

# Baseline Environmental Monitoring, Program 2: Surface Water Sampling – Exploration Permit #51985 at Puhipuhi, Northland

Evolution Mining NZ Pty Limited

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✦ Prepared for

Evolution Mining NZ Pty Limited

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## Quality Control Sheet

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## Executive Summary

Pattle Delamore Partners Ltd (PDP) was engaged by Evolution Mining New Zealand Pty Ltd (ENZ) to provide baseline surface water data within Exploration Permit 51985, to include upstream and downstream locations of the Waiariki River, and adjacent catchments.

Surface water sampling was completed at 18 sites both within and outside the tenement boundary. Water samples were analysed for a wide range of parameters including elements and nutrients.

Measured mercury concentrations are within the range of concentrations found by recent studies in the area. The mercury concentrations measured are lower than those reported in an early study by Hoggins and Brooks (1973).

Water quality results were compared against both human health guidelines (the New Zealand Drinking Water Standard guidelines and Australian and New Zealand Environment and Conservation Council (ANZECC) Contact Recreational Guidelines), and against ecological guidelines (ANZECC Livestock Drinking Water Guidelines and Aquatic Ecosystem Guidelines).

No samples exceed the health-based Maximum Acceptable Values for the New Zealand Drinking Water guidelines, although aesthetic values related to pH and iron were exceeded.

No samples exceeded ANZECC Livestock Drinking Water trigger levels from any sites.

Concentrations of total iron exceeded the ANZECC Contact Recreational guidelines in all but one sample. Manganese and ammoniacal-nitrogen were elevated above ANZECC Contact Recreational standards in several locations both inside and outside the tenement.

At two locations mercury concentrations exceeded the ANZECC (2000) trigger values for 99% Aquatic Ecosystem Protection Guidelines of 0.06 parts per billion (ppb). One of these sampling locations was located immediately adjacent to a historic mercury processing plant (site PUX). The water sample collected at this location contained dissolved mercury concentrations of 0.236 ppb. The second site (PSX) is located approximately 1 kilometre downstream of sampling location PUX and the concentration of mercury measured in stream water at that location was 0.1 ppb. Water samples from all other monitoring sites were below the ANZECC 99% trigger level of 0.06 ppb dissolved mercury.

Dissolved copper and zinc were above the ANZECC 95% trigger values for the protection of freshwater species at several sites within the tenement and one outside it. The copper values in water are comparable to background levels within other Northland Rivers (NRC 2014). The source of anomalous zinc levels is not known and cannot be related to local geology. No other elements exceeded ANZECC (2000) 95% guidelines.

The highest mercury concentrations are in water sampled within the immediate vicinity of the historic mercury processing plant at the headwaters of the Waikiore Stream, decreasing rapidly downstream.

Through the use of ultra-trace analytical techniques, very low concentrations of mercury values have been obtained at locations where mercury was undetectable in previous studies. The data has allowed dispersion patterns and potential point sources to be investigated. A historic mercury processing site at the head of Waikiore Stream appears to be a point source for dispersion of trace levels of mercury in water. At least two other sources are identified in catchments with no history of mining (the Whenuaroa and Pukekaikiore Streams), which is an indication that natural weathering and erosion has released trace levels of mercury from mineralised rock or soil to water.

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## Note on Terms Used in this Report

### Elements

The focus of this report is on concentrations of fifteen inorganic elements: antimony (Sb), arsenic (As), boron (B), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), mercury (Hg), nickel (Ni), lead (Pb), thallium (Th) and zinc (Zn). Sometimes antimony, arsenic, cadmium, chromium, cobalt, copper, nickel, manganese, mercury, lead, thallium and zinc are referred to as 'heavy metals.' However, this term is falling out of favour because it is an ambiguous one. A range of different definitions for 'heavy metal' exists in the scientific literature and the group of elements covered by that term changes depending on the definition used. Therefore the more general term "elements" is used in this report to describe both the metals and metalloids (arsenic, antimony, and boron) listed above.

### Elevated Concentrations

Elements occur naturally. When their concentrations are higher relative to other sampling locations, they are usually referred to as being **elevated**. This can be caused by either natural chemical or physical processes, or by the addition of substances into the environment by human activities.

### Units used in this Report

The standard PDP units for surface water are mg/L (milligrams per litre or ppm) and µg /L (microgram per litre or ppb) for most elements analysed at the trace level. In this study, mercury has also been assessed at the ultra-trace level which is quoted in ng/L (nanograms per litre). Nanograms per litre is equivalent to parts per trillion (ppt or 1 in 1,000,000,000,000). For the purposes of this study has been used to remain consistent with previous Puhipuhi environmental monitoring data all trace element data was been reported in terms of parts per billion. See the glossary below for a comprehensive definition of ppb.

## Note on Water Quality Guidelines

Accepted practice in New Zealand is that human drinking water quality is assessed using the New Zealand Drinking Water Standard (2008) (DWSNZ) developed by the Ministry of Health. The DWSNZ define maximum concentrations of health significance (called maximum acceptance value or MAV's) in water that, based on current knowledge, constitute no significant health risk to a person who consumes 2 litres of that water a day over their lifetime (usually taken as 70 years) (MoH, 2008).

The DWSNZ also provides guidelines values for aesthetic purposes (such as taste, odour or prevent unacceptable levels of deposition or scale formation). Exceedance of the DWSNZ guidelines for aesthetic purposes does not indicate that the water is unfit for human consumption or that consuming the water will cause an adverse health effect. Rather it indicates that the colour, odour or taste of the water may be objectionable.

The DWSNZ does not set quality standards for water used for industrial or agricultural purposes. To assess the suitability of water for the consumption by livestock the water quality results are compared to the Australian and New Zealand Environment and Conservation Council (2000) (ANZECC, 2000) Livestock Drinking Water Quality guidelines.

ANZECC (2000) Water Quality Guidelines for Contact Recreation addresses recreational contact with water through two categories of sporting activities:

- ✧ Sports in which the user comes in frequent direct contact with water; for example swimming (primary contact).
- ✧ Sports that generally have less-frequent body contact with water; boating or fishing (secondary contact).

These guideline values are based on the assumptions of the World Health Organisation (WHO) contact recreational guidelines, which are in turn based on the WHO drinking water guidelines. The WHO contact recreational guidelines assume that a person would swallow approximately 200 mL of water from the site per day (WHO, 2003). Therefore there is an implicit assumption in the derivation of the contact recreational guidelines that exposure and ingestion of 200 mL of water would need to occur nearly every day.

The WHO contact recreational guidelines state that for a water user who comes in contact with a water body once or who even have occasionally repeated exposure it is unlikely to result in any adverse effects (WHO, 2003). Therefore, the use of these guidelines is highly conservative and will overestimate the actual risk present for infrequent users.

ANZECC (2000) also provides guidelines for water quality assessment for Aquatic Ecosystems. For this study ANZECC Water Quality Guidelines for Aquatic

Ecosystems were considered in relation to the protection of 95% of freshwater species for most elements which are appropriate for this type of environment. However, due to the potential for mercury to bio-accumulate up the food chain a higher benchmark of protection of 99% of freshwater species has been used in this report for mercury only.

The use of the ANZECC (2000) aquatic ecosystem trigger values is considered to be appropriate to assess whether there is the potential for inorganic elements such as mercury or compounds such as nitrate or ammonia to have an adverse effect on aquatic ecosystems, therefore the results from the water quality sampling programme have been compared to the ANZECC (2000) trigger values for freshwater aquatic ecosystem protection. The ANZECC (2000) aquatic ecosystem trigger values have been derived to protect aquatic ecosystems from chronic or long term exposure to inorganic elements or compounds. In this study, PDP is assessing the potential impacts of long term discharges either from former mining sites or natural weathering of geological material.

For inorganic elements, the ANZECC (2000) trigger values should be compared to the dissolved fraction (i.e. the part of the sample which can pass through a 0.45µm filter) rather than the total concentration of the element within the sample (i.e. the total metal fraction). Several studies indicate that it is the dissolved elements within a water sample which are the most likely to be taken up by aquatic species and therefore have the potential to cause toxic effects (ANZECC, 2000); Markich, S,J et al. (2001); US EPA, (1993).

## Glossary<sup>1</sup>

**Acidic** Having a pH of less than 7.

**Alkaline (or basic)** Having a pH of greater than 7.

**Anion** A negatively charge ion. Includes chloride ( $\text{Cl}^-$ ), nitrate ( $\text{NO}_3^-$ ) and sulphate ( $\text{SO}_4^{2-}$ ).

**Ammonia** Compound of nitrogen toxic to stream life at high concentrations.

**Ammoniacal-N** A measure of the amount of ammonia in the water; expressed in terms of the amounts of nitrogen in the form of ammonia or ammonium.

**APHA** American Public Health Association

**Baseline study** Data collected to document existing conditions onsite.

**Bioaccumulation** The build-up of a chemical in body tissues.

**Bioavailability** How readily a chemical is taken up by living organisms either through the skin or via food.

**Cation** A positively charged ion. Includes ( $\text{Ca}^{2+}$ ), ( $\text{Mg}^{2+}$ ), ( $\text{Na}^+$ ) and most metals.

**CV-AFS** Cold Vapour Atomic Florescence Spectrometry is an analytical technique used to measure very low concentrations of mercury (typically between 0.000 5 to 1 ppb).

**Detection limit (DL)** The concentration below which a particular analytical method becomes difficult to determine with certainty.

**Dissolved** Water quality analysis is typically referred as being either dissolved or total element (or metal analysis). Total element analysis refers to water which has been analysed for elements both dissolved in water and present in the particulates in the water. To determine the fraction of the water which is associated the dissolved phase (i.e. not bound to particulates) the water samples are filtered through a 0.45  $\mu\text{m}$  filter. Elements associated with the dissolved phases are generally considered to be more mobile and biologically available than elements bound to the particulate phase. In this report dissolved phase elements are compared to guidelines for the protection of ecological receptors as the dissolved phase is more readily up taken by plants and via gills in aquatic organisms. Total element results are compared to drinking water guidelines as some elements can be released from particulates in the acidic conditions found

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<sup>1</sup> Primary sources:

Government of British Columbia, Ministry of Environment, Glossary of Water Quality Terms <http://www.env.gov.bc.ca/wat/wq/reference/glossary.html#index> accessed 05/02/16, and;

Wai Care Manual Book 6 - Fact Sheets, Wai Care, 2003.

in the stomach of humans and livestock. Total element results have also been compared to aesthetic guideline values as well as elements bound to particulates can also impact on the aesthetic qualities of the water.

**Dissolved oxygen (DO)** The amount of oxygen present in a water sample.

**DQO** Data Quality Objectives are qualitative and quantitative statements that specify the quality of the data required.

**DWSNZ** New Zealand Drinking Water Standard (2008)

**Electrical conductivity (EC)** The measure of the amount of electrical current a material can carry.

**Flow gauging** Measuring the flow of water in a river or stream.

**HDPE** High-density polyethylene is a polyethylene thermoplastic made from petroleum used for many analytical sample containers.

**IANZ** International Accreditation New Zealand. This organisation undertakes independent assessments of laboratories to verify that they have appropriate quality assurance/quality control method to assure that the analysis is undertaken in accordance with international best practice.

**Ion** A negatively or positively charged atom or molecule which has either an excess or shortage of electrons, respectively.

**ISO/IEC (JTC 1)** is a joint technical committee of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). Its purpose is to develop, maintain and promote standards in the fields of information technology (IT) and Information and Communications Technology (ICT).

**NATA** National Association of Testing Authorities, Australia. NATA is the authority that provides independent assurance of technical competence of analytical testing laboratories.

**Nitrogen** An element that is essential to all plants and animals.

**Nutrient** A substance, element or compound, necessary for the growth, development and reproduction of plants and animals; as a pollutant any element or compound, such as phosphorous or nitrogen that encourages abnormally high organic growth in the ecosystem.

**NTU (Nephelometric Turbidity Units)** A measurement of turbidity that measures the light reflected off particles.

**Major elements** Geological major elements are defined as those elements that compose 95% of the earth's crust. They are Silicon, Aluminium, Calcium, Magnesium, Sodium, Potassium, Titanium, Iron, Manganese and Phosphorus.

**Parameter** Any variable that can be measured, e.g. nitrate, electrical conductivity.

**PPE** Personal Protective Equipment

**part per billion (ppb)** Denotes one part per 1,000,000,000 parts or one part in  $10^9$ . Parts-per billion notation is used to describe very dilute solutions where the element is present at one-billionth of a gram per gram of sample solution. When working with aqueous solutions, it is common to assume that the density of water is 1.00 g/mL. Therefore, it is common to equate 1 kilogram of water with 1 L of water. Consequently, 1 ppb corresponds to 1  $\mu\text{g/L}$ . This is equivalent to one drop of water (25 mL) diluted into an Olympic size swimming pool (2500  $\text{m}^3$ ), or about three seconds out of a century.

**pH** A measure of the acidity or alkalinity of a solution.

**Quality Assurance** Evaluation of data collection and analysis techniques to ensure correct procedures was followed.

**Sediment** Particles of sand, clay, silt, and plant or animal matter carried in water.

**Tributary** A stream or river that flows into a larger stream or river.

**Trace element** In analytical chemistry, a trace element is one whose average concentration of less than 0.1 to 100,000 ppb.

**Turbidity** A measure of water clarity.

**Type 1 Water** Deionised purified water which is defined as water having a resistivity of  $>10$  megaohm-cm. This water has been treated to remove all elements from it and does not contain major elements above 0.1 ppb. In this study Type 1 water is used as a field blank.

**Ultra-trace** An analysis and sampling collection methodology which provides results with a detection limit of less 0.1 parts per billion for the purpose of this report. Ultra-trace sampling and analytical techniques (US EPA method 1669 and 1631) were used to collect and analysis dissolved and total mercury concentrations.

**US EPA** United States Environmental Protection Agency

**US EPA method 1631.** A laboratory analytical method approved by the US EPA to measure ultra-trace level of dissolved and total mercury using Cold Vapour Atomic Florescence Spectrometry.

**US EPA method 1669.** An US EPA approved method to collect ambient water for metals which is to be used in conjunction with trace and ultra-trace analytical techniques.

## 1.0 Introduction

Pattle Delamore Partners Ltd (PDP) has been engaged by Evolution Mining NZ Pty Limited (ENZ) to undertake an assessment of surface water quality within their Puhipuhi gold exploration tenement and at a number of selected sites in the upper and middle reaches of the Wairua River. The primary aim of this programme is to provide defensible and high quality baseline data prior to any exploration-related environmental disturbance at Puhipuhi, Northland.

In addition, the results aim to address a number of key questions and concerns:

- ✧ Does surface water meet safe Drinking Water Standards for humans and livestock?
- ✧ Is surface water quality of a standard that does not adversely affect aquatic ecosystems?
- ✧ Are the results consistent with earlier monitoring results from the same locations?
- ✧ Can point sources for trace levels of mercury be identified from the data?
- ✧ To what extent does downstream dispersion of mercury occur?

This report presents the results of the surface water quality sampling undertaken at 18 sites between the 7<sup>th</sup> and 13<sup>th</sup> of March 2016.

## 2.0 Project Background

The surface water sampling programme is one of several baseline environmental investigations being undertaken by PDP on behalf of ENZ. Other environmental investigations being undertaken include groundwater, ecological, sediment and air monitoring, hydrogeological assessments and physical environmental surveys. The scope of the project has incorporated the concerns expressed by local iwi and local residents about existing water quality and ecosystem health, including food sources such as eels, and the potential effects of exploration-related activities such as exploration drilling.

A number of studies of water quality have been undertaken previously at Puhipuhi, both by regulators such as Northland Regional Council and by academic researchers. Studies have focused on the levels of mercury and other metals in response to legacy issues associated with an abandoned small-scale mercury mine and processing plant, which is located in the headwaters of Waikiore Stream and was active between 1907 and 1945 (DoC, 2010). Previous geological and geochemical surveys have shown that elevated mercury values, consistent with geothermal influence such as at Ngawha (NZEL, 2003), are widespread in Puhipuhi rocks and soils and are not confined to the Waikiore Stream. The current study utilises previous sample locations as a basis for comparison and also extends sample coverage to include catchments not previously assessed.

The main streams draining the Puhipuhi area are the Pukekaikioire, Waikioire and Whenuaroa Streams which are the major tributaries of the Waiariki River. The western side of the tenement area is drained by tributaries of the Waiotu River and a small area on the eastern side is drained by tributaries of Kaimamaku Stream (see **Figure 3**). The streams and river in the tenement area are part of the Wairua/ Wairoa River catchment that drains a substantial part of central Northland. Further downstream the Wairua River becomes the Wairoa River and flows past Dargaville into the Kaipara Harbour on the west coast. The key receiving river environments downstream of the study area are the Waiariki River, Waiotu River, Kaimamaku Stream, Whakapara River, Wairua River, Wairoa River and the Kaipara Harbour.

### 3.0 Scope and Objectives

Evolution Mining has requested:

- I. Surface water sampling within and outside the exploration tenement boundaries to determine (i) baseline concentrations of metals and parameters that could be used to measure changes to the surface water if drilling was to commence and (ii) determine if there are specific areas within the tenement boundaries that are the source of any metals in the stream system, if metals are present.
- II. Surface water sampling within and beyond the tenement boundary replicating the locations of the previous sampling, to determine if there have been any changes to the system over time and again provide background data for the future.
- III. All surface water samples to be analysed at an accredited laboratory (accredited laboratories require an independent assessment of quality control and accuracy standards e.g. by IANZ).

### 4.0 Methodology

#### 4.1 Water Quality Sampling

Water samples were collected in accordance with US EPA method 1669 and sampling procedures are outlined the PDP (2016b) sampling and analysis plan. A summary of the water quality sampling methodology, analytical procedures, and quality assurance are appended, including procedures to avoid sample contamination (**Appendix A**).

##### 4.1.1 Field Parameters:

Immediately after each water sample had been collected, field parameters including dissolved oxygen, electrical conductivity, pH, redox potential, temperature, and turbidity were recorded using hand-held water quality meters.

