New Zealand Aluminium Smelters Limited

SCL GROUNDWATER STATUS

2020

Distribution: Environment Southland

Provider: NZAS

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CONTENTS

1 Summary

Reports on the groundwater monitoring data for the Cathode Pad and Treatment Plant were provided to Environment Southland (ES) in 1999, 2002 and again in 2005 to confirm satisfactory progress of natural remediation of cyanide and fluoride leaching from the SCL pad. In 2006 Environment Southland approved and signed off the completion of the rehabilitation project[1] after reviewing the NZAS 2005 SCL Groundwater Report.

ES have requested an update of the monitoring data for the period 2005 to 2020 after a spill to ground occurred from a treatment tank on 2 April 2020. This monitoring data further supports the position that there have not been discharges arising from NZAS' current SCL pad; with all discharges the subject of this monitoring program relating to historical events in the early 1990's.

Groundwater results have been graphed and are displayed in Section 4: "Data for Individual Zones". The variability in the shallow pea gravel layer may be due to the normal variation of rainfall and storm surges as well as the general movement of groundwater towards the sea. The key findings from the monitoring data from 2005 to 2020 are summarised below.

Background Zone
The deep bore 2/2 has remained unchanged and relatively stable since 2005 for all analytes monitored.

SCL Zone
Shallow pea gravel bores 3/1, 3/2, 3/3: All contaminant levels have continued to decrease significantly since 2005 but bores have showed some variability over the last fifteen years. A single spike in cyanide was observed in 2011 for all three bores possibly due to higher than usual rainfall around the month of sampling. A fluoride spike was seen between 2007 and 2009. These incidents were investigated but no root cause was found. The underground discharge pipe for treated effluent was replaced in 2006 as a precaution for potential leaks into the ground. Contaminant levels seen for fluoride and free cyanide for bore 3/3 are similar to levels observed in the background zone. Total cyanide concentrations are above background levels seen in bore 2/2.

Deep sand bore 3A/1: All contaminant levels have dropped. Fluoride and free cyanide have stabilised and are approaching the levels measured in the background zone. The concentration of total cyanide is above the level seen in background bore 2/2.

Midshore Zone
Shallow pea gravel bore 4/5: All contaminant levels have continued to decrease since 2005. The fluoride concentration has decreased by approximately a factor of 5. Fluoride is now double the background value seen in bore 2/2. A fluoride spike was observed in 2010 which corresponds with the spikes seen in the SCL zone between 2007-2009. The total cyanide concentration has also decreased by a factor of 5 since 2005. The total cyanide is above the value of background bore 2/2. A spike was observed in 2015 which corresponds to the spike seen in the SCL zone in 2011. Free cyanide is similar to the concentration seen in background bore 2/2.

Deep sand bore 4/10: All contaminant levels have continued to decrease since 2005. The conductivity appears to be trending closely with the cyanide levels. Fluoride is approaching the levels of background bore 2/2.

Coastal Zone
Shallow pea gravel bore D: Contaminant levels have continued to decrease or stabilised since 2005. Fluoride has decreased by a factor of 20. Total cyanide has decreased by a factor of 2 and stabilised. One smaller spike was observed in in 2015 matching the spike seen in the SCL and Midzone in 2015.

Deep sand bore 5/4: Contaminant levels have continued to decrease for this coastal bore.
Total cyanide has decreased by a factor of 4 and stabilised. Fluoride has decreased by a factor of 4. One smaller spike was observed in 2017 matching the spike seen in the SCL and Midzone in 2015.

[1] ES response to NZAS (Shaun), 2005 SCL Groundwater Report. Ref 2005/23479, 14/2/2006. Copy in appendix A

2 Introduction

2.1 Background Information

Spent cathode liner (SCL) material is from an aluminium reduction cell when the cell has been decommissioned at the end of the life of the cell. It comprises mostly carbon cathodes and refractory bricks. SCL material may also contain other parts of the aluminium cell such as steel cathode bars, alumina and 'bath' (sodium aluminium fluoride).

SCL has been stored on a concrete pad on the Peninsula since the 1970's. In 1976 a Cathode Effluent Treatment Plant was constructed next to the SCL pad to process water run-off from the SCL pad.

In the early 1990's it was discovered that groundwater below the SCL pad at NZAS was contaminated by leachate from the SCL pad. Reports concluded that the concrete pad on which the SCL was placed had cracked, possibly due to an earthquake or failure of joints in the concrete pad as the pad was enlarged over time. Rainwater was leaching through the SCL material into the groundwater below the pad.

The original concrete pad (south) was reconstructed to enable covering with an impermeable membrane and reconfiguration of the drainage system. The SCL material was then moved from an adjacent smaller north pad to the larger concrete pad at the south. The SCL material was covered with an impermeable geo-membrane then topped with gravel to prevent further leachate from entering groundwater. The north pad was then deconstructed and closed.

Additional groundwater bores were installed to monitor the rehabilitation of the groundwater quality in the vicinity of the SCL pad. Regular groundwater bore monitoring started in late 1995 with annual reporting in July 1996 in accordance with the SRC's resolution of 11 October 1995.[2] Regular monitoring and reporting of groundwater data ceased on recommendation of Environment Southland in August 1999[3] in favour of snapshot monitoring in 2002.

ES responded[4] to the 2002 Report with a letter requesting that another set of samples were to be collected in 2005. These samples were collected and analysed as per the 2002 request. In early 2006 Environment Southland signed off the completion of the rehabilitation project after reviewing the December 2005 Report.

NZAS have continued to sample a selection of groundwater bores located around the Cathode Plant and SCL pad to verify the integrity of the concrete foundation and cover. Monitoring data are reported and discussed in the annual compliance reports to ES.

The discharge diffuser at sea and discharge pipe was replaced in 2003/2004 as the diffuser was mostly covered with sand due to accretion. The pipeline to the diffuser was again replaced in 2015 due to suspected damage resulting from harsh sea conditions.

On 2 April 2020 an operator at the Cathode Treatment Plant was setting up for a routine batch transfer of treated effluent from a treatment tank to a settling tank. The transfer pumps were started prematurely before the tank valves were opened which resulted in "Water Hammering" in the pipework. Several valves and pipes ruptured under the pressure resulting in up to 40 m^3 of untreated effluent being released to ground.[5] No effluent was able to be recovered due to the effluent dissipating into the underlying pea gravel. The groundwater bores have been sampled at least four times since the spill occurred.

Graphical representation of the concentration of contaminants monitored in groundwater has been plotted against an accurate timeline to provide a visual display over the last three decades. Data are displayed in the Data for Individual Zones in Section 4 of this report. Data points obtained for sampling in 2020 is tabled in Appendix B.

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[2] ES response to NZAS (Nicola), "Cathode Pad Contaminant Plume, Options for Remediation Ref A277, 11 October 1995
[3] ES response to NZAS (Manager), SCL Groundwater and Diesel Bioremediation Report, Ref N015-012, 4 August 1999
[4] ES response to NZAS (Shaun), SCL Groundwater Report, Ref N015-028, 14 June 2002
[5] ES response to NZAS (Shaun), SCL Groundwater Report, Ref 2005/23479, 14 February 2006

2.2 Flow of Groundwater

The groundwater flow is towards the beach to the south of the SCL pad[6] and treatment plant. There are two distinct layers present beneath the SCL pad area,

- Pea gravel to a depth of 12 – 14 metres underlain by
- Fine sands to a depth of 18 – 20 metres.

Silts, clay and peats form the boundary at the base of the fine sands layer. Groundwater flow is greater in the pea gravel layer than in the fine sands layer because of the higher permeability of the gravels. Contour of groundwater concentrations for cyanide and fluoride are appended in Appendix C together with a conceptual view of the groundwater surrounding the SCL pad.

