ha)		1.030	
Average Catchment Slope (%)								Average Slope %		1.00	
Rainfall Erosion index		R				Tauriko (107)				147 User Defined	
Soil Erodibility Factor		K				Topsoil 40%Clay, 50%Silt, 10%Sand				0.34	
Slope Length and Steepness Factor		LS				User defined Slope length				0.26 300	
Ground Cover Factor		C				Pasture - undisturbed				0.02	
Roughness Factor		P				Pasture - undisturbed				1.00	
Sediment Delivery Ratio										0.30	
Sediment Control Measure Efficiency						pre earthworks				0%	
Duration of Exposure								Months		12.00	

								Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Catchment details	R	K	LS	C	P	Area (ha)	Time (years)				
Catchment Q2 pre development	147	0.34	0.26	0.02	1.00	1.03	1.00	0.26	0.30	0%	0.0794

Sub-Catchment Description		Catchment Q2 Year 1 Subcatchments must be named to be included in summary									
Exposed Catchment Area (ha)								Exposed Area (ha)		1.030	
Average Catchment Slope (%)								Average Slope %		1.00	
Rainfall Erosion index		R				Tauriko (107)				147 User Defined	
Soil Erodibility Factor		K				Topsoil 40%Clay, 50%Silt, 10%Sand				0.34	
Slope Length and Steepness Factor		LS				User defined Slope length				0.26 300	
Ground Cover Factor		C				Bare Soil - rough irregular surface				1.00	
Roughness Factor		P				Bare Soil - rough irregular surface				0.90	
Sediment Delivery Ratio										0.30	
Sediment Control Measure Efficiency						Sediment Retention Pond - Chemical Treatment				95%	
Duration of Exposure								Months		12.00	

								Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Catchment details	R	K	LS	C	P	Area (ha)	Time (years)				
Catchment Q2 Year 1	147	0.34	0.26	1.00	0.90	1.03	1.00	11.90	0.30	95%	0.1786

Predevelopment: 0.08 T/ha/yr

Year 1: 0.17 T/ha/yr

Assumed no contour drains.

Catchment is flat.

Catchment SRP-Q3

Universal Soil Loss Equation							Project Tauriko -SRP-Q3			Total Estimated Sediment Yield		2.5325
									Total Catchment Area (ha)		7.78	
Sub-Catchment	R	USLE Parameters			P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield	
		K	LS	C				(tonnes)	Ratio	(%)	(Tonnes)	
Catchment A pre development	147	0.34	0.67	0.02	1.00	3.89	1.00	2.5974	0.30	0%	0.7792	
Catchment A Year 1	147	0.34	0.67	1.00	0.90	3.89	1.00	116.8845	0.30	95%	1.7533	
Sub-Catchment Description		Catchment Q3 pre development Subcatchments must be named to be included in summary										
Exposed Catchment Area (ha)									Exposed Area (ha)		3.890	
Average Catchment Slope (%)									Average Slope %		3.50	
Rainfall Erosion index		R			Tauriko (107)					147	User Defined	
Soil Erodibility Factor		K			Topsoil			40%Clay, 50%Silt, 10%Sand		0.34		
Slope Length and Steepness Factor		LS			User defined Slope length					0.67	300	
Ground Cover Factor		C			Pasture - undisturbed					0.02		
Roughness Factor		P			Pasture - undisturbed					1.00		
Sediment Delivery Ratio											0.30	
Sediment Control Measure Efficiency		pre earthworks									0%	
Duration of Exposure									Months		12.00	
Catchment details	R	USLE Parameters			P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield	
		K	LS	C				(tonnes)	Ratio	(%)	(Tonnes)	
Catchment Q3 pre development	147	0.34	0.67	0.02	1.00	3.89	1.00	2.60	0.30	0%	0.7792	
Sub-Catchment Description		Catchment Q3 Year 1 Subcatchments must be named to be included in summary										
Exposed Catchment Area (ha)									Exposed Area (ha)		3.890	
Average Catchment Slope (%)									Average Slope %		3.50	
Rainfall Erosion index		R			Tauriko (107)					147	User Defined	
Soil Erodibility Factor		K			Topsoil			40%Clay, 50%Silt, 10%Sand		0.34		
Slope Length and Steepness Factor		LS			User defined Slope length					0.67	300	
Ground Cover Factor		C			Bare Soil - rough irregular surface					1.00		
Roughness Factor		P			Bare Soil - rough irregular surface					0.90		
Sediment Delivery Ratio											0.30	
Sediment Control Measure Efficiency		Sediment Retention Pond - Chemical Treatment									95%	
Duration of Exposure									Months		12.00	
Catchment details	R	USLE Parameters			P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery	Sediment Control Efficiency	Estimated Sediment Yield	
		K	LS	C				(tonnes)	Ratio	(%)	(Tonnes)	
Catchment Q3 Year 1	147	0.34	0.67	1.00	0.90	3.89	1.00	116.88	0.30	95%	1.7533	

Predevelopment: 0.20 T/ha/yr

Year 1: 0.45 T/ha/yr

Assumed no contour drains.

Steep upper terrace slopes with long flat gully floor. Majority of grade gentle.

Catchment SRP-Y

Universal Soil Loss Equation						Project Tauriko - SRP-Y		Total Estimated Sediment Yield			0.5829
						Total Catchment Area (ha)			3.82		
		USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Sub-Catchment	R	K	LS	C	P						
Catchment A pre development	147	0.34	0.31	0.02	1.00	1.91	1.00	0.5978	0.30	0%	0.1794
Catchment A Year 1	147	0.34	0.31	1.00	0.90	1.91	1.00	26.9029	0.30	95%	0.4035

Sub-Catchment Description		Catchment Y pre development		Subcatchments must be named to be included in summary							
Exposed Catchment Area (ha)						Exposed Area (ha)		1.910			
Average Catchment Slope (%)						Average Slope %		1.00			
Rainfall Erosion index		R				Tauriko (107)		147		User Defined	
Soil Erodibility Factor		K		Topsoil		40%Clay, 50%Silt, 10%Sand		0.34			
Slope Length and Steepness Factor		LS		User defined Slope length				0.31		580	
Ground Cover Factor		C				Pasture - undisturbed		0.02			
Roughness Factor		P				Pasture - undisturbed		1.00			
Sediment Delivery Ratio								0.30			
Sediment Control Measure Efficiency						pre earthworks		0%			
Duration of Exposure								Months		12.00	

		USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Catchment details	R	K	LS	C	P						
Catchment Y pre development	147	0.34	0.31	0.02	1.00	1.91	1.00	0.60	0.30	0%	0.1794

