Summary of Environmental Baseline Monitoring

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PDP's Main Practice Areas


Contaminated Land and Hazardous Waste


Stormwater Management


Geology and Geotechnics


Hydrology and River Engineering

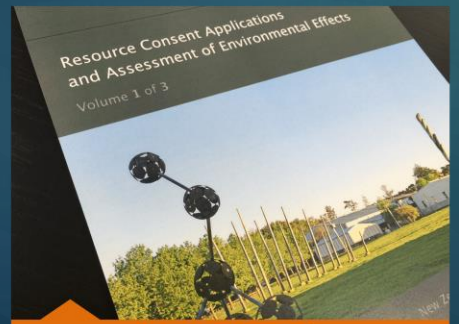

Aquatic Ecology


Groundwater


Geospatial Services


Civil Engineering


Air Quality



Consents and Environmental Management


Coastal


Wastewater Treatment


Solid Waste Management

PDP are specialists in

Water Resources	clean water
Wastewater Engineering	dirty water
Aquatic Ecology	things affecting life in water
Engineering Geology/ Geotechnical Engineering	clean dirt
Contaminated Sites	dirty dirt
Civil Engineering	moving water or dirt
Air Quality	dirty air
Environmental Planning/ Resource Consents	talking about water, ecology, dirt or air

Independent Advice

- PDP has a reputation for integrity, technical superiority, and a high standard of work

- We work for a wide range of clients in the public and private sectors, including central and local government agencies, international and home-grown companies, other consultants, and members of the public

- It is important to us to maintain our objectivity and independence when engaged by a client as any perception of bias towards the client harms the value and usefulness of our work to everyone involved

PDP selection rationale for Puhipuhi project

- New Zealand owned company rather than multinational
- Experienced in assessing and managing the impacts of different types of drilling
  - Geotechnical
  - Water supply
  - Mineral exploration
- Experience in mercury
  - Mercury Inventory for New Zealand report for MfE
  - Monitoring of Tui gold mine including mercury and acid rock drainage (ARD)
  - Working on groundwater at the Ngawha geothermal power plant

A number of studies were completed

1. Groundwater sampling
2. Surface water sampling, stream sediment, aquatic organisms and habitats
3. Hydrology & hydrogeology
4. Environmental management strategy (for exploration drilling)
5. Noise monitoring
6. Dust monitoring
7. Surface water monitoring program development
8. Terrestrial ecology
9. Soil characterisation

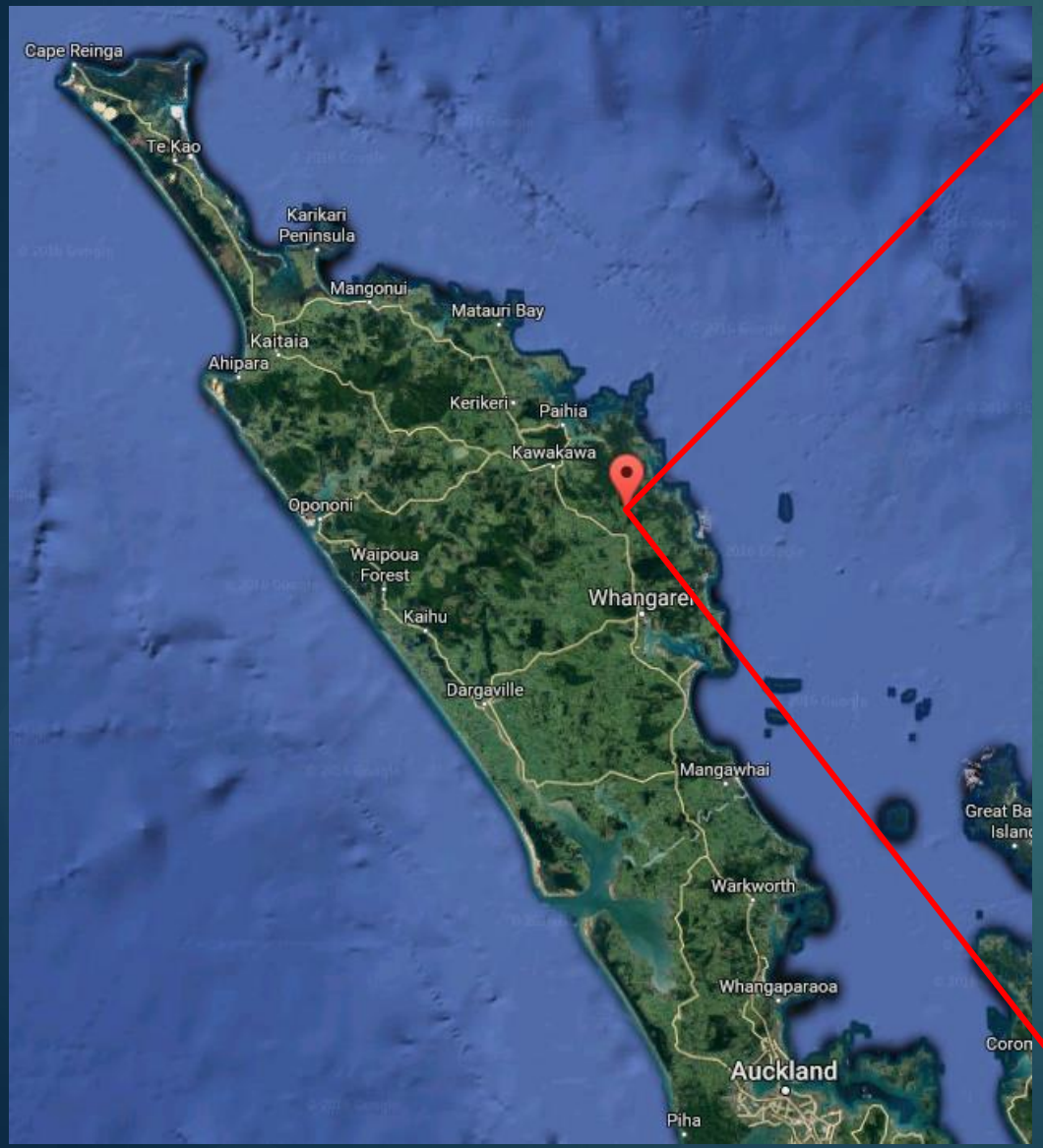
Presentation outline

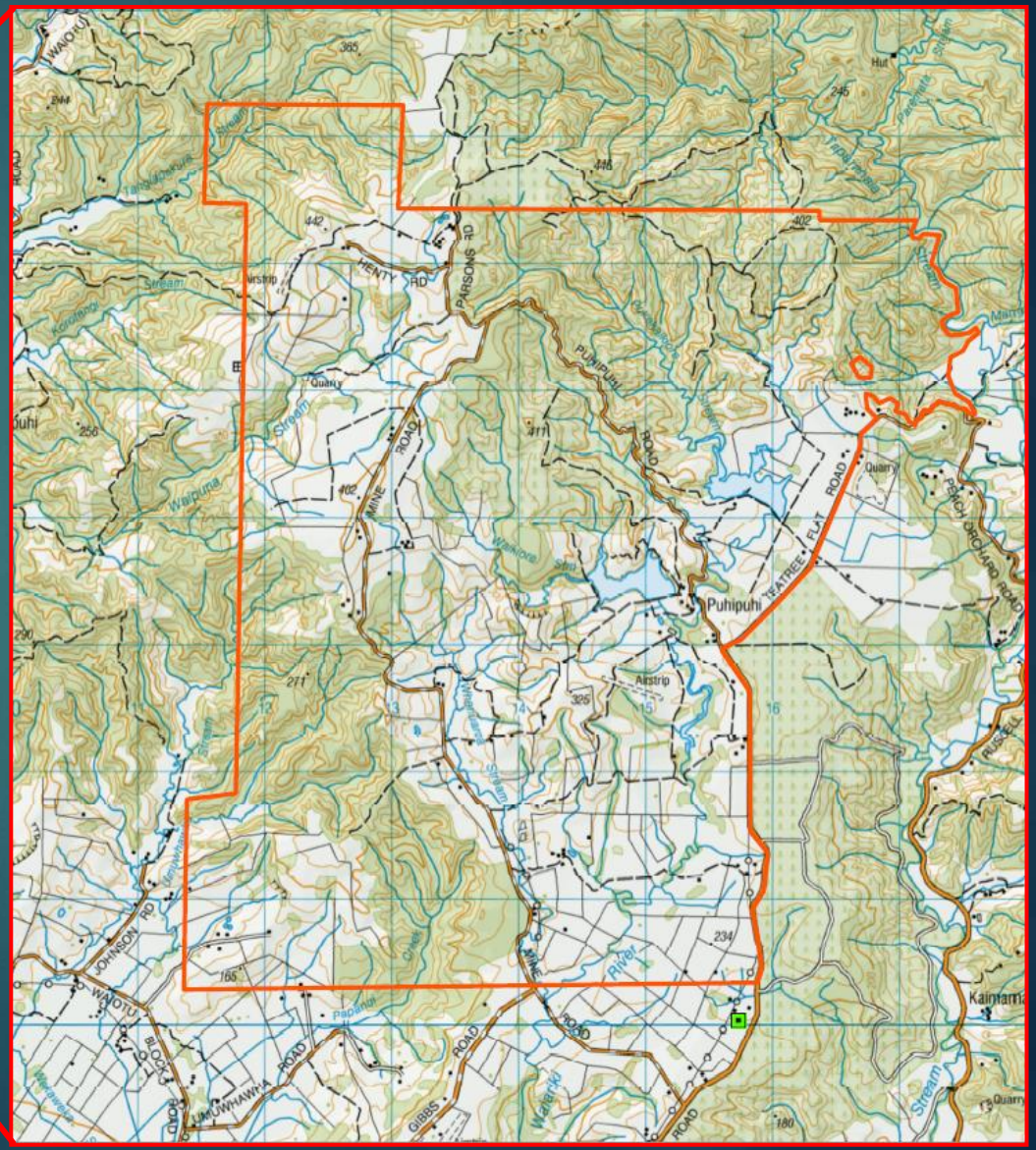
- **Presentation of the individual baseline studies in an integrated “picture” of the environment**
  - An overview summary only
  - Should be read in conjunction with the full technical reports