[6] Groundwaters of Tiwai Peninsula, Volume 1 + 2, Woodward-Clyde, 1994

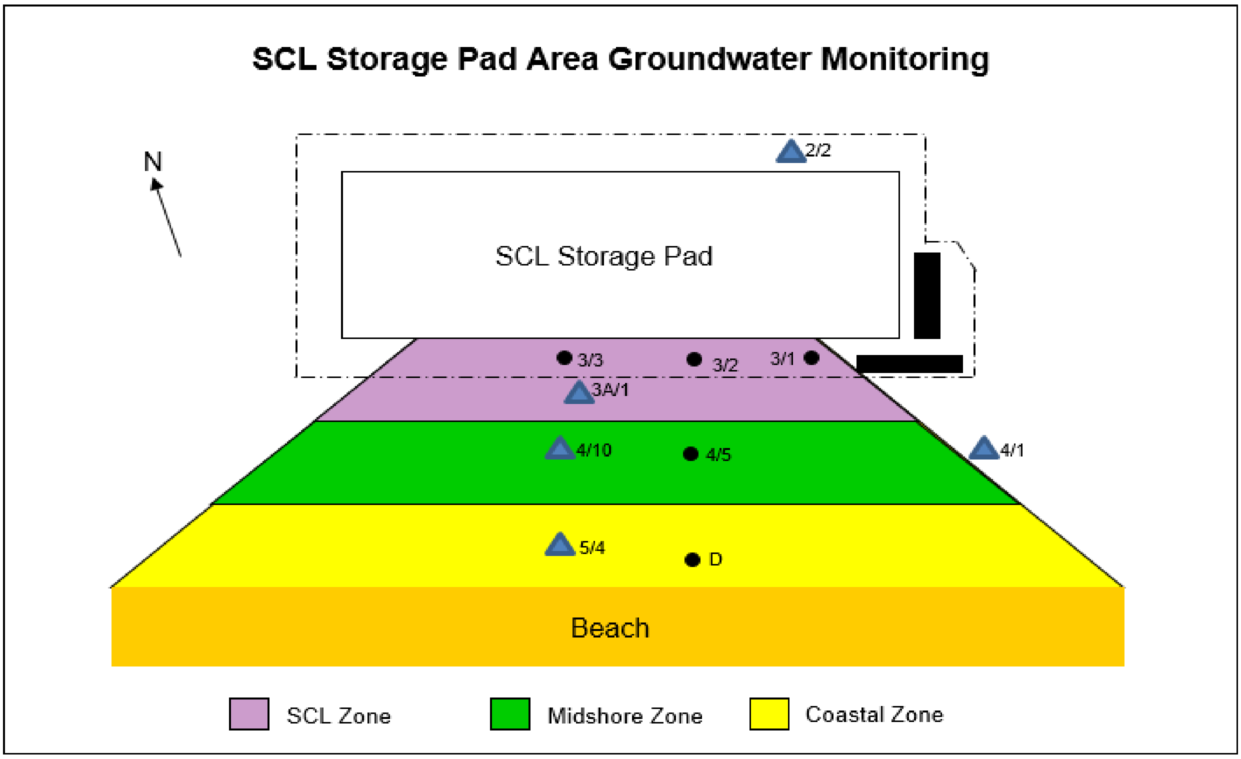
3 Groundwater Monitoring

3.1 Introduction

This section covers the groundwater monitoring of bores located around the SCL Pad and Treatment Plant. Nine bores have been regularly sampled and analysed for pH, conductivity, free cyanide, total cyanide and fluoride concentrations for 25 years. Sampling commenced for bores 3/1 and 3/2 in April 2002 and August 2020 for bore 4/1.

3.2 SCL Monitoring Bore Locations

The SCL pad is located approximately 85 metres from the beach. Monitoring bores are located between the SCL pad and the beach. The locations of the bores monitored are shown in the following diagram (not to scale).



To assist in assessing the movement of contaminants the bores have been separated to represent the groundwater in four zones:

- SCL zone, bores 3/1, 3/2, 3/3 and 3A/1, immediately south of the SCL pad,
- Midshore zone, bores 4/1, 4/5 and 4/10, the flat area between the SCL pad and the sand dunes,
- Coastal zone, bores 5/4 and D, the sand dunes near the top of the beach, and
- Background zone, bore 2/2 north and upstream of the SCL pad.

Bores 3/1, 3/2, 3/3, 4/5 and D are shallow bores ● that are used to sample groundwater in the pea gravel layer.

Bores 2/2, 3A/1, 4/1, 4/10 and 5/4 are deep bores ▲ that are suitable to sample groundwater in the underlying fine sands layer.

3.3 Sampling & Reporting

All bores are sampled twice per year for fluoride, free and total cyanide, pH and conductivity. All bores are also tested up to six times per year for fluoride as an additional line of assurance for potential changes in the groundwater quality. Annual results are calculated as an average of individual samples taken for this report.

3.4 Surrounding Groundwater Quality

Groundwater quality is monitored for potable water pumped to site from the underground aquifer on Tiwai Peninsula. Groundwater is also monitored around the land-based sewage field. Ground water monitoring locations are marked with red triangles on the map below.

3.4.1 Sewage Bores

Sewage bores are sampled twice a year for analytes specified in resource Consent 203376. Value ranges for pH, conductivity and fluoride are tabled below for the years 2019 and 2020.

Analyte	Sewage North	Sewage South
pH	7.8 - 8.0	7.3 - 7.9
Conductivity µS/cm	358 - 376	368 - 465
Fluoride mg/L	0.11 - 0.15	2.8

3.4.2 Potable Water Supply

Potable water is sampled monthly. Value ranges for pH, conductivity and fluoride are tabled below for the years 2019 and 2020.

Analyte	Potable Water Supply
pH	7.2 - 8.2
Conductivity µS/cm	229 - 407
Fluoride mg/L	< 0.05 (less than limit of detection)

3.4.3 Seawater

Seawater is sampled once a year for the discharge of treated effluent. Typical values are tabled below.

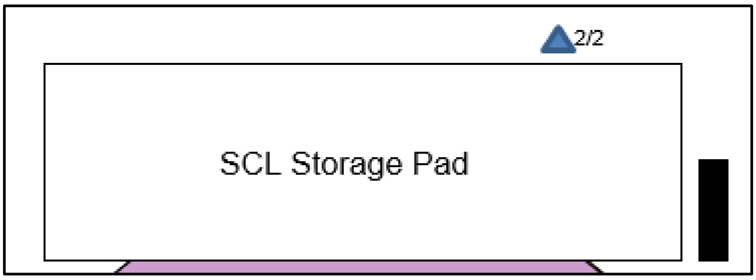
Analyte	Potable Water Supply
pH	8.1 – 8.2
Conductivity µS/cm	49000 - 50000
Fluoride mg/L	1.2 – 1.3
Total cyanide mg/L	< 0.01 (less than limit of detection)

4 Data for Individual Zones

Graphical representation of the concentration of contaminants monitored in groundwater has been plotted against an accurate timeline to provide a visual display over the last three decades for each zone. Multiple bores are present in each zone apart from the background zone representing the control sample as being upstream of the SCL pad. Each Zone is discussed in this section.

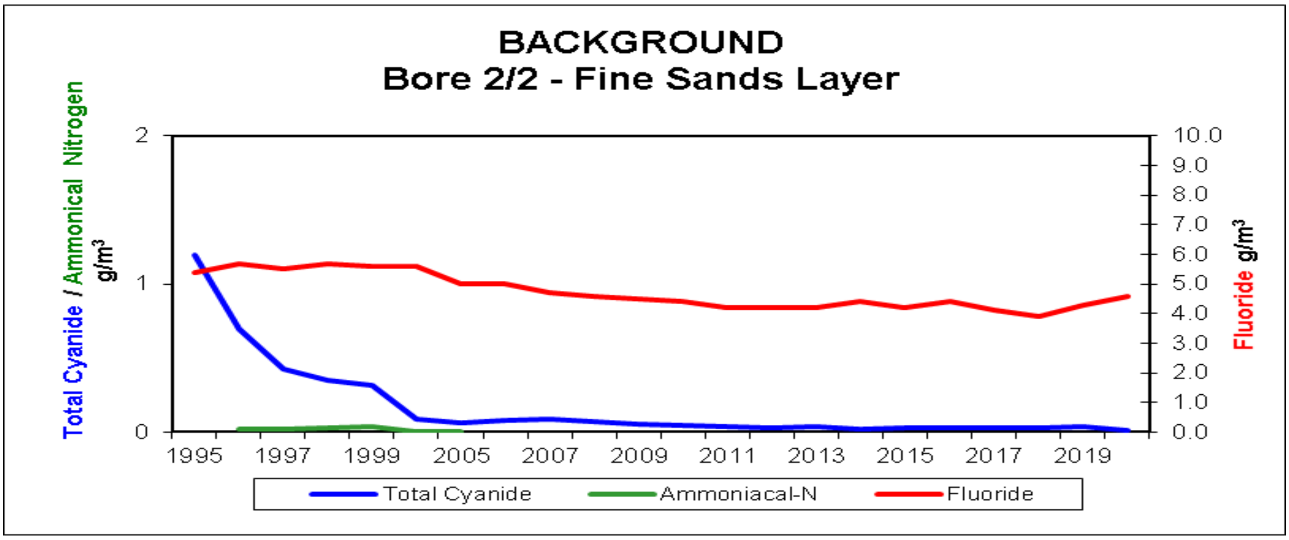
4.1 Background Zone

A single Bore 2/2, is used to monitor the background zone. This bore is a deep bore suitable for sampling the groundwater from the fine sands layer of the aquifer surrounding the SCL pad. Bore 2/2 is located immediately north/east, and 'upstream' of the SCL pad. This location indicates the quality of the groundwater flowing towards the SCL pad and eventually to the sea.



4.1.1 Results for Bore 2/2

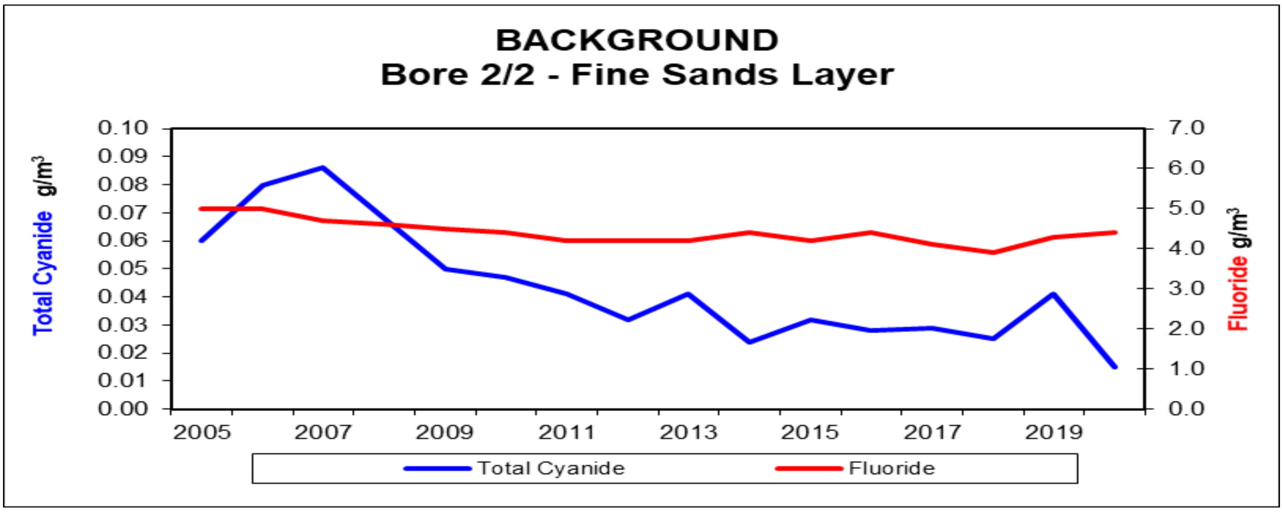
The following graph shows the annual average concentration of total cyanide, fluoride, and ammoniacal nitrogen measured in the groundwater from Bore 2/2 since 1995. Note that ammoniacal nitrogen has not been measured since May 2005. Total cyanide is typically measured at 0.05-0.02 mg/L with free cyanide < 0.01 mg/L.