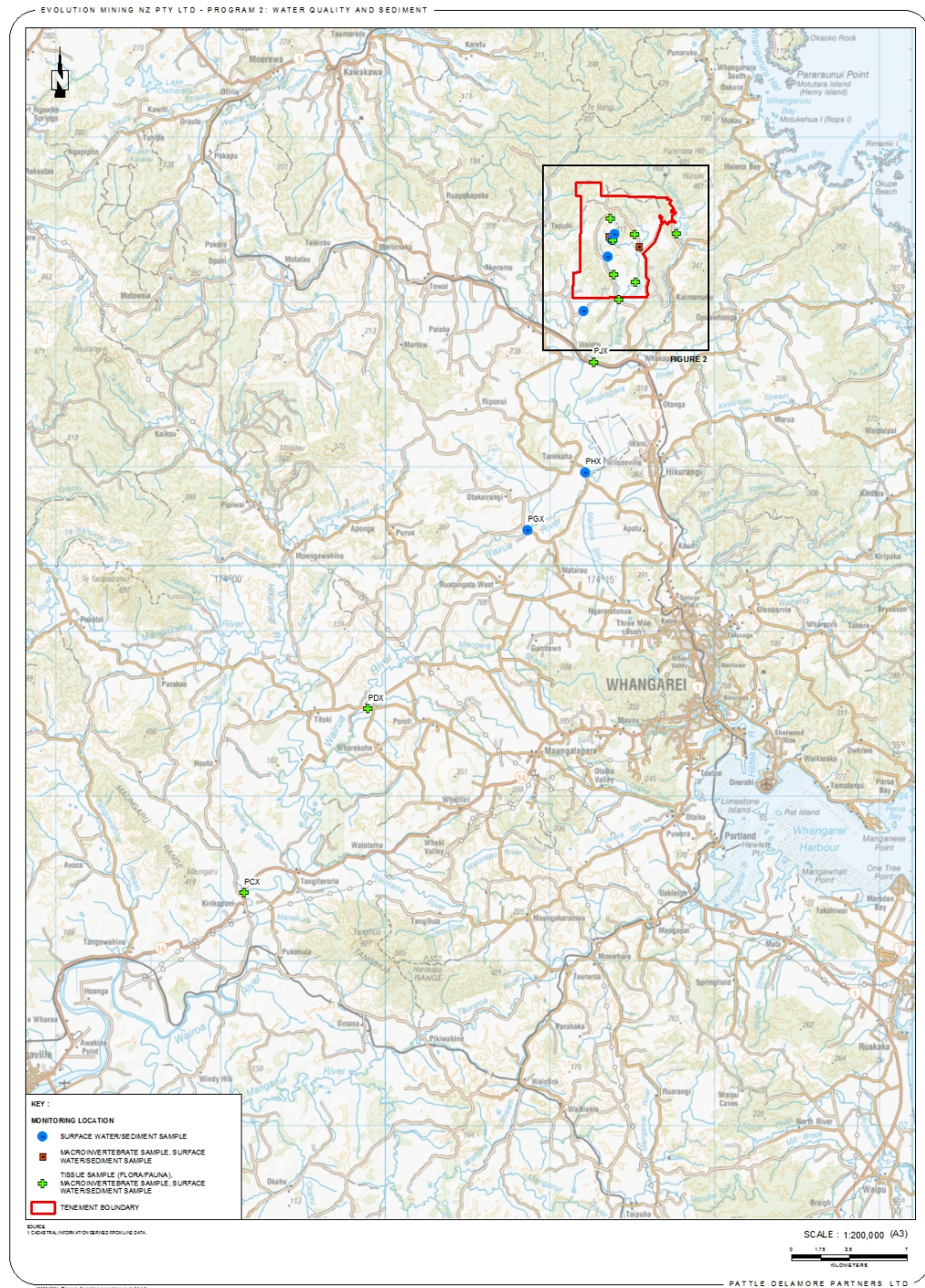
A YSI Pro-DSS field meter equipped with optical dissolved oxygen and turbidity sensors as well as electrical conductivity, redox, pH and temperature sensors was used as the primary water quality meter. A YSI Pro-plus field meter equipped with pH, redox, electrical conductivity meter, Clark type electrochemical dissolved oxygen sensor and temperature sensor was also used as a backup meter to record field parameters. Calibration checks were routinely undertaken for electrical conductivity, pH, and dissolved oxygen.

Water samples were analysed for mercury by two different methods. Water quality samples were analysed using US EPA method 200.2 to trace level detection limits similar to previous monitoring programs (1 ppb). To achieve lower (ultra-trace) detection limits for mercury (0.0005 ppb) additional samples were analysed by a US lab using US EPA method 1631 purge and trap CV-AFS. For interpretation purposes, the results have been rounded up to 0.001 parts per billion. The reason for using this lower detection sampling method was to determine whether ultra-trace levels of mercury in water could be used to map downstream dispersion patterns and identify potential point sources for the release of mercury.

#### 4.1.2 Site Locations

PDP collected water quality samples from 18 sampling locations within and downstream of the tenement boundary (see **Appendix E**). The sampling locations were chosen to collect water quality samples from most of the sites in the 1973 study by F.E. Hoggins and R. R. Brooks, and to also include several sites sampled by Northland Regional Council between 2013 and 2014. Six additional sampling locations were selected by PDP to extend sample coverage across a larger number of catchments and sub-catchments on the Kaimamaku (PYX), Papanui (PKX), Waikore (PTX) and Whenuaroa streams (PMX and PNX). Sample locations are shown in **Figure 2** and **Table 1** below (and also in **Figures 1-4** in **Appendix E**).

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**Figure 1: Sampling locations**

EVOLUTION MINING NZ PTY LIMITED - BASELINE ENVIRONMENTAL MONITORING, PROGRAM 2: SURFACE WATER SAMPLING - EXPLORATION PERMIT #51985 AT PUHIPUHI, NORTHLAND

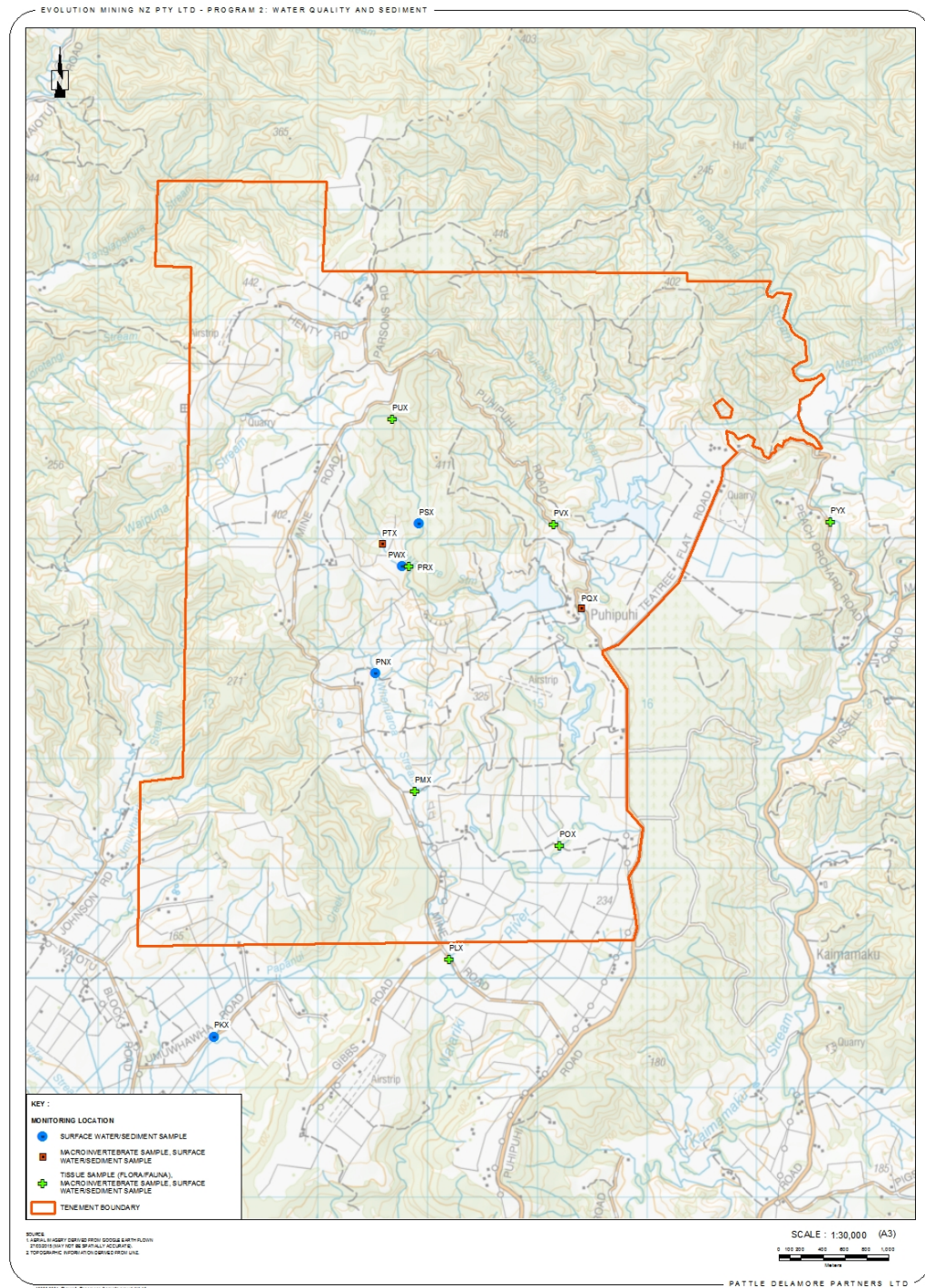


Figure 2: Sampling locations within ENZ's tenement

Table 1: Sampling Locations					
Sample Id	Sample Location	Sample Types	Easting (NZTM)	Northing (NZTM)	Previously Sampled
PDX	Wairua river bridge, Houto Road	Sed/Water	1698925	6045315	Hoggins, 1973 (Site 11)
PFX	Wairua River at Pipiwai Road Bridge	Sed/Water	1704307	6054017	Hoggins, 1973 (Site 9)
PGX	Wairua River at Matarau Road bridge	Sed/Water	1708651	6056148	Hoggins, 1973 (Site 8)
PHX	Wairua River at Jordan Valley bridge	Sed/Water	1712129	6059650	Hoggins, 1973 (Site 7)
PJX	Waiairiki River downstream of SH1 bridge and waterfall	Sed/Water	1712151	6066496	NRC, 2013 (Site 1); Hoggins, 1973 (Site 6)
PKX	Papanui Stream at Umuwhawha Road	Sed/Water	1712057	6069466	Not previously sampled
PLX	Waiairaki Stream at Mine Road	Sed/Water	1714194	6070173	Hoggins, 1973 (Site 5)
PMX	Whenuaroa stream on private farm bridge	Sed/Water	1713882	6071701	NRC, 2014 (Site 2)
PNX	Whenuaroa stream on private farm	Sed/Water	1713526	6072774	Not previously sampled
POX	Farm bridge on private farm	Sed/Water	1715202	6071209	Not previously sampled but downstream of Hoggins, 1973 (Site 4)
PQX	Pukekaikiore Stream at Puhipuhi Road Lower Bridge	Sed/Water	1715399	6073367	NRC, 2013 (Site 6)
PRX	Waikiore Stream, downstream of unnamed trib.	Sed/Water	1713834	6073747	Hoggins, 1973 (Site 3)
PSX	Waikiore Stream	Sed/Water	1713925	6074136	Hoggins, 1973 (site 2)
PTX	Unnamed tributary Of Waikiore Stream	Sed/Water	1713590	6073955	Not previously sampled
PUX	Old Mine dam at Mine road, below dam outlet	Sed/Water	1713678	6075093	NRC, 2014 (Site 3); Hoggins, 1973 (Site 1)

**Table 1: Sampling Locations**

Sample Id	Sample Location	Sample Types	Easting (NZTM)	Northing (NZTM)	Previously Sampled
PVX	Unnamed tributary of Pukekaikio Stream at Puhipuhi Road Upper Bridge	Sed/Water	1715150	6074132	NRC, 2014 (Site 4)
PWX	Waikiore Stream upstream of PRX	Sed/Water	1713768	6073748	Not previously sampled
PYX	Kaimamaku Stream at Peach Orchard Road	Sed/Water	1717673	6074154	Not previously sampled

## 5.0 Water Quality Results

The results of the water quality sampling programme are presented in **Appendix B**. The quality control procedures are summarised in **Appendix C**. Copies of the PDP field sheets are appended in **Appendix D**.

The analysis of duplicate samples collected at PMX and POX were within the project's data quality objectives (See **Appendix C** - Table C-1). This indicates that the analytical results are reproducible.

The results for the water quality sampling programme found that mercury concentrations were near the detection limit of the trace analytical techniques near the former mercury processing plant. However, to obtain reliable estimates of the dissolved and total mercury concentration ultra-trace sampling and analytical techniques were used at other sampling locations within and outside of the tenement.

### 5.1 Comparison with New Zealand Drinking Water Standards

To determine if the water in the streams and waterway are safe for human consumption as part of this sampling programme the water quality results have been compared to the maximum acceptable values (MAV's) outlined within the DWSNZ in Table B-1. The DWSNZ also provides guidelines values for aesthetic (i.e. odour, taste and scale formation) reasons and these have also been included within Table B-1, although they are not part of the water quality standards. The difference between health based and aesthetic determinants are explained in the notes of Table B-1.

Based upon the results outlined in Table B-1, PDP found that:

- ∴ No samples exceed the health based MAVs for drinking water guidelines;
- ∴ All samples except for PYW exceeded the aesthetic guideline values of 0.2 mg/L for iron;

- ✧ The highest concentration of mercury detected in this sampling programme (0.236 ppb at PUX) is more than an order of magnitude (ten times) lower than the DWSNZ MAV for mercury in drinking water of 7 ppb. At most sampling locations the concentration of mercury is more than two orders of magnitude (i.e. more than 100 times lower) lower than MAV for mercury set out in DWSNZ. Therefore, the mercury concentration measured within the water samples are significantly lower than those known to cause significant risk to human health from direct consumption of drinking water;
- ✧ All samples except PYX exceed the aesthetic value for total iron. It should be noted this aesthetic value is for the staining of laundry and sanitary ware. Iron is a relatively non-toxic element and concentrations less than 2 mg/L in drinking water do not present a hazard to human health (see footnotes 2 and 3); and
- ✧ All samples except one at PDX (which was pH 7.39) were lower (4.27-6.88 pH units) than the range of pH values (7.0 to 8.0 pH units) for aesthetic determinants set in the DWSNZ. Water with a pH value of less than 7.0 pH units can result in increased corrosion of lead pipes. Northland waterways are typically slightly acidic due to the presence of naturally occurring humic acids which are released from swamps (such as the Hikurangi Swamp) and wetlands within the catchment.

## 5.2 Comparison with ANZECC Livestock Drinking Water Guidelines

The results of the water sampling programme have been compared against the ANZECC (2000) Livestock Drinking Water trigger levels in Table B-1. No samples exceeded ANZECC (2000) Livestock Drinking Water trigger levels from any sites. The low trigger value for mercury in livestock drinking water is 2 ppb, compared to the maximum value obtained of 0.236 ppb from location PUX.

## 5.3 Comparison with ANZECC Contact Recreational Guidelines

The water quality data was compared to ANZECC (2000) Contact Recreational Standards.

The ANZECC (2000) Contact Recreational Guidelines do not state if the results for inorganic parameters should be compared against dissolved or total metal fractions. For the purposes of this investigation, they have been compared to total metals as ingestion is the primary route of exposure. When water is ingested acidic conditions within the stomach may release some or all of inorganic elements bound to particulate matter.

The results of comparison are summarised below:

- ✧ All samples except PYX exceed the trigger value for total iron. Northland lowland rivers are naturally high in inorganic elements and metals (NRC,

2015). Therefore, the presence of elevated iron within the waterways may be due to natural sources. Iron is also a relatively non-toxic element and the reason for its inclusion into guidelines is not defined<sup>2</sup>.

- ✧ Eight samples exceeded the trigger value for ammoniacal-nitrogen at sites PDX, PHX, PJX, PLX, POX, PQX, PSX, and PUX.
- ✧ Samples at sites PSX, PUX, PVX exceeded the trigger value for total manganese. This result is also possibly due to elevated natural background metal concentrations in lowland Northland rivers (NRC, 2015).
- ✧ Samples at sites PRX, PSX and PVX exceeded the range of trigger values for pH. The measured pH readings at these sites were all lower than 6.5 pH units, which is outside the desired range for contact recreational water quality. High or low pH may cause irritation to the skin and eyes of sensitive people.

#### 5.4 Comparison with ANZECC Aquatic Ecosystem Guidelines

As discussed in the note on Water Quality Guidelines on page vii, the 99% trigger values have been used for mercury while the 95% trigger levels have been used for the remaining elements.

Table B-1 in **Appendix B** presents the water sampling results and the ANZECC (2000) aquatic ecosystem trigger values. The results are summarised below.

- ✧ The concentration of dissolved mercury at location PUX is 0.236 ppb and at PSX was 0.1 ppb. Both samples exceeded the ANZECC (2000) trigger value for 99% ecosystem protection (0.06 ppb mercury) but are below the trigger value for 95% ecosystem protection (0.6 ppb mercury). This indicates that there may be a minor effect on highly sensitive species at these locations and the potential for bioaccumulation up the food chain. All other water samples contained less than 0.06 ppb mercury, indicating that adverse effects on the aquatic ecosystem from mercury are highly unlikely at all other locations.
- ✧ Five sites exceeded the 95% protection trigger levels for both dissolved copper and zinc at sampling locations PDX, PQX, PRX, PSX, and PVX.

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<sup>2</sup> The ANZECC (2000) does not provide a detailed derivation of the contact recreational guidelines but they do note they are derived from the WHO Guidelines for safe recreational water environments (Volume 1: coastal and fresh water) which in turn refer to the toxicological assessments undertaken in the WHO Drinking water Guidelines. These guidelines state the iron is an essential element in human nutrition and the consumption of 2 L of water containing 2 mg/L per day (or 10 times the contact recreational standard) does not present a hazard to human health (WHO, 2003b).