- **Presentation of exploration drilling specific information**

Baseline Environmental Monitoring

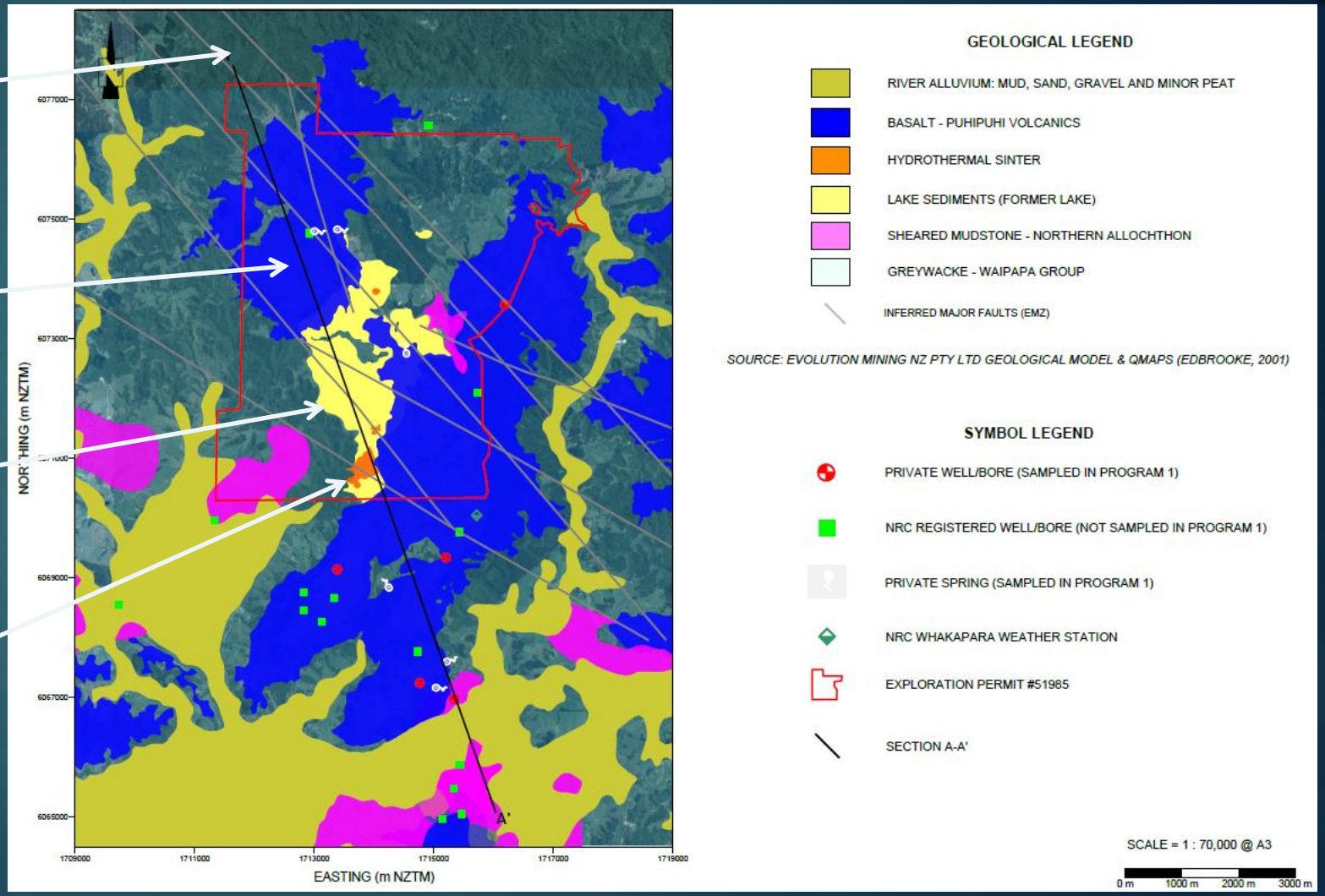
ENZ’s exploration permit at Puhipuhi





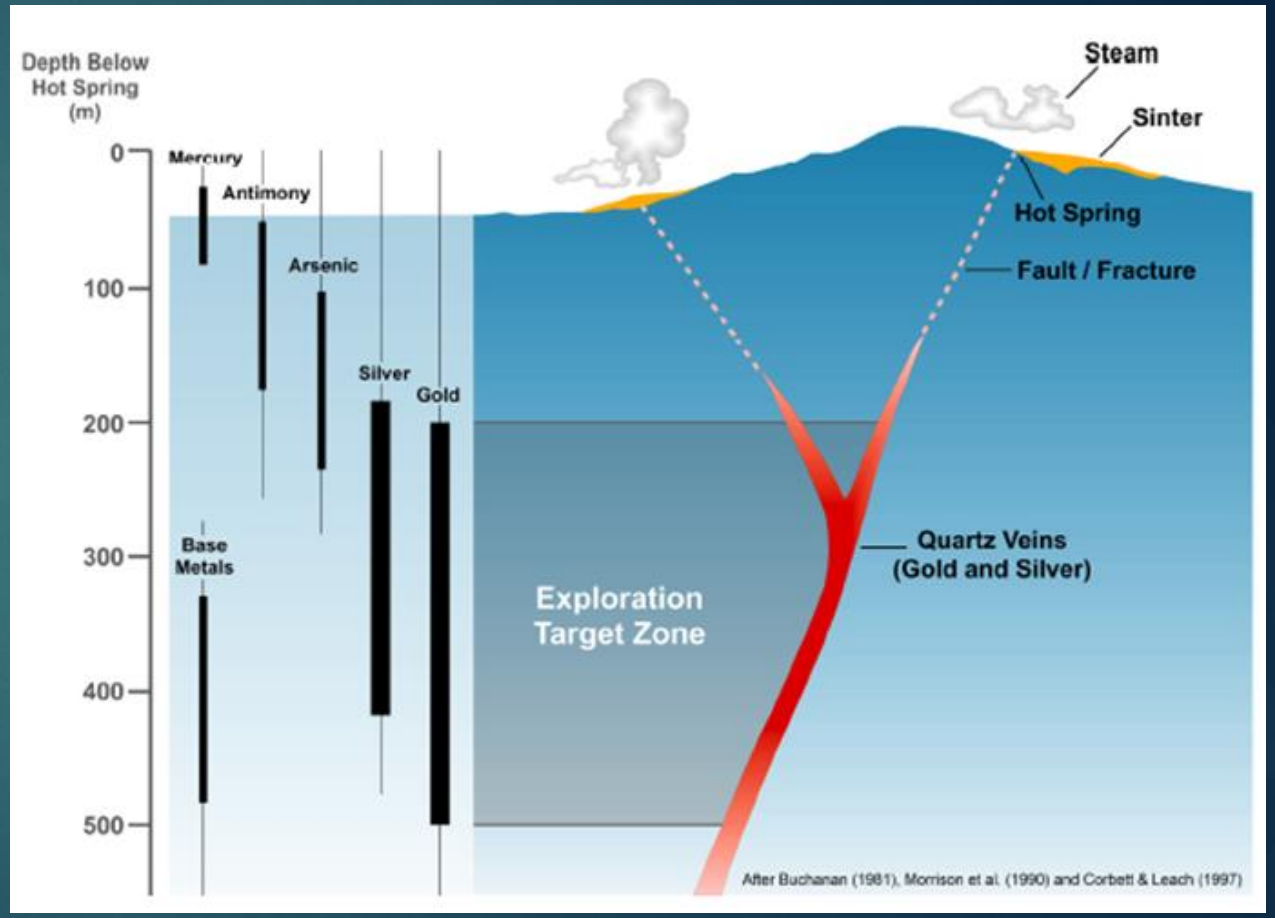
The geology is dominated by old volcanic deposits

- Originally greywacke (grey)
- Volcanics created areas of lava flows - basalt (blue)
- Some low lying areas were an old lake (yellow)
- There were hydrothermal vents that deposited sinter (orange)



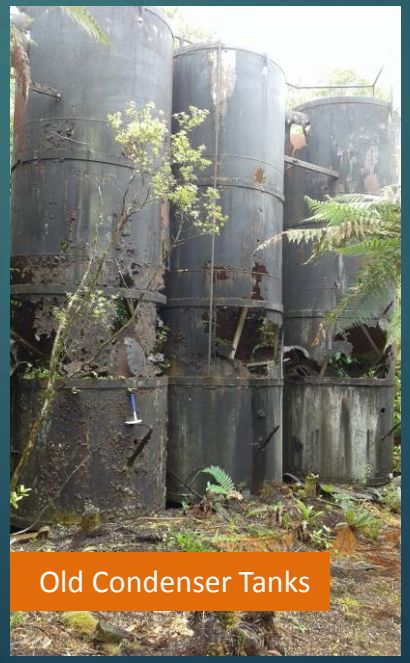
Hydrothermal vents responsible for metal deposits

- An area where hot geothermal water came to the surface with dissolved metals
- Metals deposit as the water cools near the surface - similar to Rotorua today
- Deposited gold and silver as well as mercury, antimony and arsenic
- Rocks and soils in the region are naturally enriched with these metals
- Only area in the country where mercury was mined commercially



Puhipuhi Mercury Mine

- 1882 - Alluvial cinnabar discovered
- 1907 - Quartz outcrops worked
- 1910 to 1945 - Periodic underground and opencast mining activities
- 1939 to 1945 - ~15 tonnes of mercury produced, demand driven by WWII
- 1945 - Mine closed after WWII following dramatic drop in mercury price