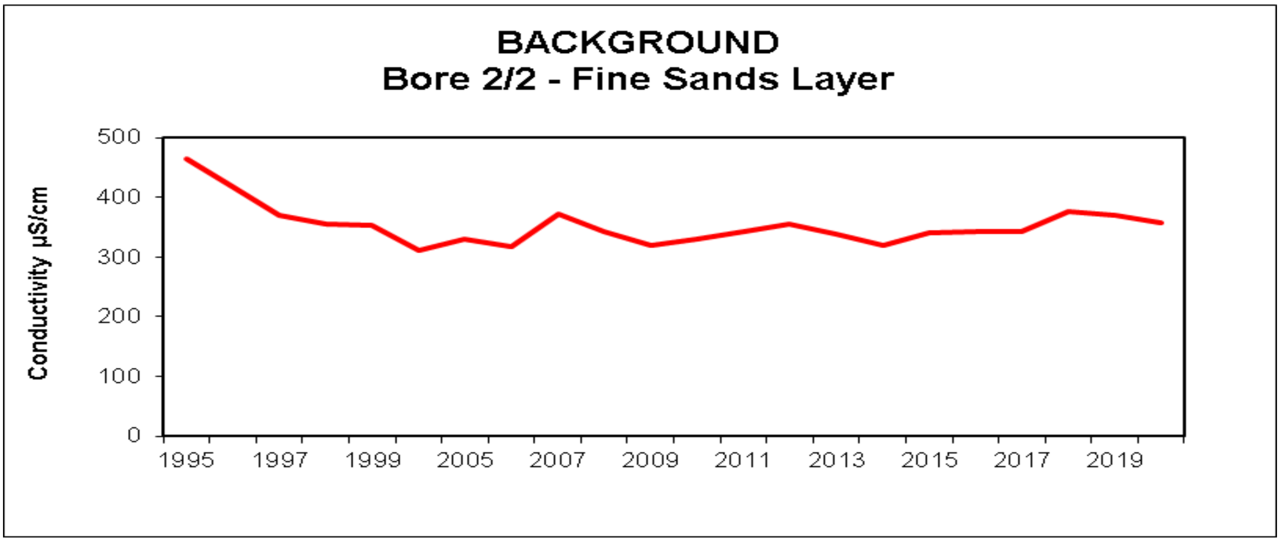
The elevated levels of total cyanide in the early 1990s were due to SCL leachate entering the groundwater around the pad. The SCL material was shifted to a temporary concrete pad to the north of the existing pad while the original location was reconstructed. The original SCL pad was covered in 1992 to stop any further leachate entering groundwater.

Part of the same data set as displayed in the graph above, is displayed in the following graph for years 2005 to 2020 to provide greater clarity of the most recent concentrations of fluoride and total cyanide.

Background Zone, continued



The following graph shows the annual average conductivity measured in groundwater samples from Bore 2/2 since 1995.



4.1.1.1 Comments on Bore 2/2

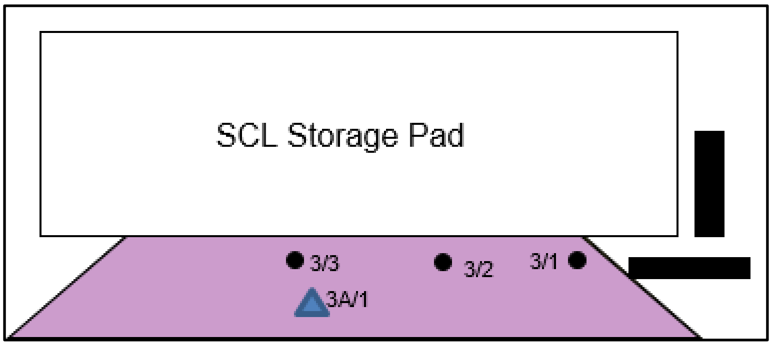
Conductivity measurements at Bore 2/2 indicate that the groundwater flowing into the SCL pad area has low levels of contamination. The conductivity is similar to values seen for groundwater in the vicinity of the sewage field and potable water supply.

By 2020 the cyanide concentration had decreased by a factor of three since 2005.

The fluoride concentration has remained relatively stable since 2005. A sample taken in May 2020 was slightly elevated, and an unexplained value of 6.3 mg/L after the spill at the treatment plant in April, however, the latest data sets show a fluoride concentration between 3.7 - 4.1 mg/L for June - December 2020 which is a range typical for this bore. Fluoride discharged to air from the smelting process is also likely to contribute to the general fluoride level in groundwater when washed with rainwater into the ground. The prevalent wind direction is north/westerly for Tiwai Peninsula.

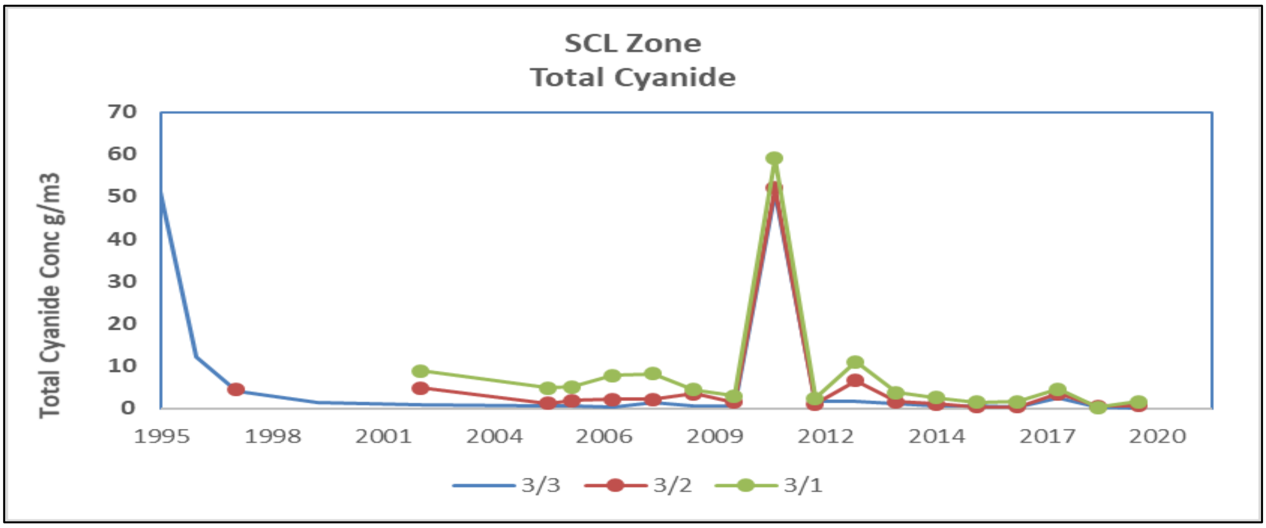
4.2 SCL Zone

Four bores, Bores 3/1, 3/2, 3/3 and 3A/1, are used to monitor the SCL zone. Bore 3/1, 3/2 and 3/3 are shallow bores suitable for sampling groundwater from the pea gravel layer of the aquifer surrounding the SCL pad. Bore 3A/1 is a deep bore suitable for sampling groundwater from the fine sands layer of the aquifer.

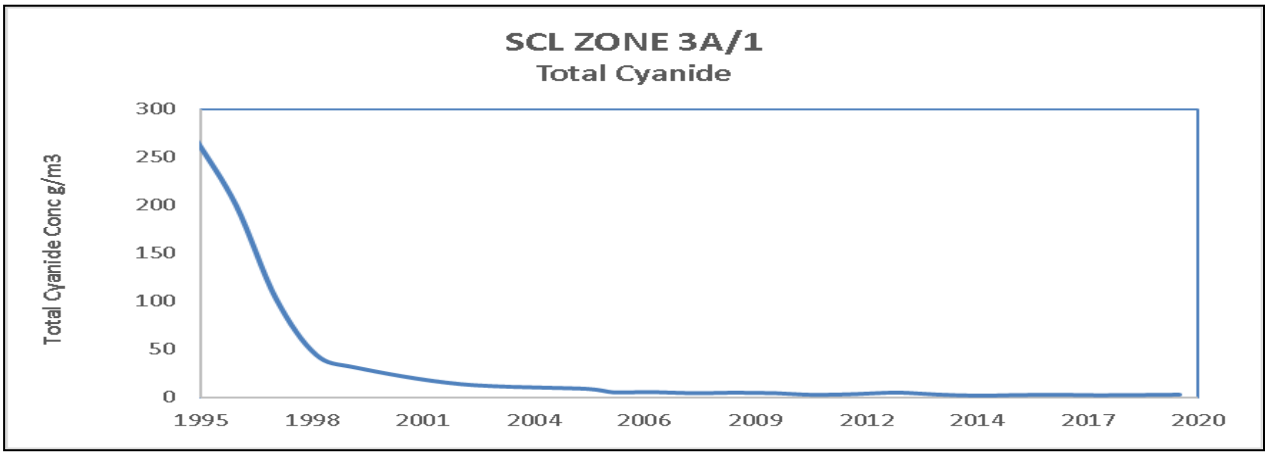


4.2.1 Results for Cyanide

Free cyanide has ranged from < 0.01 – 0.32 mg/L for bores 3/3; 3/2; 3/1 with bore 3/3 showing the lowest free cyanide concentrations typically below 0.01 mg/L. The following graph shows the annual average concentration of total cyanide since 1995 (Note – g/m^3 = mg/L).

