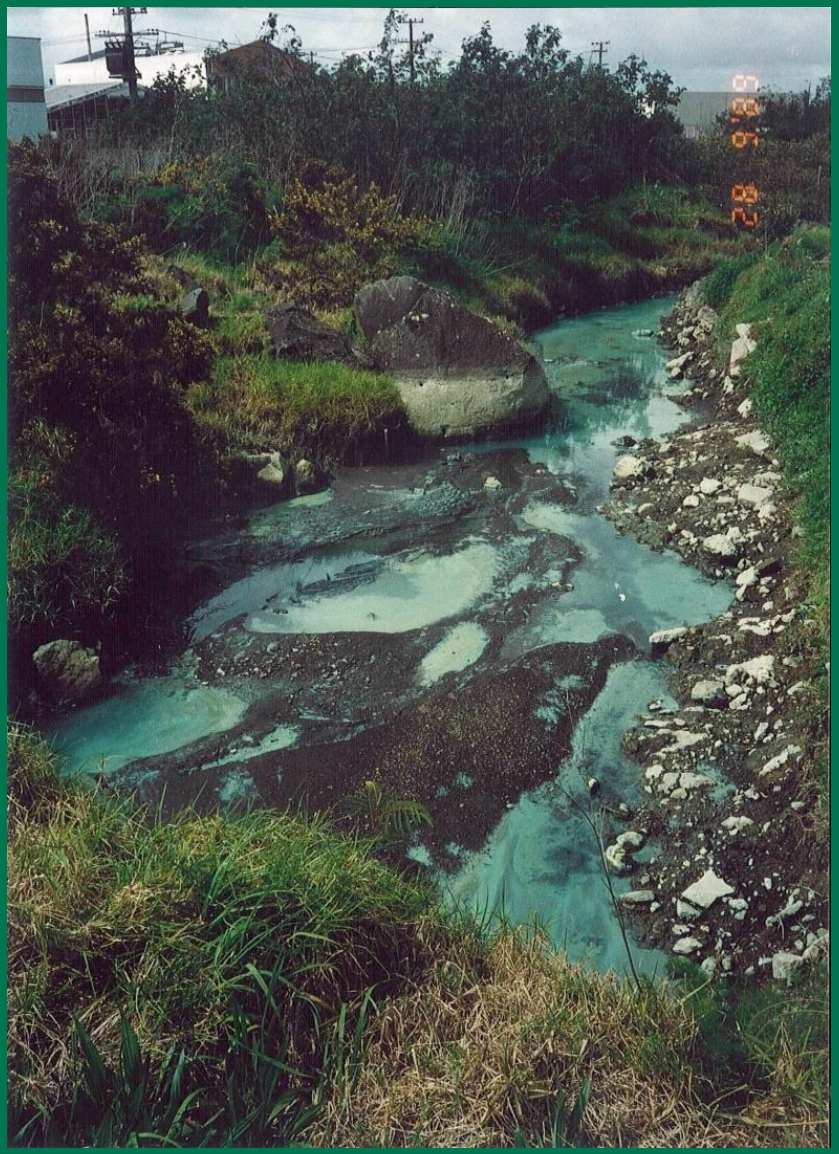
Onehunga Aquifer & 'Green Stream' Contamination

Former NZ Farmers Fertiliser Site

Presented by Sharon Vujnovich, ARC

The Green Stream



- In 1988 ARA received a pollution complaint of a '*green*' stream
- High in copper, sulphate, cadmium, phosphorus & fluoride
- Numerous ARA/ARC investigations were undertaken to trace the polluter and contaminant source

Green Stream (Miami Stream) Location & Catchment

- Miami Stream's recieves water from:
  - groundwater from One Tree Hill, Mt. Wellington and Mt. Smart volcanic basalt aquifers
  - stormwater network (public and private)
- Landuse – commercial/industrial and residential
- Miami Stream discharges to the Mangere Inlet of the Manukau Harbour

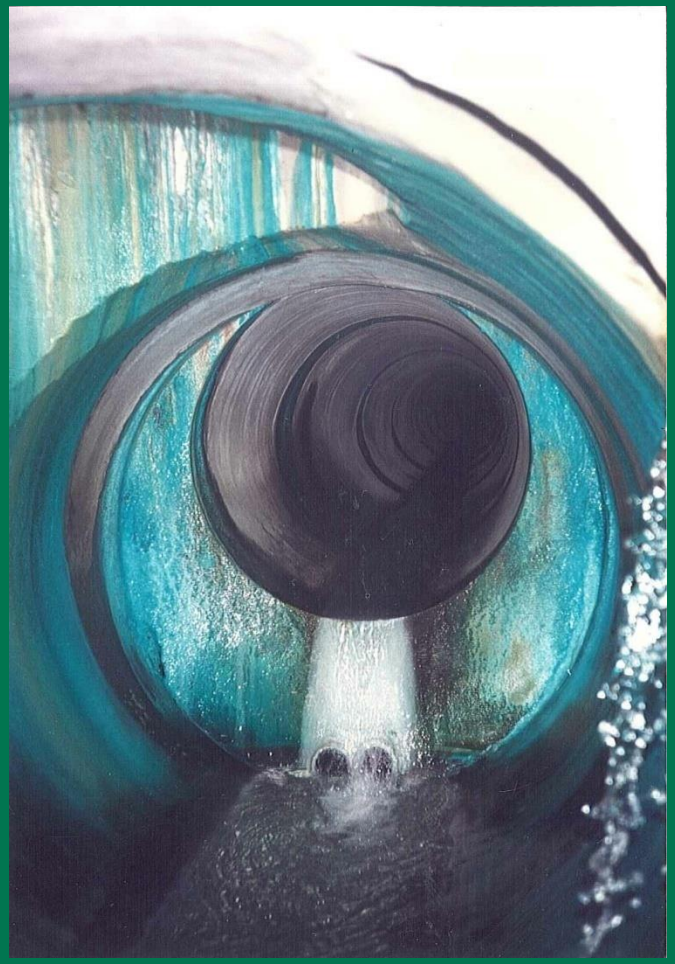
Green Stream Discharge to Mangere Inlet

- Managere Inlet consists of tidal mudflats fringed by mangroves, supporting fish & numerous invertebrate species including oysters
- Manukau Harbour is culturally and historically significant as a source of seafood to many iwi and particularly important to the people of the Tainui waka.
- A valued recreational and aesthetic resource, including boating, fishing, shellfish gathering and walking

The Green Oysters

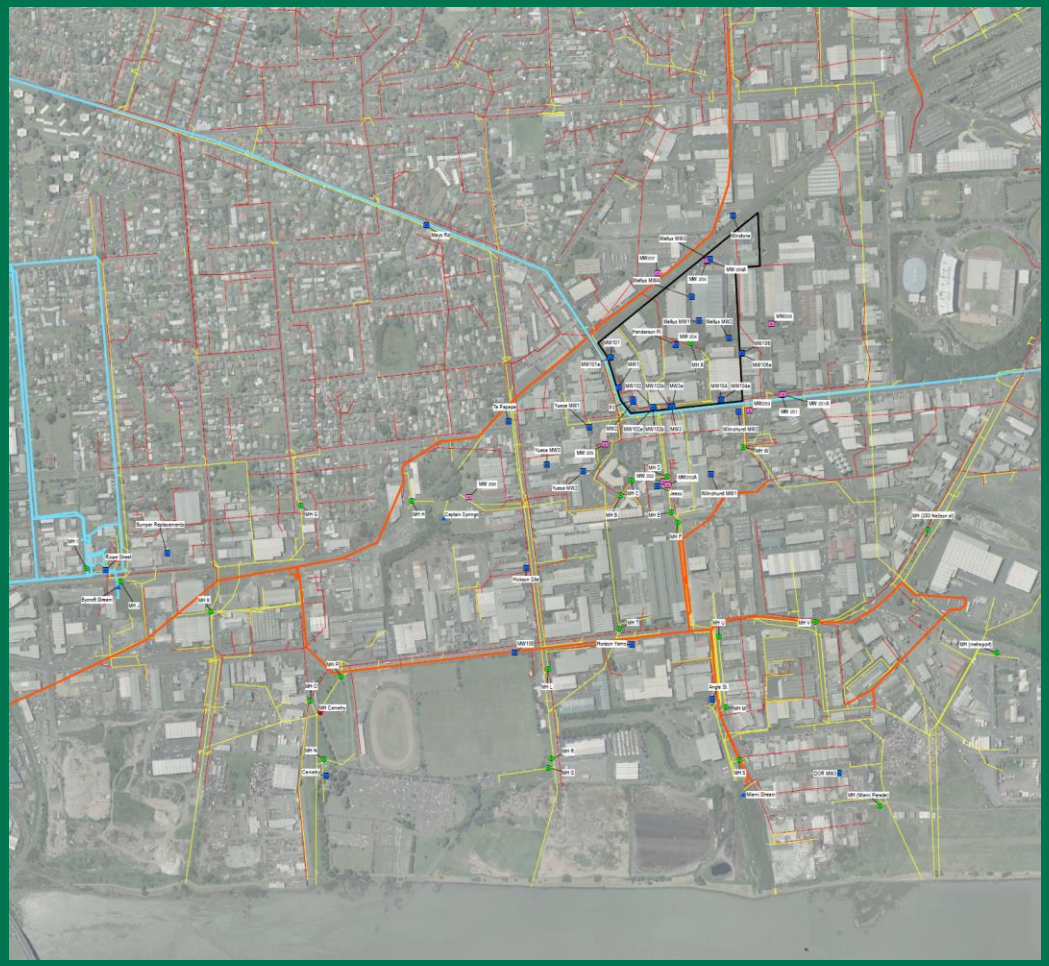
- At Green Streem discharge outfall there are many oyster beds
- Oysters - green on the inside
- Elevated copper, cadmium and chromium

Patrick Street Stormwater Line



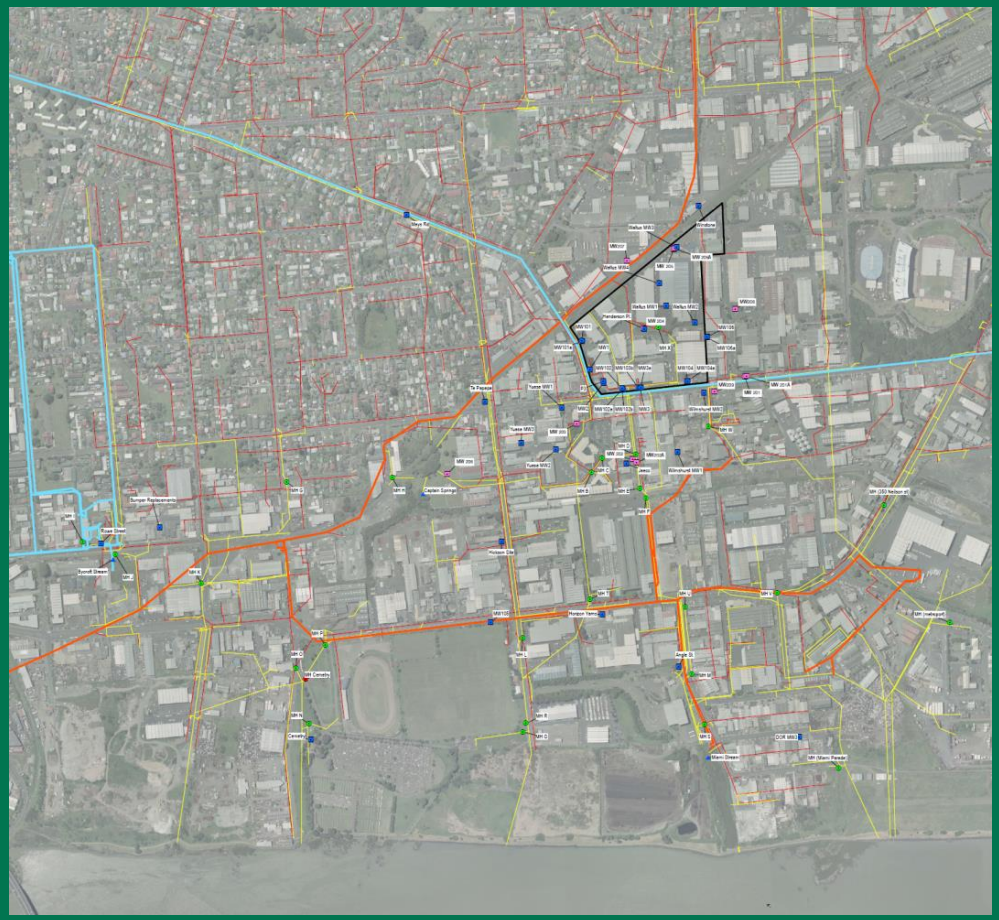
- Contamination was traced up-gradient to Patrick St. stormwater line, where contaminated groundwater was seen leaking into the pipe
- Many potential polluters were investigated, such as nearby electroplaters but the source of the contamination could not be found
- Note, the NZ Farmers Fertiliser site was gone at this stage i.e. subdivided and redeveloped