Sub-Catchment Description		Catchment Y Year 1		Subcatchments must be named to be included in summary							
Exposed Catchment Area (ha)						Exposed Area (ha)		1.910			
Average Catchment Slope (%)						Average Slope %		1.00			
Rainfall Erosion index		R				Tauriko (107)		147		User Defined	
Soil Erodibility Factor		K		Topsoil		40%Clay, 50%Silt, 10%Sand		0.34			
Slope Length and Steepness Factor		LS		User defined Slope length				0.31		580	
Ground Cover Factor		C				Bare Soil - rough irregular surface		1.00			
Roughness Factor		P				Bare Soil - rough irregular surface		0.90			
Sediment Delivery Ratio								0.30			
Sediment Control Measure Efficiency						Sediment Retention Pond - Chemical Treatment		95%			
Duration of Exposure								Months		12.00	

		USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Catchment details	R	K	LS	C	P						
Catchment Y Year 1	147	0.34	0.31	1.00	0.90	1.91	1.00	26.90	0.30	95%	0.4035

Catchment DEB-F

Universal Soil Loss Equation							Project Tauriko - DEB-F		Total Estimated Sediment Yield			0.2575
							Total Catchment Area (ha)			0.88		
Sub-Catchment	R	USLE Parameters			P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)	
Catchment A pre development	147	0.34	0.19	0.02	1.00	0.44	1.00	0.0858	0.30	0%	0.0258	
Catchment A Year 1	147	0.34	0.19	1.00	0.90	0.44	1.00	3.8632	0.30	80%	0.2318	

Sub-Catchment Description		Catchment F pre development Subcatchments must be named to be included in summary																
Exposed Catchment Area (ha)										Exposed Area (ha)	0.440							
Average Catchment Slope (%)										Average Slope %	1.00							
Rainfall Erosion index		R							Tauriko (107)	147	User Defined							
Soil Erodibility Factor		K	Topsoil		40%Clay, 50%Silt, 10%Sand					0.34								
Slope Length and Steepness Factor		LS	User defined Slope length							0.19	120							
Ground Cover Factor		C			Pasture - undisturbed					0.02								
Roughness Factor		P			Pasture - undisturbed					1.00								
Sediment Delivery Ratio										0.30								
Sediment Control Measure Efficiency		pre earthworks								0%								
Duration of Exposure										Months	12.00							

Catchment details	R	K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
Catchment F pre development	147	0.34	0.19	0.02	1.00	0.44	1.00	0.09	0.30	0%	0.0258

Sub-Catchment Description		Catchment F Year 1 Subcatchments must be named to be included in summary																
Exposed Catchment Area (ha)										Exposed Area (ha)	0.440							
Average Catchment Slope (%)										Average Slope %	1.00							
Rainfall Erosion index		R							Tauriko (107)	147	User Defined							
Soil Erodibility Factor		K	Topsoil		40%Clay, 50%Silt, 10%Sand					0.34								
Slope Length and Steepness Factor		LS	User defined Slope length							0.19	120							
Ground Cover Factor		C			Bare Soil - rough irregular surface					1.00								
Roughness Factor		P			Bare Soil - rough irregular surface					0.90								
Sediment Delivery Ratio										0.30								
Sediment Control Measure Efficiency		T-Bar Decanting Earth Bund - Chemical Treatment								80%								
Duration of Exposure										Months	12.00							

Catchment details	R	K	LS	C	P	Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
Catchment F Year 1	147	0.34	0.19	1.00	0.90	0.44	1.00	3.86	0.30	80%	0.2318

Predevelopment: 0.06 T/ha/yr

Year 1: 0.53 T/ha/yr

Assumed no contour drains.

Catchment is flat.

Catchment SRP-AC

Universal Soil Loss Equation						Project Tauriko - SRP-AC			Total Estimated Sediment Yield			1.0987
									Total Catchment Area (ha)			5.06
Sub-Catchment	R	USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)	
		K	LS	C	P							
Catchment A pre development	147	0.34	0.44	0.02	1.00	2.53	1.00	1.1268	0.30	0%	0.3380	
Catchment A Year 1	147	0.34	0.44	1.00	0.90	2.53	1.00	50.7073	0.30	95%	0.7606	

Sub-Catchment Description												Catchment AC pre development	Subcatchments must be named to be included in summary																
Exposed Catchment Area (ha)												Exposed Area (ha)												2.530					
Average Catchment Slope (%)												Average Slope %												2.00					
Rainfall Erosion index												R		Tauriko (107)												147		User Defined	
Soil Erodibility Factor												K		Topsoil				40%Clay, 50%Silt, 10%Sand								0.34			
Slope Length and Steepness Factor												LS		User defined Slope length								0.44		430					
Ground Cover Factor												C		Pasture - undisturbed								0.02							
Roughness Factor												P		Pasture - undisturbed								1.00							
Sediment Delivery Ratio																								0.30					
Sediment Control Measure Efficiency												pre earthworks												0%					
Duration of Exposure												Months												12.00					

Catchment details	R	USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated (tonnes)	Sediment Delivery Ratio	Sediment Control Efficiency (%)	Estimated Sediment Yield (Tonnes)
		K	LS	C	P						
Catchment AC pre development	147	0.34	0.44	0.02	1.00	2.53	1.00	1.13	0.30	0%	0.3380

Sub-Catchment Description												Catchment AC Year 1	Subcatchments must be named to be included in summary																
Exposed Catchment Area (ha)												Exposed Area (ha)												2.530					
Average Catchment Slope (%)												Average Slope %												2.00					
Rainfall Erosion index												R		Tauriko (107)												147		User Defined	
Soil Erodibility Factor												K		Topsoil				40%Clay, 50%Silt, 10%Sand								0.34			
Slope Length and Steepness Factor												LS		User defined Slope length								0.44		430					
Ground Cover Factor												C		Bare Soil - rough irregular surface								1.00							
Roughness Factor												P		Bare Soil - rough irregular surface								0.90							
Sediment Delivery Ratio																								0.30					
Sediment Control Measure Efficiency												Sediment Retention Pond - Chemical Treatment												95%					
Duration of Exposure												Months												12.00					

Catchment details	R	USLE Parameters				Area (ha)	Time (years)	Estimated Sediment Generated	Sediment Delivery Ratio	Sediment Control Efficiency	Estimated Sediment Yield
		K	LS	C	P						
Catchment AC Year 1	147	0.34	0.44	1.00	0.90	2.53	1.00	50.71	0.30	95%	0.7606

Predevelopment: 0.15 T/ha/yr

Year 1: 0.34 T/ha/yr

Assumed no contour drains.

Catchment is a gentle grade.

APPENDIX B – CHEMICAL ANALYSIS AND REACTIVITY TEST (CART) REPORT



CHEMICAL ANALYSIS AND REACTIVITY TEST REPORT

SH29 TAURIKO WEST ROUTE PROTECTION

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Appendices

Appendix A – Chemical Analysis Soil Sample Locations

1 Introduction

1.1 Purpose and Scope

This Chemical Analysis and Reactivity Test (CART) Report applies to the earthwork's operations associated with the consenting phase of New Zealand Transport Agency's (NZTA's) Tauriko West Route Protection Project (the Project).