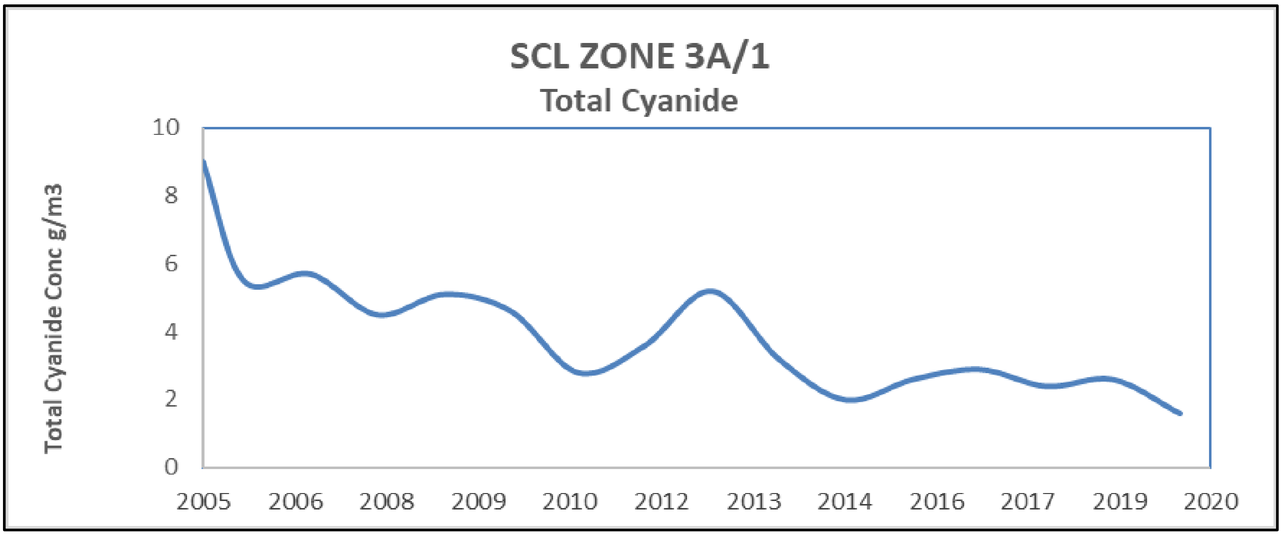


The following graph shows the annual average concentration of total cyanide from Bore 3A/1 since 1995. Free cyanide is consistently below 0.05 mg/L and typically < 0.01 mg/L.



SCL Zone, continued

Part of the same data set as displayed in the previous graph, is displayed in the graph below for years 2005 to 2020 to provide greater clarity of the most recent concentrations of total cyanide. Total cyanide remains elevated above background in Bore 3A/1.

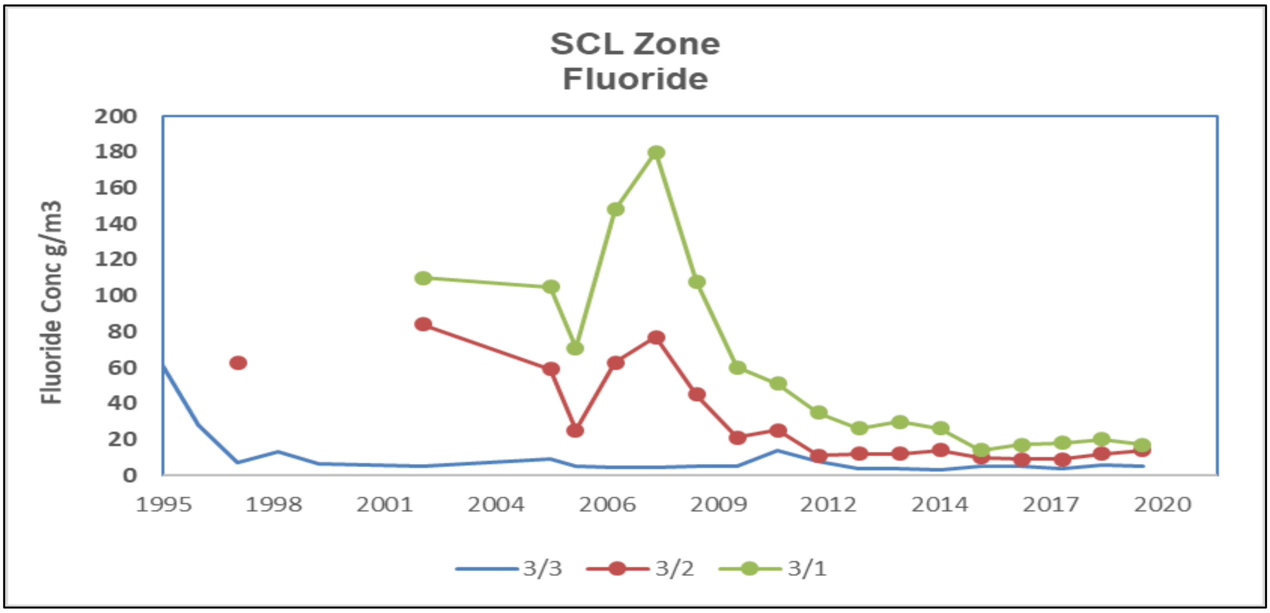


4.2.1.1 Comments on Cyanide in Bore 3A/1

Cyanide concentrations have continued to decrease over time. A cyanide spike was observed in July 2011 for the shallow bores 3/1, 3/2 and 3/3 located close to the southern side of the SCL pad. Only one sample was collected in 2011 and when re-sampled 6 months later it had decreased to previous concentrations of approximately 1 mg/L. A similar spike was not detected in deep bore 3A/1 located just a few metres downstream of bore 3/3. An investigation into the elevated levels was conducted but no underlying root cause was found.

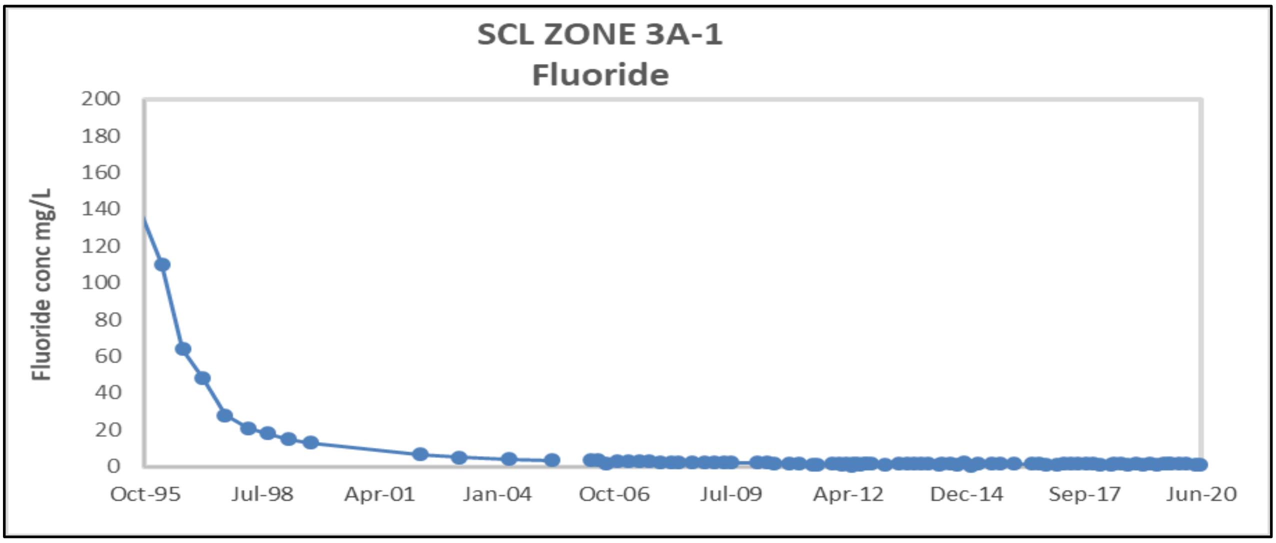
4.2.2 Results for Fluoride

The following graph shows the annual average concentration of fluoride measured in the groundwater from shallow Bores 3/3, 3/2 and 3/1 since 1995.

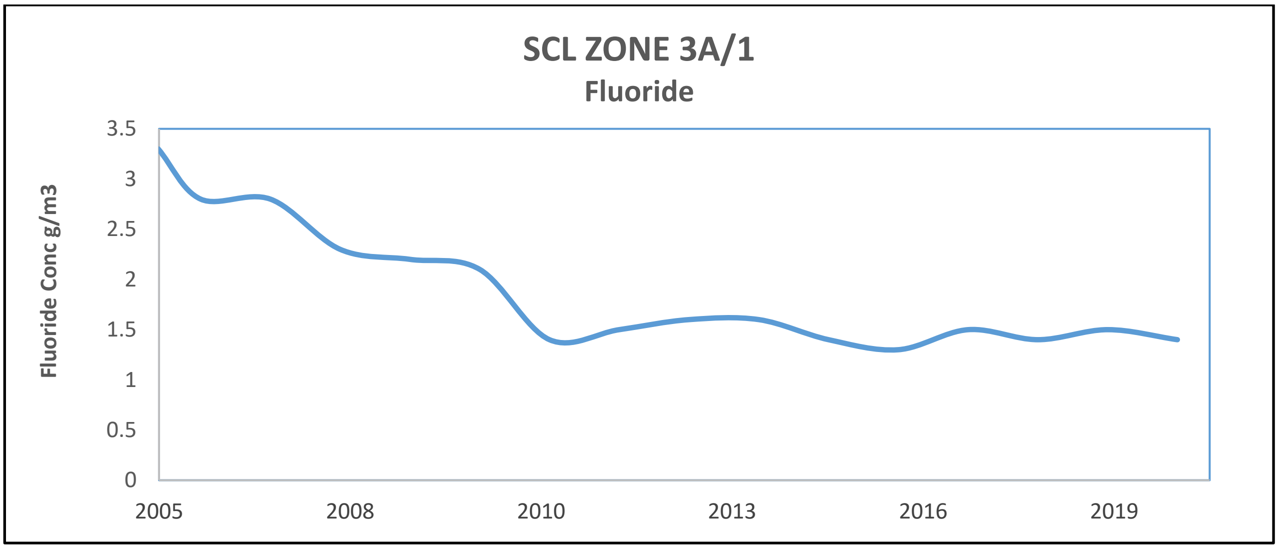


SCL Zone, continued

The following graph shows the annual average concentration of fluoride measured in deep bore 3A/1 since 1995.