Former NZ Farmers Fertiliser (NZFF) Site Location & Setting



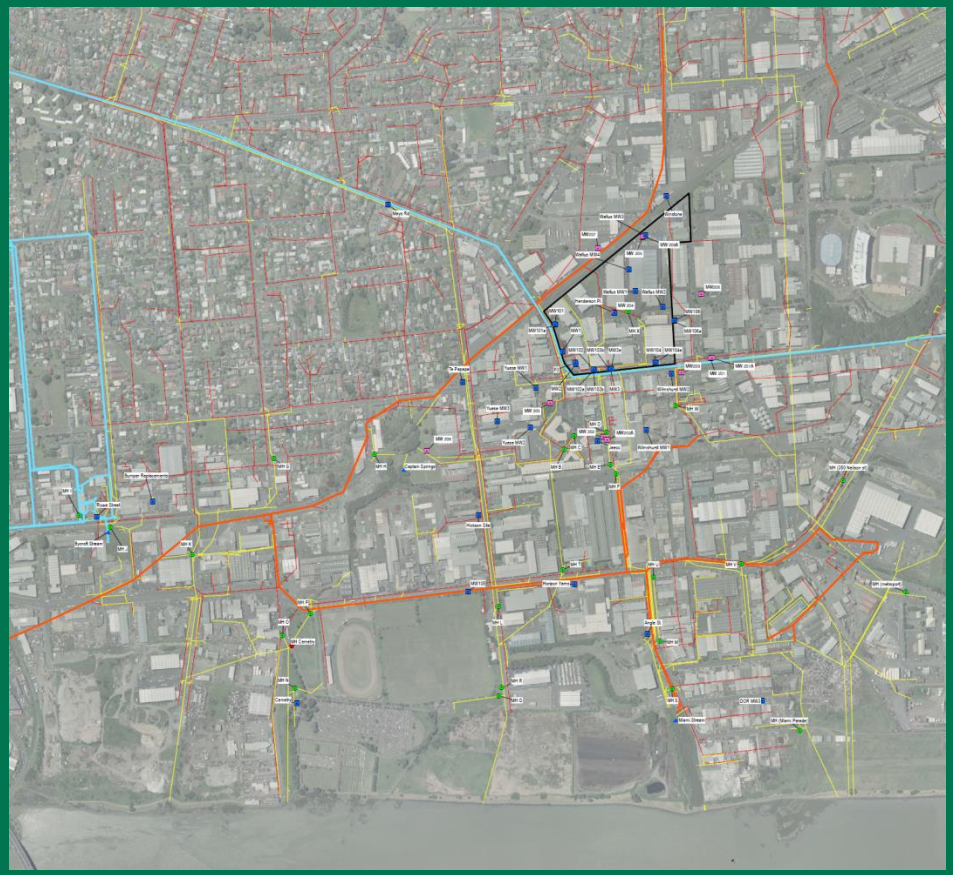
- In 1991 NZFF site was identified as potential contamination source
- The NZFF site is located 1km north of Mangere Inlet, is 9.5 hectares, slopes gently to south-west and about 15-20 masl
- Between 1984-87 the site was subdivided into 18 lots, on-sold and redeveloped into factories warehouses and offices

Main Features & Resources Down-gradient of NZFF Site



- Surface Water: Miami Stream, Captain Springs, Bycroft Stream, including nationally endangered aquatic moss ‘Fissidens berteroi’
- Marine: tidal mudflat habitats, particularly shellfish communities
- Groundwater: Onehunga Aquifer drinking water supply (DWS) production wells, closest is Watercare’s Rowe St. well
- Other groundwater extraction bores including: Jaeco Industries, Auckland Anodisers & Bumper Replacements

Utilities & Other Contaminated Sites Down-gradient of NZFF Site



- Major service utilities including: bulk drinking water supply, wastewater lines & stormwater lines (Watercare & Metrowater) and private stormwater & water supply lines
- Other known contaminated sites: Yuasa Batteries, Auckland Anodisers, former Quality Electroplaters & former Dominion Oil Refinery
- Reclaimed coastal land including Waikaraka Cemetery and Pike's Point Landfills

The NZFF Site Operations (Photo 1959)

- Operated for 74 years from 1910-1984
- Manufactured, stored and handled fertiliser products
- Principal process was conversion of rock phosphate to superphosphate fertiliser using sulphuric acid
- Rock phosphate (high in fluoride) was stored in uncovered stockpiles
- Sulphur, serpentine, potassium (potash) & acid salts were also stored on-site
- Sulphuric acid and hydrofluorosilicic acid were stored in silos
- Stormwater was disposed via on-site soakage holes and sumps
- Potential contaminants from NZFF site: copper, sulphate, cadmium, fluoride, phosphorus & low pH

Scoping the Problem
ARC/ACC Investigations

- Soil sampling onsite (1992)
- Groundwater sampling rounds on and offsite (1992-96)
- Manukau Harbour sediment & shellfish sampling (1993)
- Stormwater system sampling (1993)
- Environmental site investigation, risk assessment & remedial options (1993-94)

Challenges/Concerns

- Original polluter no longer legally exists (pre-RMA 1991)
- Potentially very high costs & difficulties in engaging current landowners (not original polluters) to undertake investigations particularly as a coordinated effort
- Groundwater plume posed a potentially high risk to Onehunga DWS, major infrastructure utilities, human health & both freshwater and marine environments
- The source(s) and migration pathways of the Patrick St. stormwater, Miami (Green) Stream & Mangere Inlet contamination was poorly understood

Challenges/Concerns (cont.)

- Soil (source) contamination is difficult to investigate due to site's redevelopment, existing buildings and infrastructure
- Complex, volcanic lava flows and tuffs and the heterogeneous, fractured basalt aquifers are difficult to accurately conceptualise and/or model
- Groundwater plume covers a very large area and was relatively poorly understood, particularly the significance of any preferential migration pathways
- Many offsite additional contamination sources are unknown or poorly defined providing significant uncertainty as to the source of some of the groundwater contamination

The ‘Green Stream’ Project Team (2003-2010)

In 2003 the ‘Green Stream’ project team was setup under the principals of ‘good science’ to assess the on-going risks posed by this contamination:

- Auckland Regional Council
- Key Infrastructure Stakeholders: ACC/Metrowater & Watercare
- URS & PDP Environmental Consultants
- MfE Contaminated Sites Remediation Fund

Principals of the ‘Value of Good Science’

- The ‘Green Stream’ project team was developed based on strong technical expertise, collaboration and ability for innovative and strategic thinking
- Significant knowledge gaps were identified based on the information needed to determine the ‘actual’ human health and environmental risks and the risks to infrastructure
- Key stakeholder were actively engaged and their specific needs integrated into the project outcomes also allowing use of their technical expertise and resources

MfE Contaminated Sites Remediation Fund (CSRF)

CSRF provided a sound framework to assess:

- the site's potential risk to human health and the environmental bench marked on a national level
- scientific, cultural and recreational values of the area
- landowner/occupier responsibility for site investigations and remediation

- Up to 40% funding of site investigations can be awarded, if project meets MfE's CSRF criteria
- Applications were made to MfE in Oct 2003 & 2007 for funding of the 'Green Stream' site investigations and remediation

Aims & Works Programme – Stage 1 (CSRF 2004-07)

- To identify significant knowledge gaps needing further investigation, preventing the production of a scientifically robust risk assessment

  Investigation works involved:

  1. Collating existing data, conducting seasonal groundwater, stormwater, stream quality and water level monitoring and a groundwater plume assessment (2004-05)
  2. Sediment & shellfish sampling in the Mangere Inlet (2005)
  3. Revision of the human health and environmental risk assessment (2006-07)

- Principal gaps identified was the poor understanding of the hydrogeology, migration pathways and significance of the risks

Site Investigation Aims – Stage 2 (CSRF 2008-10)

- To establish a robust groundwater monitoring well network focused on:

1. 'Ring-fencing' NZFF site to confirm offsite migration and contaminant levels
2. The presence and nature of any shallow (perched) groundwater system
3. The location, thickness, continuity and effect of the tuff layer
4. Providing sufficient offsite coverage of the plume, specifically concentrations and proximity to surface water courses, Watercare's drinking water supply wells and other contaminated sites
5. Determining preferential contaminant migration pathways via stormwater or other utility networks

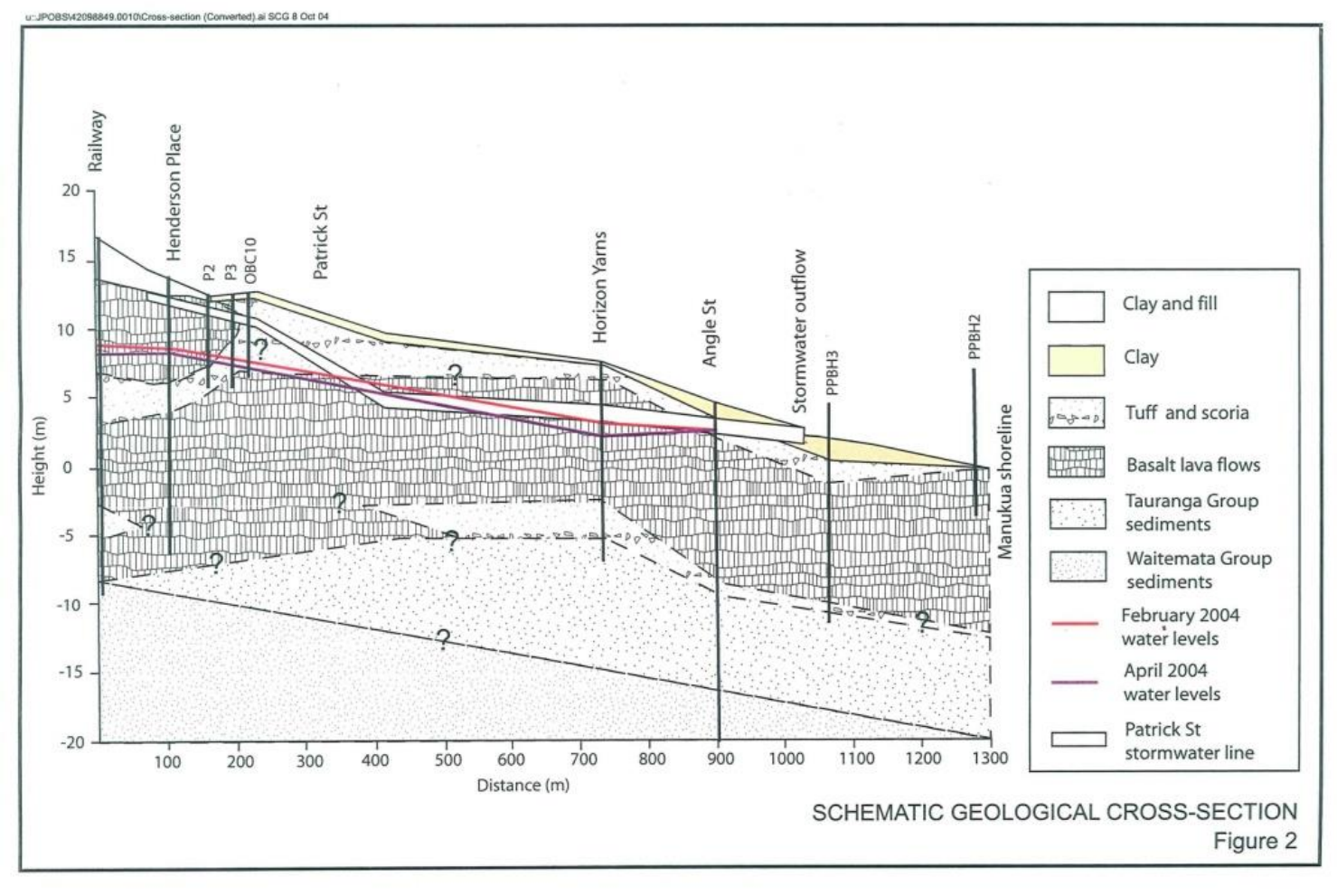
Works Programme – Stage 2 (CSRF 2008-10)

- Sediment & shellfish sampling in the Miami Stream and Mangere Inlet (2008)
- 3 stage rotary drilling, coring and groundwater monitoring well installation (27 shallow & deep wells)
- 2 rounds of integrated groundwater, stormwater & surface water quality and water level sampling (seasonal)
- Infrastructure level survey and utility network level data manipulation using GIS to accurately define the extent of the risk to infrastructure
- Assessment of on-going risks to human health & the environment