These inorganic element concentrations measured are comparable to other Northland lowland rivers, which have been recorded as naturally high in copper (NRC, 2015). This, in turn, may be related to naturally high levels of copper in basalt volcanic rocks that are common in parts of Northland.

- ∴ All other results were below the 95% protection level guidelines.

## 5.5 Comparison of Water Quality Results with Previous Studies

### 5.5.1 Mercury distribution and mobility at the abandoned Puhipuhi mercury processing site, Northland, New Zealand (Gionfriddo et al 2015)

The study cited under Gionfriddo et al (2015) was commissioned by the Department of Conservation and submitted on 23<sup>rd</sup> September 2013 but not published until 2015. The date of sampling is not mentioned in the article but is assumed to be in 2013 when the paper was first presented for review.

Gionfriddo et al (2015) collected four water samples from upstream, within and downstream of the dam below the historic Puhipuhi Mine site. They found dissolved mercury concentrations within the Waikiore stream, the upstream mine site and dam ranging between 0.069 ppb and 0.24 ppb. The Gionfriddo et al (2015) sampling locations PP1 and PP5 were in the same stream location as PDP sampling location PUX, and the same analytical technique (US EPA Method 1631 E) was used to determine mercury concentrations in both studies. The concentration of dissolved mercury at PP1/PUX was found to be similar in both studies (0.236 ppb (PDP) versus 0.24 ppb (Gionfriddo)). Both studies show the concentration of mercury decreasing as the distance from the former mine processing area increases. Gionfriddo's study also showed that water in the dam and next to the (upstream) mine location had lower levels of mercury compared to sampling sites adjacent to the historic processing plant (see **Table 2**).

**Table 2: Gionfriddo et al 2015 Surface Water Results**

Sample Site	Location	Dissolved Methyl Mercury (ppb)	Dissolved Mercury (ppb)	PDP Dissolved Mercury (ppb)
PP1	Waikiore Stream	0.00141	0.24	0.236 (PUX)
PP4	Dam	0.00195	0.118	Not Analysed
PP5	Waikiore Stream	0.000637	0.219	0.236 (PUX)
PP6	Above Dam	0.000706	0.0696	Not Analysed

#### 5.5.2 NRC 1995 Monitoring Study (Northland Regional Council, 1995)

A report was presented by the Northland Regional Council in 1995 following sampling completed in 1982 studying inorganic element concentrations within streams at Puhipuhi (Northland Regional Council, 1995). The 1982 laboratory methods of analysis were much less sensitive than methods used in more recent studies. Mercury was tested using Cold-Vapour Atomic Absorption Spectrometry (detection limit 1 ppb). Only one location was near a PDP sampling location, and due to the poor sensitivity of the laboratory analysis method, it is not included in the NRC vs PDP comparison (See **Appendix B** Table B2).

#### 5.5.3 Puhipuhi Water & Sediment Metal testing programme (Northland Regional Council, 2013-2014)

Northland Regional Council and Ngati Hau conducted a monthly monitoring program within the catchment over a 12 month period in 2013-2014 to provide background data on inorganic elements in surface water and sediment samples. Total mercury was measured below the detection limit (0.05ppb) at most sites, with the exception of Site 3 (equivalent to location PUX), where 10 of 13 results exceeded 0.06 ppb; the maximum value was 0.26 ppb. There were numerous recorded exceedances of the ANZECC 95% trigger values for copper and zinc. Chromium and lead trigger values were also exceeded during several monitoring rounds at various sites.

An additional sampling round was completed by Lincoln and Canterbury Universities in 2015 as part of a research programme funded by the Ministry of Business Innovation and Employment (Webster-Brown, J, 2015). The sites sampled were in the same location as the 2013-2014 NRC investigation and also included two new sites. There were several exceedances of the ANZECC 95% trigger values for copper and zinc, however, no exceedance of mercury was recorded.

Table B-2 in **Appendix B** compares the NRC and PDP field and lab parameters and element results from the same sampling locations (See **Appendix E**, Figures 1-4 for locations). In all cases except three, the concentrations of the samples collected by PDP were within the range of those reported by NRC. In three cases NRC reported values below PDP's analytical detection limit (for antimony at sites PUX and PVX and nickel at PJX).

PDP's onsite field parameter readings were generally comparable with NRC 2013-2014 surface water values; however, at one site (PUX) NRC dissolved oxygen concentrations (7.8-9.9 mg/L) were higher than the concentration of dissolved oxygen (3.23 mg/L) that PDP measured at the same site. Dissolved oxygen concentration can naturally vary significantly at some sites depending on the time of day, the flow rate of the stream and the season of the year. Dissolved oxygen concentration may also be affected by the concentration of reduced iron being discharged into the stream at this location. Dissolved iron concentrations measured at this sampling location was 22 mg/L which is significantly higher than the dissolved iron concentrations measured at most other monitor sites. Field staff collected the water samples at this monitoring location observed a significant amount of iron staining on the stream banks and within the stream itself. The precipitation of iron (which would result in the iron staining observed) could result in a significant depression of dissolved oxygen concentrations within the waterway.

#### 5.5.4 Natural dispersion of mercury from Puhipuhi, Northland, New Zealand, (Hoggins and Brooks, 1973)

**Table 3** below compares the surface water sampling results presented by Hoggins and Brooks (1973) (collected in 1971) and those collected by PDP in March 2016. It should be noted that water samples collected by Hoggins & Brooks and PDP were analysed by different analytical techniques (silver trap flameless AAS versus US EPA Method 1631E (CV-AFS) used by PDP). These two analytical techniques have different detection limits (0.1 ppb for the methodology used by Hoggins and Brooks compared to 0.0005 ppb for CV-AFS used in this study).

In the Hoggins & Brooks paper about the natural dispersion of mercury from Puhipuhi, the results of the water quality measurements are not presented in a tabular format. Therefore PDP had to estimate the concentration of mercury from Figure 2 of that paper. The estimate of the total mercury concentration in water presented in **Table 3** maybe  $\pm 0.2$  ppb of the value obtained by Hoggins and Brooks. It should also be noted that at sampling locations PJX and POX (Hoggins sites 4 and 6), Hoggins & Brooks report a concentration of mercury which is below their analytical detection limit. These results should be treated with extreme caution as results which are less than the analytical detection are not likely to be reliable.

Table 3: Hoggins & Brooks (1973) Comparison						
PDP Field ID	PJX		POX		PRX	
	Hoggins	PDP	Hoggins	PDP	Hoggins	PDP
Sample ID	Site 6	PJW01/02	Site 4	POW01/02	Site 3	PRW-1/-2
Sampling Date	1973	10-Mar-16	1973	11-Mar-16	1973	12-Mar-16
Total Mercury ppb	0.05	0.011	0.08	0.020	0.6	0.055
PDP Field ID	PSX		PUX			
	Hoggins	PDP	Hoggins	PDP		
Sample ID	Site 2	PSW-1/-2	Site 1	PUW-1/-2		
Sampling Date	1973	12-Mar-16	1973	13-Mar-16		
Total Mercury ppb	0.4	0.112	0.7	0.236		

Note:

- All results in parts per billion.

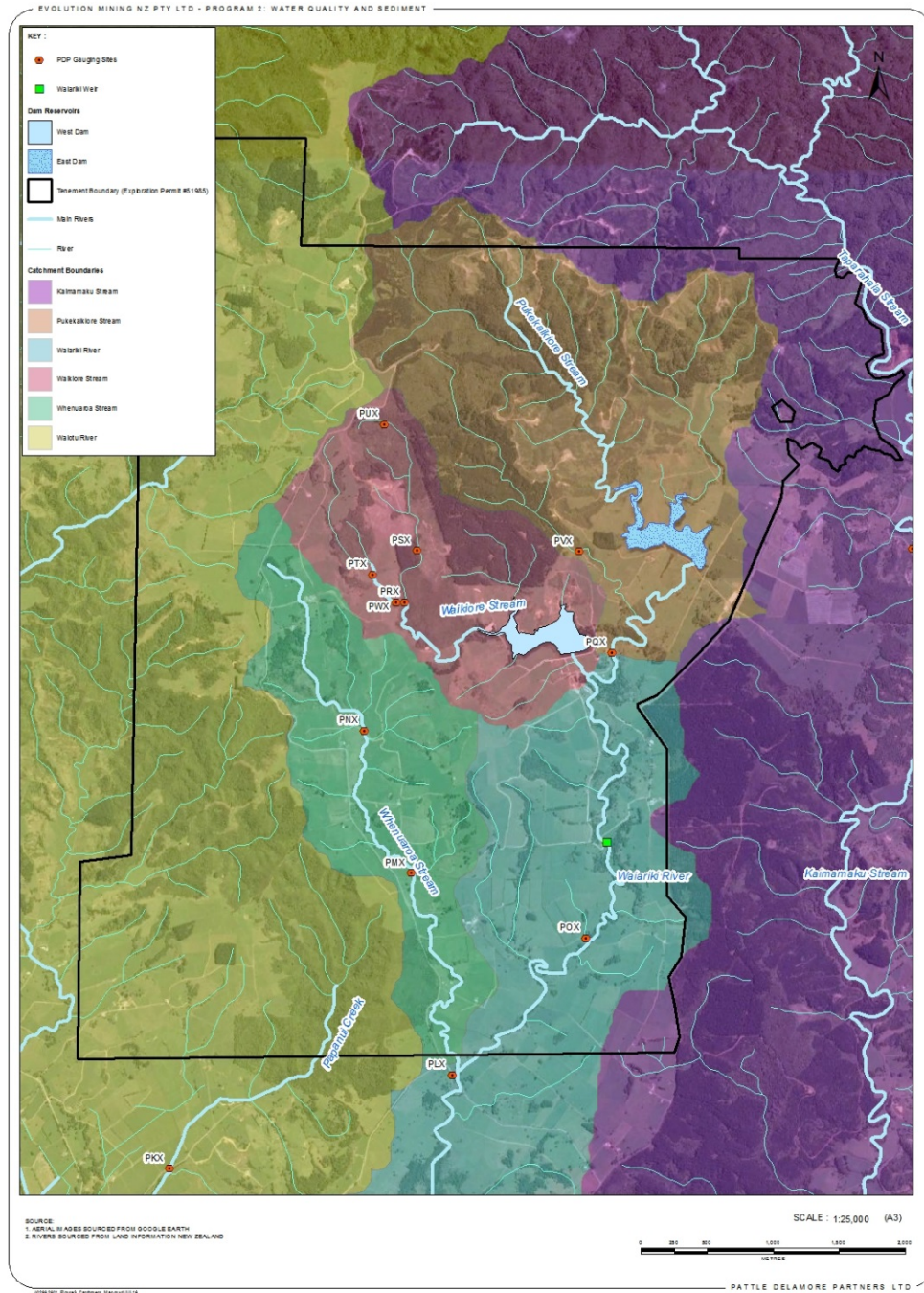
However, taking these limitations into account the mercury content of water samples obtained by PDP are generally lower than the results obtained by Hoggins & Brooks (1973). PDP results confirm the trend identified by Hoggins & Brooks (1973) that total mercury concentrations decrease away from the historic mercury mine processing site, which is also illustrated by **Figure 4** below.

## 6.0 Potential Sources of Mercury

Samples from this study were analysed by a US laboratory that is accredited for mercury analysis to extremely low levels, and significantly lower than what has been used for previous Puhipuhi studies. For example, the analytical methods for previous studies provided mercury analyses to levels as low as 0.05 ppb, whereas this study was able to detect levels as low as 0.0005 ppb. In previous studies, most water samples returned no detectable mercury other than in the vicinity of the historic mercury mine processing site. However, the ultra-trace analysis used in this study has allowed downstream dispersion and potential point sources of mercury to be investigated.

The various tributaries to the Wairua River, their catchments, and PDP sampling locations are shown below in **Figure 3**.

EVOLUTION MINING NZ PTY LIMITED - BASELINE ENVIRONMENTAL MONITORING, PROGRAM 2: SURFACE WATER SAMPLING - EXPLORATION PERMIT #51985 AT PUHIPUHI, NORTHLAND



**Figure 3: Tributaries and catchments of the Wairua River**

The results show elevated mercury (0.236 ppb dissolved mercury), iron and manganese at sample location PUX at the head of the Waikare stream. PUX is directly downstream from the historic mine/quarry face, and adjacent to the site

where mercury was processed from insoluble minerals in ore to elemental mercury from the 1930's to 1945.

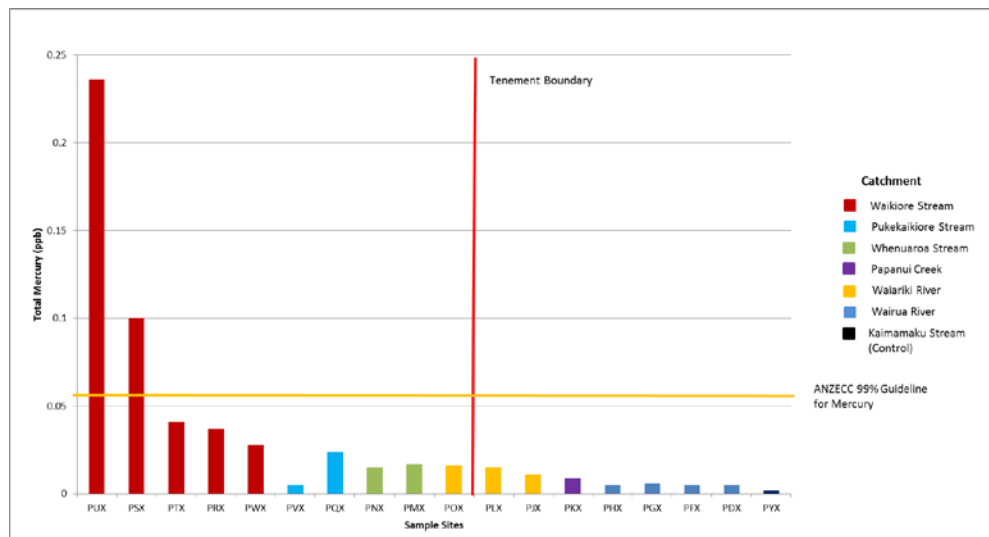
There is a significant reduction in the concentration of dissolved mercury at sample locations further downstream of site PUX (0.236ppb) at monitoring locations PSX (0.100 ppb) and PRX (0.037ppb). The concentration of dissolved mercury in water at site PRX is similar to water from PWX (0.028 ppb) and PTX (0.042 ppb), which are located on a different tributary of the Waikiore Stream where no mining activities are known to have occurred. The elevated mercury detected at these monitoring sites may be a result of natural processes such as the weathering of mineralised rocks and/or from discharges of shallow groundwater from the Purua Bed Sedimentary Aquifer.

Site PVX, on the tributary to the west of Pukekaikore Stream, has no known association with any potential mining activities. Water from site PVX contains extremely low levels of dissolved mercury (0.005 ppb) and other elements, whereas the site PQX only one kilometre downstream shows mercury results significantly higher (0.024 ppb) but still below the ANZECC guideline value (0.06ppb). PQX is located in Pukekaikore Stream above the junction of Waikiore and Pukekaikore Streams, thus the weakly elevated mercury concentrations recorded in water at PQX is not derived from the historic mine processing site. This suggests that there is a second source of mercury from weathering of mineralised rock material within the Pukekaikore Stream catchment upstream of the East Dam.

Site PNX and PMX also recorded dissolved mercury higher than that recorded at PVX (0.015 and 0.017 ppb respectively) within Whenuaroa Stream where no mining activities are known upstream. This suggests a third source of mercury, potentially from the dissolution of mercury from mineralised rock /soils and/or shallow groundwater from the Purua Bed Sedimentary Aquifer into streams within the tenement area.

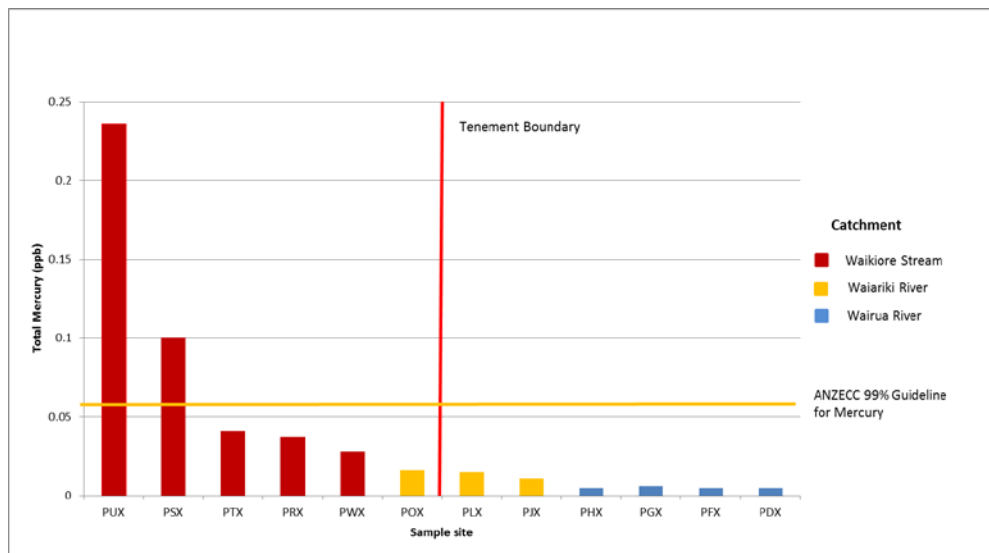
Site POX on the eastern edge of the tenement is fed by the Waikiore and the Pukekaikore Stream. It shows similar mercury levels to PMX which may be attributed to either downstream dispersion from the former mine and processing site, natural weathering of mineralised rock/soil and/or other natural sources.

**Figure 4** shows all of the monitoring sites ordered from north to south and segregated by their catchments, except for site PYX which has been put at the end. It can be seen from **Figure 4** that the surface water mercury decreases as the distance from the former mine increases and that mercury concentrations are not distributed evenly across all catchments.