The purpose of this report is to determine the effectiveness of chemical coagulants on common soil types identified within the Project area with the overall objective of minimising to the greatest extent practicable the discharge of suspended sediment into waterways. It reports on initial testing undertaken for consenting purposes, to inform the Construction Water Assessment Report, and the procedures for future testing to be undertaken during the construction phase Project.

Chemical treatment is widely used throughout New Zealand to enhance the sediment removal efficiency of sediment retention devices implemented during the earthworks phase of infrastructure and development projects.

Chemical treatment is currently absent from the Bay of Plenty Regional Council's (BoPRC) erosion and sediment control guidelines and therefore Auckland Council's Guideline Document 2016/005 '*Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region, Incorporating Amendment 1*' has been adopted.

Soil samples from representative locations within the Project site have been tested with the most common cationic coagulant used in the earthworks industry (Polyaluminium Chloride), supplied by IXOM Chemicals.

Three additional chemicals have been used during the initial testing period provided by Vital Chemicals, including:

- Aluminium Chlorohydrate (ACH) (Vital Super Clear)
- A blend of ACH and an organic polymer (Vital Super Clear Extra)
- Chitosan based bio-polymer (Vital Eco Super Flocc)

Aluminium based chemicals act to neutralise the negatively charged soil particles to improve flocculation and settlement within the sediment control device. PAC, ACH and the ACH blend contain aluminium and therefore pH monitoring must be monitored during testing and application. GD05 states that the following limitations apply to chemical treatment:

- pH must be tested as part of the bench testing methodology and should be used as a control baseline. Whatever flocculant is being used must not change that baseline pH beyond +/-1 and must not fall outside of the range of 5.5 – 8.5, as measured from the primary spillway.
- Treatment should cease when the above pH limits cannot be met.

The chitosan based product is pH stable and is composed of biodegradable organic compounds.

This report presents the initial results of bench test trials undertaken to determine the effectiveness of the chemicals tested. Clarity, turbidity, and pH measurements were undertaken and recorded for each bench test and the results used to determine the optimum chemical and dose rate for each sample provided.

Safety Data Sheets (SDS) should be made available to the contractor undertaking the work.

1.1.1 Chemical Treatment Management System

The relationship of this CART report within the overall chemical treatment management system for the Project is shown in Figure 1 below. The CART will inform the development of the Chemical Treatment Management Plan (CTMP) that will be developed for the Project. The CTMP is the overarching plan for the management, maintenance, and reporting of the chemical treatment system to be implemented across

the Project for the duration of earthworks phase. As the Project progresses, further bench testing will be undertaken as new areas are opened and earth worked. Based on the bench testing results, the CTMP will detail the specific set-up details for the chemical treatment of each sediment retention pond (SRP) and Decanting Earth Bund (DEB) to be implemented in an area i.e. roof tray and header tank outlet spacing.

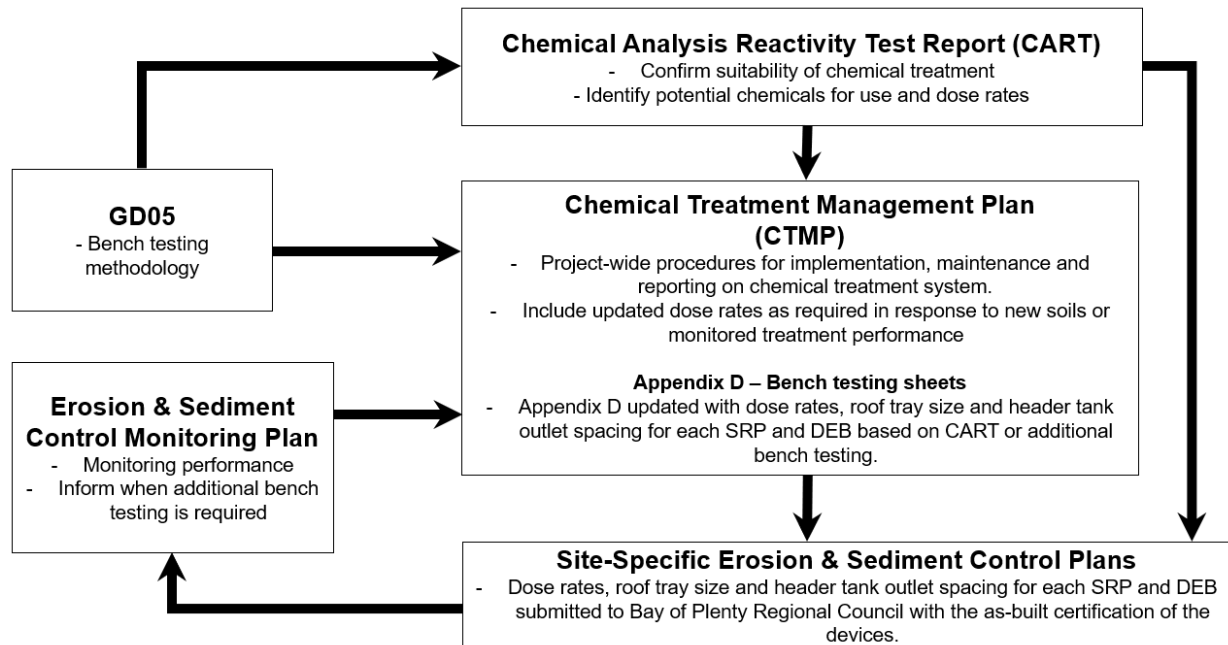


Figure 1: Chemical treatment management systems.

2 Methodology

The bench testing methodology provided in Appendix F1 of GD05 has been adopted. This methodology will be repeated for all future bench testing required in response to identified new soils, or where treatment performance is less than anticipated.

PAC testing of each sample involved the application of five dose rates (31 to 155 mls/m³) and comparison to a control. Results are reported in the following tables.

ACH, the ACH blend and the chitosan-based product were tested at 20 to 50 ml/m³ dose rates and compared to the control. Results are reported in the following tables.

2.1 Soil Samples

Soil samples were provided by BBO from Bore Hole (BH) 1001, 1009, and 1015 with depths ranging from 1.2m to 11.85m.

The location plan (Appendix A) shows the locations of soil samples.

The Geotechnical Appraisal Report, prepared by CMW Geosciences details the underlying geological landforms. In summary, *'The landform over which the alignment spans comprises undulating elevated terraces, rolling hill topography and steeply incised gullies, which in places has been extensively modified as a result of urbanisation. The ground model is anticipated to comprise a sequence of Late Quaternary Volcanic Ash overlying older weathered volcanic ashes and volcaniclastic sediments of the Matua Subgroup followed by non-welded and partially welded ignimbrites at depth. Weak recent alluvium is expected across the gully floors.'*

Throughout the project additional bench testing of soils acquired from the project will be tested to confirm the required dose rate prior to commencement of earthworks in a specific area. These results will be included in the CTMP.

3 Bench Testing Results

Highlighted green rows indicate dose rates that could be used on site. Highlighted red rows should not be used on site due to the impact on the pH.