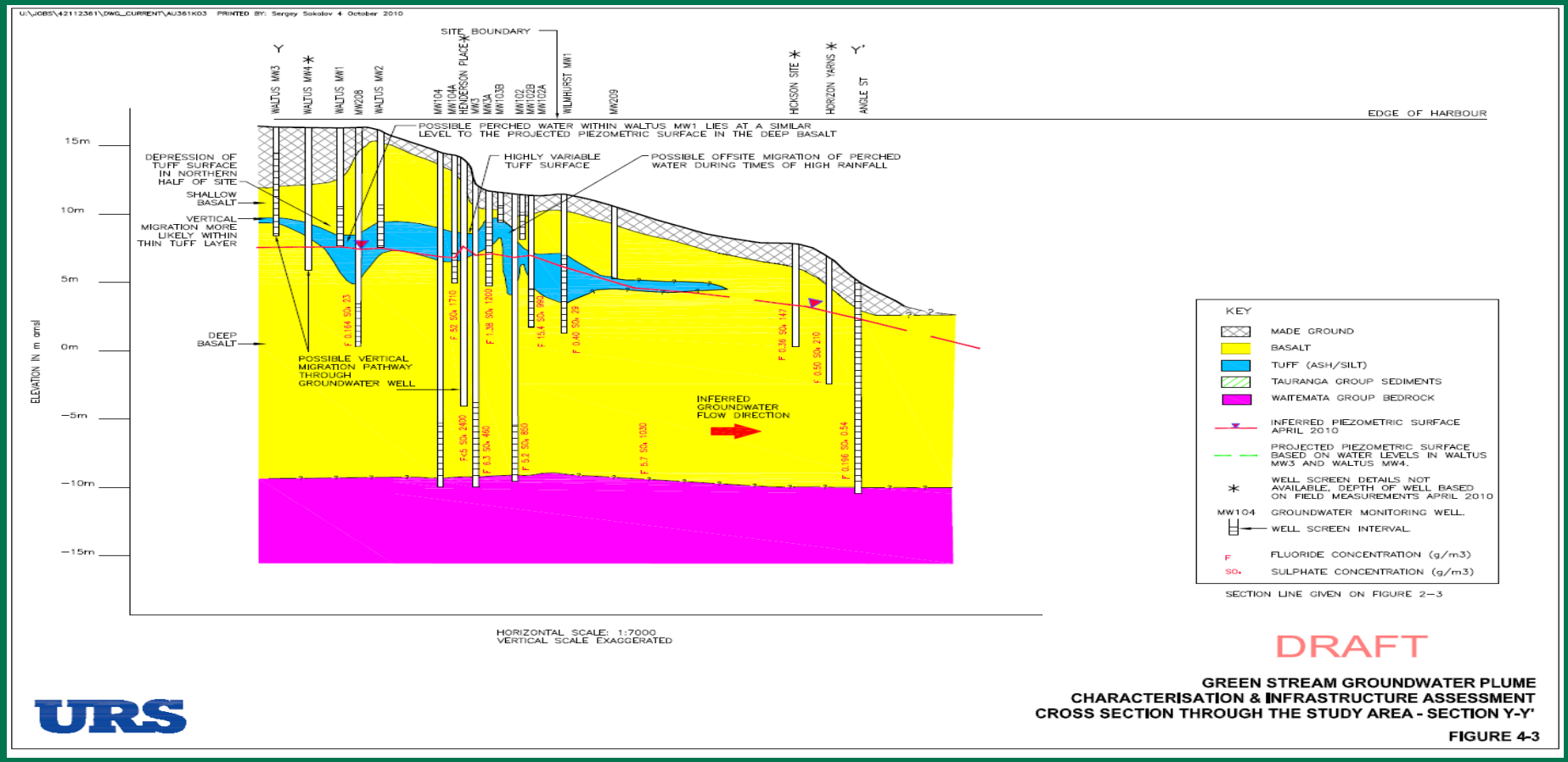
Data & Conceptual Understanding Comparison 1993 & 2010

- Geological & hydrogeological conceptual model development
- Groundwater flow patterns, contaminant concentrations & preferential flowpaths
- Infrastructure risk assessment
- Human health and environmental risk assessment summary

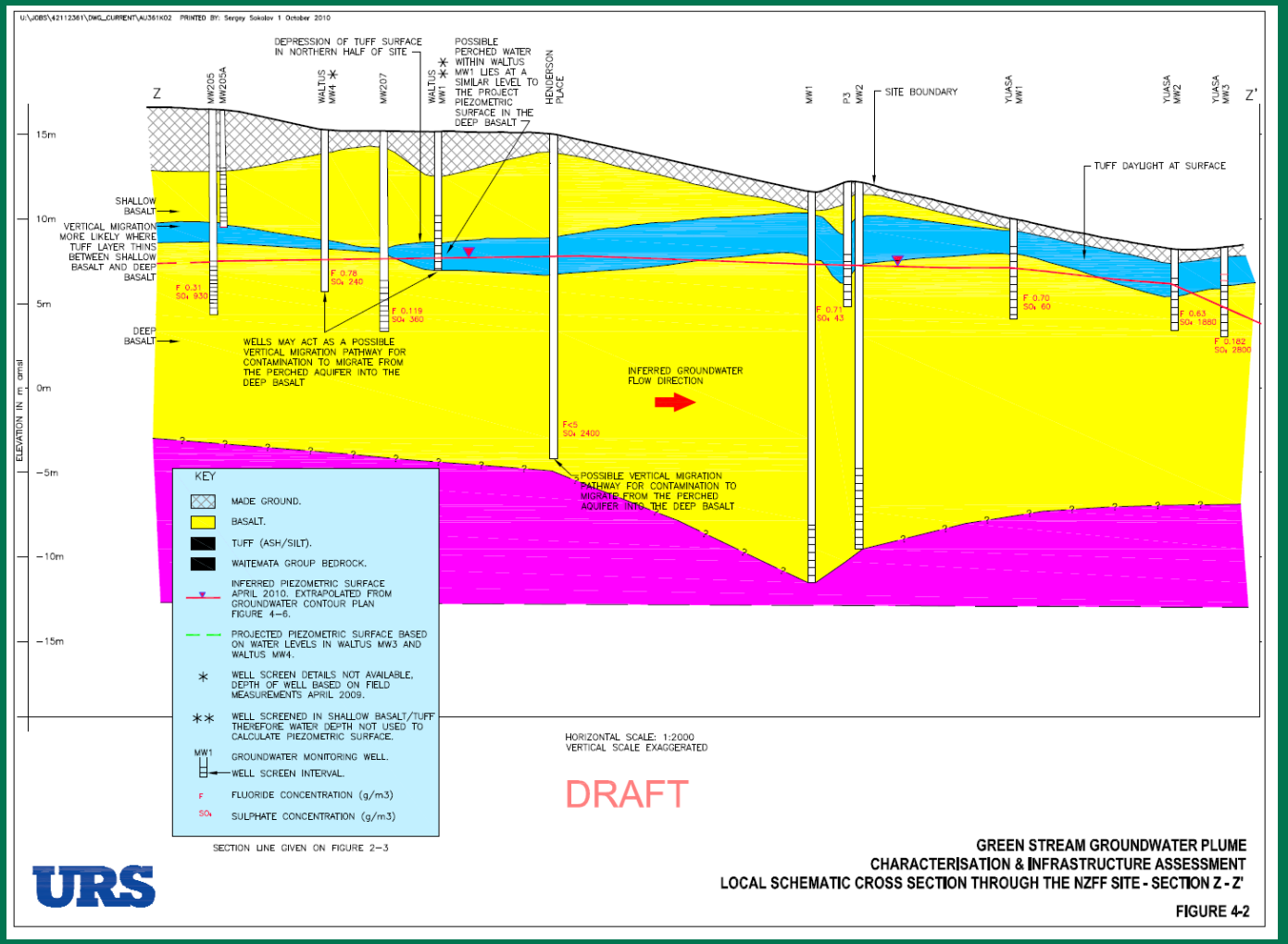
Geological X-Section NZFF-Angle St 1993



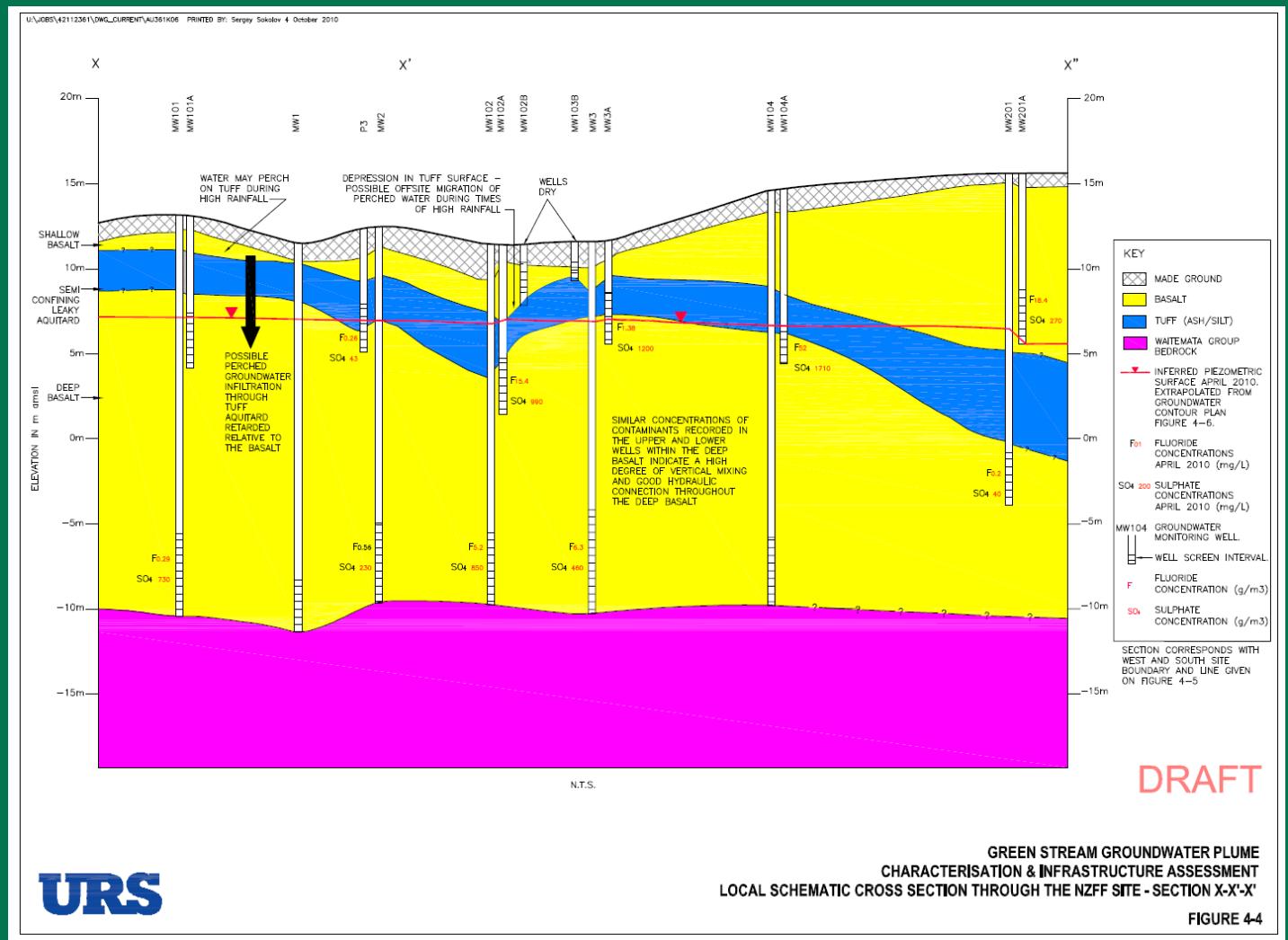
Geological Conceptual X-Section NZFF-Angle St 2010



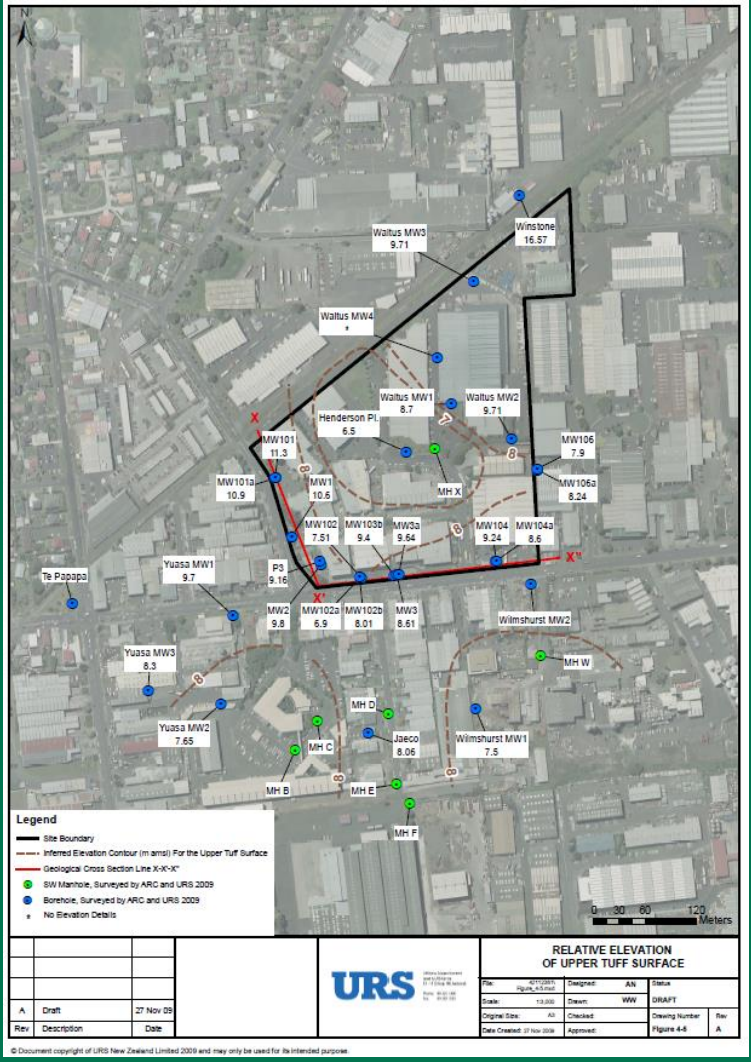
Geological Conceptual X-Section NZFF-Yuasa 2010