Old Condenser Tanks

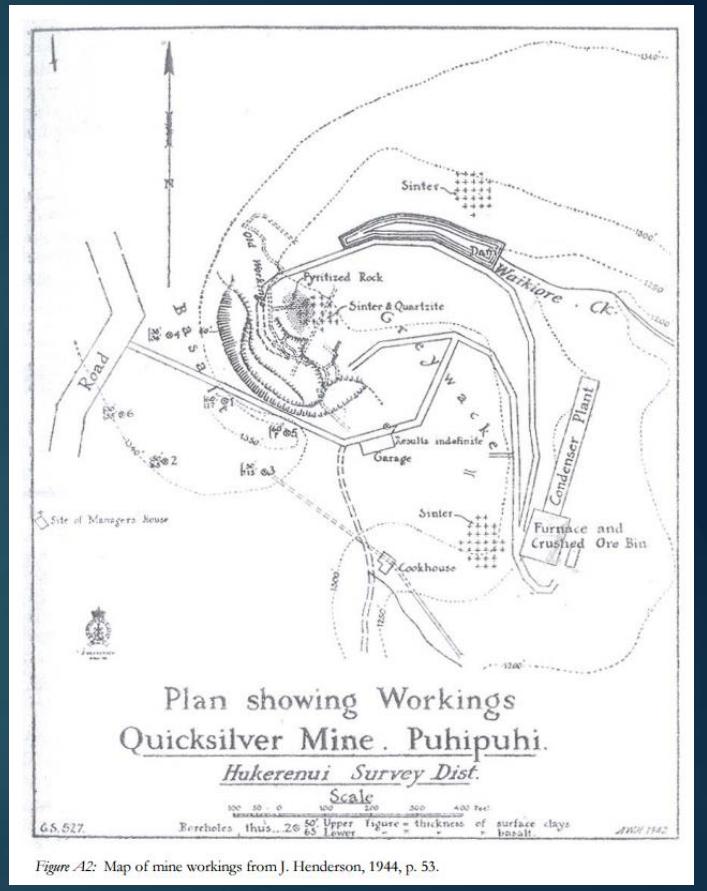


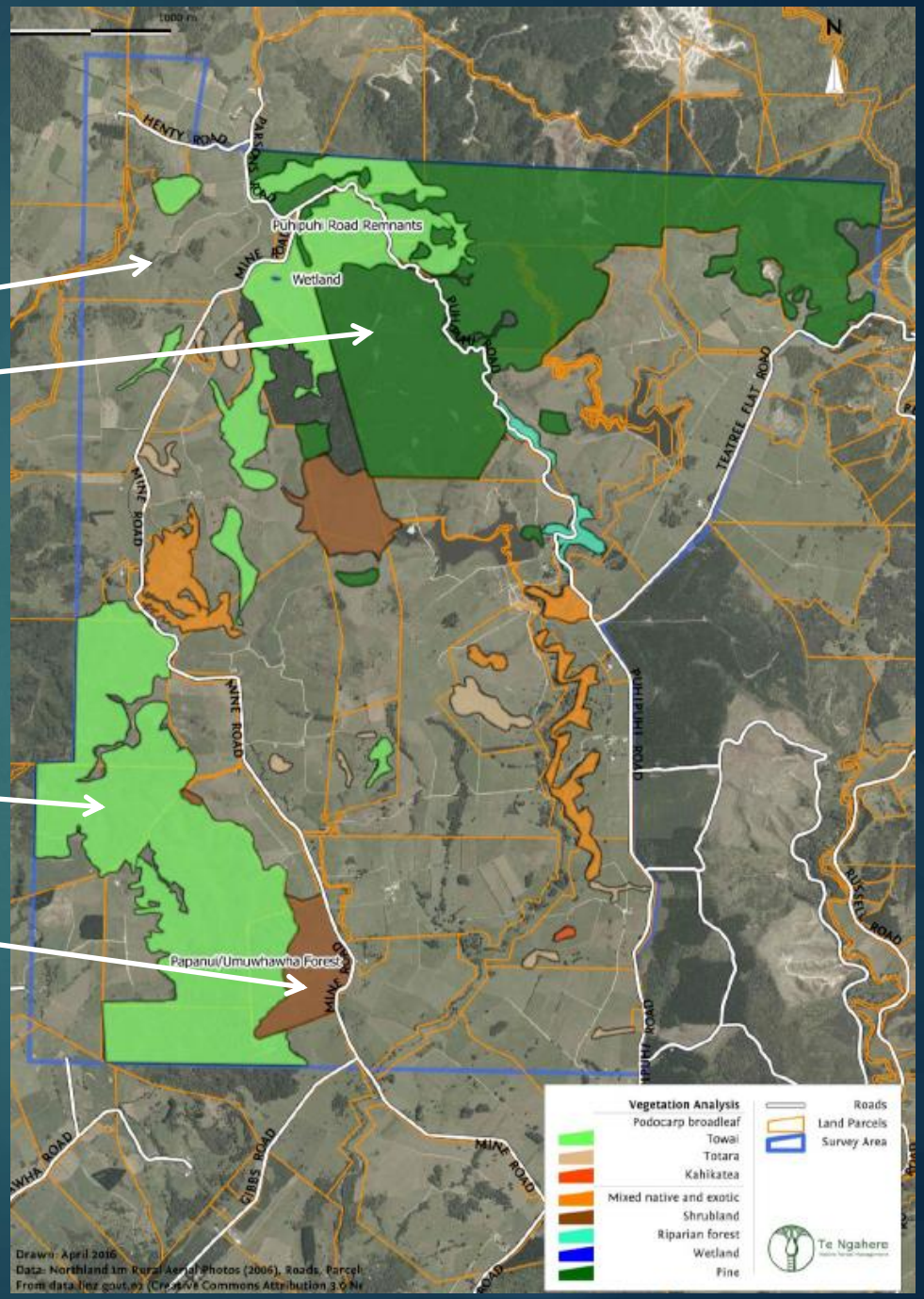
Figure A2: Map of mine workings from J. Henderson, 1944, p. 53.

Land use is highly modified

- Three main land use types
  - Pasture (dominant land use)
  - Exotic pine forest
  - Cutover native forest

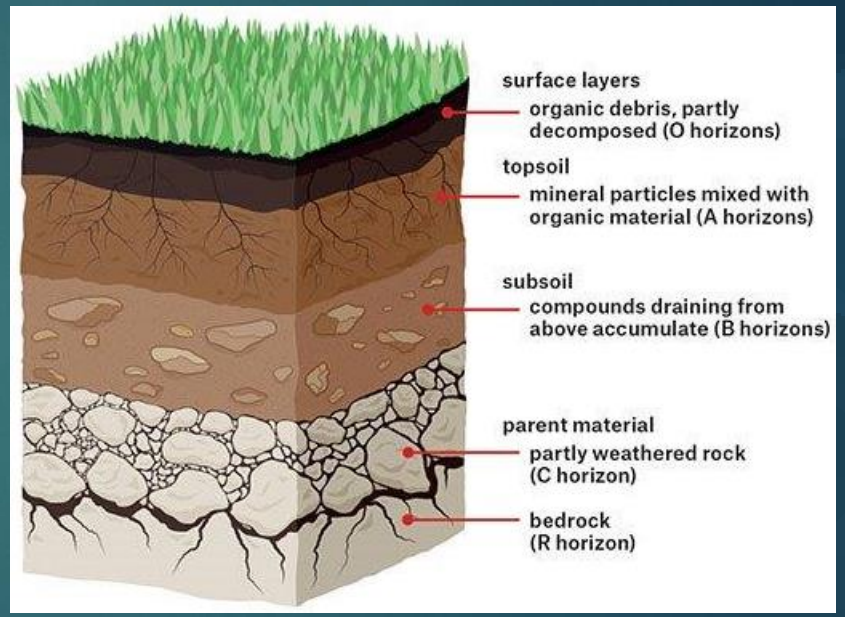
roughly equal areas

- Cutover native forest
  - Mainly towai and totara podocarp-broadleaf
  - Manuka scrubland



Mercury generally highest in soil C horizon

- Distribution of mercury within the soil profile investigated
- Samples taken from A, B and C soil horizons
- Samples taken over areas of sinter shows metal concentrations increased with soil depth
- Samples from non-sinter areas showed no relationship with soil depth



Dust levels low in area

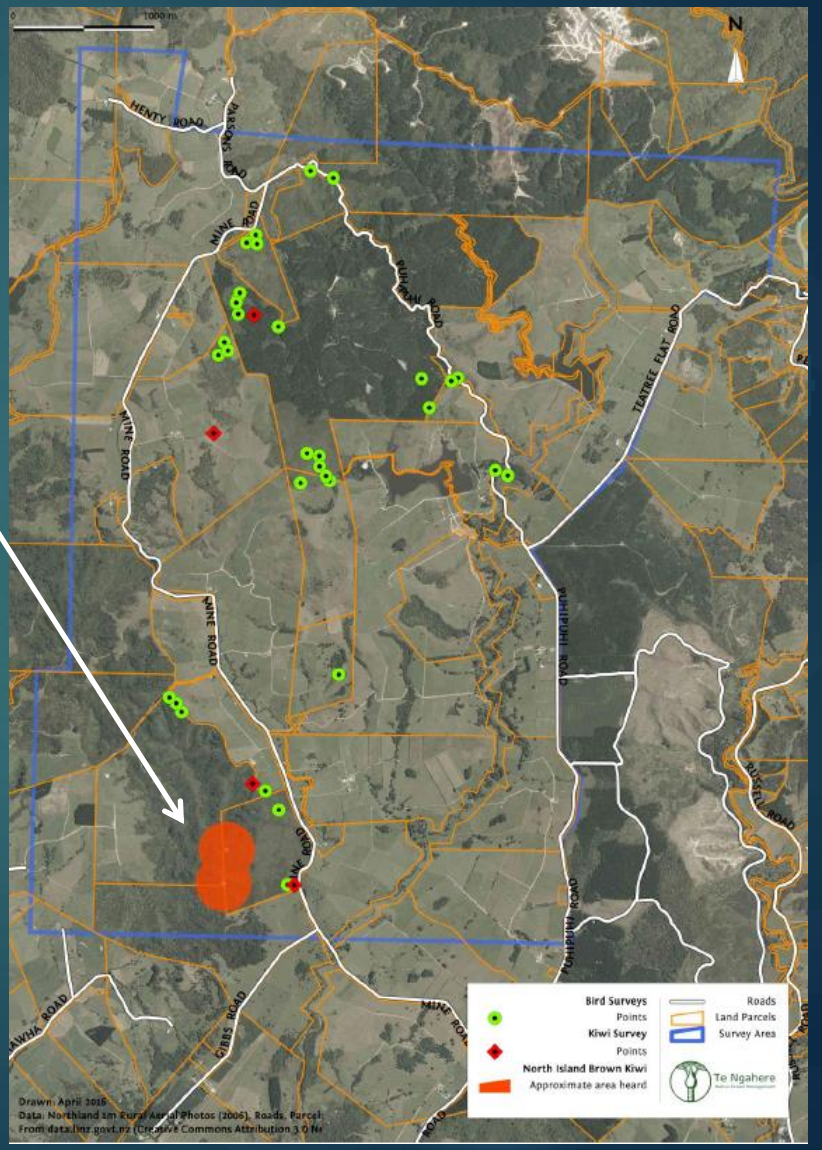
- Dust deposition rate monitoring was undertaken to establish baseline levels in the area
- Three gauges were monitored for 9 months
- One gauge tampered with then went missing so a fourth site was used
- All readings below 2 g/m^2/30 days with the majority below 1 g/m^2/30 days which is typical for NZ
- The MfE recommend a trigger level of 4 g/m^2/30 days i.e. 6 g/m^2/30 days for any large scale dust generating activity in the region