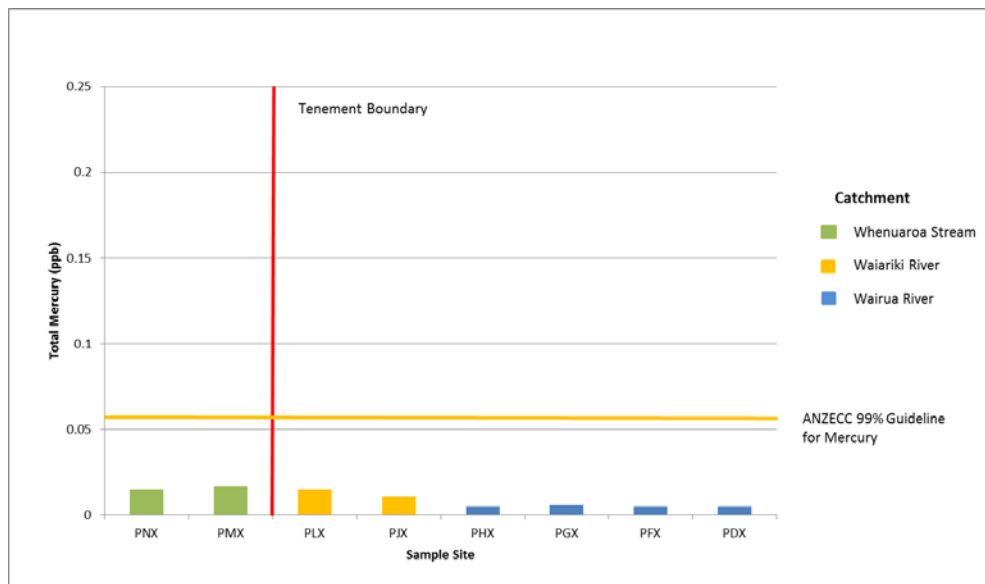


**Figure 4: Surface water mercury concentrations for all sites**

As shown in **Figure 5** below, the concentration of total mercury decreases with distance downstream from the historic Puhipuhi mercury mine processing site within the Waikiore sub-tributaries and Waiariki tributary, which feed into the Wairua River. The ANZECC 99% guideline value for mercury is shown on **Figure 4**, **Figure 5** and **Figure 6**. Exceedances are shown at only at two locations (PUX, PSX) which are within 1 kilometre downstream of the former mine processing plant. The DWSNZ threshold for mercury in drinking water of 7 ppb is not shown as it is much higher than any values measured during the study.



**Figure 5: Total mercury concentrations in the Waikiore Stream catchment**



**Figure 6: Total mercury concentrations in the Whenuaroa Stream catchment**

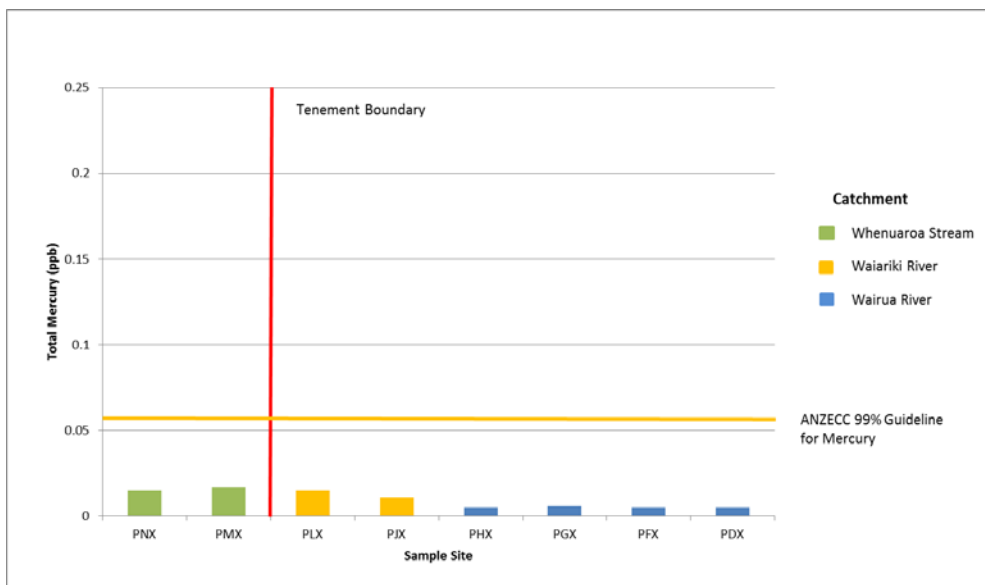


Figure 6 above shows total mercury concentrations downstream of the Whenuaroa Stream catchment which is not known to have been affected by mining activities; this catchment joins the Waiariki River and flows into the Wairua River. All sites within these catchments are below the ANZECC 99% mercury trigger value.

The inorganic point sources can be summarised as follows:

- ✧ The former mercury mining and processing site appear to be a source of mercury, iron, and manganese as shown by elevated levels at site PUX and PSX and to a lesser extent PRX.

- ✧ There is potential for another mercury source which has resulted in elevated levels of mercury in PWX and PTX in a sub-tributary to the west of Waikiore Stream and another source of mercury which has resulted in weakly elevated mercury levels at PQX.
- ✧ Mercury is known to be elevated in mineralised rock at Mt Mitchell, which has been prospected and quarried for cinnabar, but this has not resulted in elevated levels of mercury in the Papanui Creek that drains Mt Mitchell. Therefore, Mt Mitchell does not appear to be a point source for dissolved mercury.
- ✧ The elevated concentrations of mercury within catchments that have no history of mining or mineral processing can be attributed to the natural weathering of mineralised rocks and soils within the upper areas of the catchment or from shallow ground water sources.

## 7.0 Summary

The surface water mercury values reported by PDP are within the range of concentrations found in two recent studies: Gionfriddo et al. (2015) and a Northland Regional Council study carried out in partnership with Ngati Hau between 2013-2014 (NRC, 2015). The most recent studies (PDP (2016), Gionfriddo (2015) and NRC (2015)) reported mercury concentrations that are lower than those reported in an early study by Hoggins and Brooks (1973).

Mercury concentrations are strongly elevated in water within the immediate vicinity of the historic mercury processing plant at the headwaters of the Waikiore Stream. However, mercury concentrations rapidly decrease to below 0.050 ppb within 2 kilometres downstream of the processing plant. Ultra-trace sampling and analytical techniques were needed to reliably determine the concentration of dissolved and total mercury downstream of sampling location PUX. The findings of this report are summarised as follows:

- ✧ No samples exceeded the human health based maximum acceptable values in the New Zealand Drinking Water Standards;
- ✧ The concentrations of iron in surface water samples within the tenement were slightly elevated and exceeded guideline values for aesthetic determinants within the NZ Drinking Water Standards at most of the sites sampled. Therefore the water within the tenement may have an unpleasant metallic taste and may stain laundry. The elevated iron concentrations within the surface water are not a health concern because of the low toxicity of iron to humans<sup>3</sup>;

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<sup>3</sup> Iron is an essential element for humans and insufficient amounts of iron can result in severe fatigue, body weakness, and other related health ailments.

- ∴ Concentrations of total iron were elevated in all but one sample and exceeded ANZECC (2000) contact recreational guidelines. Manganese and ammoniacal-nitrogen were elevated in several locations above ANZECC (2000) Contact Recreational standards;
- ∴ The concentration of all other inorganic elements meets human drinking water, livestock, and contact recreational standards;
- ∴ Two surface water samples exceeded ANZECC (2000) dissolved mercury concentration trigger values for 99% ecosystem protection. Sample PUX located immediately adjacent to the historic mercury processing site dissolved mercury concentrations were 0.236 ppb. At PSX, approximately 1km downstream from PUX, dissolved mercury levels were 0.1 ppb. Mercury concentrations continue to decrease at sites downstream from PSX, which suggests that the historic mine site/processing site area is a point source of dissolved mercury in water within the Waiariki catchment;
- ∴ The concentration of dissolved and total mercury rapidly decreases to below the trigger level of 0.06 ppb for 99% ecosystem protection within 1.2 kilometres of the historic mercury processing site. It appears that levels of mercury in surface water within the tenement boundary may be derived from weathering of mineralised rock and soil or potentially shallow groundwater, although the historic mercury processing site and mine/dam area are also recognised as a point source of mercury in water;
- ∴ The concentrations of dissolved and total mercury measured in this study are similar to the concentrations reported by Gionfriddo et al (2015) and Northland Regional Council (2015);
- ∴ The concentration of dissolved and total mercury is slightly lower than reported by Hoggins and Brook (1973);
- ∴ Dissolved zinc and copper concentrations were marginally above the ANZECC (2000) trigger value for 95% ecosystem protection at sites PDX, PQX, PRX, PSX, and PVX. Zinc and copper concentrations were below ANZECC (2000) 95% ecosystem trigger values at PUX immediately below the mercury processing site but were elevated at sampling sites PRX and PSX further downstream; and
- ∴ Concentrations of all other inorganic elements are below ANZECC (2000) 95% ecosystem trigger values.

## 8.0 Conclusions

Most previous Puhipuhi surveys have used analysis methods that can detect mercury at levels above 0.05-0.08 ppb. For this study, samples were sent to a US laboratory that is accredited to detect mercury in water to levels as low as 0.0005 ppb. Therefore ultra-trace analytical techniques have been used to measure mercury concentrations at locations where mercury was undetectable in previous studies. This data has allowed dispersion patterns and potential point sources to be investigated. A historic mercury processing site at the head of Waikiore Stream appears to be a point source for dispersion of mercury into water.

This study found localised elevation of mercury concentrations in water in the immediate area surrounding a historic mercury processing site. However, mercury concentrations rapidly decrease downstream away from the historic mercury processing site, to below 0.06 ppb within 1.2 kilometres.

No samples exceeded the human health based maximum acceptable values in the New Zealand Drinking Water Standards.

Only two samples exceeded the relevant guideline values for mercury and they were in closest proximity to the former mercury processing site. Other metals and inorganic elements were slightly elevated at background levels which are comparable to generally elevated levels in Northland Rivers (NRC, 2014).

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## Appendix A: Sampling and Analysis Plans

Water samples were collected in accordance with the PDP Sampling and Analysis Plan, 2016. This document set out the proposed sample methodology, addressed contaminants of concern, detailed QA/QC field procedures

The following is a summary of this document:

To avoid sample contamination PDP undertook the following steps:

1. PDP field staff wore disposable Tyvek suits and gloves (certified metal free for ultra-trace metal analysis) which were changed at each monitoring site or whenever the PPE got visually contaminated.
2. Water samples were collected upstream of field staff and water samples were collected before any other samples (sediment or biota) were collected at each site.
3. US EPA method 1669 was utilised to collect water samples at each sampling location. Dedicated sampling lines and inline filters were used at each sampling location and had been cleaned and certified by Eurofins Global Frontiers laboratory.
4. The water samples were collected in the main flow of the stream, upstream of the sampler, and care was taken not to disturb any of the sediment at the bottom of the stream during sampling.
5. Where the stream depth was greater than 0.3 m water samples were collected at least 0.1 m from the top and bottom of the stream.

### Order of sampling

Samples were collected in a specific order to minimise the potential for cross contamination of samples from earlier sampling events. Downstream, potentially less elevated samples were collected before upstream (potentially more highly elevated) samples.

At each monitoring site, water samples were collected before any field measurements, sediment sampling, flow monitoring and ecological sampling was undertaken to prevent disturbance of the water quality. Sediment sampling, flow monitoring, and ecological sampling were conducted after the physiochemical measurements were completed.

### Variation from Sampling and Analysis Plan

The following variations were noted from the sampling and analysis plan:

- ✧ Sampling location PCX was not sampled for surface water due to health and safety reasons (thick mud on the banks which potentially could have entrapped staff and contaminated sampling equipment).

- ✧ Sampling locations PIX and PPX were not sampled as land owner permission could not be obtained within the timeframe of the survey.
- ✧ Due to the width of the waterway at sampling locations PDX, PFX, PGX, PHX, PJX, PLX and PYX samples could not be collected from the mid-stream location. At these sampling locations, water samples were collected approximately 2 m from the bank within the main stream flow.
- ✧ Sampling location PNX was sampled after the upstream sampling sites PUX, PSX, PTX, PWX, and PRX because there was a delay in obtaining landowner permission.

### Water Sample Laboratory Parameters

Water quality samples were collected and stored in the appropriate sample bottles (as outlined in the Sampling and Analysis Plan), which had been supplied by the analysing laboratory. Each sample bottle was uniquely identified in accordance with PDP chain of custody and sampling labelling procedure.

After collection, the water samples were sent under standard PDP chain of custody documentation to the appropriate laboratories as soon as possible. This was to ensure the laboratories received the samples within the required hold times and to ensure sample integrity was maintained.

Water samples from each of the monitoring sites were analysed by the selected laboratory for the following parameters:

- ✧ pH and Electrical Conductivity (EC);
- ✧ Hardness;
- ✧ Major dissolved ions: magnesium, potassium, sodium, calcium, chlorine, sulphate, alkalinity;
- ✧ Dissolved Nutrients: nitrate, nitrite, ammoniacal-nitrogen;
- ✧ Dissolved and total metals/metalloids including antimony (Sb), arsenic (As), boron (B), cadmium (Cd), Cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), nickel (Ni), thallium (Tl) and zinc (Zn) using US EPA method 200.2;
- ✧ Total and dissolved mercury using US EPA method 1631.

The laboratory pH determinations are considered reliable and should be used in preference to the field pH data.

## Appendix B

Tabulated Field Results

Table B-1: Laboratory Results <sup>1</sup>

Sample ID		PDW01/02	PFW01/02	PGW01/02	PHW01/02	PJW01/02	PKW01/02	PLW01/02	PMW01/02	PNW01/02	New Zealand Drinking Water Standards <sup>2</sup>	ANZECC Water Quality Guidelines 95% Protection <sup>3, 4a</sup>	ANZECC Water Quality Guidelines 99% Protection <sup>3, 4b</sup>	ANZECC Water Quality Guidelines - Livestock Drinking Water Quality <sup>5</sup>	ANZECC Water Quality Guidelines - Contact Recreational <sup>3</sup>
Sample Site Location		PDX	PFX	PGX	PHX	PJX	PKX	PLX	PMX	PNX					
Eurofins Laboratory ID		M16-Ap02182 M16-Ap02183	M16-Ap02184 M16-Ap02185	M16-Ap02186 M16-Ap02187	M16-Ap02188 M16-Ap02189	M16-Ap02190 M16-Ap02191	M16-Ap02192 M16-Ap02193	M16-Ap02194 M16-Ap02195	M16-Ap02197 M16-Ap02198	M16-Ap02200 M16-Ap02201					
Sampling Date		8-Mar-16	8-Mar-16	9-Mar-16	9-Mar-16	10-Mar-16	10-Mar-16	10-Mar-16	11-Mar-16	13-Mar-16					
Sampling time (approximate)		15:00	17:00	9:00	16:00	8:00	11:45	14:30	16:00	13:00					
Field Parameters															
pH	pH units	7.39	6.88	6.8	6.87	6.14	6.58	6.07	6.19	6.13	7.0-8.5 <sup>6</sup>	-	-	-	5.0-9.0
ORP	mV	235.7	231.3	189.2	176.1	241.8	186.3	238.2	274.3	232	-	-	-	-	-
Dissolved Oxygen (DO)	mg/L	9.21	7.53	5.64	7.49	8.69	9.85	9.58	8.3	9.82	-	-	-	-	-
DO (% Saturation)	% saturation	105.4	80.8	62.1	83.3	92.4	99.5	105.4	89.2	101.3	-	-	-	-	-
Conductivity (at 25°C)	µS/cm	132.6	116.9	112.8	103.5	69.9	76.9	67.4	76.9	73.8	-	-	-	-	-
Turbidity	NTU	358.4	302.8	307	9.5	4.2	4.9	3.4	5	3.6	-	-	-	-	-
Temperature	°C	21.9	21.3	20.2	20.6	18.3	15.9	20	18.9	16.8					
Laboratory Parameters															
Conductivity (at 25°C)	µS/cm	140	120	120	110	75	83	73	81	78	-	-	-	-	-
pH	pH units	6.9	6.8	6.8	6.7	6.4	6.6	6.2	6.5	6.4	7.0-8.5 <sup>6</sup>	-	-	-	5.0-9.0
Phosphorus filterable reactive (as P)	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	-	-	-	-
Chloride	mg/L	17	17	16	16	13	15	13	14	17	250 <sup>6a, b</sup>	-	-	-	-
Sulphate (as S)	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	250 <sup>6a</sup>	-	-	1000	400
Alkali Metals															
Calcium	mg/L	9.8	8.1	7.2	6.7	2.3	2.2	2.2	2.8	2.2	-	-	-	1000	-
Magnesium	mg/L	2.6	2.3	2.2	1.8	1.4	1.4	1.4	1.4	1.5	-	-	-	ID	-
Potassium	mg/L	2.1	1.4	1.3	1.3	0.7	0.7	0.7	0.7	< 0.5	-	-	-	-	-
Sodium	mg/L	15	13	13	13	11	12	10	10	10	200 <sup>6a</sup>	-	-	-	300
Alkalinity (speciated)															
Bicarbonate Alkalinity (as CaCO3)	mg/L	22	22	23	20	< 20	< 20	< 20	< 20	< 20	-	-	-	-	-
Carbonate Alkalinity (as CaCO3)	mg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-	-
Inorganic Elements															
Total Antimony	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.02	ID	ID	-	-
Dissolved Antimony	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-	-	-	-	-
Total Arsenic	mg/L	0.001	< 0.001	< 0.001	< 0.001	0.002	0.003	0.003	0.007	0.002	0.01	-	-	0.5 up to 5 <sup>8</sup>	0.05
Dissolved Arsenic	mg/L	0.001	0.001	< 0.001	< 0.001	0.001	0.002	0.002	0.006	0.002	-	0.013 <sup>9</sup>	0.0008 <sup>9</sup>	-	-
Total Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1.4 <sup>10</sup>	-	-	5	1
Dissolved Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	0.37 <sup>11</sup>	0.09	-	-
Total Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.004	-	-	0.01	0.005
Dissolved Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	0.0002	0.00006	-	-
Total Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.05 <sup>12</sup>	-	-	1	0.05
Dissolved Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	0.001 <sup>7, 11</sup>	0.00001 <sup>7</sup>	-	-
Total Cobalt	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-	-	1	-
Dissolved Cobalt	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	ID	ID	-	-
Total Copper	mg/L	0.002	0.001	0.001	< 0.001	0.001	< 0.001	0.002	< 0.001	< 0.001	2	-	-	0.4 (sheep); 1 (cattle)	1
Dissolved Copper	mg/L	0.002	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	0.0014	0.001	-	-
Total Iron	mg/L	0.94	0.96	1.1	0.92	0.79	0.53	0.89	0.86	0.31	0.2 <sup>6c</sup>	-	-	NST	0.3
Dissolved Iron	mg/L	0.73	0.75	0.82	0.54	0.42	0.31	0.5	0.62	0.2	-	ID	ID	-	-
Total Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.01	-	-	0.1	0.05
Dissolved Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	0.0034	0.001	-	-
Total Manganese	mg/L	0.023	0.028	0.044	0.034	0.024	0.029	0.021	0.029	0.02	0.4	-	-	NST	0.1
Dissolved Manganese	mg/L	0.021	0.027	0.044	0.035	0.022	0.029	0.018	0.027	0.02	-	1.9 <sup>11</sup>	1.2	-	-
Total Mercury <sup>17</sup>	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.007 <sup>13</sup>	-	-	0.002	0.001
Dissolved Mercury <sup>17</sup>	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-	0.0006 <sup>13</sup>	0.00006 <sup>13</sup>	-	-
Total Mercury <sup>18</sup>	mg/L	0.000005	0.000005	0.000006	0.000005	0.000011	0.000009	0.000015	0.000017	0.000015	0.007 <sup>13</sup>	-	-	0.002	0.001
Dissolved Mercury <sup>18</sup>	mg/L	0.000005	0.000004	0.000005	0.000004	0.000009	0.000007	0.000013	0.000018	0.000010	-	0.0006 <sup>13</sup>	0.00006 <sup>13</sup>	-	-
Total Mercury <sup>18</sup>	ng/L	5	5	6	5	11	9	15	17	15	7000 <sup>13</sup>	-	-	2000	1000
Dissolved Mercury <sup>18</sup>	ng/L	5	4	5	4	9	7	13	18	10	-	600 <sup>13</sup>	60 <sup>13</sup>	-	-
Total Nickel	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	0.08	-	-	1	0.1
Dissolved Nickel	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	0.011	0.008	-	-
Total Thallium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-	-	-	-
Dissolved Thallium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	ID	ID	-	-
Total Zinc	mg/L	0.007	0.007	0.007	0.006	0.006	0.006	0.008	0.009	0.007	1.5 <sup>6a</sup>	-	-	20	5
Dissolved Zinc	mg/L	0.008	0.006	0.007	0.005	0.005	0.006	0.007	0.007	0.006	-	0.008 <sup>11</sup>	0.0024	-	-
Nitrogen Species															
Ammonia (as N)	mg/L	0.02	< 0.01	< 0.01	0.02	0.03	< 0.01	0.03	0.37	< 0.01	1.5 <sup>6d</sup>	0.9 <sup>11, 14</sup>	0.32 <sup>14</sup>	-	0.01
Ammonium Ion (as N)	mg/L	0.02	< 0.01	< 0.01	0.02	0.03	< 0.01	0.03	0.40	< 0.01	-	-	-	-	-
Nitrate (as N)	mg/L	0.41	0.27	0.23	0.20	0.57	0.29	0.47	0.37	0.54	50 <sup>15</sup>	-	-	90 <sup>17</sup>	10