Part of the same data set as displayed in the graph above, is displayed in the following graph for year 2005 to 2020 to provide greater clarity of the most recent concentrations of fluoride.



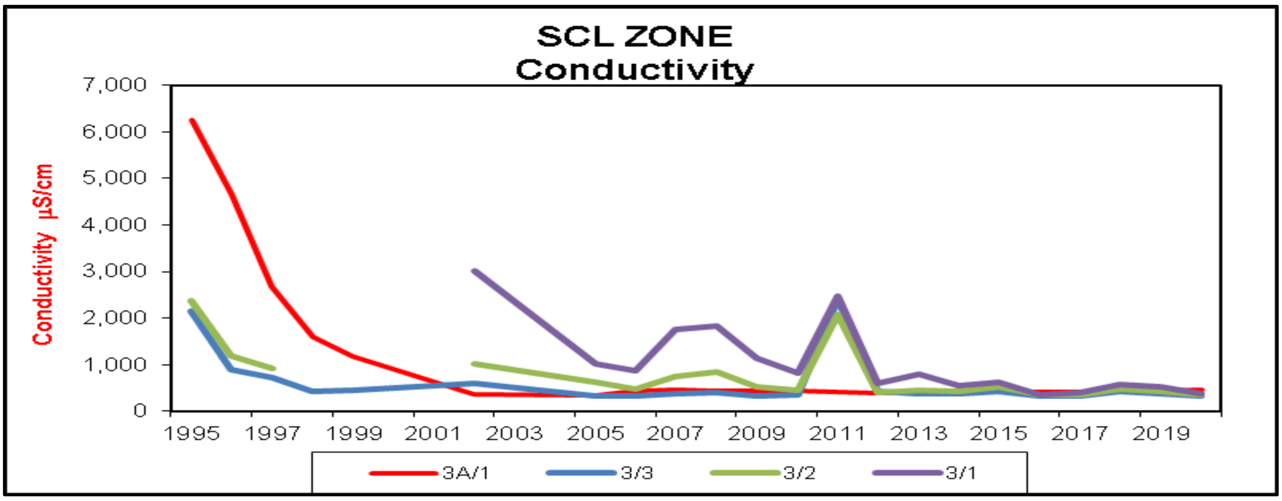
4.2.2.1 Comments on Fluoride in Bore 3A/1

The fluoride concentrations in the SCL zone have significantly decreased from 2005 till 2020. The decreases in concentration in groundwater from east to west with deep bore 3/1A showing the lowest concentration. A fluoride spike was observed for bore 3/2 and 3/1 between 2007-2009. No spike in fluoride was detected for deep bore 3A-1. The root cause for the spike was never identified. The underground discharge pipe which was replaced in 2003/2004 but is unlikely to be the source of contamination. Since 2010 the fluoride concentration in bore 3A/1 is nearing background levels found in seawater surrounding the Peninsula.

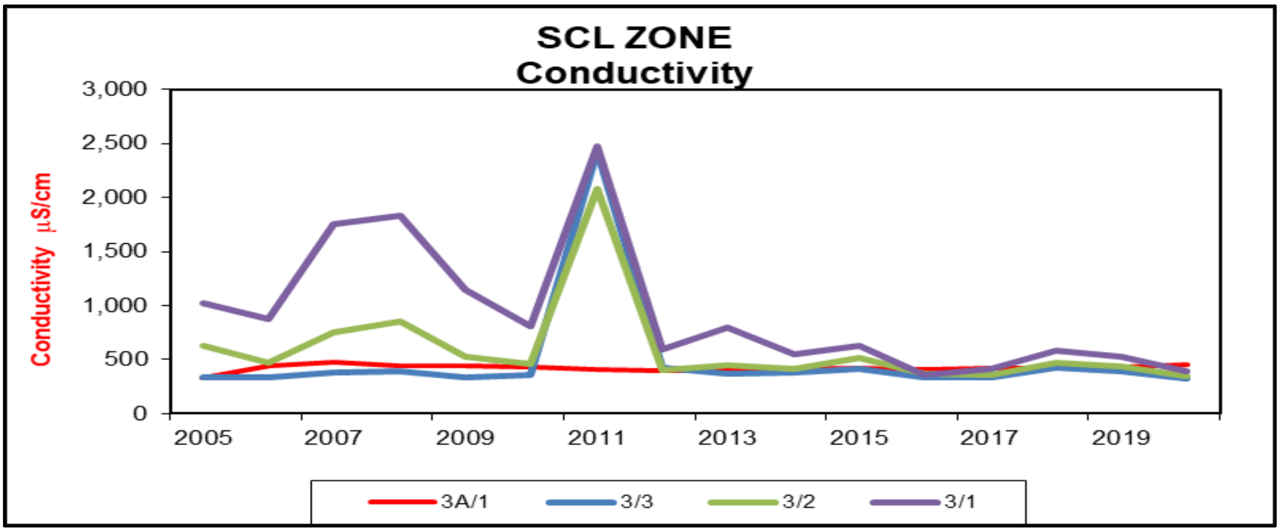
SCL Zone, continued

4.2.3 Results for Conductivity

The following graph shows the annual average conductivity measured in groundwater sampled from Bores 3/1; 3/2; 3/3 and 3A/1 since 1995.



Part of the same data set as displayed in the graph above, is displayed in the following graph for year 2005 to 2020 to provide greater clarity of the most recent conductivity values.



4.2.3.1 Comments on Conductivity

Conductivity has continued to decrease over time for bore 3/1 and 3/2. Monitoring at Bore 3A/1 indicates that the conductivity of the deeper groundwater layer in fine sands had recovered by 2005 and has maintained a conductivity of just below 500 µS/cm ever since. The same level of conductivity is observed at the sewage field and potable water supply areas of the aquifer.

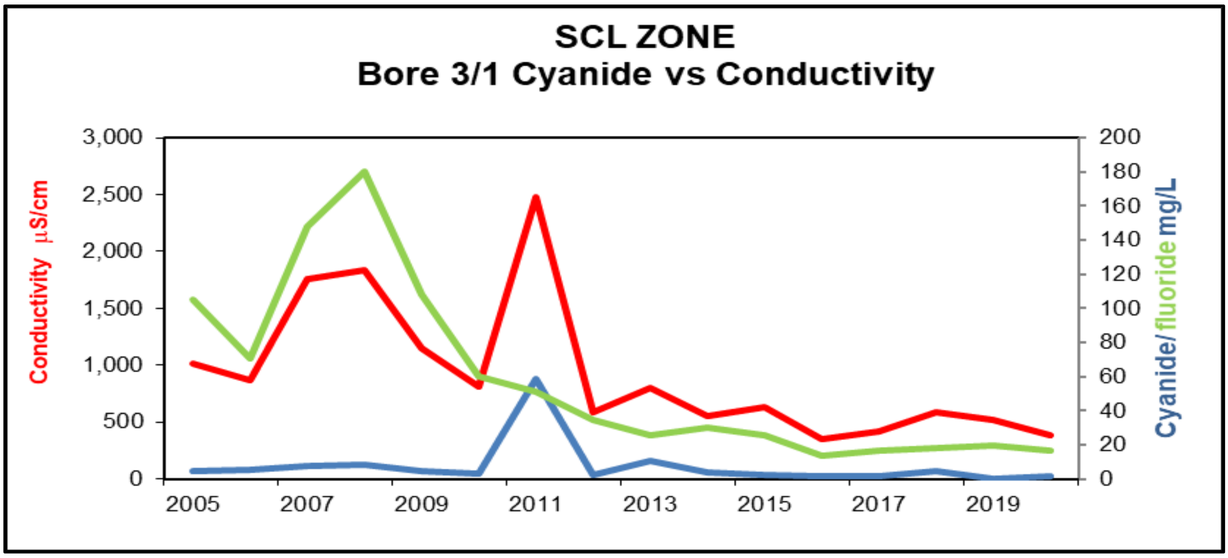
An increase in conductivity was observed for Bores 3/1, 3/2 and 3/3 when the fluoride (2007-9) and cyanide (2011) levels increased. Currently the conductivity for these bores is approaching those of background bore 2/2.

The variability in the pea gravel layer may be due to normal variation in groundwater analyte concentrations with rainfall and storm surges as well as the general movement of groundwater towards the sea.