A range of wildlife is found in the area

- Native birds observed in the forested areas included:
  - Fantail
  - Grey warbler
- Threatened species included:
  - New Zealand pipit
  - Black shag
  - Brown kiwi
  - Kauri snail
- No long tailed bats were recorded
- Geckos and skinks were not included in the survey

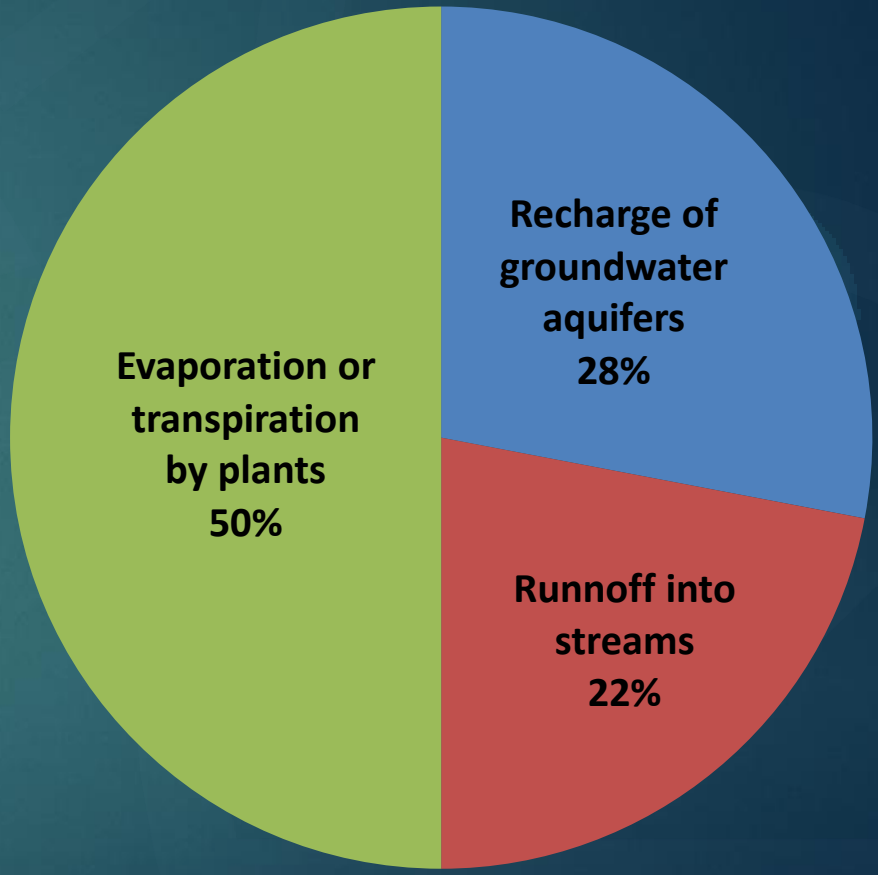
North Island brown kiwi were heard

- Male calls heard in the southern part of the Papanui/Umuwhawha forest
- No calls were heard in the Puhipuhi Road forest remnants, shrubland or forest fragments within agricultural land



The rainfall is mostly evaporated

- Average rainfall is 2,000 mm/year
- Mostly evaporated with the rest recharging aquifers or flowing into streams



Groundwater was sampled from bores and springs

Water bores

Springs

Groundwater sampled for a range of parameters

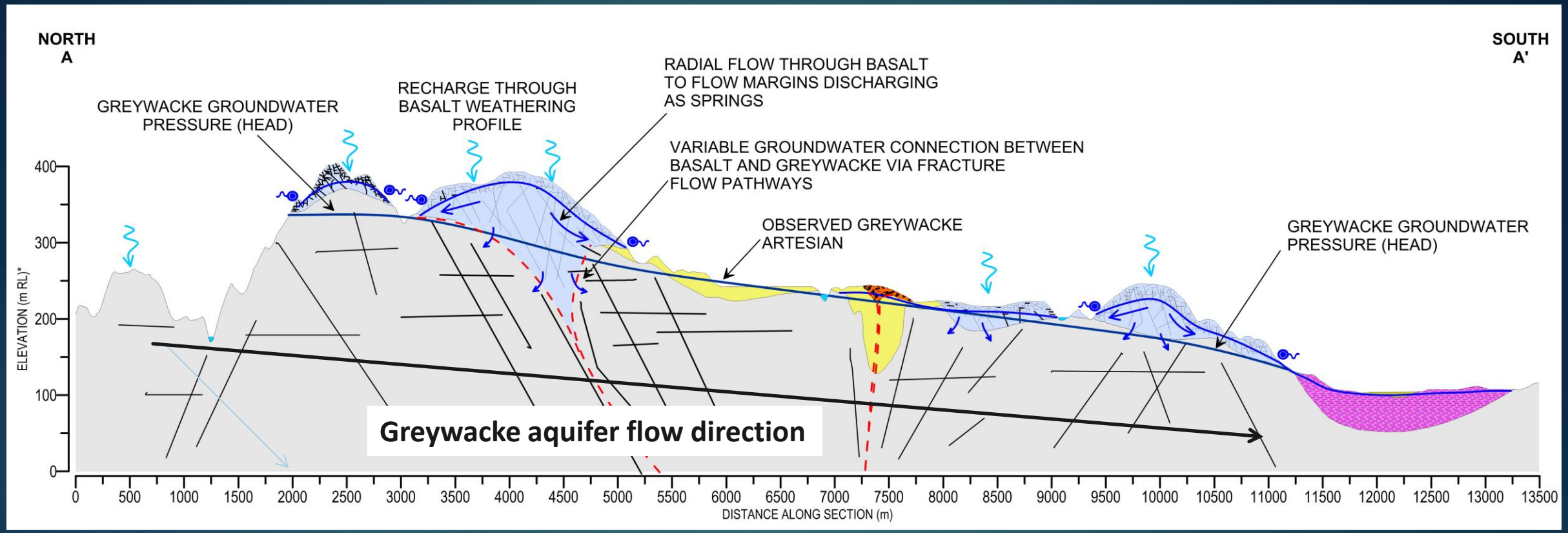
Sampling for physical and chemical analyses.

Sampling of Stygofauna

Stygofauna

- Stygofauna are small animals that live in groundwater systems
- It is not usual to test for stygofauna as so little is known about Stygofauna in New Zealand compared to overseas
- May give an indication of the health of the groundwater system in the same sort of way macroinvertebrates do for the health of surface waterways
- This study provides some baseline data for future reference

There are three aquifers in the area



- Water in the deep greywacke aquifer (grey) flows from NE to SW (black arrow)
  - Limited impact on surface water
- Water in the shallow basalt aquifer flows down hill into streams (blue arrows)
- Water in the lake bed sediments (yellow) flows downhill into streams