Notes:

1. All results in mg/L unless otherwise stated.
2. Maximum Acceptable Values (MAV) from Tables 2.1 and 2.2, Guideline Values for aesthetic determinands from Table 2.5 of the *Drinking-water Standards for New Zealand 2005 (Revised 2008)* (Ministry of Health, 2008).
3. Criteria from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council (ANZECC, 2000).
- 4a. ANZECC (2000) trigger values for protection of 95% of aquatic species. Applicable guideline values for surface water.
- 4b. ANZECC (2000) trigger values for protection of 99% of aquatic species. Applicable guideline values for surface water.
5. ANZECC (2000) trigger values (low risk) for livestock drinking water.
6. Guideline value only, for the following aesthetic qualities: a - taste, b - corrosion, c - staining of laundry and sanitary ware, d - odour.
7. Trigger Value is for Chromium VI.
8. May be tolerated if not provided as a food additive and natural levels in the diet are low.
9. Trigger value is for AsV.
10. The WHO guideline value (provisional) is 0.5 mg/L.
11. Trigger value may not protect key test species from chronic toxicity.
12. MAV is for total chromium. Limited information on health effects.
13. Trigger value is for inorganic mercury.
14. Value varies with pH, see table 8.3.7 in ANZECC guidelines 2000.
15. The short-term exposure MAVs for nitrate and nitrite have been established to protect against methaemoglobinaemia in bottle-fed infants.
16. Trigger values derived from Nitrate guideline values, conversion is required for Nitrate-N.
17. Mercury determined by ICP-MS (with a detection limit of 0.00001 mg/L or 100 ng/L)
18. Mercury determined by purge and trap CV-AFS (with a detection limit of 0.000 000 5 mg/L or 0.5 ng/L). Results have been rounded to the nearest 1 ng/L.

ID	Insufficient data to derive a reliable trigger value (ANZECC, 2000).
NST	Not sufficiently toxic.
0.01	Value equals or exceeds ANZECC (2000) Trigger Values for Protection of Freshwater Species (95%).
0.01	Value equals or exceeds ANZECC (2000) Trigger Values for Protection of Freshwater Species (99%).
105	Value equals or exceeds ANZECC (2000) Trigger Values for Recreational Contact.
3.6	Value equals or exceeds ANZECC (2000) Trigger Values for Livestock.
3.6	Sample result exceeds the Maximum Acceptable Value from the NZ Drinking Water Standards.
0.2	Sample result exceeds the Guideline Value for aesthetic determinands from the NZ Drinking Water Standards.

Table B-1: Laboratory Results <sup>1</sup>

Sample ID		POW01/02	PQW-1/-2	PRW-1/-2	PSW-1/-2	PTW-1/-2	PUW-1/-2	PVW-1/-2	PWW-1/-2	PYW-1/-2	New Zealand Drinking Water Standards <sup>2</sup>	ANZECC Water Quality Guidelines 95% Protection <sup>3, 4a</sup>	ANZECC Water Quality Guidelines 99% Protection <sup>3, 4b</sup>	ANZECC Water Quality Guidelines - Livestock Drinking Water Quality <sup>5</sup>	ANZECC Water Quality Guidelines - Contact Recreational <sup>3</sup>
Sample Site Location		POX	PQX	PRX	PSX	PTX	PUX	PVX	PWX	PYX		ANZECC Water Quality Guidelines 95% Protection <sup>3, 4a</sup>	ANZECC Water Quality Guidelines 99% Protection <sup>3, 4b</sup>	ANZECC Water Quality Guidelines - Livestock Drinking Water Quality <sup>5</sup>	ANZECC Water Quality Guidelines - Contact Recreational <sup>3</sup>
Eurofins Laboratory ID		M16-Ap02202	M16-Ap02206	M16-Ap02208	M16-Ap02210	M16-Ap02212	M16-Ap02214	M16-Ap02216	M16-Ap02218	M16-Ap02220					
Sampling Date		11-Mar-16	11-Mar-16	12-Mar-16	12-Mar-16	12-Mar-16	13-Mar-16	11-Mar-16	12-Mar-16	10-Mar-16					
Sampling time (approximate)		7:45	13:30	15:45	15:30	9:00	9:30	15:45	11:00	16:00		Freshwater	Freshwater		
Field Parameters															
pH	pH units	6.39	6.36	5.17	4.27	6.21	6.78	4.74	6.27	6.47	7.0-8.5 <sup>6</sup>	-	-	-	5.0-9.0
ORP	mV	346	259.7	374	457	259	66.7	407	336	384	-	-	-	-	-
Dissolved Oxygen (DO)	mg/L	8.23	9.37	9.85	9.78	9.91	3.23	8.49	9.99	9.61	-	-	-	-	-
DO (% Saturation)	% saturation	89.5	104.7	100.7	100	100.2	32.8	87.1	101.5	105.2	-	-	-	-	-
Conductivity (at 25°C)	µS/cm	66.8	62.6	69.3	83.4	68.6	129.4	68.2	68.3	51.4	-	-	-	-	-
Turbidity	NTU	3.3	4.5	6.6	4.5	6.9	4.9	3.2	7.8	4.5	-	-	-	-	-
Temperature	°C	19.4	20.8	16.4	16.4	15.9	16.1	16.6	16.1	19.8	-	-	-	-	-
Laboratory Parameters															
Conductivity (at 25°C)	µS/cm	70	65	71	79	71	76	79	70	72	-	-	-	-	-
pH	pH units	6.3	5.7	4.8	6.1	6.3	5.1	4.5	6.4	6.7	7.0-8.5 <sup>6</sup>	-	-	-	5.0-9.0
Phosphorus filterable reactive (as P)	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	-	-	-	-
Chloride	mg/L	13	15	15	16	14	15	15	13	13	250 <sup>6a, b</sup>	-	-	-	-
Sulphate (as S)	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	250 <sup>6a</sup>	-	-	1000	400
Alkali Metals															
Calcium	mg/L	1.9	1.5	1.7	1.0	2.3	2.0	1.1	2.4	1.6	-	-	-	1000	-
Magnesium	mg/L	1.4	1.3	1.4	1.3	1.5	1.6	1.4	1.5	1.5	-	-	-	ID	-
Potassium	mg/L	0.8	0.9	0.7	0.7	0.7	0.7	0.9	0.7	0.9	-	-	-	-	-
Sodium	mg/L	9.6	9.6	9.5	10	7.6	6.4	8.1	7.4	8.2	200 <sup>6a</sup>	-	-	-	300
Alkalinity (speciated)															
Bicarbonate Alkalinity (as CaCO3)	mg/L	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	-	-	-	-	-
Carbonate Alkalinity (as CaCO3)	mg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	-	-	-	-
Heavy Metals															
Total Antimony	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.02	ID	ID	-	-
Dissolved Antimony	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-	-	-	-	-
Total Arsenic	mg/L	0.002	0.002	0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	0.01	-	-	0.5 up to 5 <sup>8</sup>	0.05
Dissolved Arsenic	mg/L	0.002	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	-	0.013 <sup>9</sup>	0.0008 <sup>9</sup>	-	-
Total Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	1.4 <sup>10</sup>	-	-	5	1
Dissolved Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	-	0.37 <sup>11</sup>	0.09	-	-
Total Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.004	-	-	0.01	0.005
Dissolved Cadmium	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	-	0.0002	0.00006	-	-
Total Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.05 <sup>12</sup>	-	-	1	0.05
Dissolved Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	0.001 <sup>7, 11</sup>	0.00001 <sup>7</sup>	-	-
Total Cobalt	mg/L	< 0.001	< 0.001	0.002	0.004	< 0.001	0.004	0.002	< 0.001	< 0.001	-	-	-	1	-
Dissolved Cobalt	mg/L	< 0.001	< 0.001	0.002	0.004	< 0.001	0.004	0.002	< 0.001	< 0.001	-	ID	ID	-	-
Total Copper	mg/L	0.002	0.002	0.002	0.003	< 0.001	0.003	0.006	< 0.001	< 0.001	2	-	-	0.4 (sheep); 1 (cattle)	1
Dissolved Copper	mg/L	0.001	0.002	0.002	0.003	< 0.001	< 0.001	0.006	< 0.001	< 0.001	-	0.0014	0.001	-	-
Total Iron	mg/L	0.94	0.78	0.84	2.2	0.5	23	0.37	0.59	0.16	0.2 <sup>6c</sup>	-	-	NST	0.3
Dissolved Iron	mg/L	0.64	0.55	0.45	1.7	0.36	22	0.29	0.40	< 0.05	-	ID	ID	-	-
Total Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.01	-	-	0.1	0.05
Dissolved Lead	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	0.0034	0.001	-	-
Total Manganese	mg/L	0.025	0.031	0.072	0.14	0.014	0.30	0.16	0.013	0.007	0.4	-	-	NST	0.1
Dissolved Manganese	mg/L	0.024	0.031	0.063	0.14	0.012	0.31	0.16	0.012	0.006	-	1.9 <sup>11</sup>	1.2	-	-
Total Mercury <sup>17</sup>	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	0.0003	< 0.0001	< 0.0001	< 0.0001	0.007 <sup>13</sup>	-	-	0.002	0.001
Dissolved Mercury <sup>17</sup>	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	-	0.0006 <sup>13</sup>	0.00006 <sup>13</sup>	-	-
Total Mercury <sup>18</sup>	mg/L	0.000020	0.000031	0.000055	0.000112	0.000048	0.000277	0.000007	0.000042	0.000003	0.007 <sup>13</sup>	-	-	0.002	0.001
Dissolved Mercury <sup>18</sup>	mg/L	0.000016	0.000024	0.000037	0.000100	0.000042	0.000236	0.000005	0.000028	0.000002	-	0.0006 <sup>13</sup>	0.00006 <sup>13</sup>	-	-
Total Mercury <sup>18</sup>	ng/L	20	31	55	112	48	277	7	42	3	7000 <sup>13</sup>	-	-	2000	1000
Dissolved Mercury <sup>18</sup>	ng/L	16	24	37	100	42	236	5	28	2	-	600 <sup>13</sup>	60 <sup>13</sup>	-	-
Total Nickel	mg/L	< 0.001	< 0.001	0.002	0.004	< 0.001	0.004	0.003	< 0.001	< 0.001	0.08	-	-	1	0.1
Dissolved Nickel	mg/L	< 0.001	< 0.001	0.002	0.003	< 0.001	0.003	0.002	< 0.001	< 0.001	-	0.011	0.008	-	-
Total Thallium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-	-	-	-
Dissolved Thallium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	ID	ID	-	-
Total Zinc	mg/L	0.008	0.009	0.013	0.016	0.007	0.007	0.018	0.007	0.006	1.5 <sup>6a</sup>	-	-	20	5
Dissolved Zinc	mg/L	0.007	0.009	0.011	0.016	0.006	0.006	0.017	0.006	0.005	-	0.008 <sup>11</sup>	0.0024	-	-
Nitrogen Species															
Ammonia (as N)	mg/L	0.04	0.05	< 0.01	0.02	< 0.01	0.25	< 0.01	< 0.01	< 0.01	1.5 <sup>6d</sup>	0.9 <sup>11, 14</sup>	0.32 <sup>14</sup>	-	0.01
Ammonium Ion (as N)	mg/L	0.05	0.05	< 0.01	0.02	< 0.01	0.27	< 0.01	< 0.01	< 0.01	-	-	-	-	-
Nitrate (as N)	mg/L	0.42	0.20	0.41	0.30	0.81	< 0.02	0.12	0.75	0.14	50 <sup>15</sup>	-	-	90 <sup>17</sup>	10

Notes:

1. All results in mg/L unless otherwise stated.
2. Maximum Acceptable Values (MAV) from Tables 2.1 and 2.2, Guideline Values for aesthetic determinands from Table 2.5 of the *Drinking-water Standards for New Zealand 2005 (Revised 2008)* (Ministry of Health, 2008).
3. Criteria from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council (ANZECC, 2000).
- 4a. ANZECC (2000) trigger values for protection of 95% of aquatic species. Applicable guideline values for surface water.
- 4b. ANZECC (2000) trigger values for protection of 99% of aquatic species. Applicable guideline values for surface water.
5. ANZECC (2000) trigger values (low risk) for livestock drinking water.
6. Guideline value only, for the following aesthetic qualities: a - taste, b - corrosion, c - staining of laundry and sanitary ware, d - odour.
7. Trigger Value is for Chromium VI.
8. May be tolerated if not provided as a food additive and natural levels in the diet are low.
9. Trigger value is for AsV.
10. The WHO guideline value (provisional) is 0.5 mg/L.
11. Trigger value may not protect key test species from chronic toxicity.
12. MAV is for total chromium. Limited information on health effects.
13. Trigger value is for inorganic mercury.
14. Value varies with pH, see table 8.3.7 in ANZECC guidelines 2000.
15. The short-term exposure MAVs for nitrate and nitrite have been established to protect against methaemoglobinaemia in bottle-fed infants.
16. Trigger values derived from Nitrate guideline values, conversion is required for Nitrate-N.
17. Mercury determined by ICP-MS (with a detection limit of 0.00001 mg/L or 100 ng/L)
18. Mercury determined by purge and trap CV-AFS (with a detection limit of 0.000 000 5 mg/L or 0.5 ng/L). Results have been rounded to the nearest 1 ng/L.

ID	Insufficient data to derive a reliable trigger value (ANZECC, 2000).
NST	Not sufficiently toxic.
0.01	Value equals or exceeds ANZECC (2000) Trigger Values for Protection of Freshwater Species (95%).
0.01	Value equals or exceeds ANZECC (2000) Trigger Values for Protection of Freshwater Species (99%).
105	Value equals or exceeds ANZECC (2000) Trigger Values for Recreational Contact.
3.6	Value equals or exceeds ANZECC (2000) Trigger Values for Livestock.
3.6	Sample result exceeds the Maximum Acceptable Value from the NZ Drinking Water Standards.
0.2	Sample result exceeds the Guideline Value for aesthetic determinands from the NZ Drinking Water Standards.