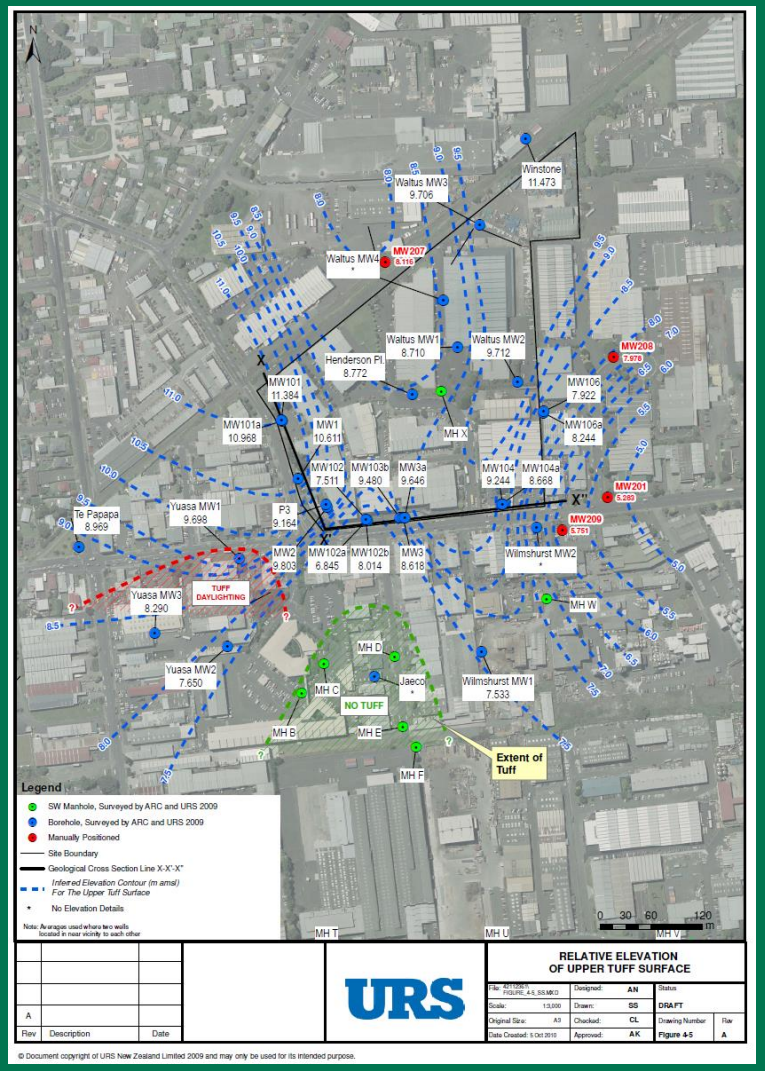


Geological Conceptual X-Section NZFF Site Boundary 2010

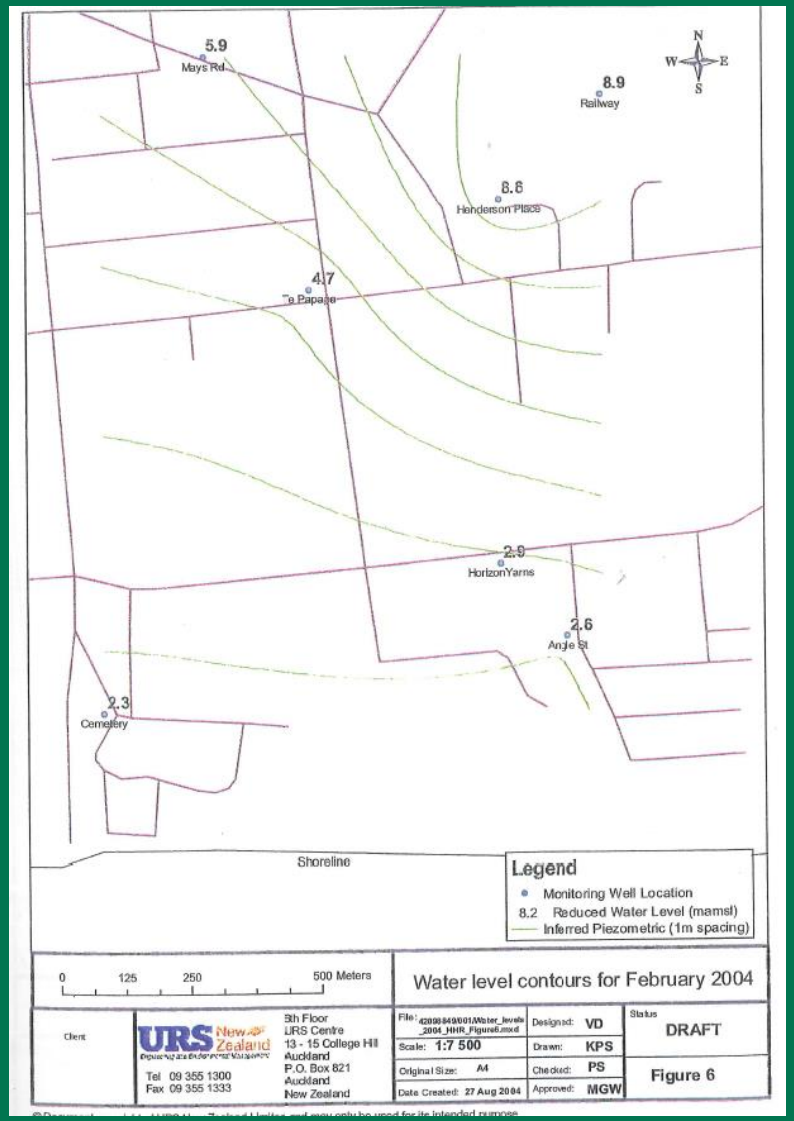


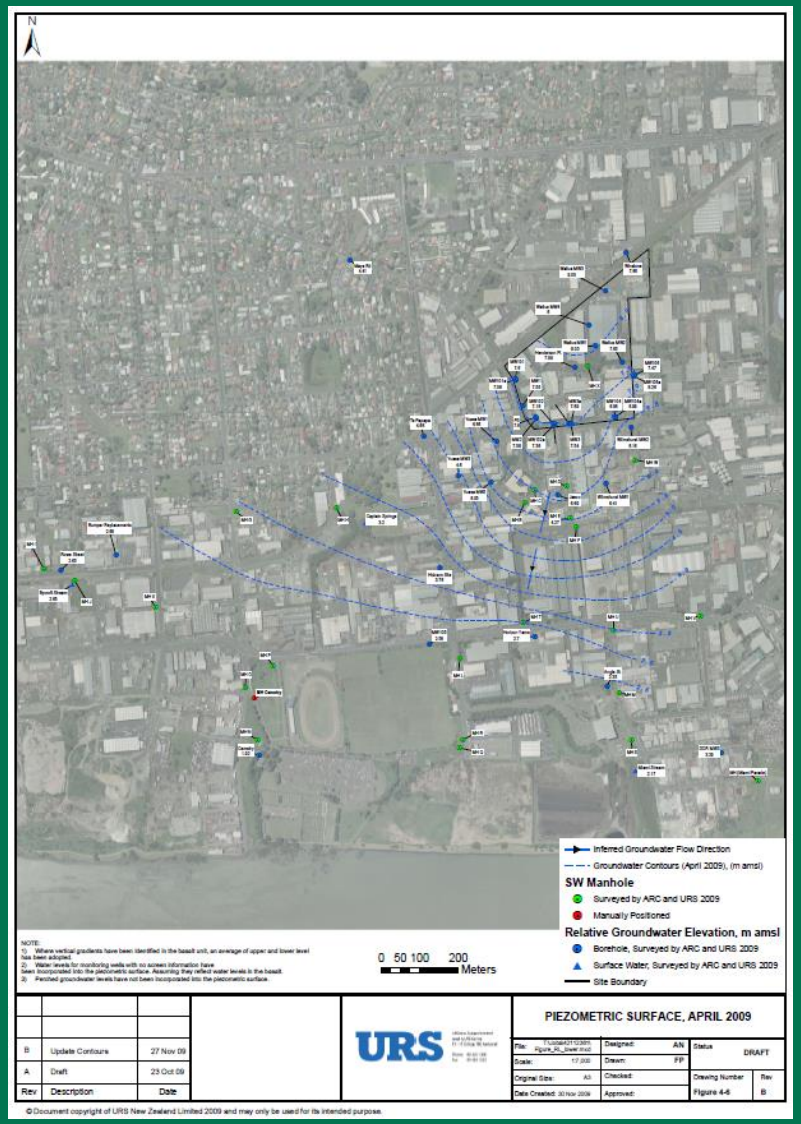
Upper Tuff Surface



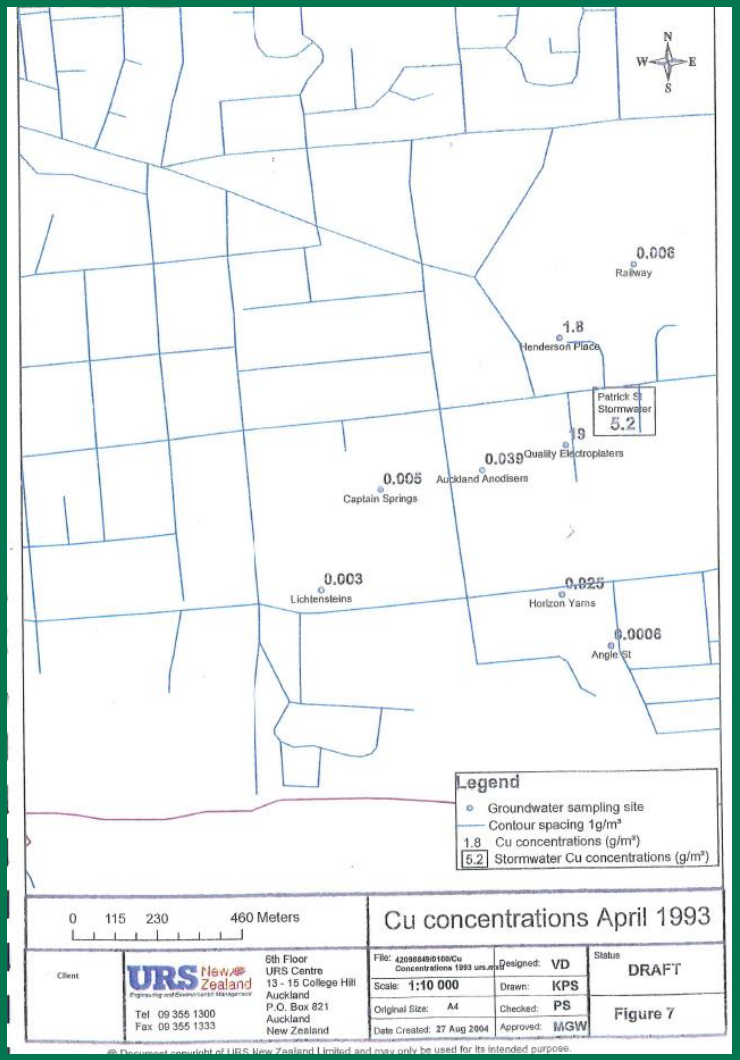


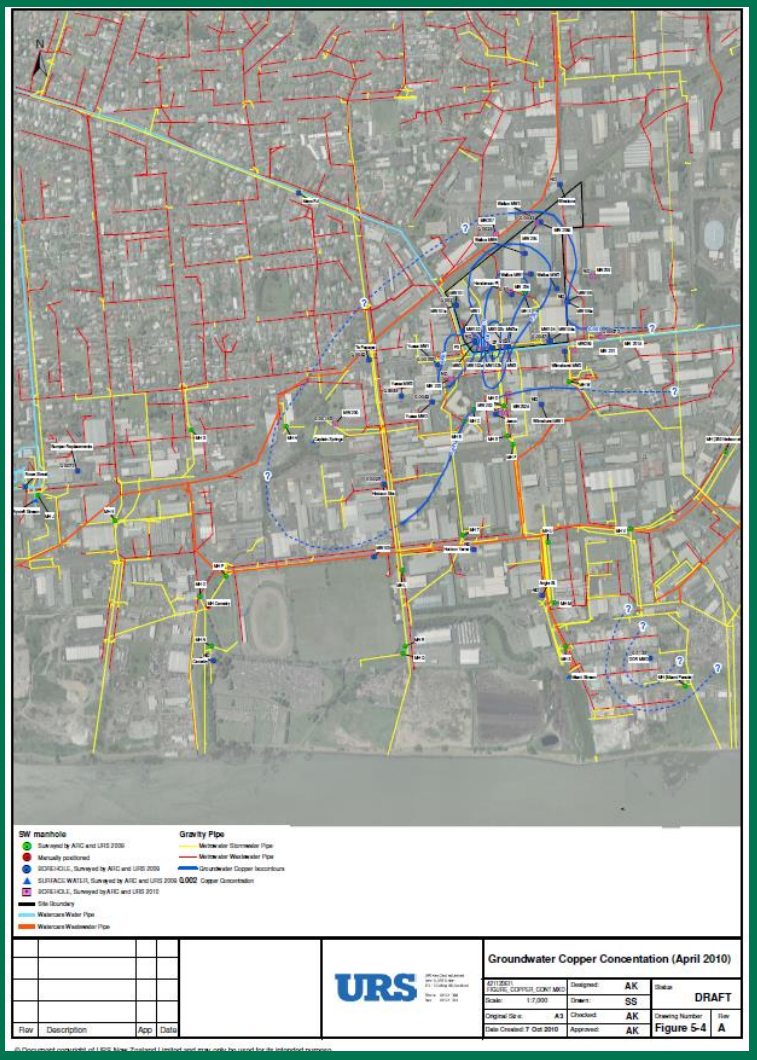
Groundwater Flow Directions



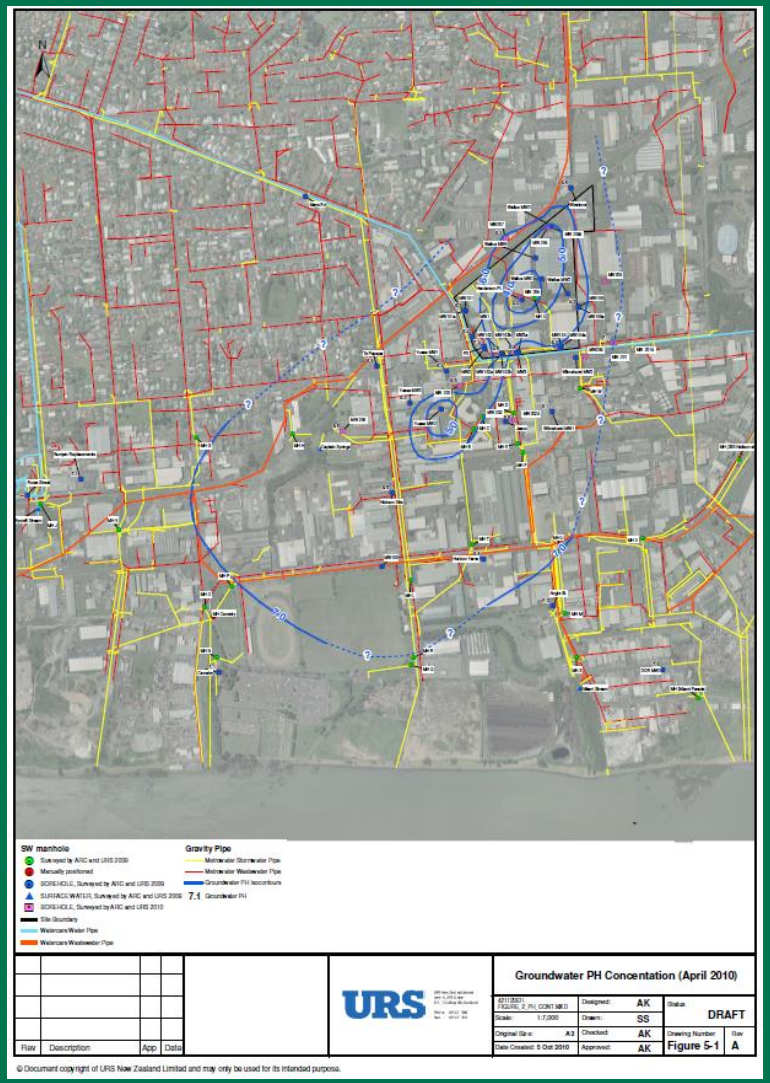


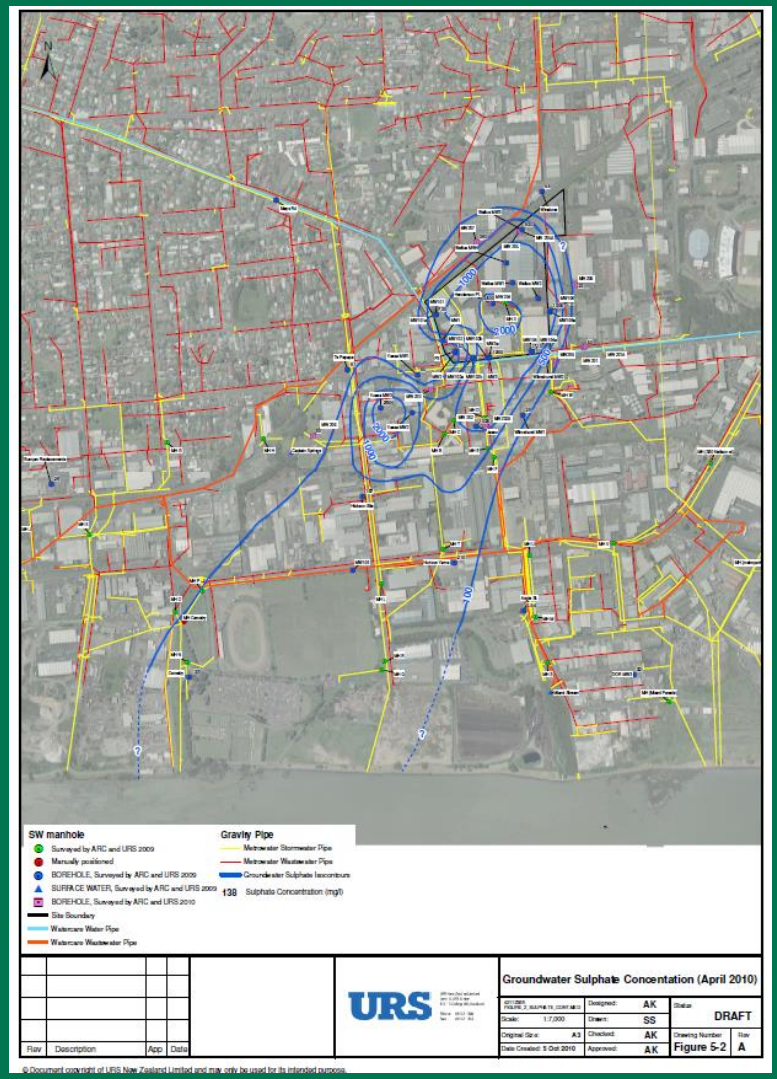
Groundwater Copper Concentrations



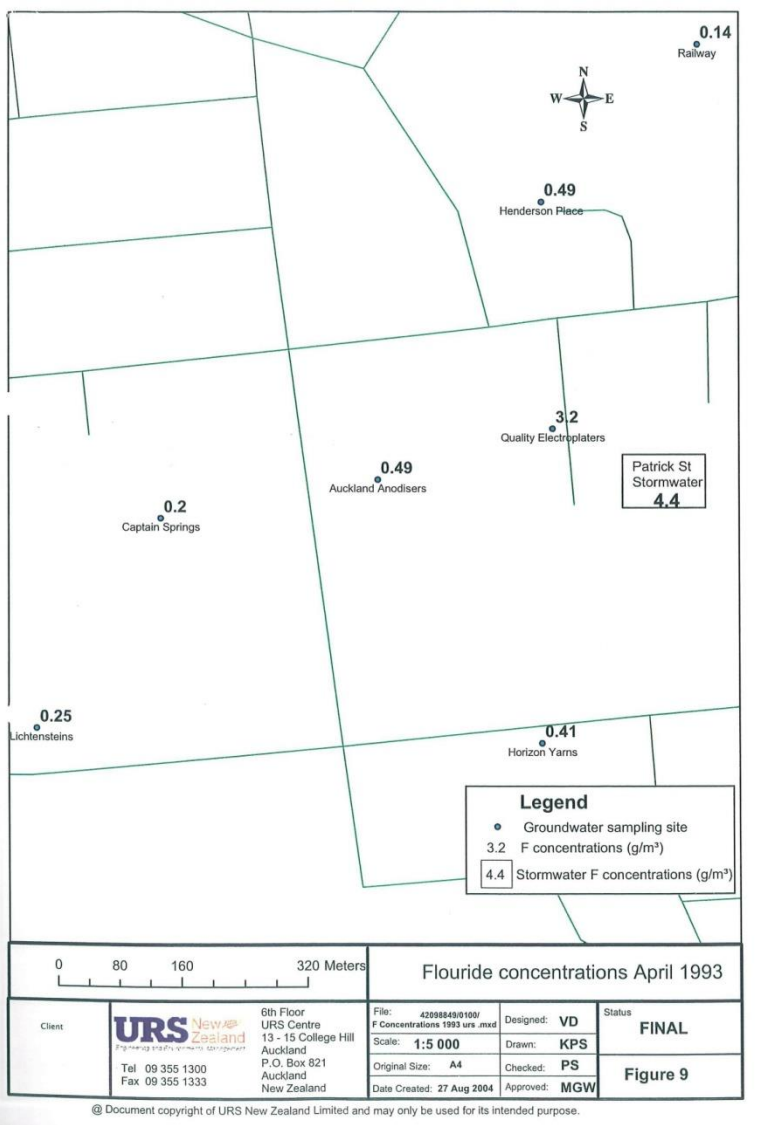


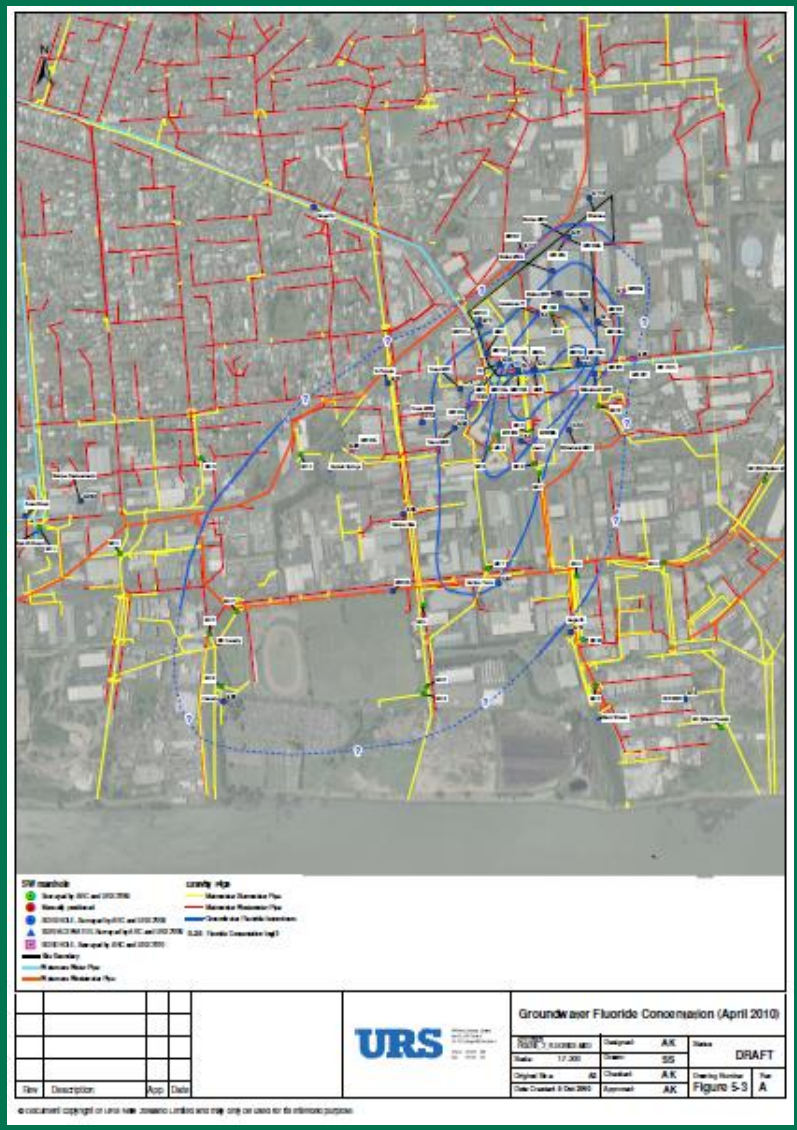
pH & Sulphate Concentrations 2010



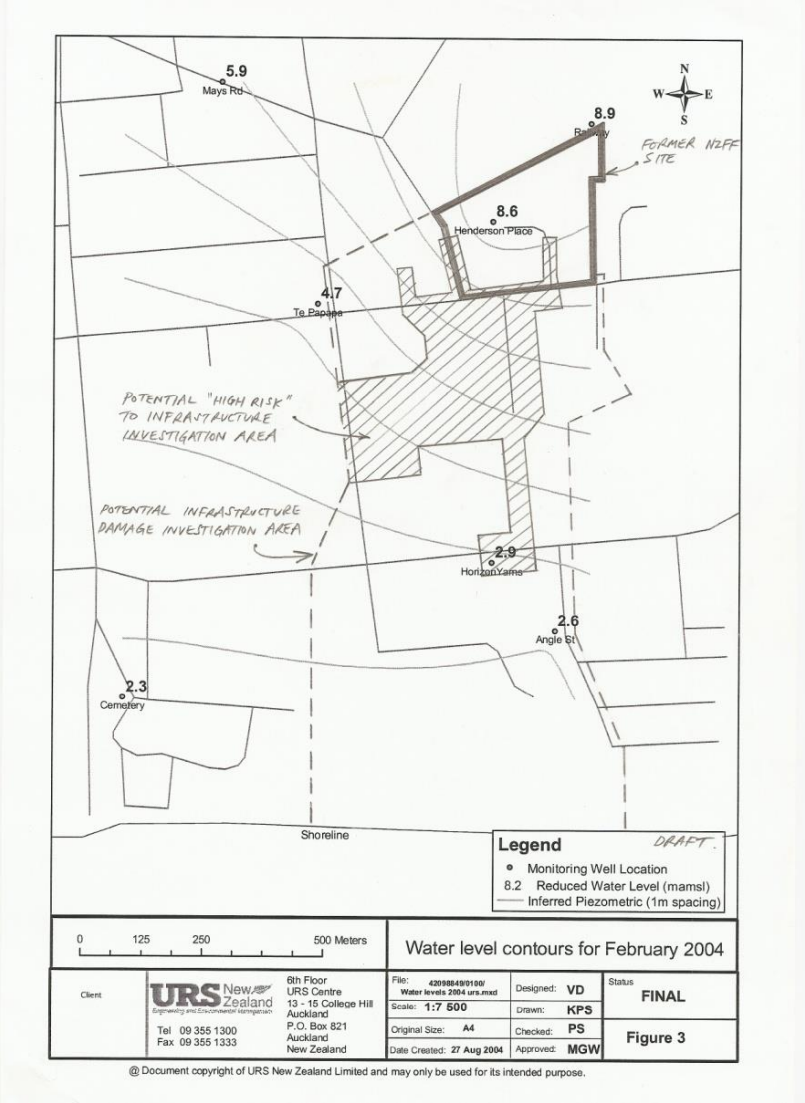


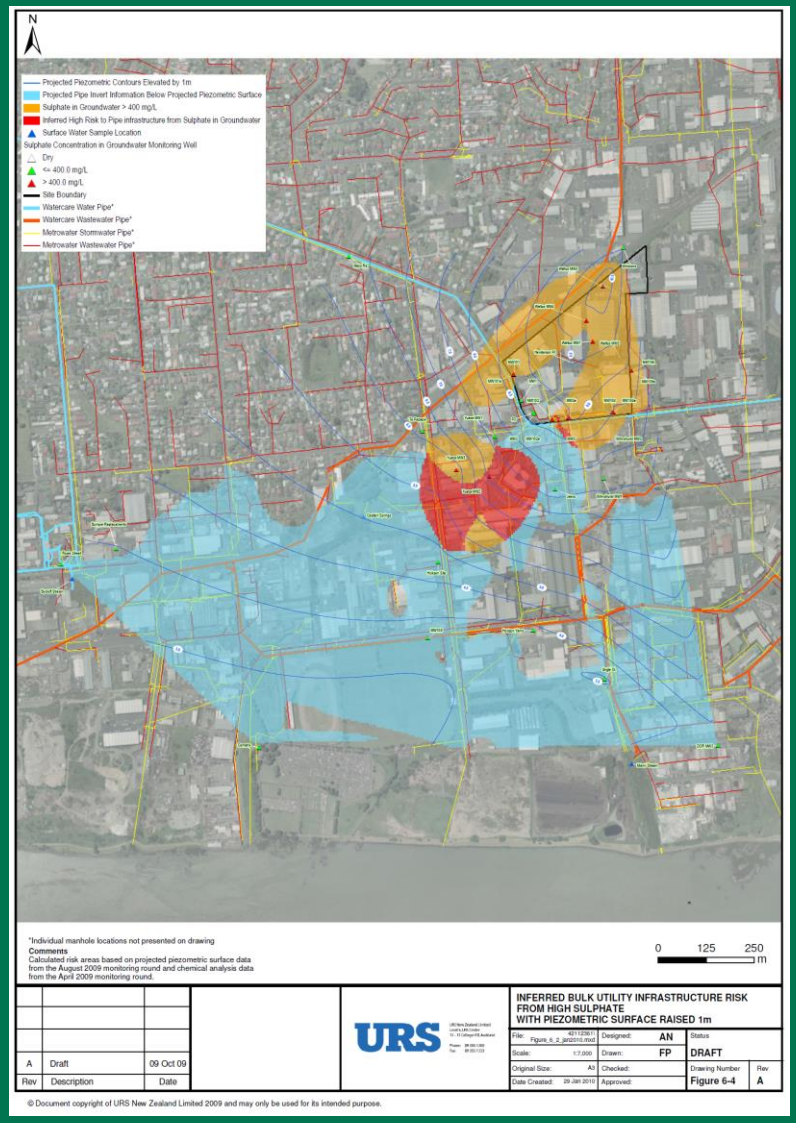
Groundwater Fluoride Concentrations



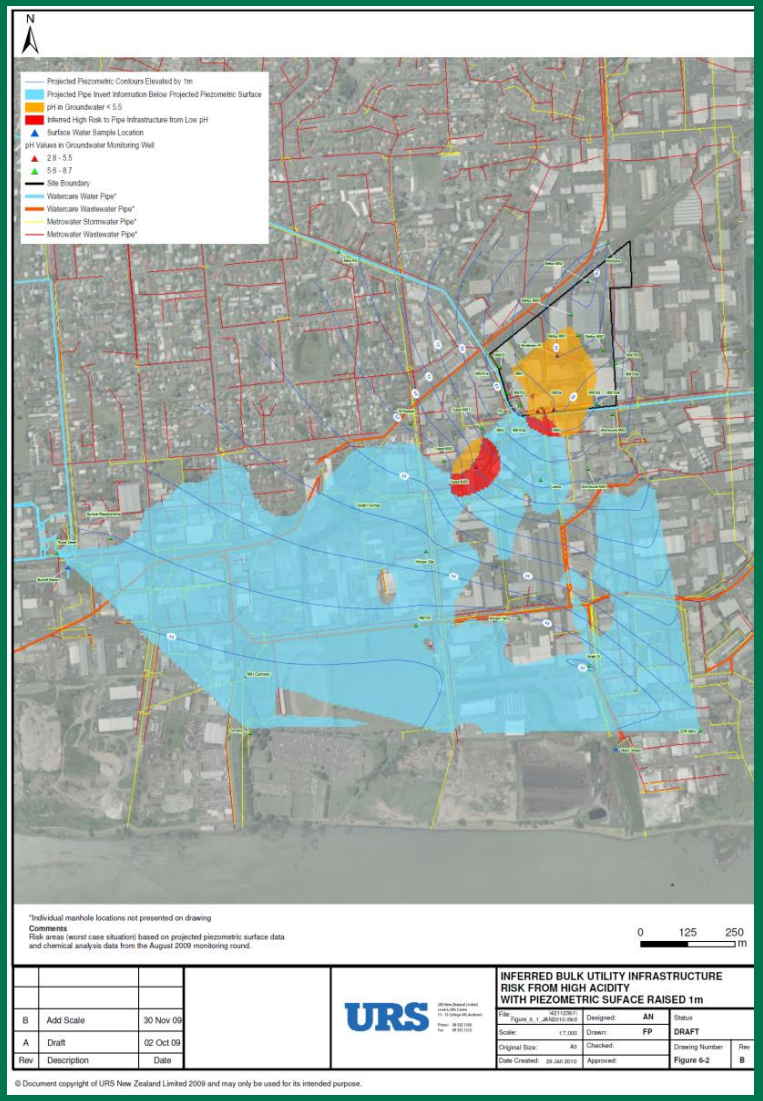


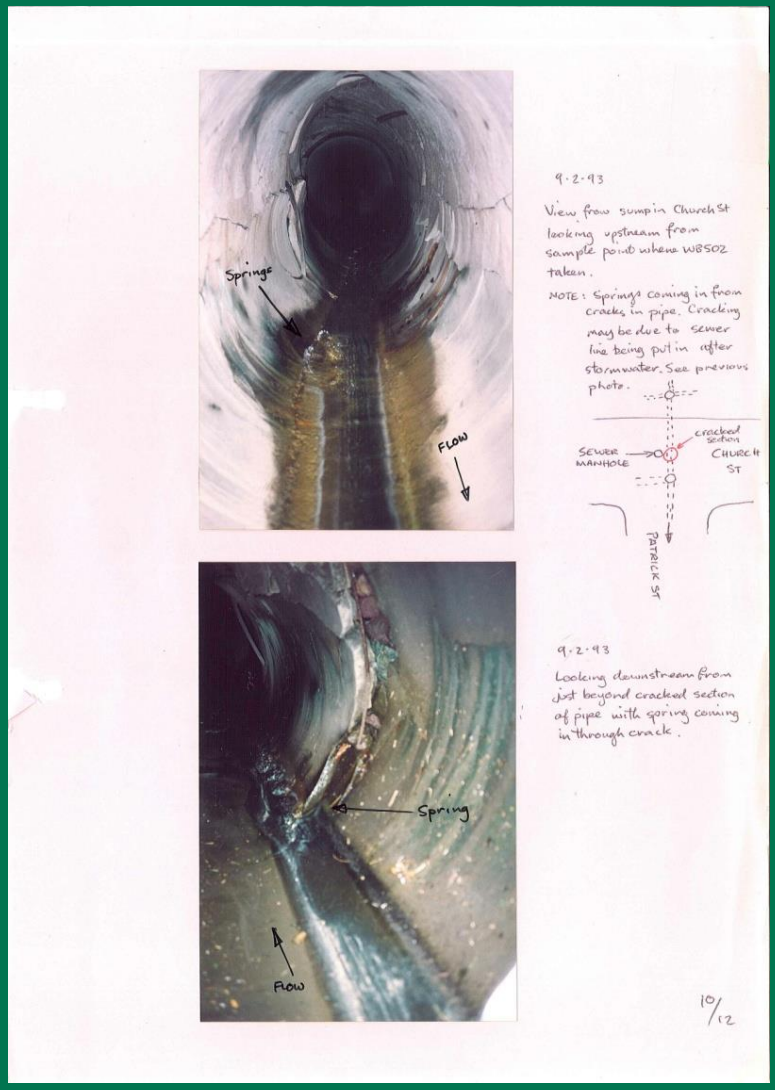
Infrastructure Risk Maps





pH Infrastructure Risk Map





What We Now Know

- Significant very acidic soil/fill contamination from the former NZFF site operations remains on-site as a source of contamination and potentially used as fill offsite
- Contaminants migrate vertically down through the unsaturated zone via natural recharge processes
- Two key aquifers exist in the vicinity of the site, the shallow unconfined above the tuff and the deep semi-confined aquifer below the tuff
- The tuff acts as a semi-confining layer allowing vertical leakage particularly where it is thin, it is likely that a number of the old boreholes that are screened across both aquifers provide a preferential pathway for contaminant migration into the deep basalt aquifer
- The top of the tuff topography, leading from the centre of the site southwards along Patrick St., forms a low lying channel which likely acts as a natural flowpath for contaminant migration

What We Now Know (cont.)

- The main contaminant plume (copper, sulphate, cadmium, fluoride, phosphorus) migrates within the deep basalt aquifer in a south-westerly direction
- Smaller localised ‘perched’ contaminant plumes are apparent in times of groundwater recharge, the occurrence and groundwater flow direction appears to be controlled by the topographic surface of the tuff
- In the south-east corner of the site, a perched groundwater system with elevated fluoride flows towards the south-east