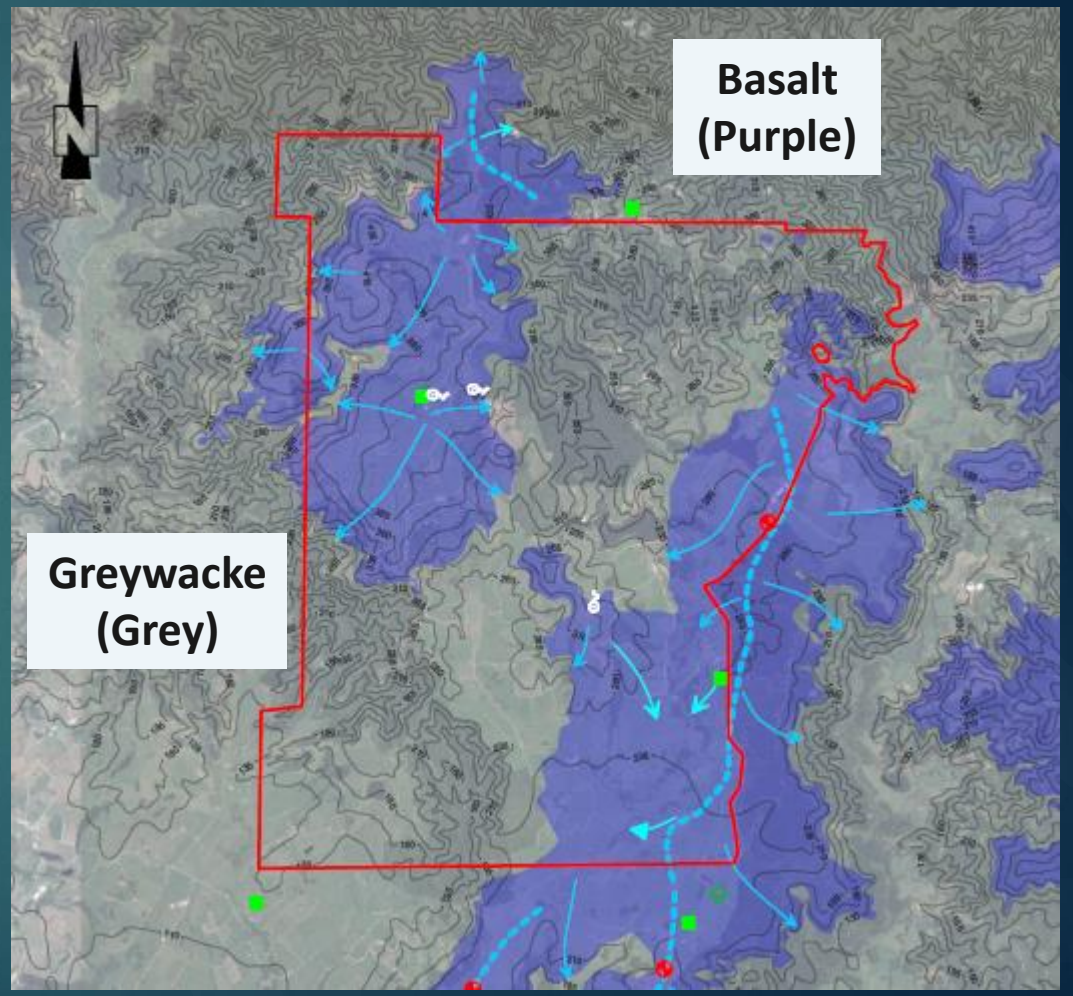
Greywacke aquifer

- Lies below the Puhipuhi volcanic basalts
- Rainwater enters aquifer largely from exposed greywacke to north of tenement
- Flow of groundwater is NE to SW
- Long residence times
- Good quality water, all mercury below detection limit (<0.0001 mg/litre or <0.1 part per billion)
- Appears to have little impact on surface waterways (all springs sampled contained water from the basalt aquifer)

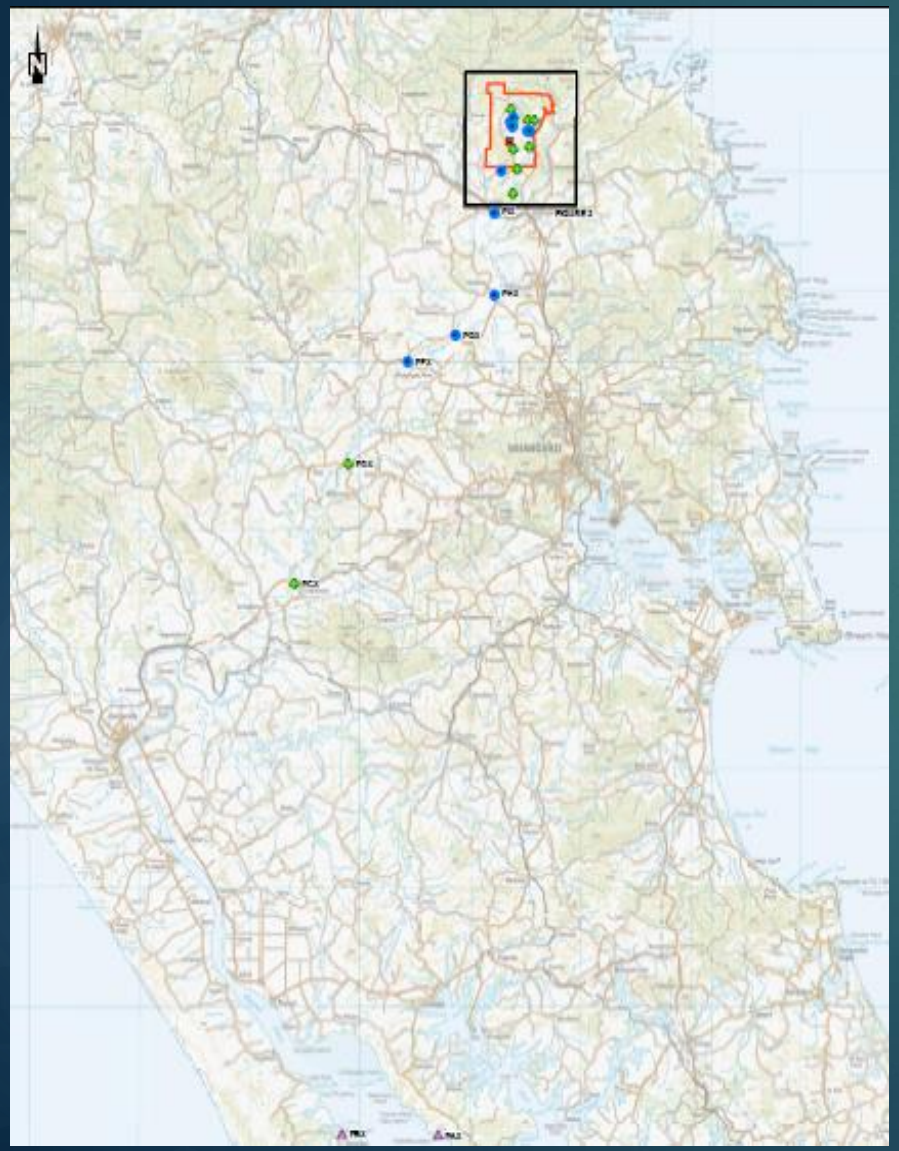
Basalt and lake bed sediment aquifers

- Basalt aquifers
  - Sits above the greywacke aquifer
  - Rainwater fed, good quality, short residence times
  - Flows down hill into streams and springs (blue arrows)
  - Main source of water supply in the area
  - One spring had mercury greater than detection limit (0.0002 vs <0.0001 mg/litre). NZ drinking water standard is 0.007 mg/litre so concentration measured was 3% of the standard

- Lake bed sediment aquifer
  - Water quality unknown, likely to feed streams



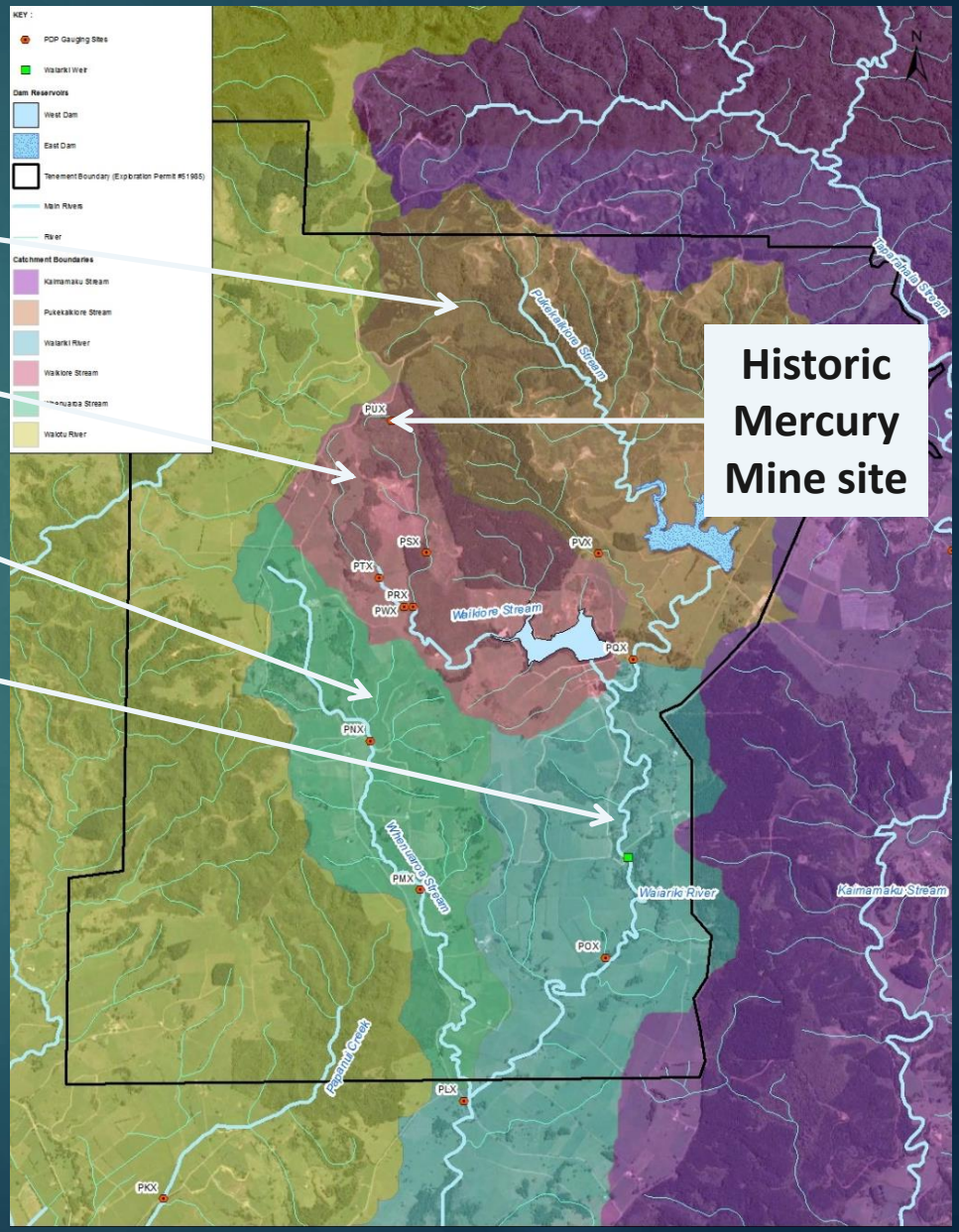
Surface waters were extensively sampled



- Surface water and stream sediment sampling:
  - within and downstream of tenement
  - ~20 locations (including the Wairua and Northern Wairoa rivers)
  - stream flow gauging
- Fauna tissue analysis for mercury
- Stream macroinvertebrate study
- Habitat assessment and desktop survey of potential barriers to fish passage

The Waiariki river has three tributaries

- Pukekaikiore Stream
- Waikiore Stream
- Whenuaroa Stream
- Waiariki River
- The historical mercury processing plant is located in the Waikiore stream catchment



Surface water sampling activities

Stream sediment samples

Protective suits worn by staff to avoid accidently contaminating the water they are sampling