Table B-2: PDP vs NRC surface water results

PDP Field ID	PJX		PLX		PUX		PVX	
	NRC Site 1	PDP	NRC site 2	PDP	NRC site 3	PDP	NRC site 4	PDP
Sample ID	301201	PJW01	301203	PLW01	301205	PUW-1	301207	PVW-1
Sampling Date	2013-2014	10-Mar-16	2013-2014	10-Mar-16	2013-2014	13-Mar-16	2013-2014	11-Mar-16
Field Parameters								
pH	4.35-7.36	6.14	4.27-6.85	6.07	2.95-6.27	6.78	2.95-5.45	4.74
DO (mg/L)	8.6-10.1	8.69	7.4-9.3	9.58	7.8-9.9	3.23	7.4-9.3	8.49
DO (% Saturation)	87.1-94.1	92.4	74.5-88.8	105.4	78.0-91.1	32.8	73.1-88.2	87.1
Temperature °C	9.8-19.1	18.3	10.1-18.9	20	9.4-18.7	16.1	10-16.3	16.6
Heavy Metals								
Total Antimony	0.00069-0.0023	<0.005	0.0027-0.011	<0.005	<0.0001-0.0003	<0.005	0.00095-0.0025	<0.005
Total Cadmium	<0.00005	<0.0002	<0.00005	<0.0002	<0.00005	<0.0002	<0.00005	<0.0002
Total Chromium	0.00031-0.001	<0.001	0.00053-0.001	<0.001	0.00052-0.001	<0.001	0.00019-0.0075	<0.001
Total Copper	0.00079-0.0029	0.001	0.00068-0.0021	0.002	0.00024-0.0046	0.003	0.0044-0.014	0.006
Total Mercury	<0.00005-0.00042	<0.0001	<0.00005-0.00005	<0.0001	<0.00005-0.00026	0.000236	<0.00005-0.00007	<0.0001
Total Nickel	0.0003-0.00095	<0.001	0.00077-0.0018	<0.001	0.0024-0.006	0.004	0.0006-0.0031	0.003
Total Lead	<0.0001-0.00043	<0.001	<0.0001-0.00047	<0.001	<0.0001-0.00037	<0.001	<0.0001-0.0002	<0.001
Total Zinc	0.0013-0.13	0.006	0.0028-0.12	0.008	0.0017-0.11	0.007	0.0021-0.018	0.018

Notes:

1. All values unless stated are mg/L.

	PDP results exceed or are below range of values collected by NRC
	Limit of detection is higher than values collected by NRC

**Table B-3: PDP vs Hoggins Surface water results.**

PDP Field ID	Units	PJX		POX		PRX		PSX		PUX	
		Hoggins	PDP	Hoggins	PDP	Hoggins	PDP	Hoggins	PDP	Hoggins	PDP
Sample ID		Site 6	PJW01/02	Site 4	POW01/02	Site 3	PRW-1/-2	Site 2	PSW-1/-2	Site 1	PUW-1/-2
Sampling Date		1973	10-Mar-16	1973	11-Mar-16	1973	12-Mar-16	1973	12-Mar-16	1973	13-Mar-16
Total Mercury	mg/L	0.00008	0.000011	0.0001	0.000020	0.0006	0.000055	0.0004	0.000112	0.0007	0.000236

# Appendix C

Data Quality Evaluation (QA/QC)

## Appendix C: Data Quality Evaluation (QA/QC)

Quality Assurance/Quality Control procedures that were followed are detailed below:

- ✧ Field conditions (weather, flow, etc.), station locations, sampling method and handling and storage methods, date, time and identity of the sampler have been noted.
- ✧ Duplicate samples were collected at a rate of one per 10 samples.
- ✧ Field blank a rate of one per 20 samples.
- ✧ An NAFA and ISO/IEC 17025 accredited laboratory (the equivalent of IANZ) was used for all chemical analysis.

### Water Quality Sampling

Quality assurance and quality control (QA/QC) samples (duplicates, field blanks and filter blanks) were collected as part of the monitoring programme. The data quality objectives of the QA/QC monitoring undertaken as part of this project are presented in **Table 4** below and the analytical results of the QA/QC testing are presented in **Appendix C**.

Table 4: Data Quality Objectives		
Parameter	DQO	Proposed Action
<b>Anion/Cation Balance</b>		
✧ 0-3.0 meq/L	±0.2 meq/L	Check with Lab., identify if missing parameter or lab error.
✧ 3.0-10.0 meq/L	± 2%	Check with Lab., identify if missing parameter or lab error.
✧ 10.0 - 80.0 meq/L	± 5%	Check with Lab., identify if missing parameter or lab error.
Calculated Total Dissolved Solids versus measured EC	0.55 to 0.7	Check with Lab., identify if missing parameter or lab error.
Field pH versus Lab pH	±0.5 pH units	Check with lab if precipitation of iron has occurred.
Field Conductivity versus Lab Conductivity	± 20%	Check calibration of instruments and if precipitation of iron has occurred.
Calculated Total Dissolved Solids versus measured EC	0.55 to 0.7	Check with Lab., identify if missing parameter or lab error.

Table 4: Data Quality Objectives		
Parameter	DQO	Proposed Action
Split/Duplicate analysis		
Results more than 10 x Detection Limit (DL) and results are greater than 0.1 ppb	± 30%	Check with lab and re-analyse if necessary.
Results more than 5 x DL but less than 10 x DL or results between 1 x e <sup>-06</sup> g/m <sup>3</sup> (1 ppt) to 0.0001 g/m <sup>3</sup> (1 ppb)	± 50%	Check with lab and re-analyse if necessary.
Results less than 5 x DL	± 100%	Check with lab and re-analyse if necessary.
General Results Check		
Check if dissolved metal concentration is equal or less than Total metal Concentrations	Check with lab and re-analyse if necessary.	
Note:		
1. Based Upon American Public Health Association (APHA) and Contaminated Land Management Guideline Number 5 (CLMG#5) Recommendations (MfE, 2004).		

### Technical Sampling Issues

A field blank collected at sampling location PLX was found to contain trace levels of dissolved and total zinc (5 ppb) and nitrate-N (150 ppb). Leaching of low levels of zinc from HDPE sample containers is a known issue which can affect some HDPE bottles, particularly if the samples bottles contain acid sample preservatives. PDP believes that this is the most likely cause for the trace amounts of zinc being detected in the field blank. The reasons are:

1. A similar level of zinc was detected in the field blank of PDP's groundwater monitoring programme. The elevated zinc cannot be attributed to the water used for the blank samples, or to sampling techniques, for the reasons below:
  - a. A different source of Type 1 water was used in the field blanks for groundwater vs surface water sampling programmes (the Type 1 water used in the surface water sampling programme was sourced from Eurofins Global Frontiers in Seattle).
  - b. Different sampling techniques and sampling personnel were used in the two different sampling projects.
  - c. Different types of gloves were used when handling samples (Metal free clean room type 100 gloves were supplied to PDP from Eurofins Global Frontiers in Seattle for doing trace analysis sampling).

Note: The field blank container for ultra-trace mercury was broken during transit to the USA and could not be analysed.

The source of the nitrate within the field blank has not been identified.

All other QA/QC samples meet the data quality objectives outlined in **Table 4** above.

Table C-1: Quality Control/Quality Assurance Samples <sup>1</sup>

Sample ID	PMW01	PMW03	% RPD <sup>2</sup>	POW01	POW-3	% RPD <sup>2</sup>	PUW01	PUW-3	% RPD <sup>2</sup>	PLW03
Sample Site Location	PMX	Duplicate of PMW01		POX	Duplicate of POW01		PUX	Duplicate of POW01		Field Blank (collected @ PLX)
Eurofins Laboratory ID										
Sampling Date	11-Mar-16	11-Mar-16		11-Mar-16	11-Mar-16					10-Mar-16
Sampling time (approximate)	16:00	16:00		7:45	7:45					14:30
Field Parameters										
pH	6.19	-	-	6.39	-	-	-	-	-	-
ORP (mV)	274.3	-	-	346	-	-	-	-	-	-
DO (mg/L)	8.3	-	-	8.23	-	-	-	-	-	-
DO (% Saturation)	89.2	-	-	89.5	-	-	-	-	-	-
Conductivity (at 25°C) (µS/cm)	76.9	-	-	66.8	-	-	-	-	-	-
Turbidity (NTU)	5	-	-	3.3	-	-	-	-	-	-
Temperature ©	18.9	-	-	19.4	-	-	-	-	-	-
Laboratory Parameters										
Conductivity (at 25°C) (µS/cm)	81	-	-	70	69	1.4	-	-	-	4.4
pH	6.5	-	-	6.3	6.1	3.2	-	-	-	4.7
Phosphorus filterable reactive (as P)	< 0.05	-	-	< 0.05	< 0.05	0.0	-	-	-	< 0.05
Chloride	14	-	-	13	14	7.4	-	-	-	< 1
Sulphate (as S)	< 5	-	-	< 5	< 5	0.0	-	-	-	< 5
Alkali Metals										
Calcium	2.8	-	-	1.9	1.9	0.0	-	-	-	< 0.5
Magnesium	1.4	-	-	1.4	1.4	0.0	-	-	-	< 0.5
Potassium	0.7	-	-	0.8	0.9	11.8	-	-	-	< 0.5
Sodium	10	-	-	9.6	9.7	1.0	-	-	-	< 0.5
Alkalinity (speciated)										
Bicarbonate Alkalinity (as CaCO3)	< 20	-	-	< 20	< 20	0	-	-	-	< 20
Carbonate Alkalinity (as CaCO3)	< 10	-	-	< 10	< 10	0	-	-	-	< 10
Heavy Metals										
Total Antimony	< 0.005	< 0.005	0	< 0.005	< 0.005	0	-	-	-	< 0.005
Dissolved Antimony	< 0.005	< 0.005	0	< 0.005	< 0.005	0	-	-	-	< 0.005
Total Arsenic	0.007	0.007	0	0.002	0.002	0	-	-	-	< 0.001
Dissolved Arsenic	0.006	0.007	15.4	0.002	0.002	0	-	-	-	< 0.001
Total Boron	< 0.05	< 0.05	0	< 0.05	< 0.05	0	-	-	-	< 0.05
Dissolved Boron	< 0.05	< 0.05	0	< 0.05	< 0.05	0	-	-	-	< 0.05
Total Cadmium	< 0.0002	< 0.0002	0	< 0.0002	< 0.0002	0	-	-	-	< 0.0002
Dissolved Cadmium	< 0.0002	< 0.0002	0	< 0.0002	< 0.0002	0	-	-	-	< 0.0002
Total Chromium	< 0.001	< 0.001	0	< 0.001	< 0.001	0	-	-	-	< 0.001
Dissolved Chromium	< 0.001	< 0.001	0	< 0.001	< 0.001	0	-	-	-	< 0.001
Total Cobalt	< 0.001	< 0.001	0	< 0.001	< 0.001	0	-	-	-	< 0.001
Dissolved Cobalt	< 0.001	< 0.001	0	< 0.001	< 0.001	0	-	-	-	< 0.001
Total Copper	< 0.001	< 0.001	0	0.002	0.002	0	-	-	-	< 0.001
Dissolved Copper	< 0.001	< 0.001	0	0.001	0.001	0	-	-	-	< 0.001
Total Iron	0.86	0.92	0.2	0.94	0.99	5.2	-	-	-	< 0.05
Dissolved Iron	0.62	0.82	27.8	0.64	0.62	3.2	-	-	-	< 0.05
Total Lead	< 0.001	< 0.001	0	< 0.001	< 0.001	0.0	-	-	-	< 0.001
Dissolved Lead	< 0.001	< 0.001	0	0.002	< 0.001	66.7	-	-	-	< 0.001
Total Manganese	0.029	0.033	12.9	0.025	0.027	7.7	-	-	-	< 0.005
Dissolved Manganese	0.027	0.033	20	0.024	0.023	4.3	-	-	-	< 0.005
Total Mercury <sup>19</sup>	< 0.0001	< 0.0001	0	< 0.0001	< 0.0001	0	-	-	-	< 0.0001
Dissolved Mercury <sup>19</sup>	< 0.0001	< 0.0001	0	< 0.0001	< 0.0001	0	-	-	-	< 0.0001
Total Mercury <sup>20</sup>	0.0000171	0.0000191	11.0	0.0000196	0.0000199	1.5	0.000277	0.0003	8.0	-
Dissolved Mercury <sup>20</sup>	0.0000181	0.0000177	2.2	0.0000155	0.0000158	1.9	0.000236	0.000254	7.3	-
Total Nickel	0.001	< 0.001	0	< 0.001	< 0.001	0	-	-	-	< 0.001
Dissolved Nickel	< 0.001	< 0.001	0	< 0.001	< 0.001	0	-	-	-	< 0.001
Total Thallium	< 0.001	< 0.001	0	< 0.001	< 0.001	0	-	-	-	< 0.001
Dissolved Thallium	< 0.001	< 0.001	0	< 0.001	< 0.001	0	-	-	-	< 0.001
Total Zinc	0.009	0.009	0	0.008	0.008	0	-	-	-	0.005
Dissolved Zinc	0.007	0.009	25	0.007	0.007	0	-	-	-	0.005
Nitrogen Species										
Ammonia (as N)	0.37	-	-	0.04	0.04	0.0	-	-	-	< 0.01
Ammonium Ion (as N)	0.400	-	-	0.050	0.050	0.0	-	-	-	< 0.01
Nitrate (as N)	0.37	-	-	0.42	0.43	2.4	-	-	-	0.15

- Notes:
- All results in mg/L unless otherwise stated.
  - Maxiumum Acceptable Values (MAV) from Tables 2.1 and 2.2, Guideline Values for aesthetic determinands from Table 2.5 of the *Drinking-water Standards for New Zealand 2005 (Revised 2008)* (Ministry of Health, 2008).
  - Criteria from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council (ANZECC, 2000).
  - ANZECC (2000) trigger values for protection of 80% of aquatic species. Applicable guideline values for groundwater.
  - ANZECC (2000) tigger values for protection of 95% of aquatic species. Applicable guideline values for surface water.
  - ANZECC (2000) trigger values (low risk) for livestock drinking water.
  - Guideline value only, for the following aesthetic qualities: a - taste, b - corrosion, c - staining of laundry and snitary ware, d -odour.
  - Aesthetic guideline value, high hardness causes scale deposition, scum formation. Low hardness (<100) may be more corrosive.
  - May be tolerated if not provided as a food additive and natural levels in the diet are low.
  - Trigger value is for AsV.
  - Trigger value may not protect key test species from chronic toxicity.
  - MAV is for total chromium. Limited information on health effects.
  - Trigger value may not protect key test species from acute toxicity.
  - MAV is for inorganic mercury.
  - Trigger value is for inorganic mercury.
  - Aesthetic guideline value, odour threshold in alkaline conditions.
  - The short-term exposure MAVs for nitrate and nitrite have been established to protect against methaemoglobinaemia in bottle-fed infants.
  - Long-term exposure MAV.
  - Mercury determined by ICP-MS (with a detection limit of 0.00001 mg/L or 100 ng/L)
  - Mercury determined by purge and trap CV-AFS (with a detection limit of 0.000 000 5 mg/L or 0.5 ng/L)

Table C2: Field Parameter against Lab parameters

Sample ID	PDW01			PFW01			PGW01			PHW01			PJW01			PKW01		
Sample Site Location	PDX			PFX			PGX			PHX			PJX			PKX		
Eurofins Laboratory ID																		
Sampling Date	8-Mar-16			8-Mar-16			9-Mar-16			9-Mar-16			10-Mar-16			10-Mar-16		
Sampling time (approximate)	15:00			17:00			9:00			16:00			8:00			11:45		
	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %
pH	7.39	6.9	6.9	6.88	6.8	1.2	6.8	6.8	0.0	6.87	6.7	2.5	6.14	6.4	4.1	6.58	6.6	0.3
Conductivity (at 25°C) (µS/cm)	132.6	140	5.4	116.9	120	2.6	112.8	120	6.2	103.5	110	6.1	69.9	75	7.0	76.9	83	7.6

Sample ID	PLW01			PMW01			PNW01			POW01			PQW-1			PRW-1		
Sample Site Location	PLX			PMX			PNX			POX			PQX			PRX		
Eurofins Laboratory ID																		
Sampling Date	10-Mar-16			11-Mar-16			13-Mar-16			11-Mar-16			11-Mar-16			12-Mar-16		
Sampling time (approximate)	14:30			16:00			13:00			7:45			13:30			15:45		
	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %
pH	6.07	6.2	2.1	6.19	6.5	4.9	6.13	6.4	4.3	6.39	6.3	1.4	6.36	5.7	10.9	5.17	4.8	7.4
Conductivity (at 25°C) (µS/cm)	67.4	73	8.0	76.9	81	5.2	73.8	78	5.5	66.8	70	4.7	62.6	65	3.8	69.3	71	2.4

Sample ID	PSW-1			PTW-1			PUW-1			PVW-1			PWW-1			PYW-1		
Sample Site Location	PSX			PTX			PUX			PVX			PWX			PYX		
Eurofins Laboratory ID																		
Sampling Date	12-Mar-16			12-Mar-16			13-Mar-16			11-Mar-16			12-Mar-16			10-Mar-16		
Sampling time (approximate)	15:30			9:00			9:30			15:45			11:00			16:00		
	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %	Field Parameters	Laboratory Parameters	RPD %
pH	4.27	6.1	35.3	6.21	6.3	1.4	6.78	5.1	28.3	4.74	4.5	5.2	6.27	6.4	2.1	6.47	6.7	3.5
Conductivity (at 25°C) (µS/cm)	83.4	79	5.4	68.6	71	3.4	129.4	76	52.0	68.2	79	14.7	68.3	70	2.5	51.4	72	33.4