- The deep basalt plumes lateral dispersion is relatively consistent under the current groundwater abstraction use due to the high aquifer transmissivity and natural topographic flow channels within the deep basalt aquifer
- The Watercare Rowe St. drinking water supply well, lying sufficient distance cross gradient from the plume, is assessed as currently outside the immediate high risk envelope, however the Captain Springs wetland and watercourse remains an area of concern and potential risk from the groundwater contamination
- The contaminant concentrations within the plume, stormwater, sediments and oysters are slowly reducing over time, however in areas of sediment deposition higher contaminant concentrations are found at depth

What We Now Know (cont.)

- On-site high soil acidity causes poor condition, leaky utility lines enabling lateral (offsite) contaminant migration and a preferential pathway to the environment
- The stormwater network is a very significant preferential pathway in areas where the groundwater levels are at or above the pipe and the pipe's integrity through acidic corrosion or age allows groundwater ingress
- The Patrick St. stormwater line acts as a major preferential pathway for contaminant migration due to its poor integrity from both age and acidic corrosion and it's location in the heart of the natural channel preferential pathway in the tuff
- Wastewater and drinking water supply lines are also at risk of corrosion dependant on their age, materials and period of time exposed to high sulphate and/or low pH
- Certainty around the existence of other offsite contaminant source areas and groundwater plumes, so allowing the ARC to require investigations appropriate remediation and management from the given landowner

Risks & Remediation 2010

Potential Risks:

- Human health risk to maintenance/excavation workers on-site and in the immediate vicinity of the site (Church Street and Patrick Street)
- Building material durability namely:

  - on-site building foundations and below ground services