Stream flow measurement

Care was taken with surface water sampling

- Knew from historical work that majority of metals and ions we were trying to measure are only present at very low levels

- Took measures to get most accurate measurements possible
  - Began downstream, furthest away from mercury source
  - Worked upstream to minimise risk of contaminating the next sample
  - Replaced sample tubing and fittings between sites
  - Field staff wore clean suits (white overalls) and masks to minimise sample contamination NOT to protect themselves from anything they were handling
  - Used an international laboratory with lowest detection limits

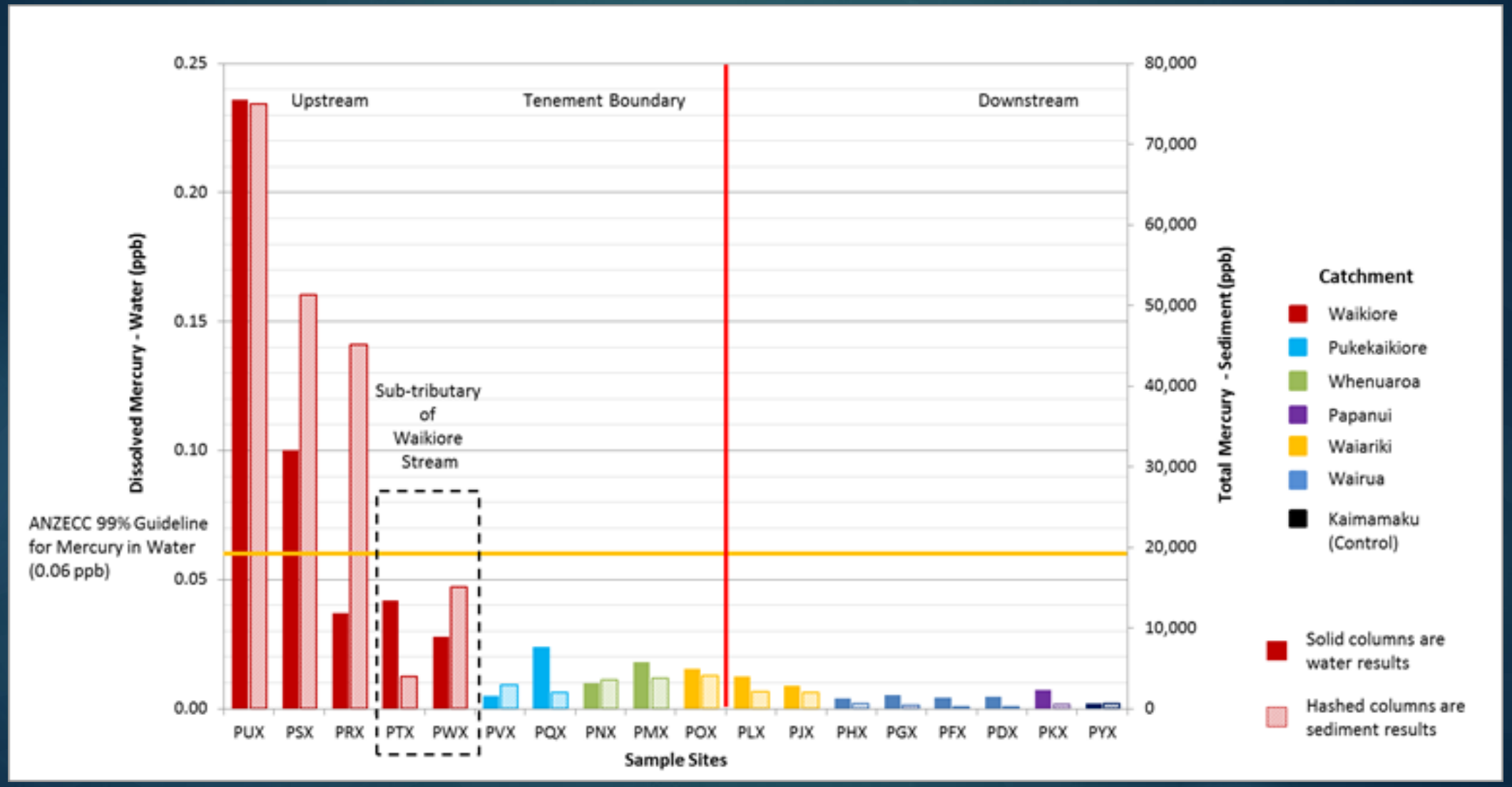
Surface water quality is good

- No samples exceeded the following guidelines for mercury
  - NZ drinking water standard
  - Australia and New Zealand Environment and Conservation Council (ANZECC) contact recreational guidelines
  - ANZECC livestock drinking water trigger levels
- ANZECC guideline trigger values for 99% aquatic ecosystem protection were exceeded at two locations close to the historic Puhipuhi mercury processing plant at the head of the Waikiore Stream
  - Exceeding the trigger value for a chemical or nutrient only means there is the potential to cause a problem for sensitive aquatic organisms, not that there is a problem
- Concentrations of mercury in water decreased significantly with distance downstream from the historic Puhipuhi mercury mine and processing site

Stream sediment quality is poor

- Thirteen sites (out of 19) exceeded the ANZECC ISQG-high sediment trigger values for one or more inorganic element (antimony, arsenic and mercury)
  - The ISQG-High concentration is intended to represent a concentration above which adverse biological effects are expected to occur more frequently
- Concentrations of mercury in sediment were greatest in the Waikiore Stream catchment close to the historic Puhipuhi mercury mine and processing site
- Concentrations of mercury in sediment decreased significantly with distance downstream from the historic Puhipuhi mercury mine and processing site
- Mercury in sediment is not particularly soluble and only a small fraction in the form of toxic methyl mercury

Waikiore catchment is the major source of mercury



Aquatic organisms were caught and sampled

- In addition to water quality, there is stakeholder interest in the potential for metals such as mercury to accumulate in aquatic life
- Eels and freshwater crayfish were caught to provide samples
- No eels were caught above the waterfall on the Waiariki River

Waiariki waterfall a potential fish passage barrier

- No eels were caught in the catchment above the waterfall
- Waterfall was visited, photographed and assessed
- Considered a barrier due to :
  - a significant overhang
  - overall vertical height (15m)
  - limited resting and wetted areas