## Appendix D

Field Sheets

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: A02982801		Staff Name: Scott N & Andrew P		Date: 8/03/16.	
Project Name: P - Evolution					
Weather Conditions: Fine / Windy				Tide:	
Sample Location:		PDX			
Sample Method:		Peristaltic Pump.			
Coordinates (NZTM) N					
E		0.634m			
Depth of Sample (m)		PDS YG1			
<b>Field Measurements</b>					
pH	pH units	6.46	7.39		
pE/ORP	mV	207.9	285.7		
DO	ppm	9.21 mg/L	7.39 mg/L		
%DO	%	105.4	84.4		
EC	mS/cm	132.6 $\mu$ S/cm	131.2 $\mu$ S/cm		
Salinity	ppt	0.06 PSU			
TDS	g/L TDS	0.06 mg/L			
Turbidity	NTU	358.4			
Temp.	°C	21.9	21.9		
Water Sample name					
<b>Sediment Description</b>					
Sample Name		PDS-01A	PDS-01-B		
Depth of oxic layer (mm)		< 200mm	As here		
Subordinate Fraction		Clayey			
MAJOR	Grain Size	Silt			
Minor	Some	Sand (fine)			
	With				
	Trace				
Colour		Light Grey			
<b>Qualifying paragraph</b>					
Strength		Weak			
Moisture					
Grading					
Bedding					
Plasticity		Mod Plastic			
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour		NONE			
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

PDS PDX-02 - Total  
PDS PDX-02 - Dissolved

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: 102982801		Staff Name: Scott Nicol		Date: 8/03/16	
Project Name: EVOLUTION					
Weather Conditions: Fine & Windy				Tide:	
Sample Location:		PEX			
Sample Method:		Peristaltic			
Coordinates (NZTM) N					
E		0.813m			
Depth of Sample (m)		Pro DSS		Pro Plus	
Field Measurements					
pH	pH units	5.71	6.88		
pE/ORP	mV	231.3	226.7		
DO	ppm	7.53 mg/L	6.84 mg/L		
%DO	%	80.8	85.4%		
EC	mS/cm	116.9 us/cm	116.1		
Salinity	ppt	0.05 PSU			
TDS TSS	mg/L	0.00			
Turbidity	NTU	302.8			
Temp.	°C	21.3	21.4		
Water Sample name					
Sediment Description					
Sample Name		200mm			
Depth of oxic layer (mm)		PFS B.			
Subordinate Fraction		Sandy			
MAJOR	Grain Size	CLAY			
Minor	Some	Gravel			
	With				
	Trace				
Colour	light orange	grey mottled orange			
Qualifying paragraph					
Strength		Firm			
Moisture		Sat			
Grading		-			
Bedding		-			
Plasticity		non plastic			
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour		NONE			
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					
		rocks, organics, fibres			

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: <i>AD2982801</i>		Staff Name: <i>S. Nicol &amp; Andrew P</i>		Date: <i>9/03/16</i>	
Project Name: <i>EVOLUTION</i>					
Weather Conditions: <i>Fine - Clear</i>				Tide:	
Sample Location:		<i>PGX</i>			
Sample Method:		<i>Pristine</i>			
Coordinates (NZTM) N					
E					
Depth of Sample (m)		<i>Pro Plug 1155</i>			
<b>Field Measurements</b>					
pH	pH units	<i>6.55</i>	<i>6.80</i>		
pE/ORP	mV		<i>189.2</i>		
DO	ppm	<i>5.64</i>	<i>3.12</i>		
%DO	%	<i>62.11</i>	<i>28%</i>		
EC	µmS/cm	<i>117.8</i>	<i>112.6</i>		
Salinity	ppt		<i>0.05 PSU</i>		
TDS	g/L				
Turbidity	NTU		<i>370.3</i>		
Temp.	°C	<i>20.2</i>	<i>20.2</i>		
Water Sample name					
<b>Sediment Description</b>					
Sample Name		<i>PGS 01B</i>			
Depth of oxic layer (mm)					
Subordinate Fraction		<i>Sandy</i>			
MAJOR	Grain Size	<i>Silt</i>			
Minor	Some	<i>CLAY</i>			
	With				
	Trace				
Colour	<i>light grey mottled black</i>				
<b>Qualifying paragraph</b>					
Strength	<i>weak - firm</i>				
Moisture	<i>SAT</i>				
Grading	<i>None</i>				
Bedding	<i>None</i>				
Plasticity	<i>Slight - med plastic</i>				
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour	<i>None</i>				
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					
	<i>Organic debris, roots</i>				

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: 102982801		Staff Name: SHN & AH		Date: 9/3/16	
Project Name: EVOLUTION					
Weather Conditions: Overcast				Tide:	
Sample Location:		PHX			
Sample Method:		Peristaltic			
Coordinates (NZTM) N					
E					
Depth of Sample (m)		PHX	Pro DSS	Pro Plus	
<b>Field Measurements</b>					
pH	pH units		20.5-81	6.87	
pE/ORP	mV		176.1	185.9	
DO	ppm		7.49 mg/L	61.5 mg/L	
%DO	%		83.3	70.0	
EC	mS/cm		103.5	105.1 uS/cm	
Salinity	ppt		0.05 PSU		
TDS	g/L				
Turbidity	NTU		9.5		
Temp.	°C		20.6	20.7	
Water Sample name					
<b>Sediment Description</b>					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction		Sand			
MAJOR	Grain Size	Silt			
Minor	Some	Gravels.			
	With				
	Trace				
Colour		light brown orange			
<b>Qualifying paragraph</b>					
Strength		weak			
Moisture		SAT			
Grading		-			
Bedding		-			
Plasticity		slight Plastic			
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					
		Organics.			

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: A02982801		Staff Name: SHN & AA		Date: 10/03/16	
Project Name: EVOLUTION					
Weather Conditions: Fine, Crisp.				Tide:	
Sample Location:		PKX			
Sample Method:		Peristaltic.			
Coordinates (NZTM) N					
E					
Depth of Sample (m)		P. DSS Pro Hus.			
Field Measurements					
pH	pH units	8.44	8.58		
pE/ORP	mV	186.3	218.8		
DO	ppm	9.85	7.24		
%DO	%	99.5	73.2		
EC	mS/cm	76.7	101.9		
Salinity	ppt	0.04 PSU			
TDS	g/L TSS	0.00			
Turbidity	NTU	4.9			
Temp.	°C	15.9	15.9		
Water Sample name					
Sediment Description					
Sample Name		PK5 01A PK5 01 B.			
Depth of oxic layer (mm)					
Subordinate Fraction					
MAJOR	Grain Size	Sandy			
Minor	Some	SILT			
	With				
	Trace				
Colour		Dark brownish grey.			
Qualifying paragraph					
Strength		weak			
Moisture		SAT.			
Grading					
Bedding					
Plasticity		moderate.			
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					
		Organics near surface.			

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: 102982801		Staff Name: SHN A AR		Date: 10/03/16	
Project Name: Evt					
Weather Conditions: Fine!!				Tide:	
Sample Location:		PJX			
Sample Method:					
Coordinates (NZTM) N					
E					
Depth of Sample (m)		Pro DSS	Pro Plug		
<b>Field Measurements</b>					
pH	pH units	5.64	6.14		
pE/ORP	mV	214.8	129.8		
DO	ppm	8.69	7.92 mg/L		
%DO	%	92.4	84.3		
EC	mS/cm	69.9	72.2		
Salinity	ppt	0.03 PSU			
TDS	g/L TSS	0.00			
Turbidity	NTU	4.2			
Temp.	°C	19.3	18.3		
Water Sample name					
<b>Sediment Description</b>					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction					
MAJOR	Grain Size	Sandy SILT			
Minor	Some	Gravels.			
	With				
	Trace				
Colour	Dark grey streaked black.				
<b>Qualifying paragraph</b>					
Strength	Weak-firm				
Moisture	SAT.				
Grading					
Bedding					
Plasticity	low				
Sensitivity					
Major Fraction					
Weathering of clasts	angular				
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: 102982901		Staff Name: SHN & AR.		Date: 10/3/16	
Project Name:					
Weather Conditions: Fine				Tide:	
Sample Location:		PLX			
Sample Method:					
Coordinates (NZTM) N					
E		0.517 m. depth.			
Depth of Sample (m)		Pro DSS Pro Plus			
<b>Field Measurements</b>					
pH	pH units	8.80	6.07		
pE/ORP	mV	238.3	178.9		
DO	ppm	9.88 mg/L	9.26 mg/L		
%DO	%	105.4	102.0		
EC	µS/cm	67.4	68.6		
Salinity	ppt	0.03 PSU			
TDS	g/L				
Turbidity	NTU	3.4 NTU			
Temp.	°C	20.0	20.0		
Water Sample name					
<b>Sediment Description</b>					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction					
MAJOR	Grain Size	Sandy			
Minor	Some	Silt			
	With some	Clay & Gravel.			
	Trace	Gravel.			
Colour		Dark orange brown.			
<b>Qualifying paragraph</b>					
Strength		weak-firm			
Moisture		SAT.			
Grading					
Bedding					
Plasticity		moderate			
Sensitivity					
Major Fraction		Gravels are angular.			
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour		None.			
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					
		Organics present			

PLX  
PLW 3  
is field  
bank.  
PLW 4  
is field  
DUPLICATE  
PLW 2 is  
Total.

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: A0298289		Staff Name: A. Rumsby		Date: 10/10/16	
Project Name: A02					
Weather Conditions: fine			Tide: low		
Sample Location: PYX					
Sample Method: Trowel					
Coordinates (NZTM) N					
E					
Depth of Sample (m)		Surface			
Field Measurements					
pH	pH units	14.5/13.2	6.47		
pE/ORP	mV	286	185		
DO	ppm	9.51	9.48		
%DO	%	105.2	103.4		
EC	µS/cm	57.8	51.4		
Salinity	ppt	-	-		
TDS	g/L	-	-		
Turbidity	NTU	4.5	-		
Temp.	°C	19.8	19.8		
Water Sample name		PY401 (b) PY402 (v)			
Sediment Description					
Sample Name		PY501	PY502		
Depth of oxic layer (mm)		-	-		
Subordinate Fraction		Sand	Sand		
MAJOR	Grain Size	Gravel	Gravel		
Minor	Some	Silt	Silt		
	With				
	Trace				
Colour		Yellowish			
Qualifying paragraph					
Strength					
Moisture					
Grading					
Bedding					
Plasticity					
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour		None	None		
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					
		Drake			
		Wood			
		Organics			

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: <b>A02982801</b>		Staff Name: <b>SHN &amp; AR</b>		Date: <b>11/8/16</b>	
Project Name: <b>Evolution</b>					
Weather Conditions: <b>fine &amp; windy</b>				Tide:	
Sample Location:		<b>PMX</b>			
Sample Method:		<b>Peristaltic.</b>			
Coordinates (NZTM) N					
E					
Depth of Sample (m)					
Field Measurements					
pH	pH units	<b>6.02</b>	<b>6.19</b>		
pE/ORP	mV	<b>224.7</b>	<b>177.5</b>		
DO	ppm	<b>8.2</b>	<b>6.32</b>		
%DO	%	<b>89.2</b>	<b>68.0</b>		
EC	mS/cm	<b>76.9</b>	<b>77.7</b>		
Salinity	ppt	<b>-</b>	<b>-</b>		
TDS	g/L	<b>-</b>	<b>-</b>		
Turbidity	NTU	<b>5.0</b>	<b>-</b>		
Temp.	°C	<b>18.9</b>	<b>18.6</b>		
Water Sample name		<b>SPM201</b>	<b>PM202</b>	<b>PM203</b>	<b>PM204</b>
Sediment Description					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction		<b>Sandy</b>			
MAJOR	Grain Size	<b>SILT</b>			
Minor	Some	<b>clay.</b>			
	With				
	Trace				
Colour		<b>Dark orange brown.</b>			
Qualifying paragraph					
Strength		<b>Soft</b>			
Moisture		<b>Sat.</b>			
Grading					
Bedding					
Plasticity		<b>low-med.</b>			
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: A02582801		Staff Name: Anna Rung		Date: 11/3/16	
Project Name:					
Weather Conditions: Fine			Tide: —		
Sample Location:		POX.			
Sample Method:		Ogeechee			
Coordinates (NZTM) N					
E					
Depth of Sample (m)					
Field Measurements					
pH	pH units	6.39			
pE/ORP	mV	346.6	209		
DO	ppm	8.23	6.20		
%DO	%	89.5	67.1		
EC	mS/cm	66.8	67.9		
Salinity	ppt	—	—		
TDS	g/L	—	—		
Turbidity	NTU	3.2			
Temp.	°C	19.4	19.4		
Water Sample name		POW-1	POW-2	POW-3	POW-4
Sediment Description					
Sample Name		POS-1	POS-2		
Depth of oxic layer (mm)		—	—		
Subordinate Fraction					
MAJOR	Grain Size	silt	silt		
Minor	Some	crust.	crust		
	With	Sandy	Sandy		
	Trace				
Colour		grey	green		
Qualifying paragraph					
Strength					
Moisture					
Grading					
Bedding					
Plasticity					
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

Duplicate

POW-3 - dissolved  
POW-4 - Total

POW-1  
POW-2

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: 102982801		Staff Name: SHN & AR		Date: 11/3/16	
Project Name: Evolution					
Weather Conditions: Overcast				Tide:	
Sample Location:		PRX			
Sample Method:		Peristaltic			
Coordinates (NZTM) N					
E					
Depth of Sample (m)		Pro DS 451			
Field Measurements					
pH	pH units	6.29	6.36		
pE/ORP	mV	259.7	178.1		
DO	ppm	93.7	8.99		
%DO	%	104.7	100		
EC	µS/cm	67.6	61.7		
Salinity	ppt	-	-		
TDS	g/L	-	-		
Turbidity	NTU	4.5	-		
Temp.	°C	20.8	20.9		
Water Sample name		PCW01 PCW02			
Sediment Description					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction		Silty			
MAJOR	Grain Size	Gravel			
Minor	Some	Sand			
	With				
	Trace				
Colour		light brownish grey			
Qualifying paragraph					
Strength		loosely packed			
Moisture		SAT			
Grading					
Bedding					
Plasticity		-			
Sensitivity		-			
Major Fraction					
Weathering of clasts		Clasts are sub-angular			
Subordinate Fraction					
Minor Fraction					
Odour		NONE			
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: A02982801		Staff Name: Andrew Rumbold		Date: 11/3/16	
Project Name:					
Weather Conditions: OLC - occ. shows			Tide:		
Sample Location:		PUX			
Sample Method:		Trawl			
Coordinates (NZTM) N					
E					
Depth of Sample (m)		ProDSS	VSI		
Field Measurements					
pH	pH units	4.96	4.74		
pE/ORP	mV	407	329		
DO	ppm	8.49	8.02		
%DO	%	87.1	82.3		
EC	µS/cm	68.2	26.5		
Salinity	ppt	—	—		
TDS	g/L	—	—		
Turbidity	NTU	3.2	—		
Temp.	°C	16.6	16.2		
Water Sample name		PUQ01	PUQ02		
Sediment Description					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction					
MAJOR	Grain Size	Silty			
Minor	Some	CLAY			
	With	some gravel			
	Trace				
Colour		light orange grey.			
Qualifying paragraph					
Strength		Soft			
Moisture		SAT			
Grading					
Bedding					
Plasticity					
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					
		Marine water draining seabed			

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: A02482801		Staff Name: AL/SW		Date: 12/03/16	
Project Name: Shallow OC					
Weather Conditions: snows/OC				Tide: —	
Sample Location:		PTX			
Sample Method:		trawel			
Coordinates (NZTM) N					
E					
Depth of Sample (m)		ProDSS	YSI.		
Field Measurements					
pH	pH units	6.33	6.21		
pE/ORP	mV	259.	229.6		
DO	ppm	9.41	9.42		
%DO	%	100.2	95.91		
EC	µS/cm	68.6	67.5		
Salinity	ppt	—	—		
TDS	g/L	—	—		
Turbidity	NTU	6.9	—		
Temp.	°C	15.9	15.9		
Water Sample name		PTW01	PTW02		
Sediment Description					
Sample Name		PTS01	PTS02		
Depth of oxic layer (mm)		—	—		
Subordinate Fraction		C			
MAJOR	Grain Size	CLAY	CLAY		
Minor	Some	gravel	gravel.		
	With	sand	sand		
	Trace	cobble	robbie.		
Colour		yellow	yellow.		
Qualifying paragraph					
Strength					
Moisture					
Grading					
Bedding					
Plasticity					
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: <i>A02982801</i>		Staff Name: <i>SHN &amp; AR</i>		Date: <i>12/3/16</i>	
Project Name:					
Weather Conditions: <i>Fine</i>				Tide:	
Sample Location:		<i>PWX</i>			
Sample Method:		<i>Trowel</i>			
Coordinates (NZTM) N		<i>607</i>			
E					
Depth of Sample (m)		<i>YS1</i>	<i>P0 DSS</i>		
Field Measurements					
pH	pH units	<i>6.27</i>	<i>6.50</i>		
pE/ORP	mV	<i>229</i>	<i>336</i>		
DO	ppm	<i>8.87</i>	<i>9.99</i>		
%DO	%	<i>92.7</i>	<i>101.5</i>		
EC	<del>uS</del> /cm	<i>68.6</i>	<i>68.3</i>		
Salinity	ppt	<i>-</i>	<i>-</i>		
TDS	g/L				
Turbidity	NTU		<i>7.8</i>		
Temp.	°C	<i>16.1</i>	<i>16.1</i>		
Water Sample name		<i>PWW01</i>	<i>PWW02</i>		
Sediment Description					
Sample Name		<i>PWS01</i>	<i>PWS02</i>		
Depth of oxic layer (mm)					
Subordinate Fraction		<i>Sandy</i>			
MAJOR	Grain Size	<i>GRAVEL</i>			
Minor	Some				
	With	<i>silt</i>			
	Trace				
Colour		<i>light grey</i>			
Qualifying paragraph					
Strength	<i>-</i>	<i>Soft</i>			
Moisture		<i>Soft</i>			
Grading					
Bedding					
Plasticity					
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

## Notes:

1. All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
2. Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
3. Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
4. All cores/samples should be photographed

# PDP Sediment Sampling Form

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Job Number: A02982801		Staff Name: SHN · AR		Date: 12/3/16	
Project Name: Evolution					
Weather Conditions:				Tide:	
Sample Location:		PRX			
Sample Method:					
Coordinates (NZTM) N		6073747			
E		1713834			
Depth of Sample (m)		DSS	YSI		
Field Measurements					
pH	pH units	5.01	5.17		
pE/ORP	mV	374	277		
DO	ppm	9.85	9.49		
%DO	%	100.7	97.1		
EC	mS/cm	69.3	70		
Salinity	ppt				
TDS	g/L				
Turbidity	NTU	6.6			
Temp.	°C	16.4	16.4		
Water Sample name					
Sediment Description					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction		Sandily			
MAJOR	Grain Size	GRAVEL			
Minor	Some	Silt			
	With				
	Trace				
Colour		Dark bluish Brown			
Qualifying paragraph					
Strength		loosely packed - soft			
Moisture		SAT.			
Grading					
Bedding					
Plasticity					
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

PRW01 - dissolved  
PRW02 - total  
PRSQ1 } sediment  
PRSQ2 }

## Notes:

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- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: <u>A02 982801</u>		Staff Name: <u>SHN - AR</u>		Date: <u>12/3/16</u>	
Project Name: <u>Evolution</u>					
Weather Conditions:				Tide:	
Sample Location:		<u>PSX</u>			
Sample Method:					
Coordinates (NZTM) N		<u>6074136</u>			
E		<u>1713925</u>			
Depth of Sample (m)		<u>DSS</u>	<u>YSI</u>		
Field Measurements					
pH	pH units	<u>4.33</u>	<u>4.27</u>		
pE/ORP	mV	<u>457</u>	<u>379.5</u>		
DO	ppm	<u>9.78</u>	<u>8.85</u>		
%DO	%	<u>100</u>	<u>91</u>		
EC	mS/cm	<u>83.4</u>	<u>84.5</u>		
Salinity	ppt				
TDS	g/L				
Turbidity	NTU	<u>4.5</u>			
Temp.	°C	<u>16.4</u>	<u>16.4</u>		
Water Sample name					
Sediment Description					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction		<u>Sandily</u>			
MAJOR	Grain Size	<u>SILT</u>			
Minor	Some	<u>Gravel/s - angular.</u>			
	With				
	Trace				
Colour		<u>light greyish brown streaked black.</u>			
Qualifying paragraph					
Strength		<u>Soft</u>			
Moisture		<u>Sat.</u>			
Grading					
Bedding					
Plasticity		<u>low</u>			
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour					
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

Humic colour  
water  
pSW61 - dissolved  
pSW02 - total  
pSS01, pSS02  
sed.