  - off-site bulk utility services (lying at depth) intersecting the groundwater contamination plume, yielding high sulphate concentrations and high acidity
- Groundwater abstraction and use
- Environmental risk arising from contaminated stormwater discharges to the:

  - Miami Stream and Mangere Inlet sediment and shellfish (actual)

  - Captain Springs wetland and water course (potential)

Remediation planning:

- This understanding of contaminant migration and associated risks will enabled targeted, appropriate and cost effective remediation/management options to be developed

Conclusions

Investment of ‘Good Science’ driven and facilitated by strong collaboration and effective partnerships has provided:

- an accurate, rigourous and scientifically robust understanding of the:
  1. Nature and extent of the geology, hydrogeology & contamination
  2. Contaminant migration pathways
  3. Real risks requiring management, mitigation and remediation planning
- Financial savings, estimated at over $1 million dollars, from innovative and effective, staged evaluation of investigations, consistently using new data to revise, redefine and reduce project scope
- Key stakeholders actively involved and engaged providing information accurately taylored to meet their individual needs

Outcomes

- Project goals achieve far beyond initial expectations
- Clear conceptual understanding of technically complex contamination & risks
- Complete and robust information enabling effective, timely and targeted remediation and management planning and significant on-going cost savings

“The Value of ‘Excellent’ Science”

Acknowledgements to a Great Team

- MfE CSRF – Bruce Croucher
- ACC/Metrowater – Grant Ockleston & Xeno Captain
- Watercare – Shayne Cunis
- URS – Simon Hunt, Anthony Kirk, Antonia Newlands
- PDP – Neil Crampton
- ARC staff – Alastair Smaill, Eddie Grogan, Mary Manastyrski, Ross Winterburn, Peter Hancock, Clive Colemen
- Auckland University – Dr. Brian Ricketts, Vanessa Dally
- Numerous other staff and contributing parties

Auckland
Regional Council
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09 366 2000 www.arc.govt.nz

Staff Dedication – How we use to do it!
PPE – Did I forget something?