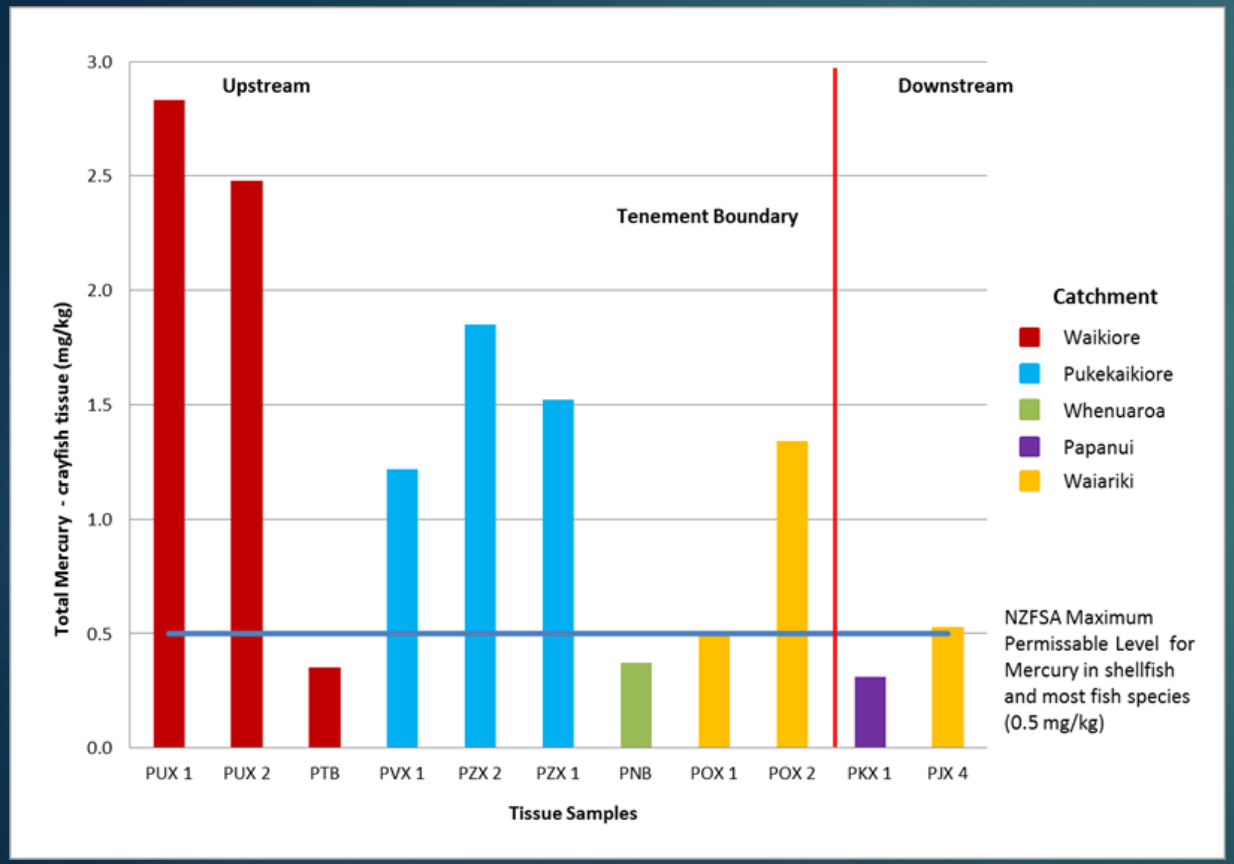
Eels and crayfish were caught …

… and mercury concentrations in flesh measured

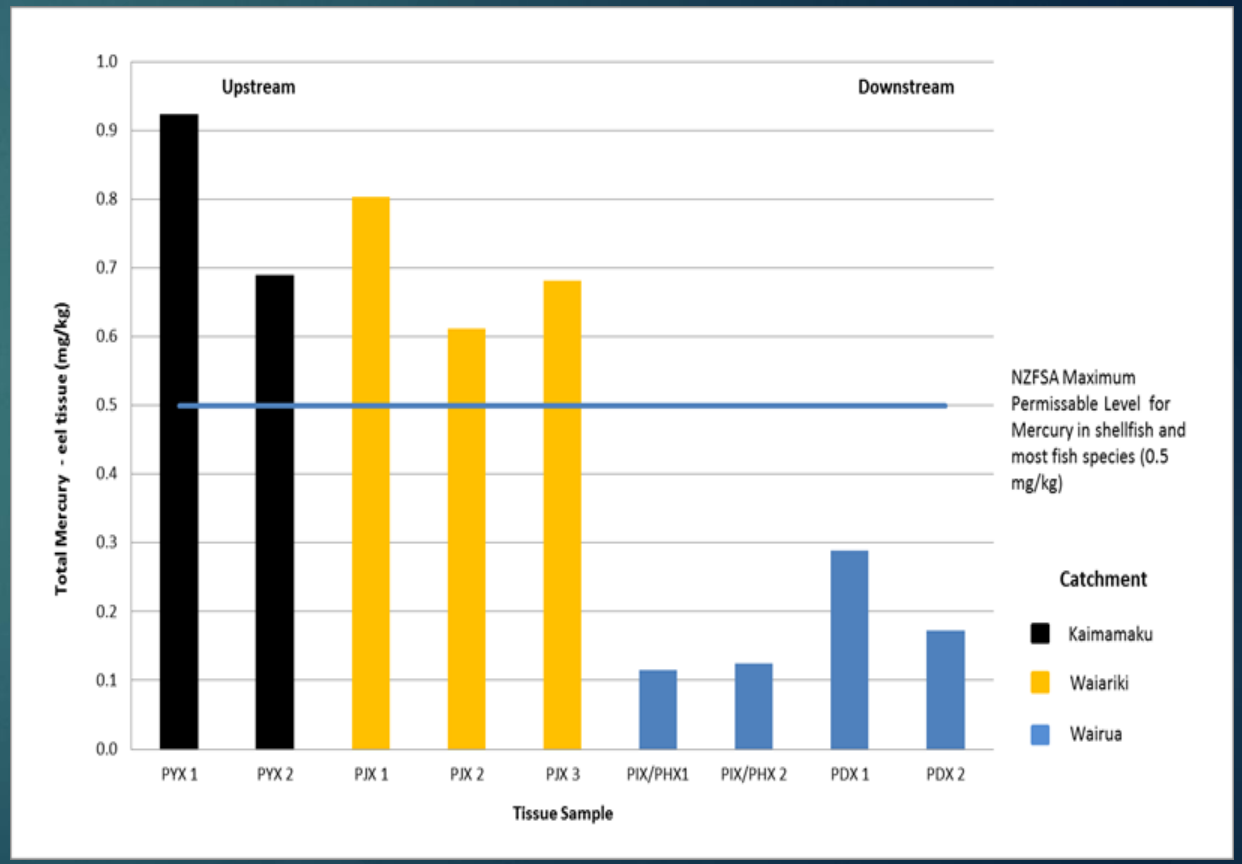
- Mercury concentrations in tissue samples from crayfish within the tenement boundary were above the NZ Food Safety Authority (NZFSA) guideline criteria (0.5 mg/kg)
- Mercury concentrations in freshwater crayfish were highest in the Waikiore stream closest to the historic mercury mine
- Mercury concentrations in eels caught in the Waiariki and Kaimamaku rivers also exceeded the NZFSA guideline criteria (0.5 mg/kg)
- Concentrations of mercury in both eels and crayfish decreased with distance downstream

Concentrations of mercury decrease downstream

Crayfish

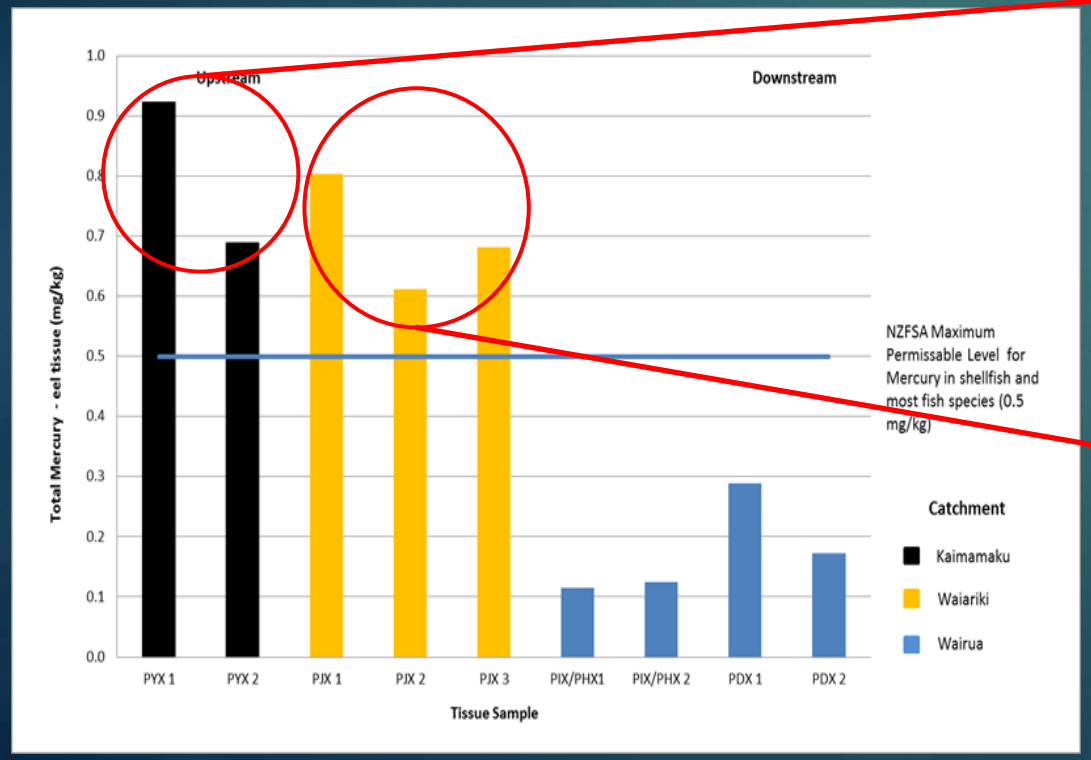


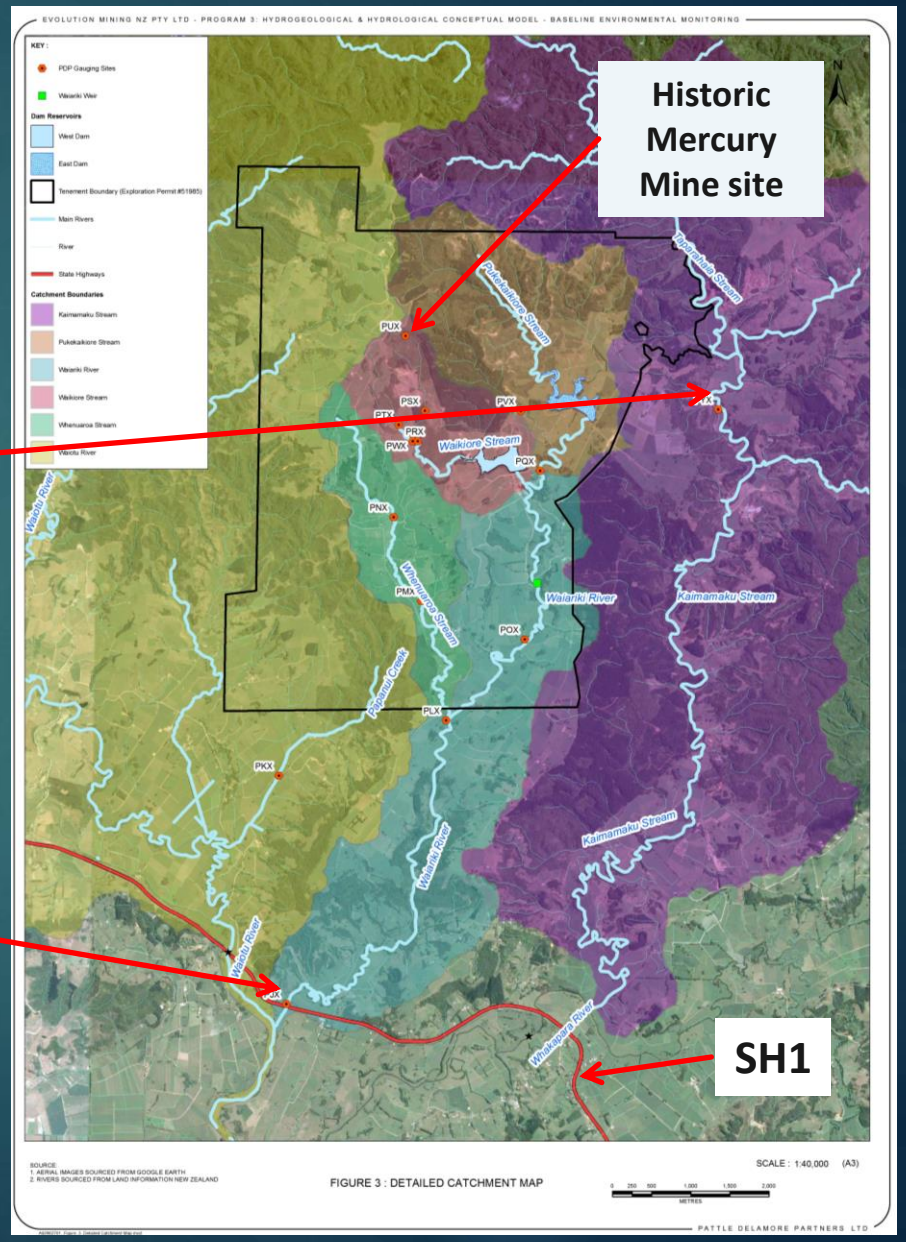
Eels



Mercury in eels likely to be a regional issue

- Eels caught in the Kaimamaku Stream, which is not impacted by historic mining, have similar mercury concentrations as eels caught in the Waiariki River downstream from the historic mercury mining and processing