3.1 BH1001 Depth: 11.65 – 11.85m

PAC

Initial pH: 6.96

Initial turbidity: 4016 NTU

Aluminium Dose (mg/L)	Clarity (mm) after 5mins	Clarity (mm) after 30mins	Clarity (mm) after 60mins	Final pH after 60mins	Final Turbidity after 60mins
0	15	15	20	6.92	731
2	50	55	60	6.85	113
4	100	105	105	6.72	53
6	120+	120+	120+	6.60	32
8	120	120+	120+	6.41	80
10	100	100	110	6.10	58



Control 2mg/L 4mg/L 6mg/L 8mg/L 10mg/L

Chemical	Clarity (mm) after Test 1 (+5 mins)	Clarity (mm) after Test 2 (+5 mins)	Clarity (mm) after Test 3 (+5 mins)	Clarity (mm) after Test 4 (+5 mins)	Final pH after 60mins	Final Turbidity after 60mins
Chemical dose rate added	20ml/m ³	30ml/m ³	40ml/m ³	50ml/m ³		
Control	15	15	20	20	6.92	731
ACH	45	90	70	70	6.52	67
ACH Blend	20	85	95	120+	6.53	32
Chitosan	15	15	30	45	6.54	127



Control ACH ACH Blend Chitosan

Test results after Test 4.

3.2 BH1009 Depth: 1.2 – 1.5m

PAC

Initial pH: 6.68

Initial turbidity: 836 NTU

Aluminium Dose (mg/L)	Clarity (mm) after 5mins	Clarity (mm) after 30mins	Clarity (mm) after 60mins	Final pH after 60mins	Final Turbidity after 60mins
0	30	45	50	6.73	125
2	90	110	110	6.60	36
4	110	120+	120+	6.55	27
6	110	120+	120+	6.47	32
8	100	120+	120+	6.33	38
10	85	110	110	6.20	51



Control 2mg/L 4mg/L 6mg/L 8mg/L 10mg/L

Chemical	Clarity (mm) after Test 1 (+5 mins)	Clarity (mm) after Test 2 (+5 mins)	Clarity (mm) after Test 3 (+5 mins)	Clarity (mm) after Test 4 (+5 mins)	Final pH after 60mins	Final Turbidity after 60mins
Chemical dose rate added	20ml/m ³	30ml/m ³	40ml/m ³	50ml/m ³		
Control	30	45	50	50	6.73	125
ACH	50	60	55	60	6.64	91
ACH Blend	65	90	80	80	6.61	54
Chitosan	50	75	95	105	6.62	31



Control ACH ACH Blend Chitosan

Test results after Test 4.

3.3 BH1015 Depth: 9.75 – 10.0m

PAC

Initial pH: 6.59

Initial turbidity: 4081 NTU

Aluminium Dose (mg/L)	Clarity (mm) after 5mins	Clarity (mm) after 30mins	Clarity (mm) after 60mins	Final pH after 60mins	Final Turbidity after 60mins
0	10	15	15	6.67	1249
2	35	45	55	6.60	236
4	45	55	65	6.52	176
6	30	30	40	6.43	279
8	20	25	30	6.26	330
10	15	20	20	6.01	466



Control 2mg/L 4mg/L 6mg/L 8mg/L 10mg/L

Chemical	Clarity (mm) after Test 1 (+5 mins)	Clarity (mm) after Test 2 (+5 mins)	Clarity (mm) after Test 3 (+5 mins)	Clarity (mm) after Test 4 (+5 mins)	Final pH after 60mins	Final Turbidity after 60mins
Chemical dose rate added	20ml/m ³	30ml/m ³	40ml/m ³	50ml/m ³		
Control	10	15	15	15	6.67	1249
ACH	45	80	55	50	6.64	110
ACH Blend	25	80	80	100	6.57	43
Chitosan	15	15	20	30	6.60	291



Control ACH ACH Blend Chitosan

Test results after Test 4.

4 Discussion

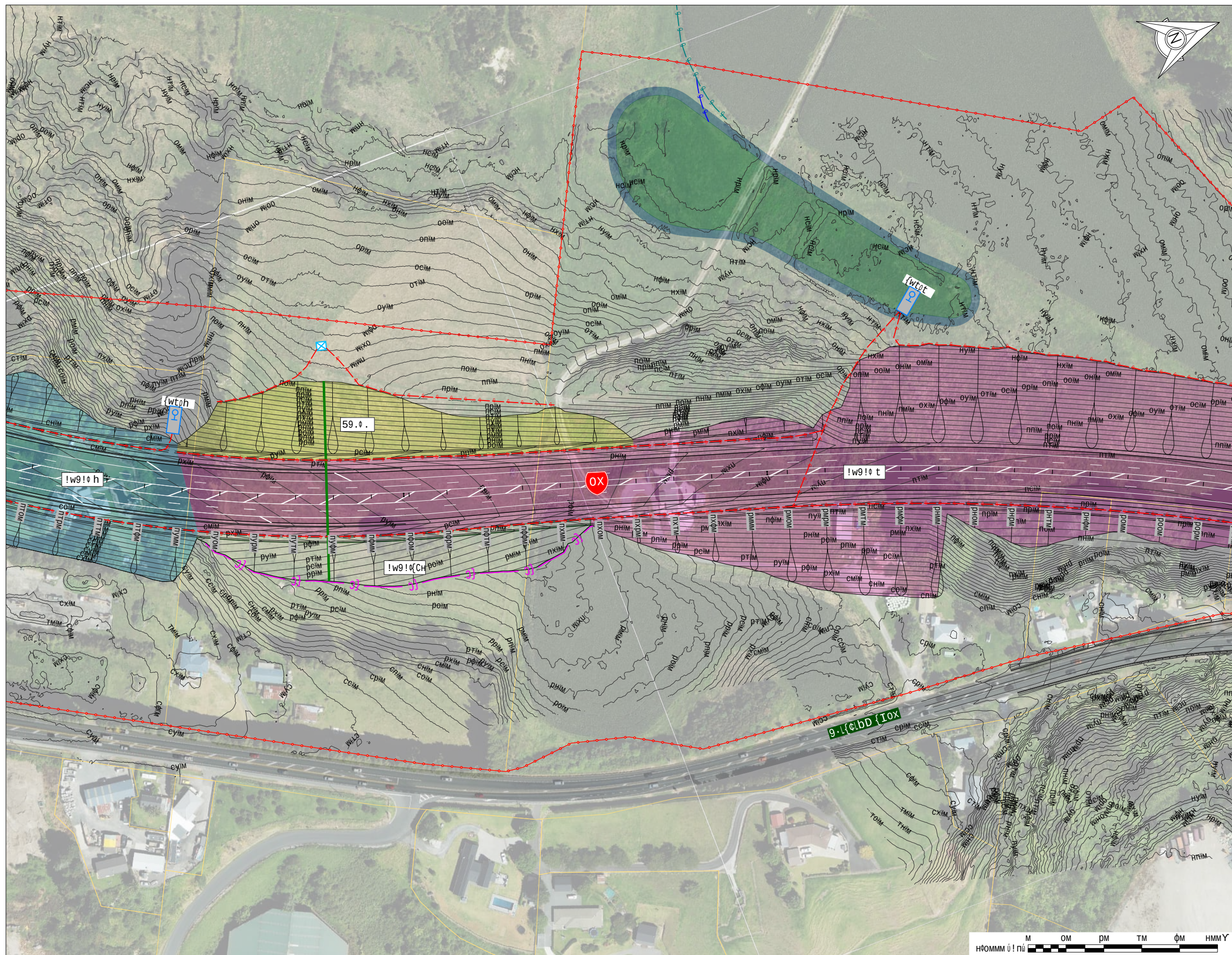
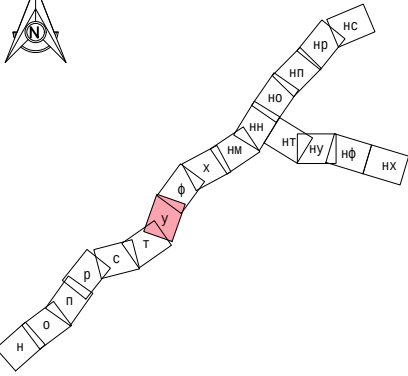
The most efficient dose rate achieves the best balance between settlement response, pH response and cost of chemical throughout the duration of the Project.