SCL Zone, continued

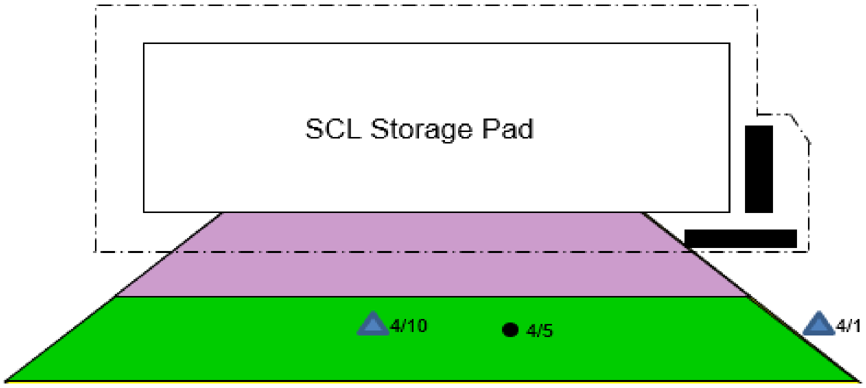
4.2.4 Trends for Bore 3/1

The cyanide concentrations track well with conductivity but not with fluoride for shallow bore 3/1 in the SCL Zone. See the graphs below for details. There appears to be limited or no correlation between total cyanide and fluoride concentrations for this bore.



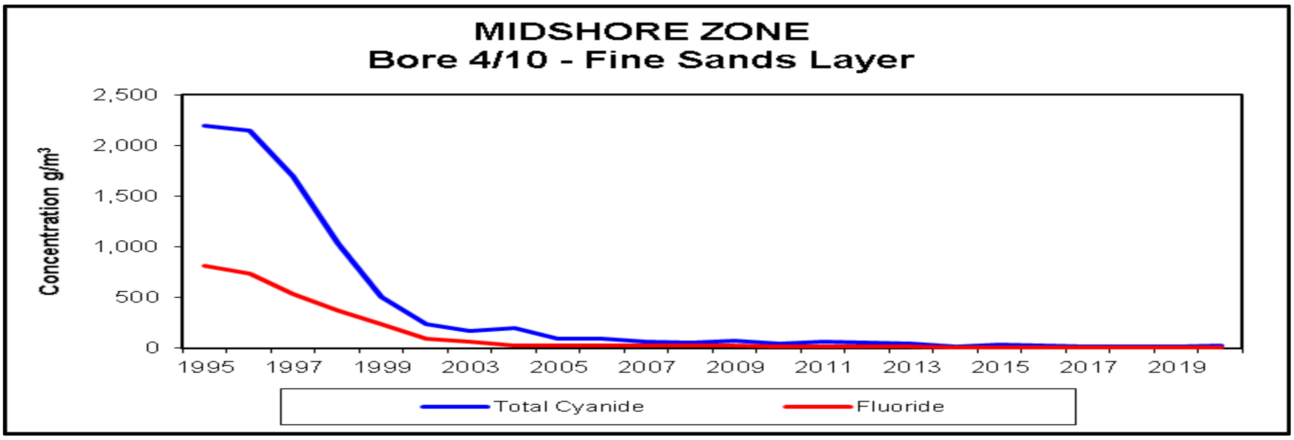
4.3 Midshore Zone

Two bores, Bores 4/5 and 4/10, have been used to monitor the Midshore zone since 1995. Bore 4/5 is a shallow bore suitable for sampling groundwater from the pea gravel layer of the aquifer surrounding the SCL pad. Bore 4/10 is a deep bore suitable for sampling of groundwater from the fine sands layer of the aquifer. In August 2020 sampling also began from shallow bore 4/1 as a replacement for bore D in the Coastal Zone. Seawater intrusion started to occur in early 2020 due to coastal erosion of the southern coast. The rate of coastal erosion has been actively monitored since 2017.

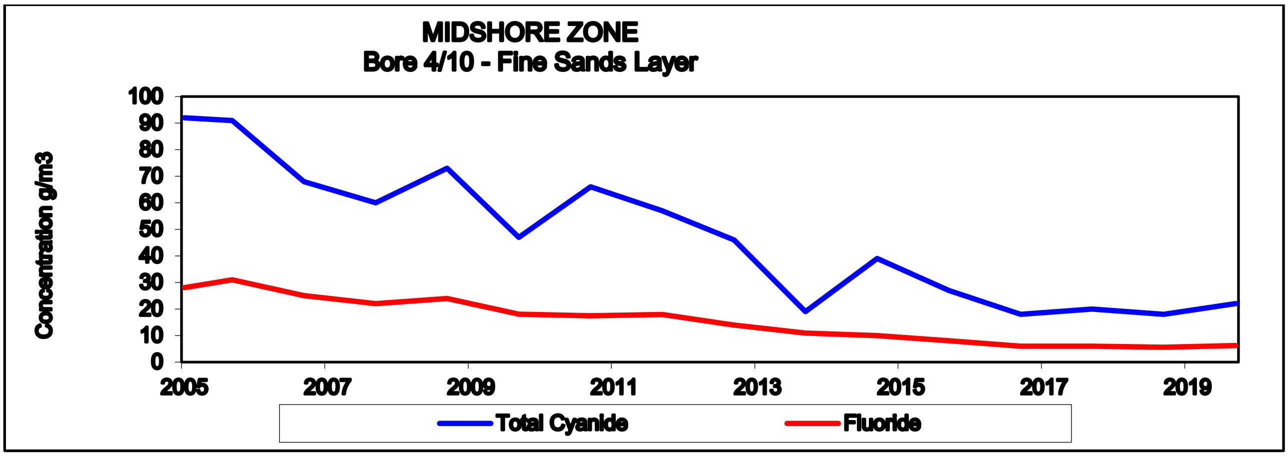


4.3.1 Results for Bore 4/10

The following graph shows the annual average concentration of total cyanide and fluoride measured in the groundwater samples from deep Bore 4/10 since 1995.



Part of the same data set as displayed in the graph above, is displayed in the following graph for year 2005 to 2020 to provide greater clarity of the most recent concentrations of fluoride and total cyanide. Free cyanide is typically 0.03 mg/L.



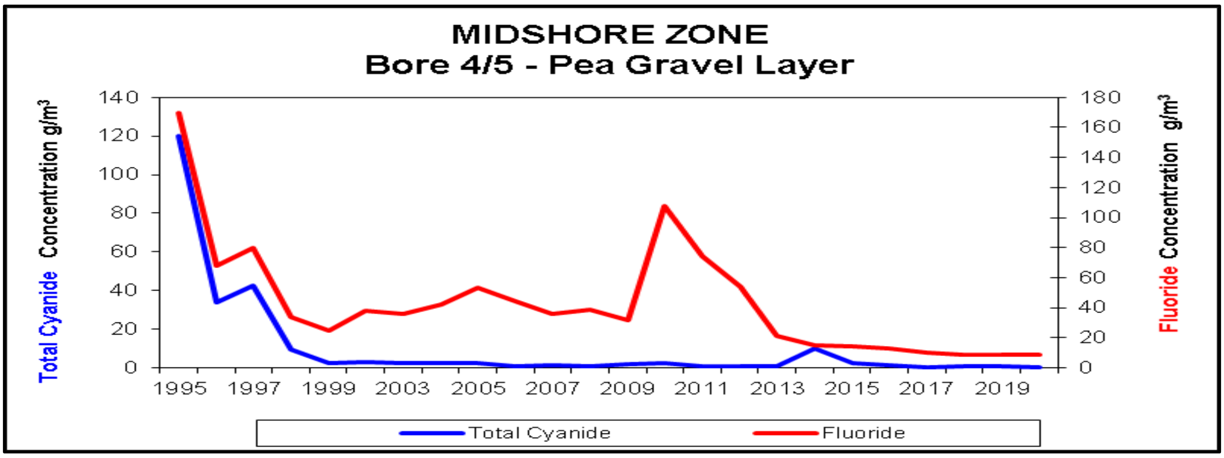
Midshore Zone, continued

4.3.1.1 Comments on Bore 4/10

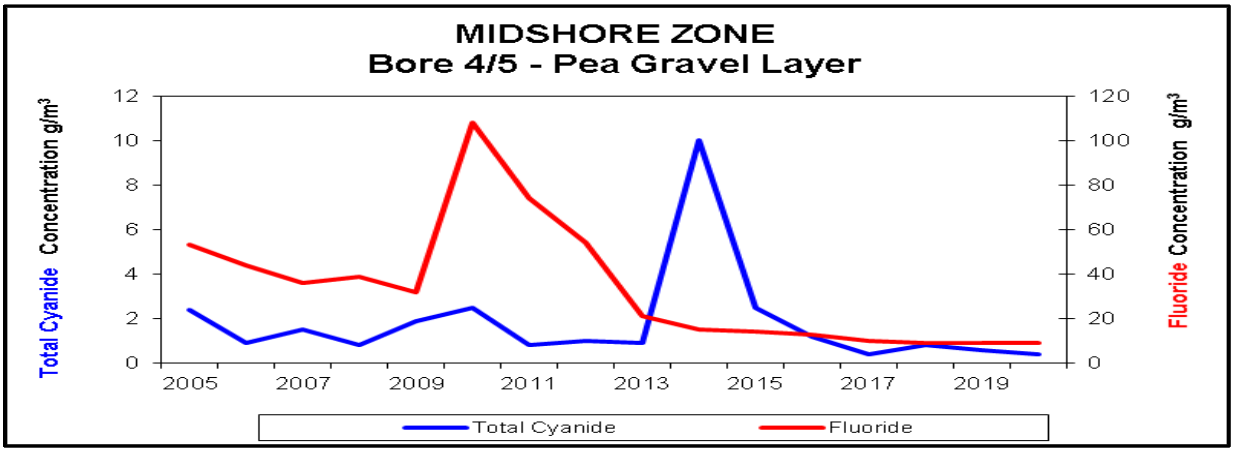
Both cyanide and fluoride concentrations have decreased significantly since monitoring began in 1995. The concentration of fluoride is near the background value but the total cyanide remains elevated above the background level as measured in bore 2/2.

4.3.2 Results for Bore 4/5

The following graph shows the annual average concentration of total cyanide and fluoride measured in the groundwater from shallow Bore 4/5 since 1995.