Auckland
Regional Council
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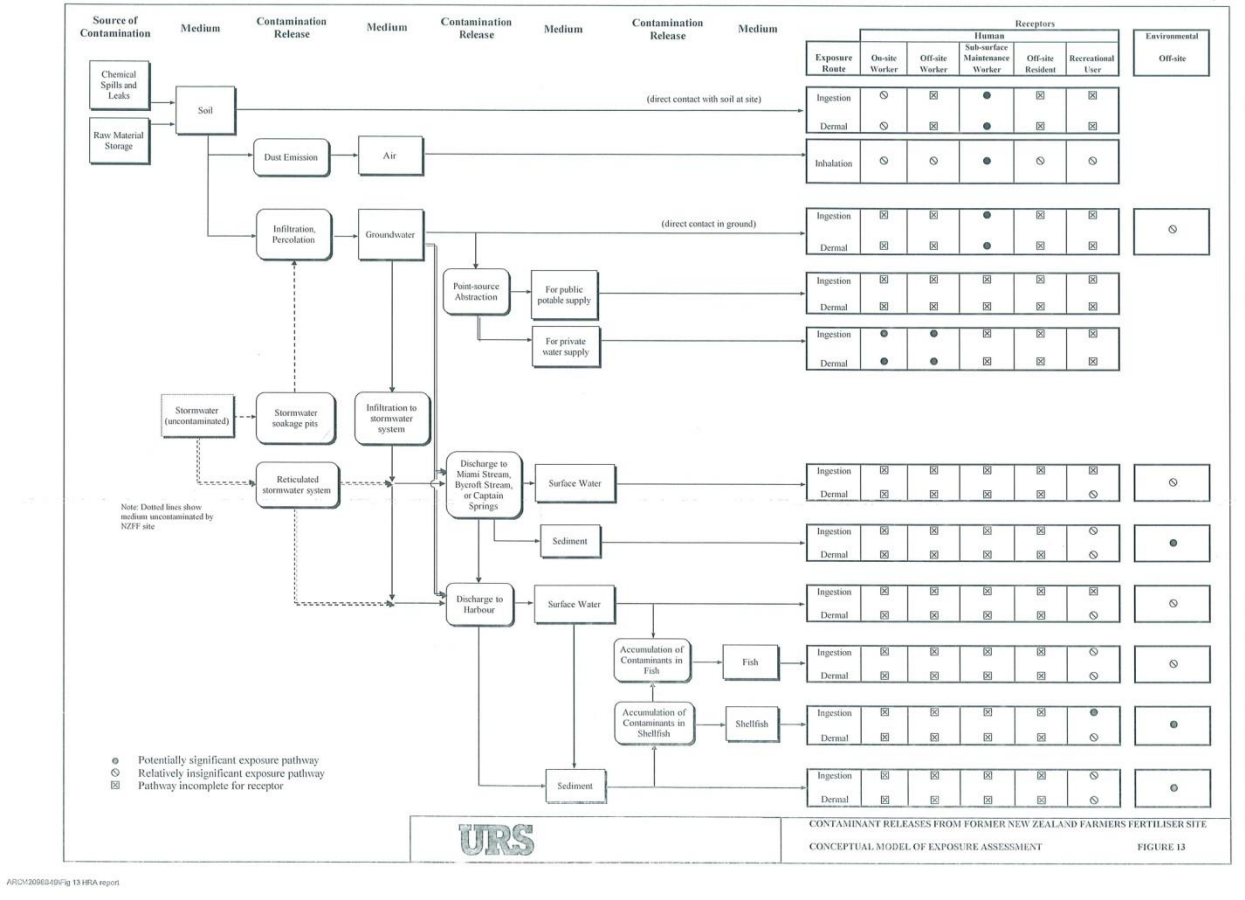
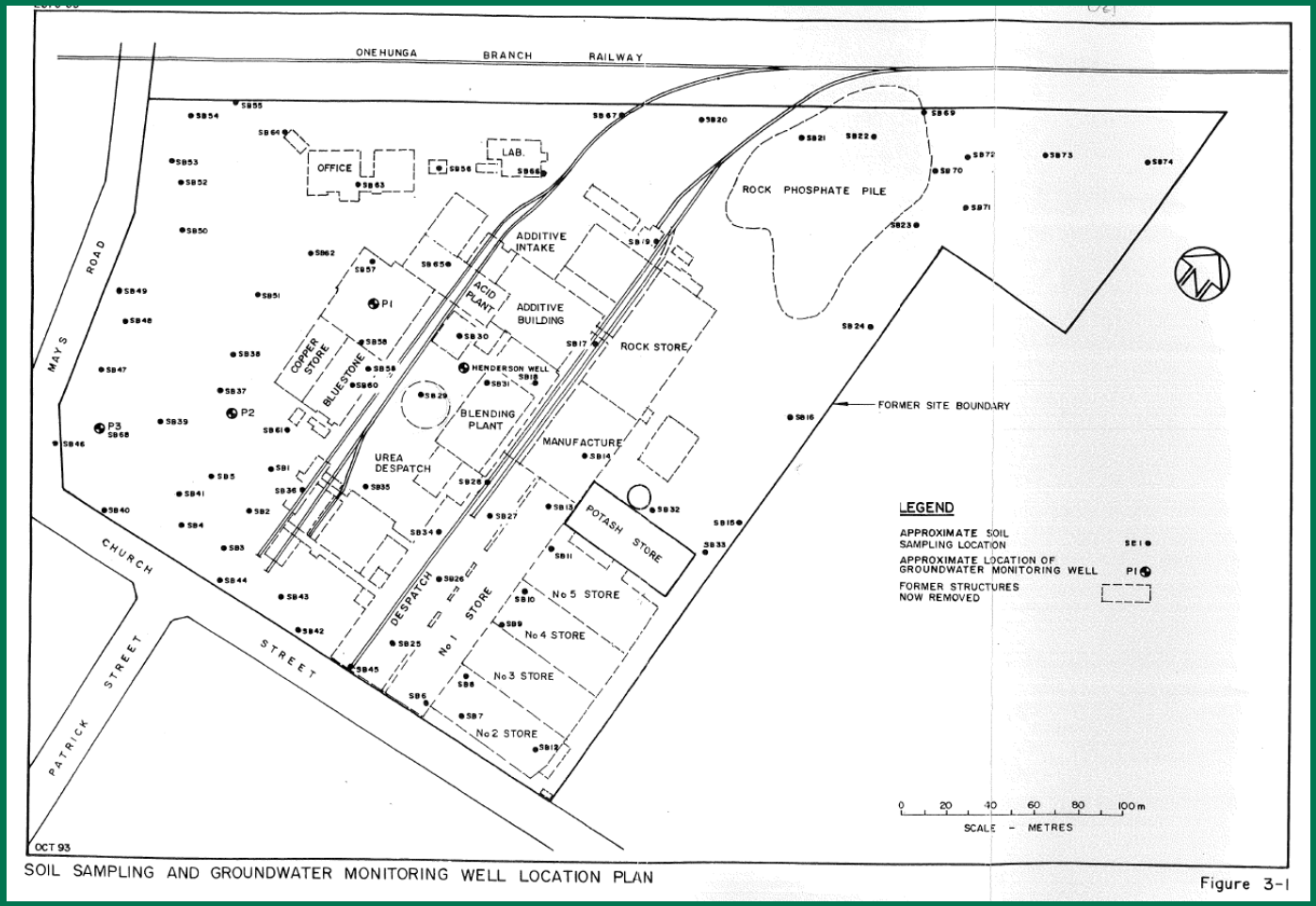
Accurate Information
Comprehensive Understanding
Informed Decisions based on
'Real' Risks

- Founded on solid, robust technical expertise facilitated by an exceptional, outcome focussed, collaborative team:

"The Value of 'Excellent' Science"

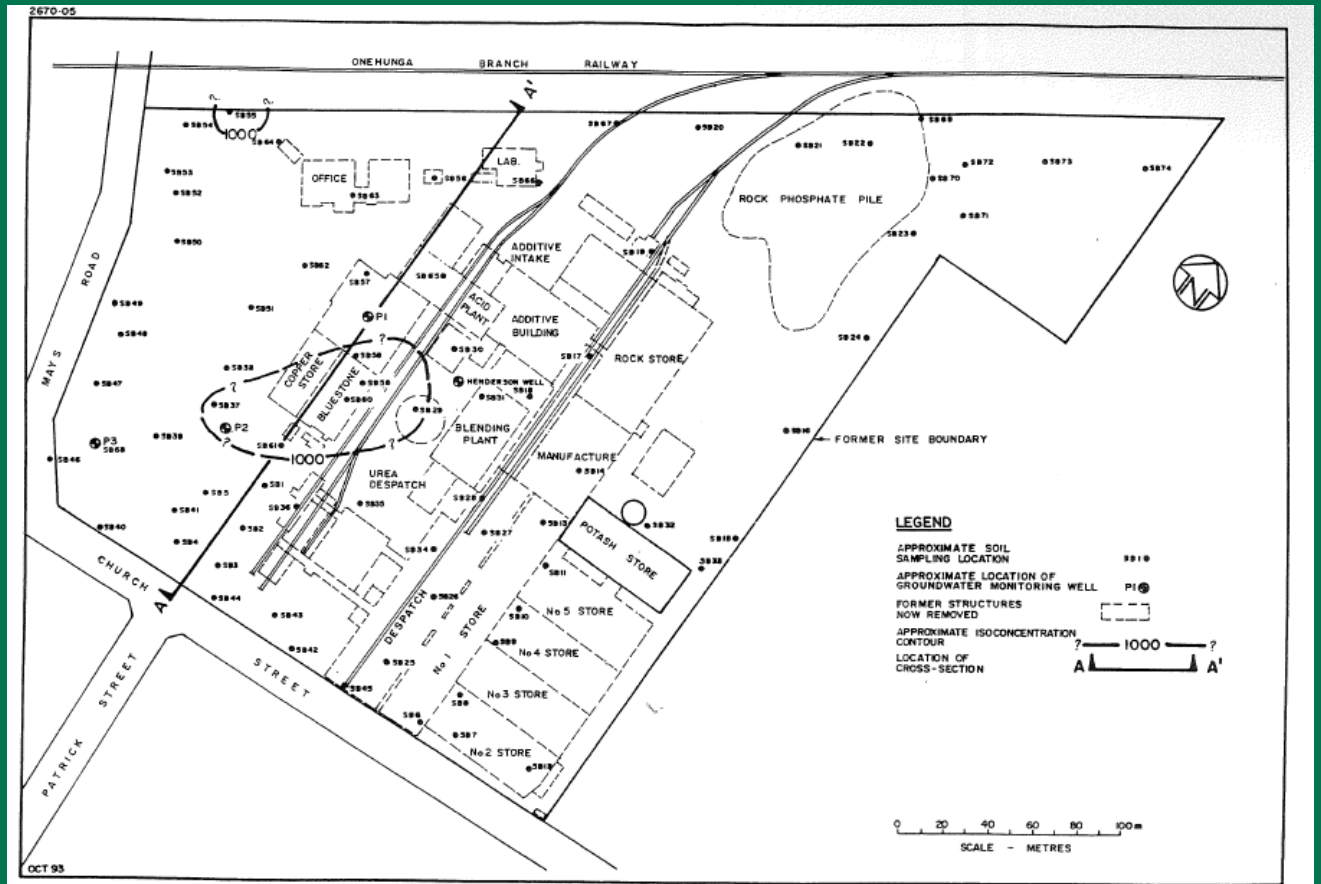
Human Health & Environmental Risk Assessment 2004-05