The soil samples generally retained persistently mobile fine colloidal particles and had variable clarity and turbidity responses. In most cases the coagulants provided significant improvement of clarity and turbidity compared to the control.

All of the chemicals provided an improvement in clarity over the control test. Either of these chemicals could be used on site but requires additional bench testing (as part of the pre-construction phase of the Project) to be completed before a chemical and dose rate can be determined.

Appendix A – Chemical Analysis Soil Sample Locations

APPENDIX C – CONCEPT EROSION AND SEDIMENT CONTROL PLANS

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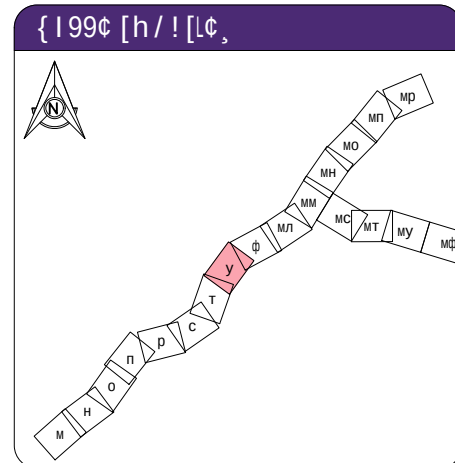
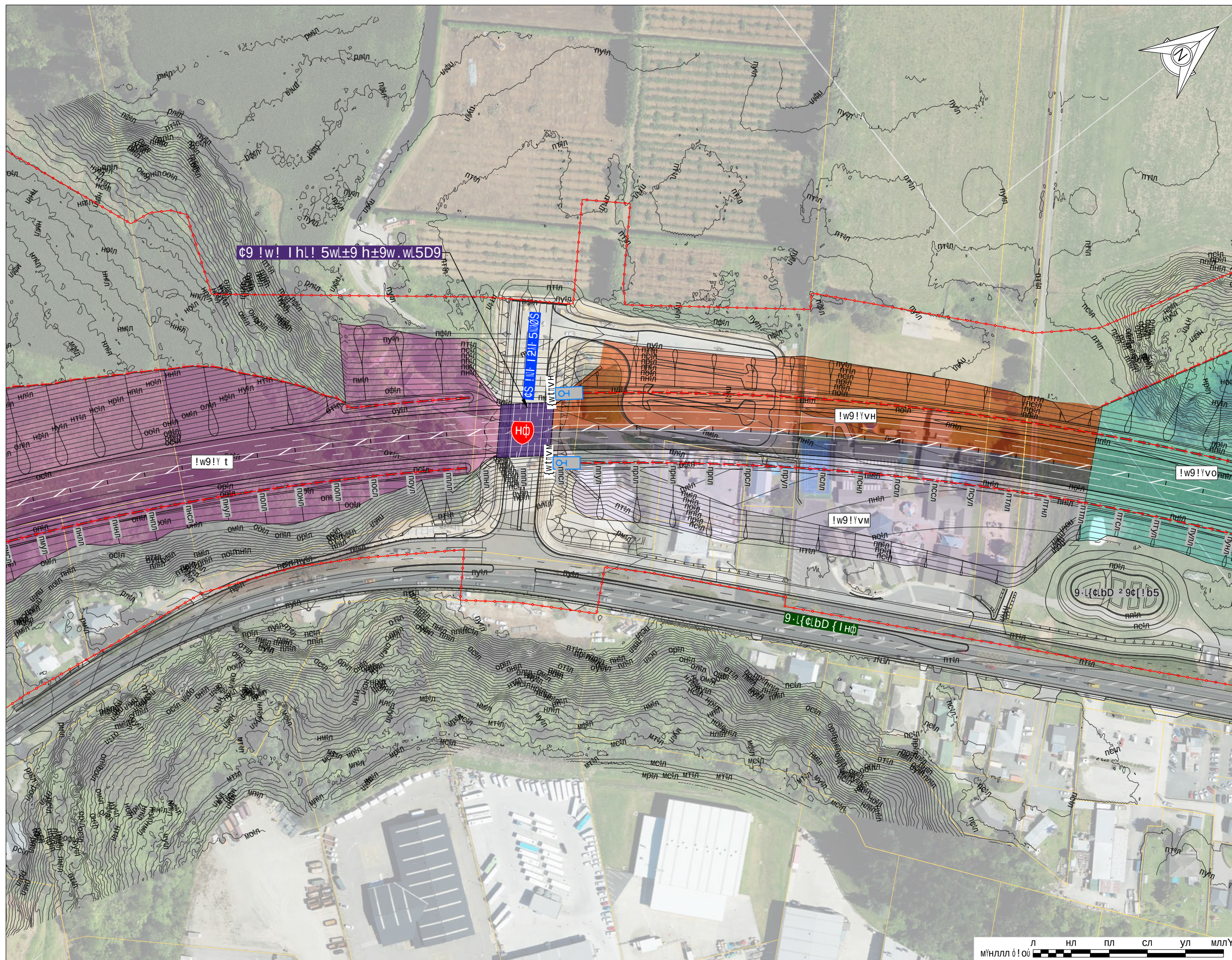
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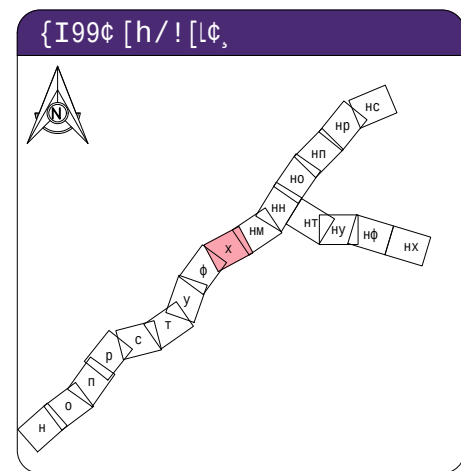
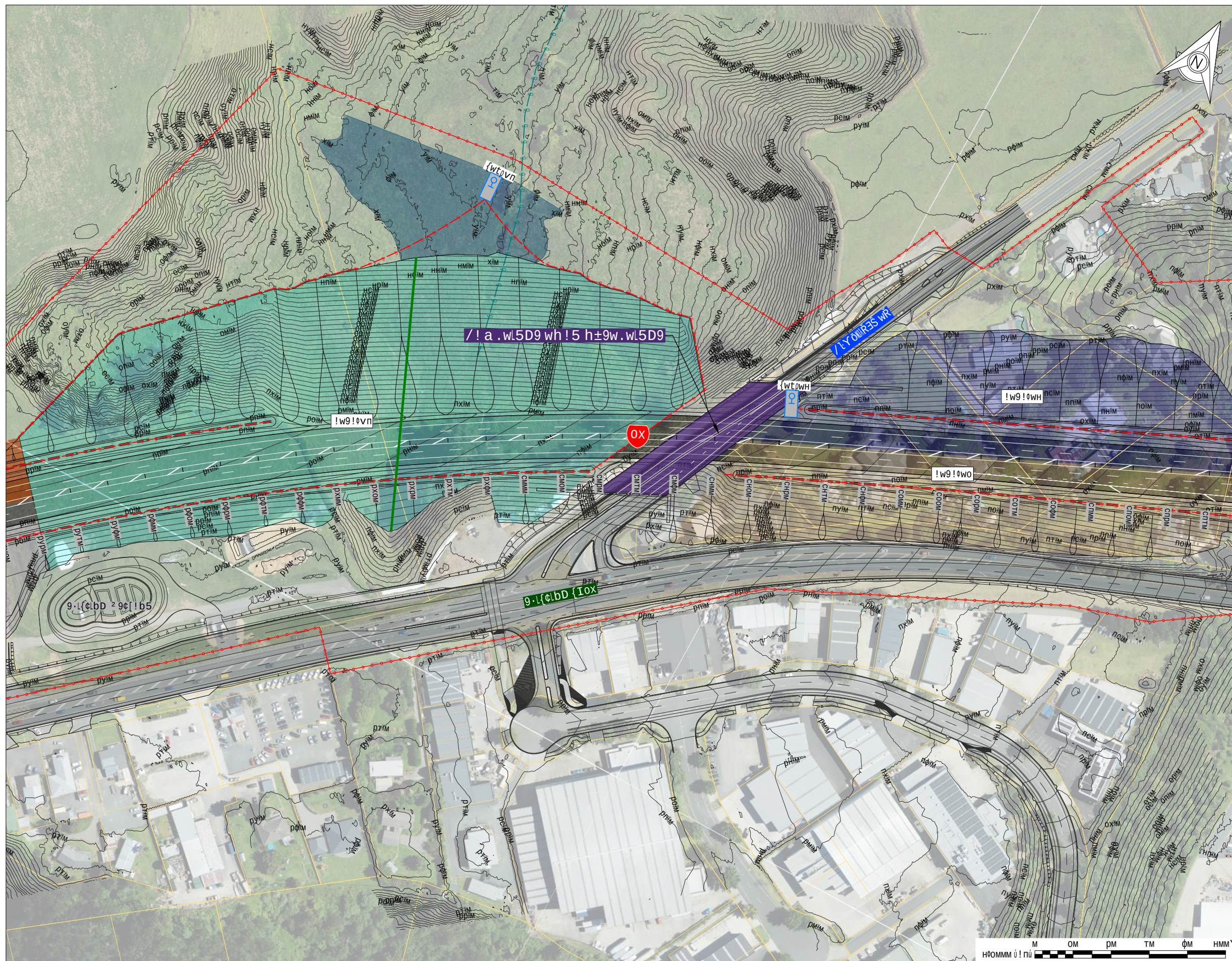
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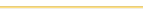
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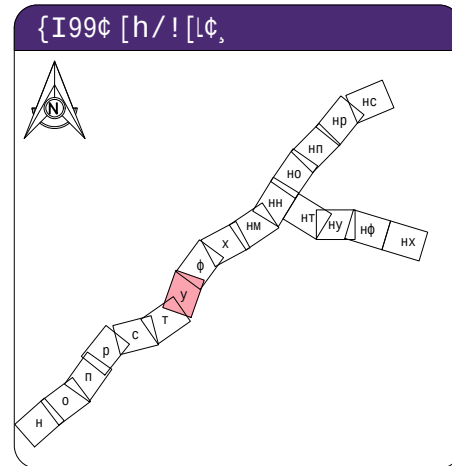
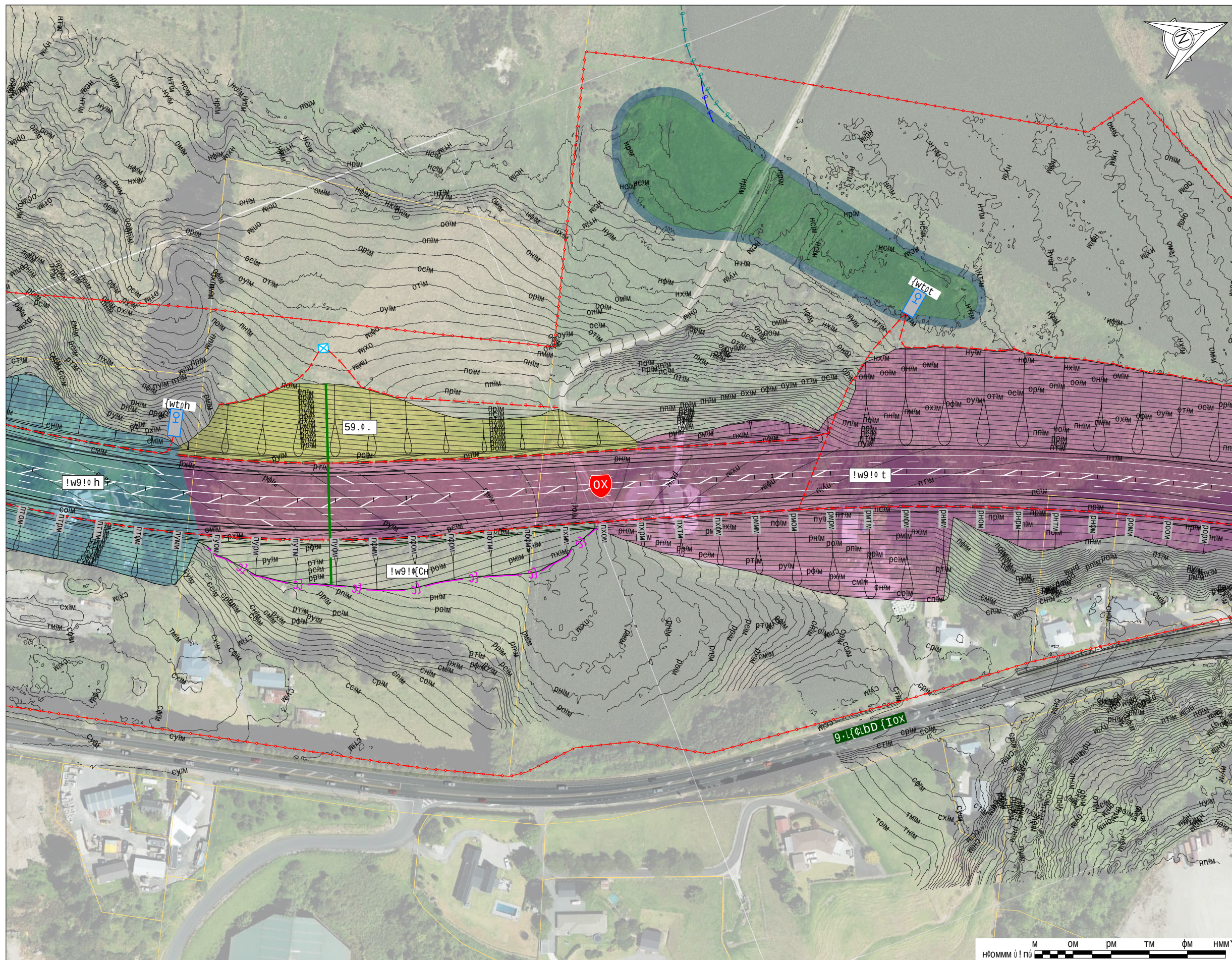
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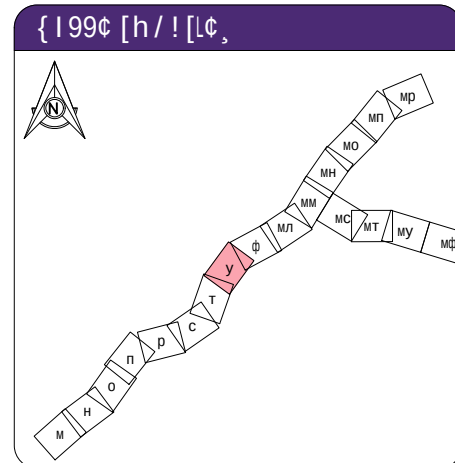
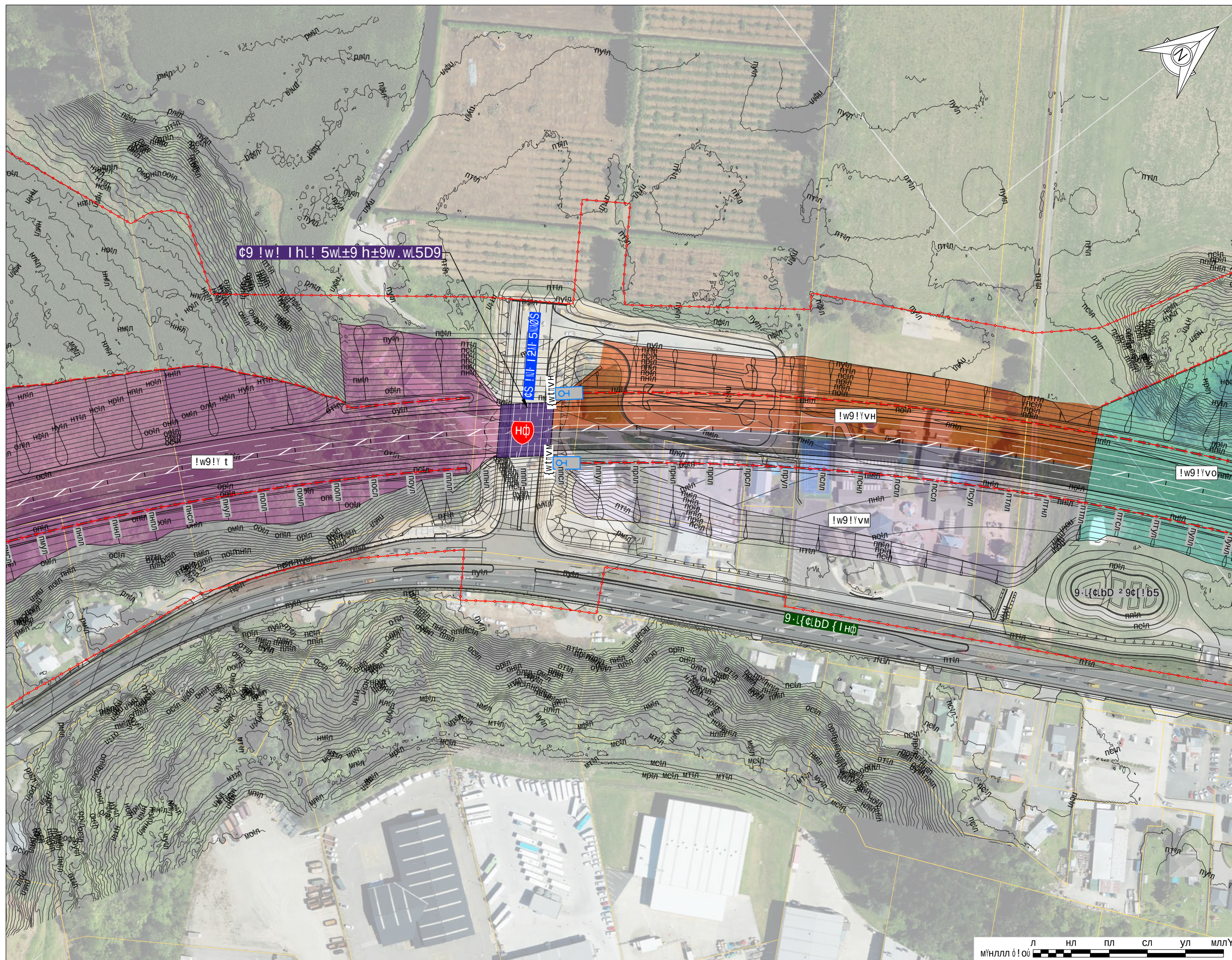