Part of the same data as displayed in the graph above is displayed in the following graph for year 2005 to 2020, to provide greater clarity of the most recent concentrations of fluoride and total cyanide. Free cyanide is typically < 0.04 mg/L.



4.3.2.1 Comments on Bore 4/5

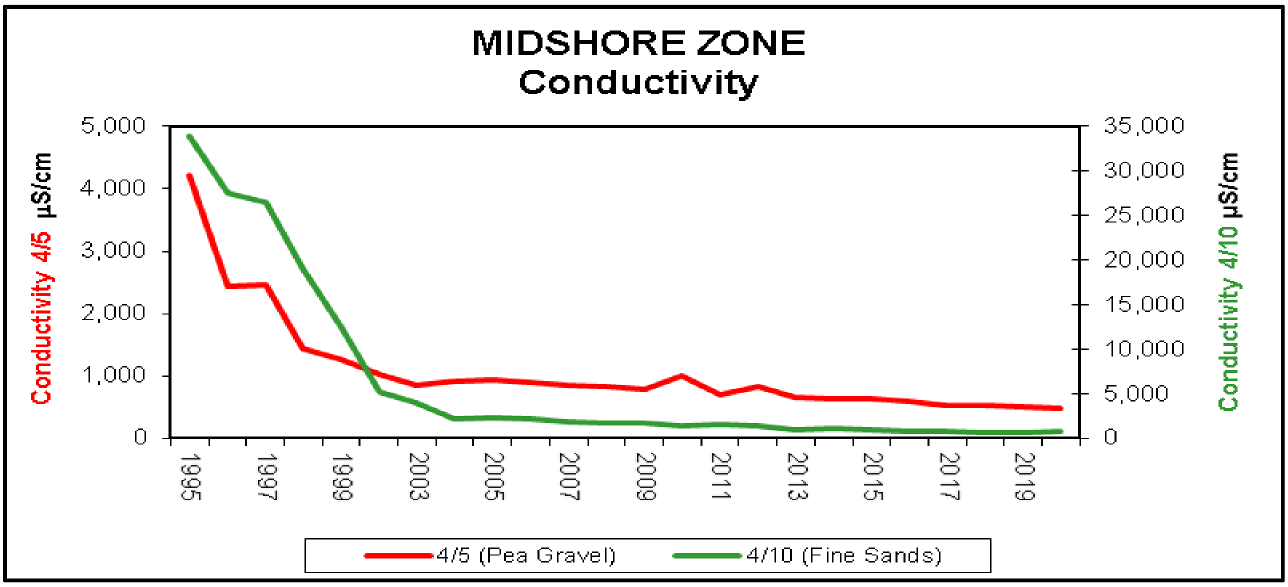
Both fluoride and cyanide levels have decreased significantly since monitoring began in 1995 and nearing the background values found in Bore 2/2. Total cyanide is higher than background but is much lower than that in the underlying fine sands layer. A spike in concentration for the analytes was observed for:

- fluoride in 2010/2011 which corresponds to a spike seen for bores in the SCL Zone occurring 3 years prior.
- cyanide in 2015 which corresponded to the spike observed for the SCL Zone bores in 2011. The underground discharge pipe was replaced in 2015 due to potential leakage.

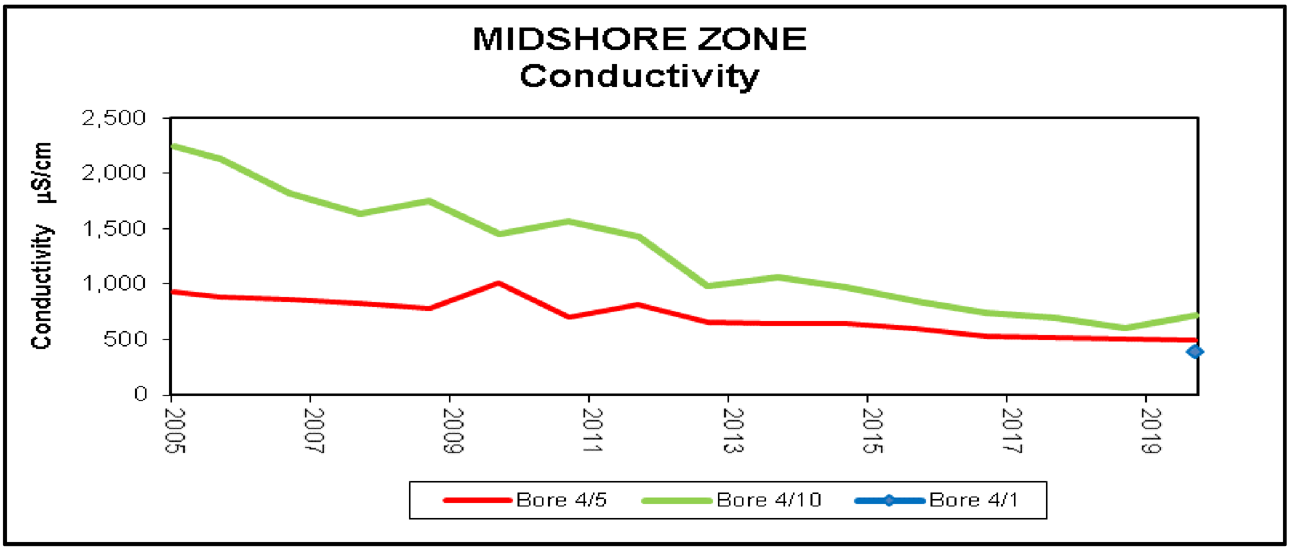
Midshore Zone, continued

4.3.3 Results for Conductivity

The following graph shows the conductivity measured in groundwater sampled from Bores 4/5 and 4/10 since 1995.



Part of the same data as displayed in the graph above is displayed in the following graph for year 2005 to 2020 to provide greater clarity of the most recent conductivity measurements. Bore 4/1 was sampled for the first time since 1998 in August 2020 to assess the area to the east of the pad now that bore D and 5/1 are destroyed by coastal erosion.