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

Auckland (09) 523 6900, Wellington (04) 471 4130, Christchurch (03) 345 7100

Job Number: 102982801		Staff Name: SHN & AR		Date: 13/2/16	
Project Name: Evolution					
Weather Conditions:				Tide:	
Sample Location:		PUX			
Sample Method:		Peristaltic			
Coordinates (NZTM) N					
E					
Depth of Sample (m)		Pro DSS	X51		
Field Measurements					
pH	pH units	6.01	6.78		
pE/ORP	mV	66.7	-55.3		
DO	ppm	3.23	2.63		
%DO	%	32.8	26.8		
EC	mS/cm	129.4	127.7		
Salinity	ppt				
TDS	g/L				
Turbidity	NTU	4.9			
Temp.	°C	16.1	16.1		
Water Sample name					
Sediment Description					
Sample Name		PU001	PU002	PU003	
Depth of oxic layer (mm)		10-15mm			
Subordinate Fraction		Sandy			
MAJOR	Grain Size	Gravel			
Minor	Some	silt			
	With				
	Trace	organics			
Colour		black			
Qualifying paragraph					
Strength		loosely packed			
Moisture		Sat			
Grading					
Bedding					
Plasticity					
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour		organic odour			
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

PU001  
PU002  
dissolved

PU003  
PU004  
Total.

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed

# PDP Sediment Sampling Form

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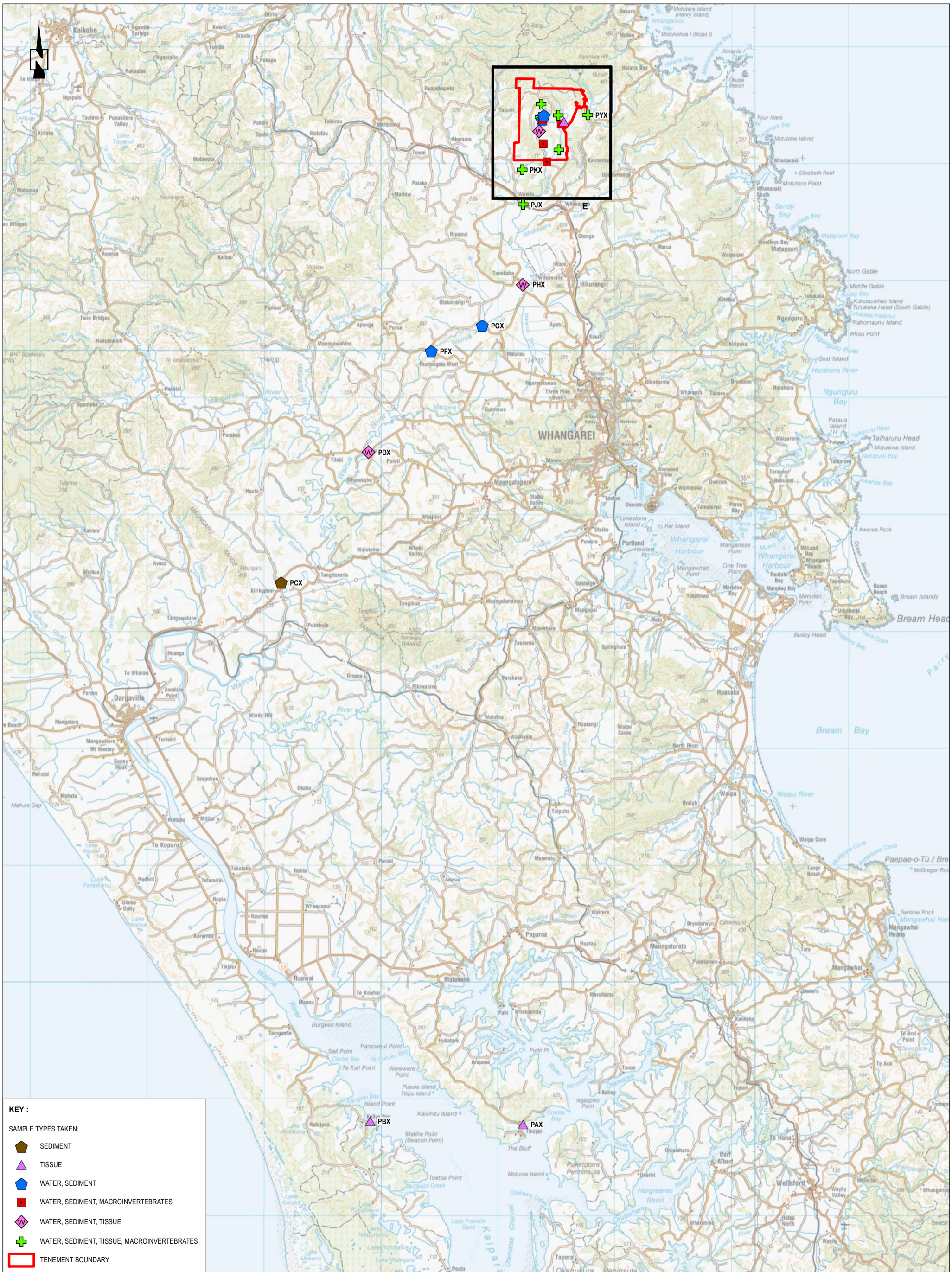
Job Number: <u>AO2982801</u>		Staff Name: <u>SHN: AR</u>		Date: <u>13/3/16</u>	
Project Name: <u>Evolution</u>					
Weather Conditions:				Tide:	
Sample Location:		<u>PNX</u>			
Sample Method:					
Coordinates (NZTM) N		<u>6072774</u>			
E		<u>1713526</u>			
Depth of Sample (m)		<u>DSS</u>	<u>YSI</u>		
Field Measurements					
pH	pH units	<u>6.15</u>	<u>6.13</u>		
pE/ORP	mV	<u>232</u>	<u>166</u>		
DO	ppm	<u>9.12</u>	<u>7.71</u>		
%DO	%	<u>101.3</u>	<u>79.5</u>		
EC	mS/cm	<u>73.8</u>	<u>76.8</u>		
Salinity	ppt				
TDS	g/L				
Turbidity	NTU	<u>3.6</u>			
Temp.	°C	<u>16.1</u>	<u>16.9</u>		
Water Sample name					
Sediment Description					
Sample Name					
Depth of oxic layer (mm)					
Subordinate Fraction		<u>fine clayey</u>			
MAJOR	Grain Size	<u>SILT</u>			
Minor	Some	<u>GRAVEL - Angular</u>			
	With				
	Trace				
Colour		<u>light orange grey brown.</u>			
Qualifying paragraph					
Strength		<u>soft</u>			
Moisture					
Grading		<u>slight deposit 1-5mm.</u>			
Bedding					
Plasticity		<u>low - none</u>			
Sensitivity					
Major Fraction					
Weathering of clasts					
Subordinate Fraction					
Minor Fraction					
Odour		<u>none.</u>			
Other (e.g. biota, shell fragments, woody debris, foreign material, evidence of oil etc.)					

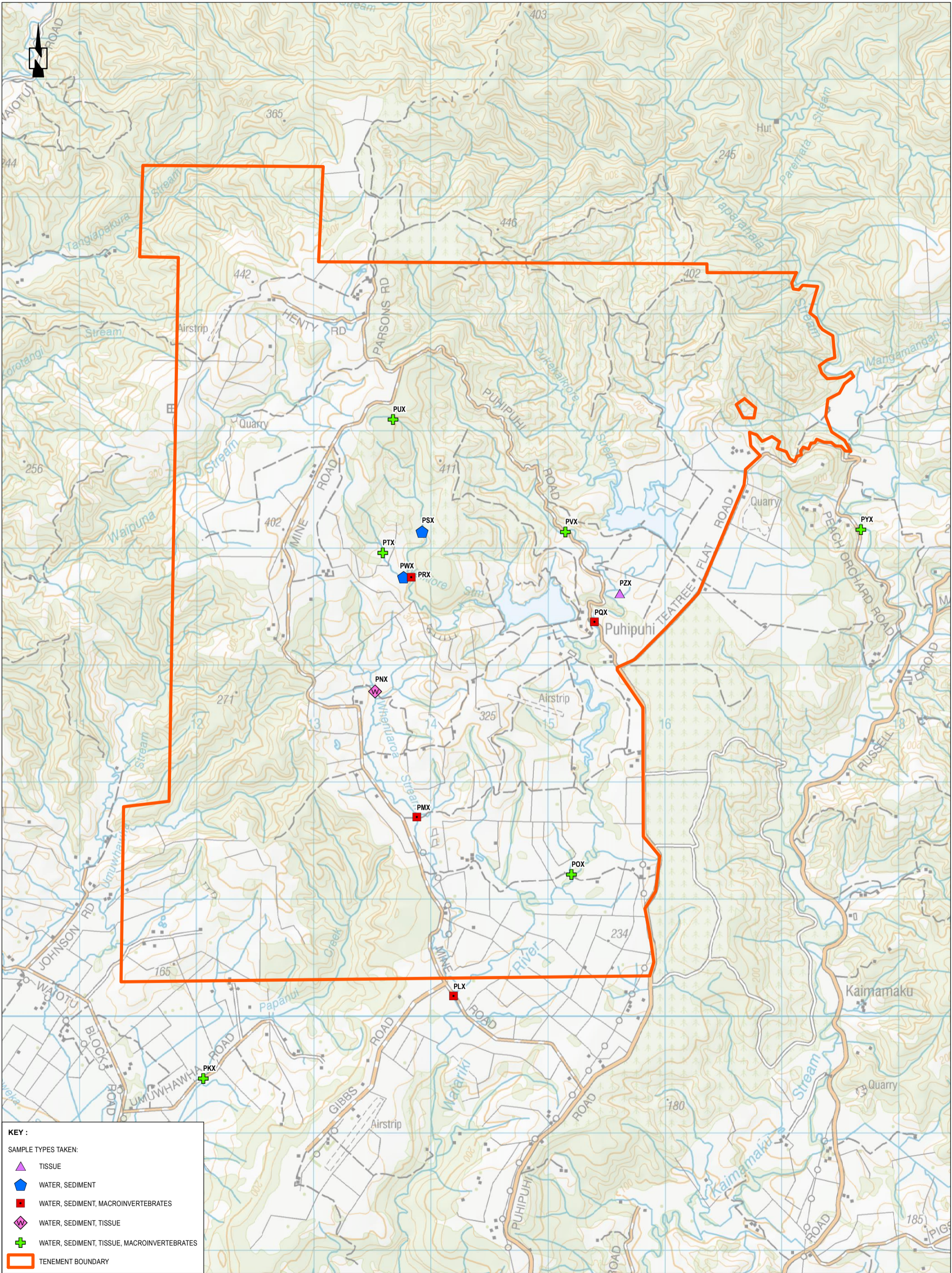
colour  
sl. tan  
coarse  
sprayed w  
blue substance

## Notes:

- All sediment logged in accordance with NZ Geotechnical Society (2005) Field Description of Soil and Rock.
- Sampling and field observations should be made in accordance with CECR (2005) Handbook for Sediment Quality Assessment.
- Odour should be described as none, organic (compost/silage), anoxic (Sulphidic), oily (petrol smell), earthy, sea/marine, sewage, putrid (dead animal)
- All cores/samples should be photographed







SOURCE:  
1. AERIAL IMAGERY DERIVED FROM GOOGLE EARTH FLOWN  
27/03/2015 (MAY NOT BE SPATIALLY ACCURATE).  
2. TOPOGRAPHIC INFORMATION DERIVED FROM LINZ.

FIGURE 2: SEDIMENT AND WATER SAMPLING LOCATIONS MARCH 2016  
(INSIDE TENEMENT)

SCALE : 1:30,000 (A3)

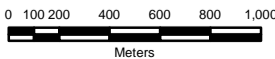




FIGURE 3 : SAMPLING LOCATIONS - PDP AND HOGGINS (OUTSIDE TENEMENT)

SCALE : 1:300,000 (A3)



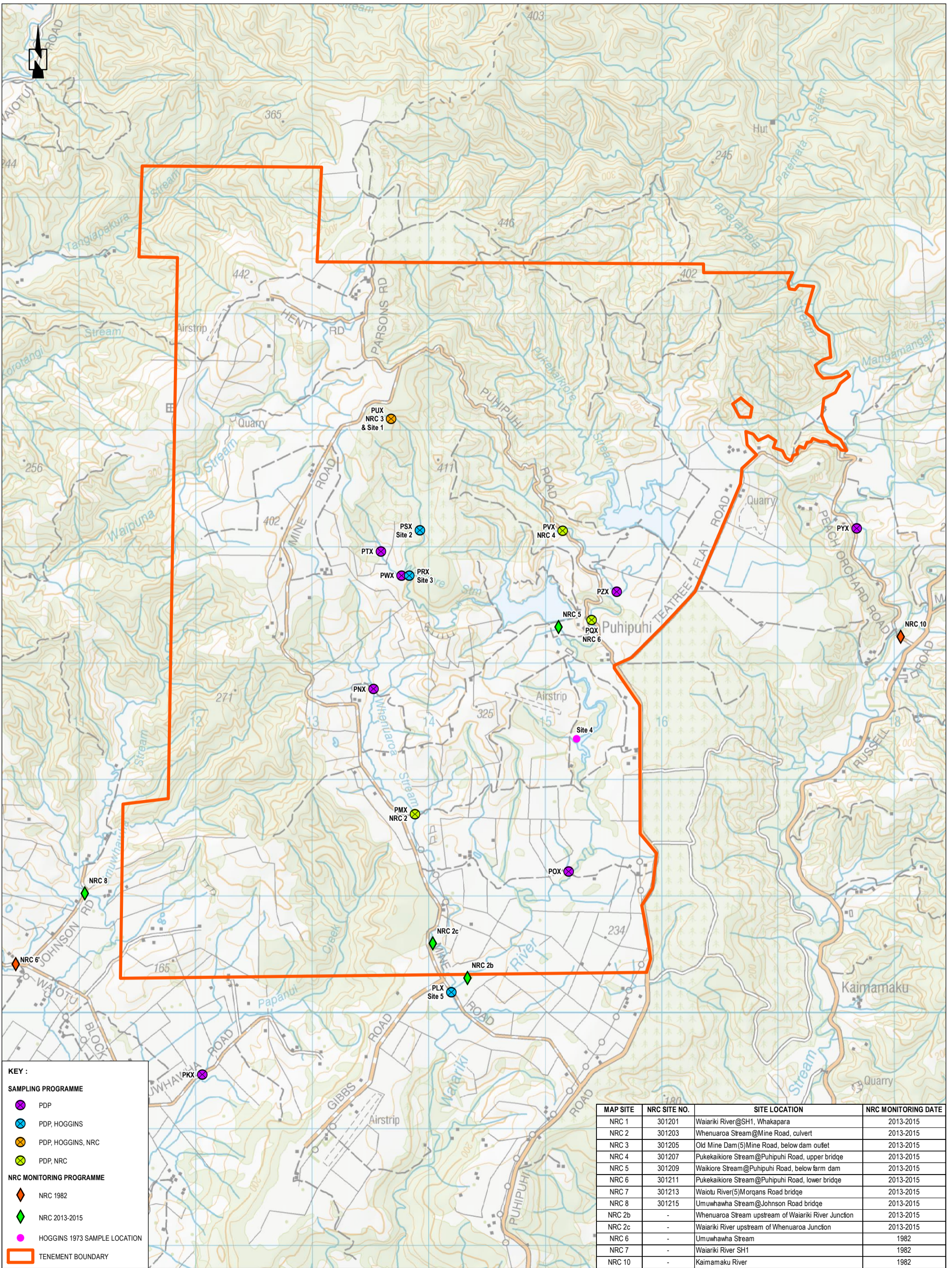


FIGURE 4: PDP, NRC AND HOGGINS SAMPLING LOCATIONS

SCALE : 1:30,000 (A3)