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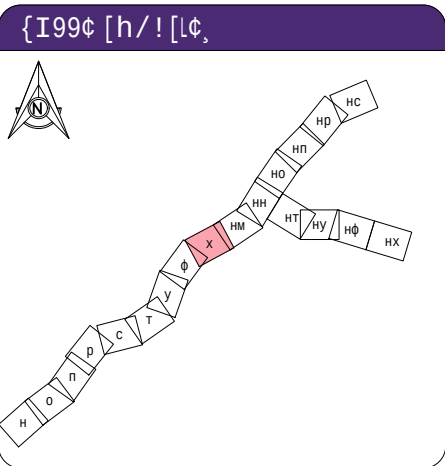
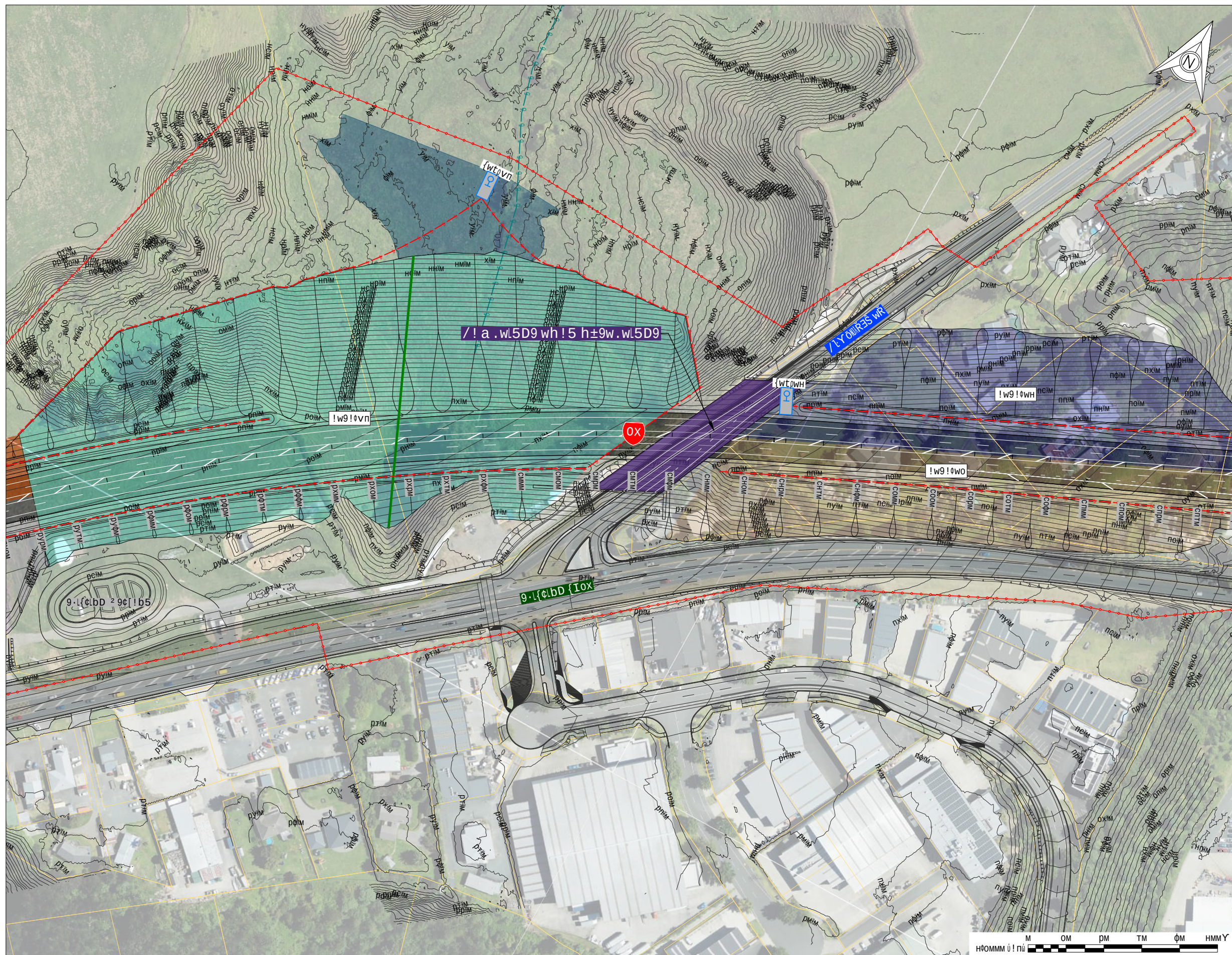
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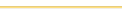
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APPENDIX D – SUMMARY OF RECEIVING ENVIRONMENT