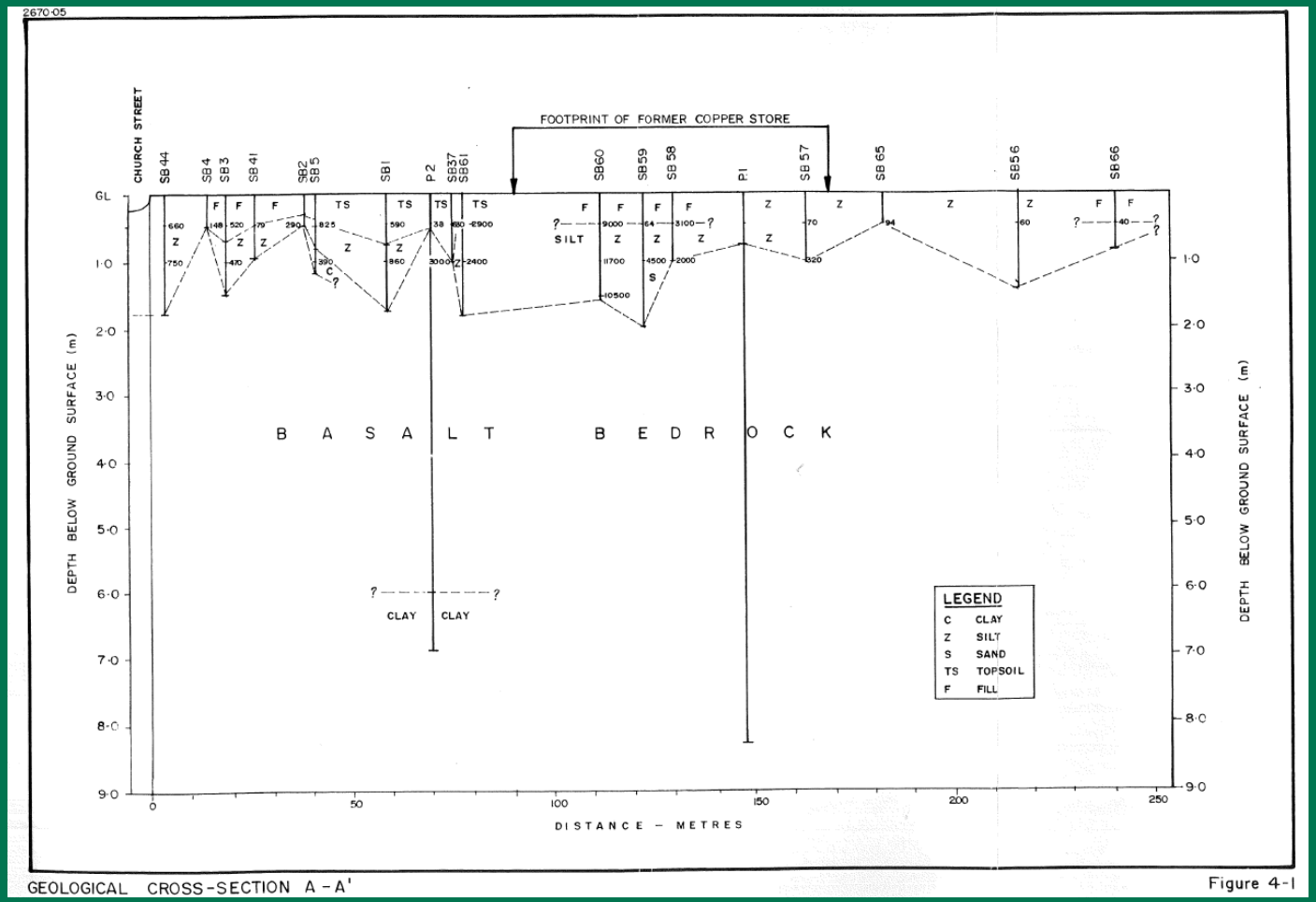
SOIL SAMPLING AND GROUNDWATER MONITORING WELL LOCATION PLAN

Figure 3-1



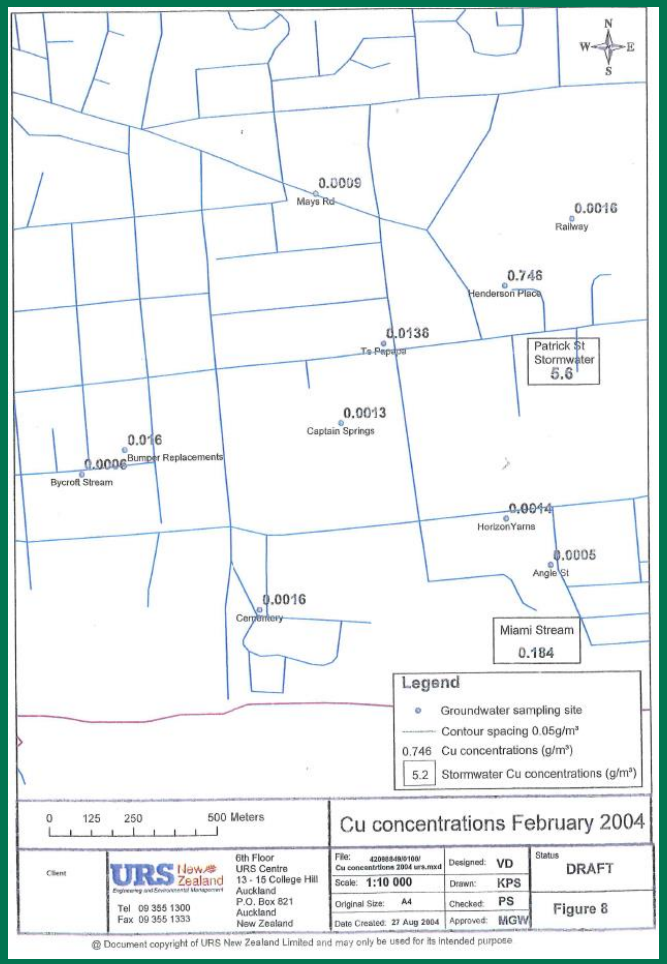
SOIL COPPER CONCENTRATION CONTOUR MAP (1·0m SAMPLING DEPTH)

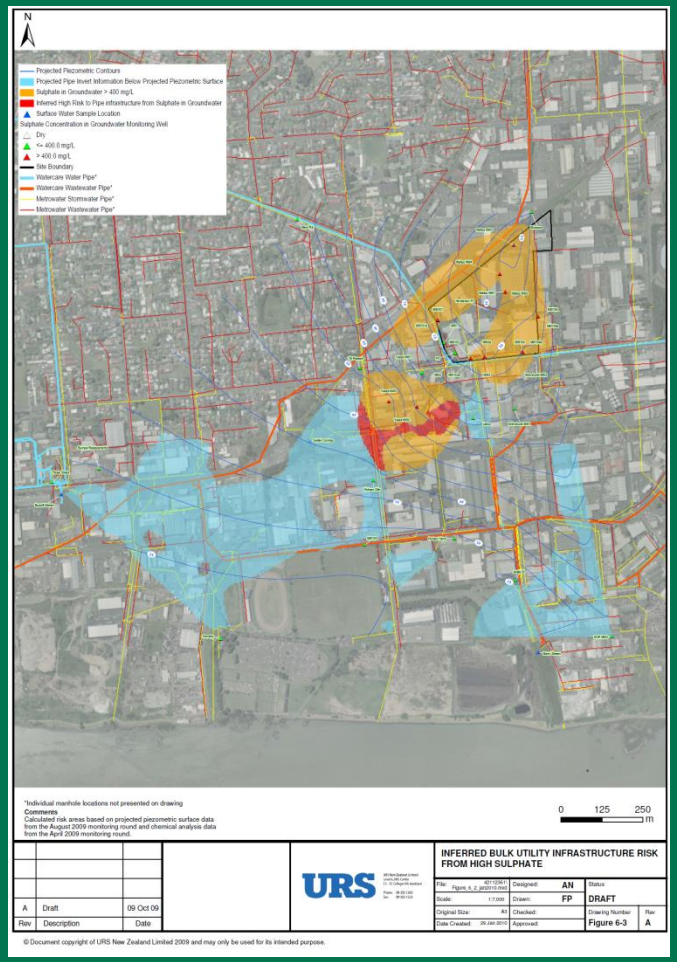
Figure 4-2b



GEOLOGICAL CROSS-SECTION A-A'

Figure 4-1




N
Projected Piezometric Contours
Projected Pipe Invert Information Below Projected Piezometric Surface
Sulphate in Groundwater > 400 mg/L
Inferred High Risk to Pipe infrastructure from Sulphate in Groundwater
Surface Water Sample Location
Sulphate Concentration in Groundwater Monitoring Well
Dry
<= 400.0 mg/L
> 400.0 mg/L
Site Boundary
Watercare Water Pipe*
Watercare Wastewater Pipe*
Metrowater Stormwater Pipe*
Metrowater Wastewater Pipe*
*Individual manhole locations not presented on drawing
Comments
Calculated risk areas based on projected piezometric surface data from the August 2009 monitoring round and chemical analysis data from the April 2009 monitoring round.
0 125 250
m
A Draft 09 Oct 09
Rev Description Date
URS
INFERRED BULK UTILITY INFRASTRUCTURE RISK FROM HIGH SULPHATE
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Rev: A
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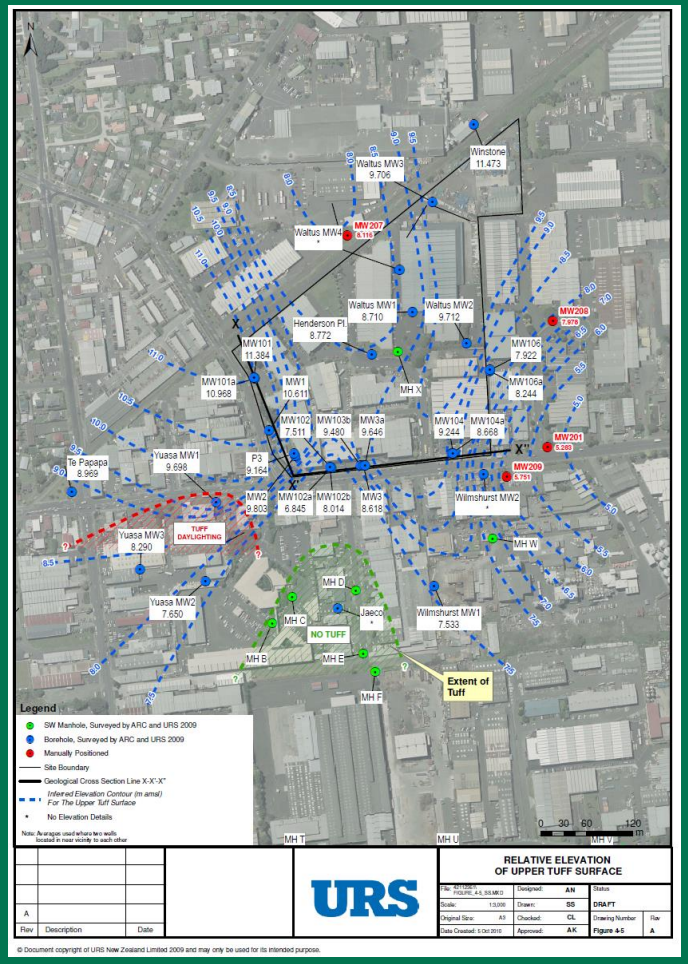
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Winstone
11.473
Waltus MW3
9.706
Waltus MW4
MW207
5.111
Waltus MW1
8.710
Waltus MW2
9.712
MW208
7.976
Henderson Pl
8.772
MW101
11.384
MW106
7.922
MW101a
10.968
MW1
10.611
MH X
MW106a
8.244
MW102
7.511
MW103b
9.480
MW3a
9.646
MW104
9.244
MW104a
8.668
MW201
5.283
X
X'
P3
9.164
MW209
5.751
Te Papapa
8.969
Yuasa MW1
9.698
MW2
9.803
MW102a
6.845
MW102b
8.014
MW3
8.618
Wilmshurst MW2
TUFF DAYLIGHTING
Yuasa MW3
8.290
MH W
MH D
MH C
Jaeco
NO TUFF
Wilmshurst MW1
7.533
Yuasa MW2
7.650
MH B
MH E
MH F
Extent of Tuff
MH T
MH U
MH V
0 30 60 120 m
Legend
SW Manhole, Surveyed by ARC and URS 2009
Borehole, Surveyed by ARC and URS 2009
Manually Positioned
Site Boundary
Geological Cross Section Line X-X'-X"
Inferred Elevation Contour (m amsl) For The Upper Tuff Surface
No Elevation Details
Note: Averages used where two wells located in near vicinity to each other
A
Rev
Description
Date
URS
RELATIVE ELEVATION OF UPPER TUFF SURFACE
File: 42115825 / FIGURE_4-5_RELMC3
Designed: AN
Status
Scale: 1:3,000
Drawn: SS
DRAFT
Original Size: A3
Checked: CL
Drawing Number
Rev
Date Created: 5 Oct 2010
Approved: AK
Figure 4-5
A
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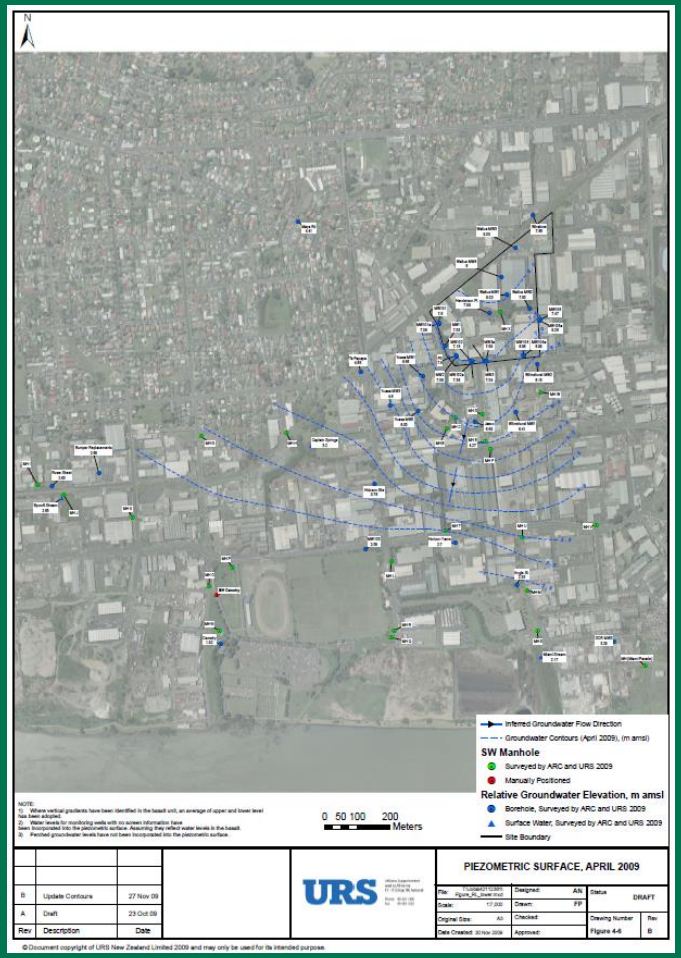
N
Inferred Groundwater Flow Direction
Groundwater Contours (April 2009), (m amsl)
SW Manhole
Surveyed by ARC and URS 2009
Manually Positioned
Relative Groundwater Elevation, m amsl
Borehole, Surveyed by ARC and URS 2009
Surface Water, Surveyed by ARC and URS 2009
Site Boundary
0 50 100 200 Meters
B
Update Contours
27 Nov 09
A
Draft
23 Oct 09
Rev
Description
Date
URS
PIEZOMETRIC SURFACE, APRIL 2009
Designed: AN
Status
DRAFT
Drawn: FP
Checked:
Original Size: A3
Drawing Number
Rev
Approved:
Figure 4-6
B
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