Eating crayfish and eels should be limited

- The following recommendations are based on an assessment of human exposure to methyl mercury

- Recommend that consumption of shortfin eels from the Puhipuhi area is limited to less than 3.5 servings of 150 grams per month for a 70 kg adult

- Recommend that freshwater crayfish collected from within the catchments sampled are not regularly consumed as part of an individual's regular diet

Macroinvertebrate survey and habitat assessment

- Macroinvertebrates are small animals that live in surface waterways
- Macroinvertebrate surveys are commonly undertaken and they are widely used for environmental monitoring
- Their wide use enables assessment of the health of surface waterways, and to compare between different sites

Macroinvertebrate survey and habitat assessment

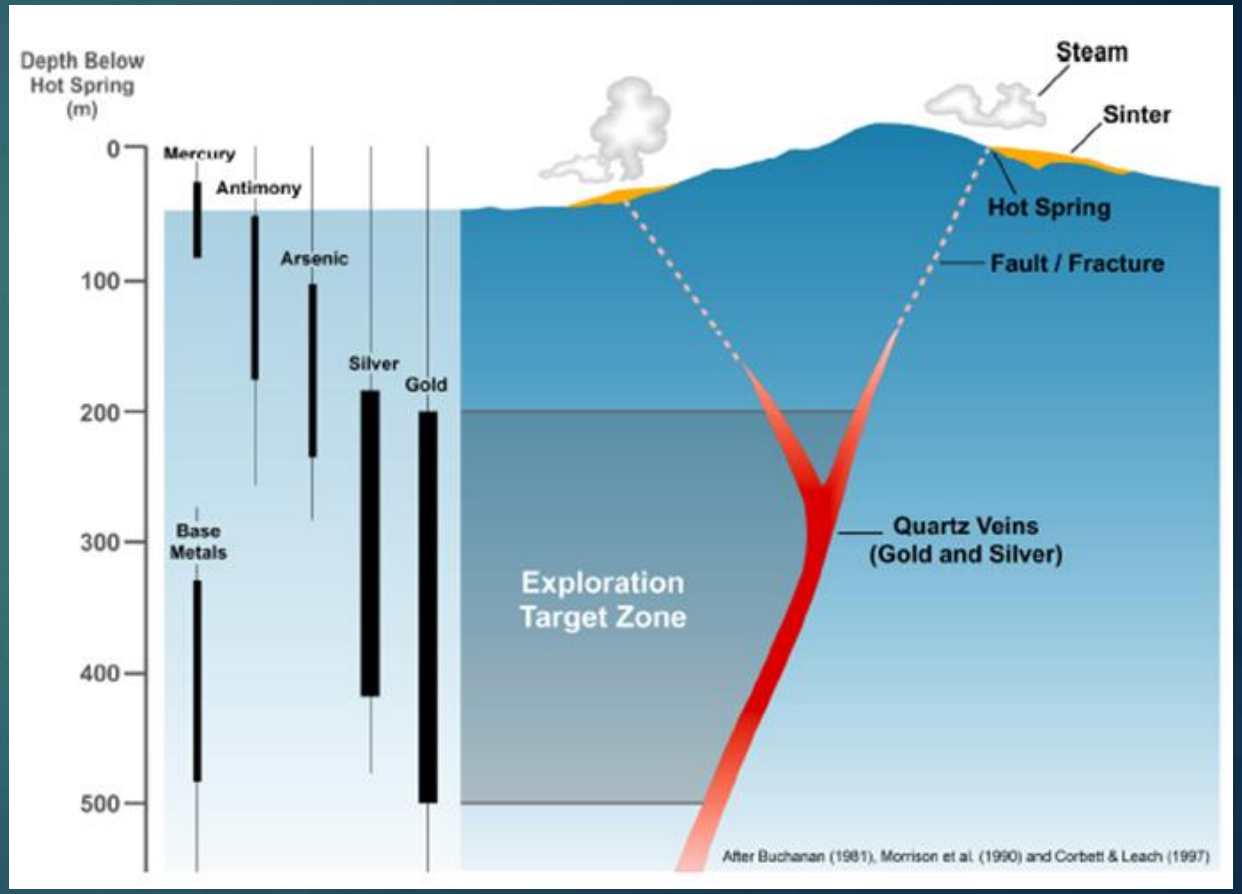
Found aquatic ecosystem health is linked to habitat

- In general the headwaters of streams had the highest ecosystem health (quality and diversity of macroinvertebrates) despite having poorest quality water and sediment
  - Water mercury concentrations exceeding 99% aquatic ecosystem protection guideline value
  - Sediment mercury concentrations exceeding the ANZECC ISQG-high sediment trigger values
- In-stream habitat changes from faster flowing, diverse depth/velocity combinations to slow flowing as you travel downstream
- Surrounding land use changes from cutover native forest/exotic pine forest to open farmland resulting in:
  - Reduced shade
  - High levels of deposited sediment
  - Reduced habitat diversity

Exploration Drilling

Gold and silver is deposited at depth

- Exploration drilling required to assess potential
- Target depth range ~200 – 500 m



An environmental management strategy was prepared

- Identify key environmental risks
- Formulate management plans to eliminate, isolate or minimise the risks
- Monitor to assess the effectiveness of controls
- Revise management plans as required to maximise their effectiveness

Key risks and controls were identified

Potential Environmental Risk	Recommended Control Measure
1. Increased soil erosion	i. Drill rig selection ii. Minimise and control disturbance and mobilisation of soil
2. Discharge of sediment to waterway	i. Zero discharge at site ii. Utilise removable above-ground sumps iii. Offsite disposal of waste at approved facilities
3. Interconnection of aquifers	i. Seal and grout drill holes to comply with the NZ Drilling Environmental Standard NZS4411-2001

Erosion minimised and controlled

Rubber-tracked vehicles minimised soil damage

Truck mats minimised soil damage

Silt fences contained any sediment

Routine water clarity monitoring undertaken

- Key potential effect on surface waterways is sediment runoff
- Clarity tubes were selected as the preferred way of assessing the impact of sediment runoff
  - Ease of use
  - No calibration required
  - Linked to guidelines in the Northland Regional Plan for water clarity
  - Instant results allowing immediate corrective actions to be taken
- Monitoring carried out three times per week
  - Visual inspections of erosion control measures
  - Surface water clarity monitoring

Clarity monitoring confirmed no sediment erosion

- A reduction of ≥20% in water clarity between upstream and downstream of the drill site triggered an inspection to determine if the increased turbidity was a result of drilling related activities
- 288 water clarity readings taken
- On 2 occasions clarity had decreased by more than 20%
- Investigations determined drilling activities were not the cause of increased runoff of sediment from pasture

All drilling fluids were disposed appropriately

- Drilling cuttings collected in 1,000 litre ICB's
- Analysed to determine metal concentrations
- Disposed of at approved waste disposal facilities (Class A landfill)

Noise monitoring

- Undertaken at three locations, both while the exploration rig was operating and not
  - One 60m downwind from the drill rig
  - The other two close to the nearest houses (1,000 and 1,400 m away)
- Calculated that the sound pressure level of the operating drill rig was 90 dB
- In order to comply with the night time District Plan noise levels (40 dB), it was calculated that the drill rig needs to be located ~320m from the nearest property boundary
- Neither of the two other monitoring sites were impacted by drill rig noise

Drill holes sealed to protect aquifers

- After the completion of drilling, each hole was plugged at a depth of 150m
- Hole grouted above the plug to 0.5m below ground level
- The result is a sealed hole and groundwater prevented from interacting between aquifers

All sites rehabilitated at completion of work

Before

After grass seeding (note silt fences still in place

After

- All drill sites rehabilitated to ensure no ongoing risk of environmental impact

Overall Conclusions

Environmental baseline monitoring summary

- Gold and silver deposits at Puhipuhi are a result of historic volcanic activity
  - Key associated contaminants of interest are antimony, arsenic and mercury
- The land use is highly modified; mainly farmland with native and exotic forest
- Water quality in the greywacke and basalt aquifers meets the NZ Drinking Water Standard for key contaminants
- Surface water quality met all guidelines for mercury except for the trigger value for 99% aquatic ecosystem protection which was exceeded within 1km of the historic Puhipuhi mercury processing plant
- The environmental baseline outcome of most significance is the levels of some inorganic elements in sediment
  - Thirteen sites (out of 19) exceeded the ANZECC ISQG-high sediment trigger values for one or more inorganic elements (antimony, arsenic and mercury)

Environmental baseline monitoring (cont.)

- Concentrations of mercury in both water and sediment were greatest in the Waikiore Stream catchment close to the historic Puhipuhi mercury mine and processing site
- Concentrations decrease significantly as distance downstream increases
- In general the headwaters of streams had the highest ecosystem health due to better in-stream and surrounding habitat, despite having the poorest water and sediment quality
- No eels were captured above the Waiariki waterfall which was assessed as a fish passage barrier
- Crayfish and eels had mercury concentrations above the NZ Food Safety Authority guideline of 0.5mg/kg. Consumption of crayfish and eels should be limited
- Mercury in eels likely to be a regional issue as eels caught in the Kaimamaku Stream, which is not impacted by historic mining, have similar mercury concentrations as eels caught in the Waiariki River downstream from the historic mercury mining and processing

Exploration drilling summary

- An environmental management strategy identified three areas of risk:
  - Increased soil erosion
  - Discharge of sediment into waterways
  - Interconnection of aquifers

- Risks were successfully managed by:
  - Using rubber-tracked drill rigs and truck mats
  - The use of silt fences to contain any soil erosion that did occur
  - Disposing all drilling fluids and cuttings offsite at approved facilities
  - Plugging and cementing all holes to prevent aquifer mixing
  - Site rehabilitation by contouring and re-grassing pasture

Exploration drilling (cont.)

- The environmental performance was assessed by:
  - Monitoring surface water for changes in clarity (evidence of erosion)
  - Noise monitoring
  - Inspections of rehabilitation after completion of drilling
- No immediate or long term environmental impacts observed