Waterway	BML Classification	Discharge Location (Chainage)	Device Reference
<i>Wairoa River Catchment</i>			
Unnamed watercourse Wetland 17a	N/A Low value	560	SRP-A
Omanawa River	High value	1030	SRP-B
		1430	SRP-C
		1430	SRP-E
Belk Road Stream	Moderate value	1820	SRP-E2
Wetland 15a	Moderate value	1880	SRP-D
Wetland 15a	Low value	1900	SRP-H
Wetland 16	Moderate value	1960	SRP-F
		2000	SRP-G
		2350	SRP-J
Unnamed watercourse	Low value	2380	SRP-K
Unnamed watercourse Wetland 4	Low value Low value	2900	SRP-L
Unnamed watercourse Wetland 3a	Low value	2780	SRP-M
Unnamed watercourse	Low value	3140	SRP-N
Overland flow	N/A	3780	DEB-B
Overland flow	N/A	3690	SRP-O
Unnamed watercourse Wetland 6	Low value Low value	4080	SRP-P
Overland flow	N/A	4460	SRP-Q1
Overland flow	N/A	4460	SRP-Q2
Unnamed watercourse Wetland 9	Low value Low value	4980	SRP-Q3
<i>Kōpūrerua Stream Catchment</i>			
Overland flow	N/A	5140	SRP-R1
Overland flow	N/A	5750	SRP-R2
Unnamed watercourse Wetland 10a	Low value Low value	6080	SRP-S
Overland flow	N/A	6000	SRP-T
Unnamed watercourse	Low value	6020 (0060)	SRP-U
Realigned Kōpūrerua Stream	High value	0080	SRP-V
Unnamed watercourse Wetland 10b	Low value Low value	6230	SRP-W
Existing drain Wetland 13	Low value High value	6660	SRP-X
Overland flow	N/A	6800	SRP-Y
Existing drain Wetland 13	Low value High value	6800	SRP-Z1
Overland flow	N/A	7580	DEB-B
Existing drain Wetland 13	Low value High value	7560	DEB-C

Existing drain Wetland 13	Low value High value	7860	DEB-F
Unnamed watercourse	Low to moderate	7920	DEB-E
Existing drain Wetland 13	Low value High value	8140	DEB-H
Existing drain Wetland 13	Low value High value	8150	DEB-I
Existing drain Wetland 13	Low value High value	8180	DEB-J
Existing drain Wetland 13	Low value High value	8580	SRP-Z2
Existing drain Wetland 13	Low value High value	8580	SRP-Z3
<i>Nanako Stream Catchment</i>			
Realigned Kōpūrererua Stream	High value	0220	SRP-AA
Realigned Nanako Stream Wetland 13	Moderate value High Value	0610	SRP-AB
Realigned Nanako Stream	Moderate value	0730	SRP-AC
Realigned Nanako Stream	Moderate value	0800	SRP-AD
Overland flow	N/A	0940	SRP-AE
<i>Waiorohi Stream</i>			
Unnamed watercourse	Moderate value	2120	Silt fencing