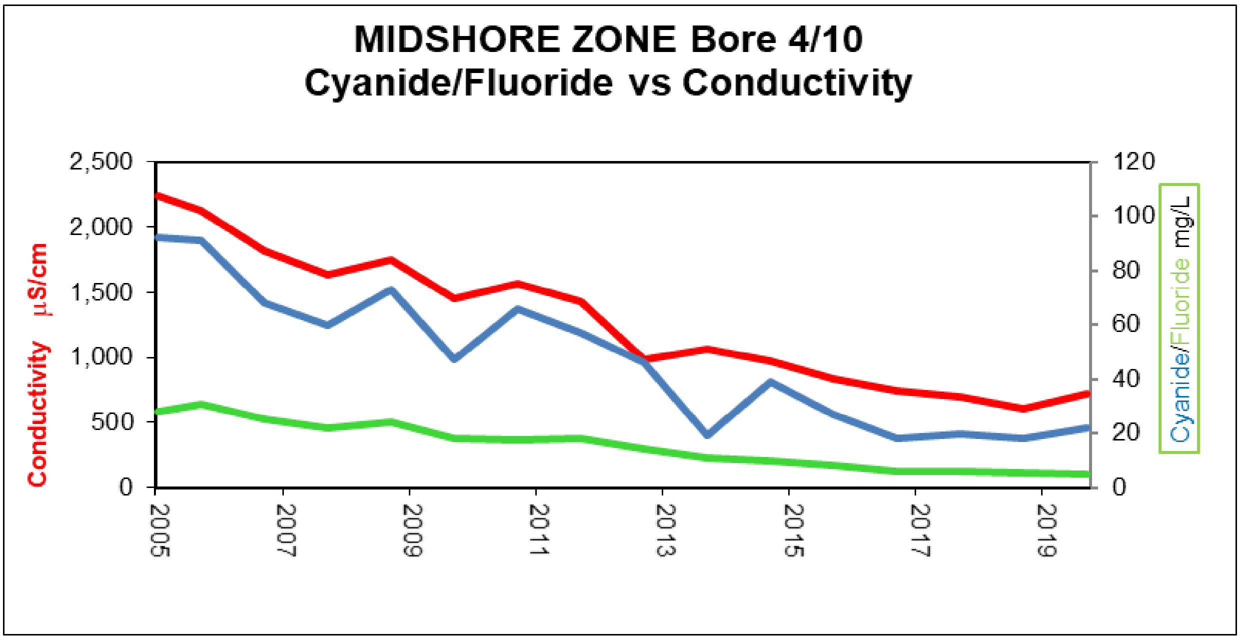
4.3.3.1 Comments on Conductivity

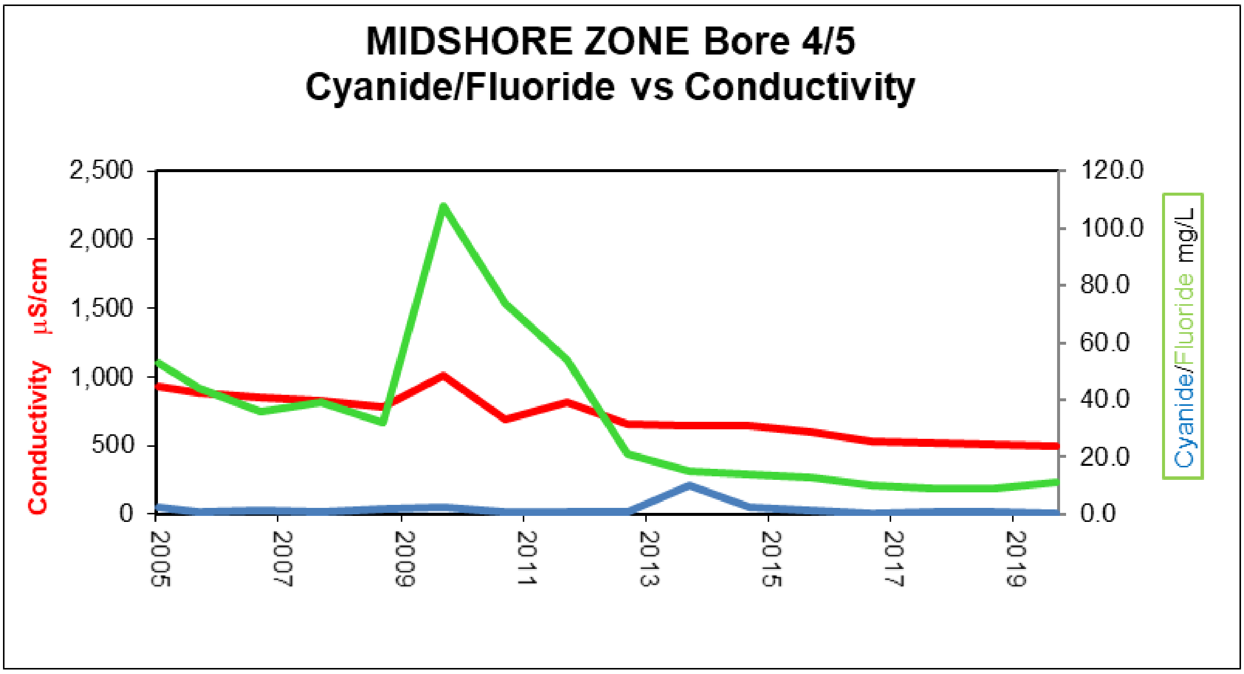
Contaminants are present in both layers, with the highest concentrations seen in the fine sands layer. The conductivity of the midshore bores 4/10 (deep) and 4/5 (shallow) have recovered significantly since monitoring began in 1995 and is approaching background levels, as are already seen in bore 4/1 (shallow). The conductivity in the midshore zone bores is 100-200 µS/cm above levels observed for the sewage field to the west of the pad.

Midshore Zone, continued

4.3.4 Trends in the Midshore Zone

The cyanide concentrations track well with conductivity but less with fluoride for deep bore 4/10 in the Midshore Zone. There is limited correlation between cyanide and fluoride with conductivity for shallow bore 4/5. Both cyanide and fluoride have continued to decrease in the midshore zone.

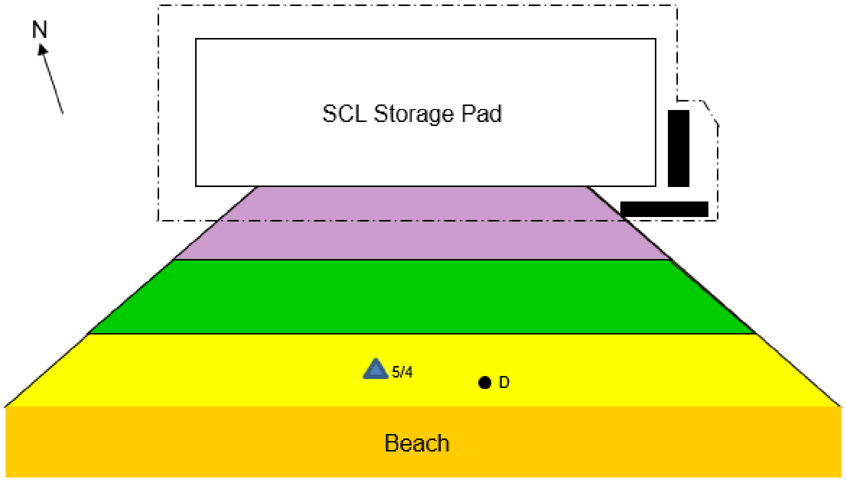




There appears to be limited correlation between fluoride and total cyanide concentrations for the midshore bores. This is to be expected given the differences in the underlying pea gravel and fine sands layers.

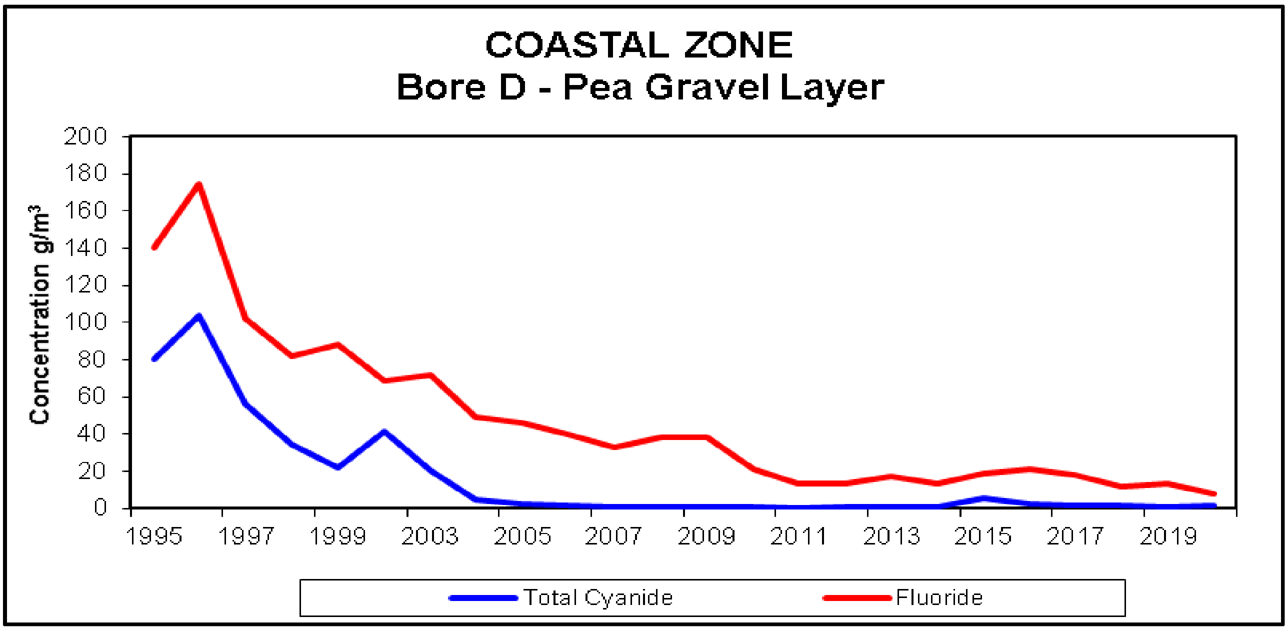
4.4 Coastal Zone

Bores D and 5/4, were used to monitor the Coastal zone until 2020. Bore D was a shallow bore suitable for sampling groundwater from the pea gravel layer of the aquifer surrounding the SCL pad but due to coastal erosion this bore is now fully flooded with seawater. Monitoring of bore D ceased in August 2020 when the bore was within 5 metres from the edge of the sand dunes. Bore 5/4 is a deep bore located a little further inland and is still suitable for sampling the groundwater from the fine sands layer of the aquifer.



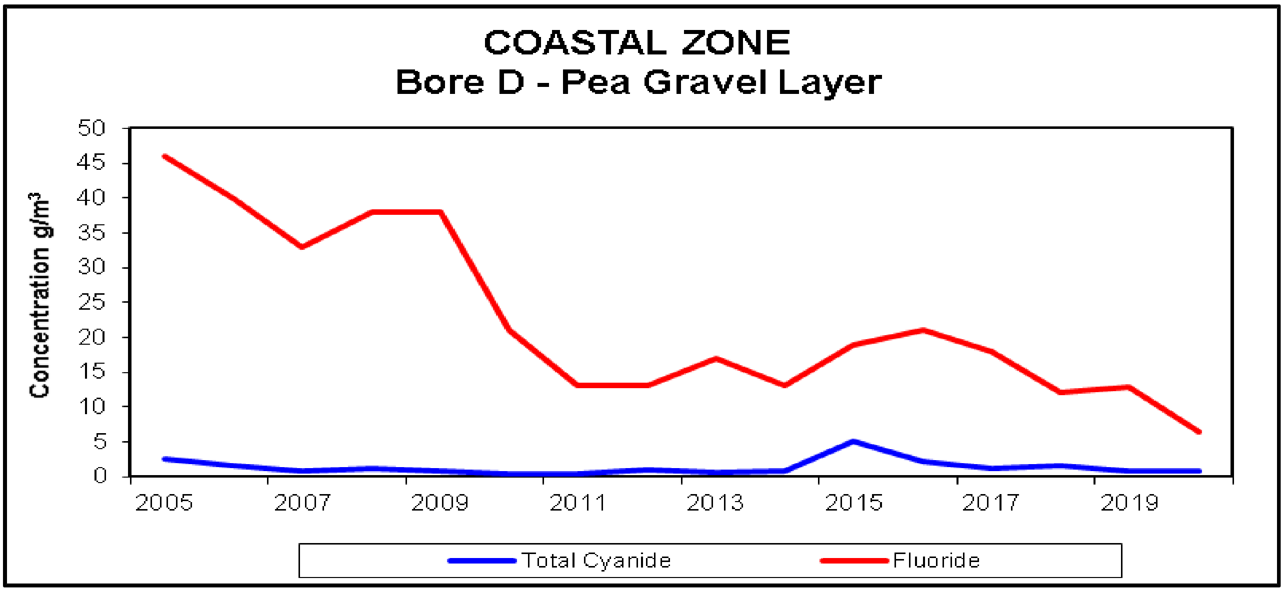
4.4.1 Results of Cyanide & Fluoride in Bore D

The following graph shows the annual average concentration of total cyanide and fluoride measured in the groundwater samples from Bore D since 1995. Free cyanide was typically < 0.04 mg/L.



Part of the same data as displayed in the graph above is displayed in the following graph for year 2005 to 2020 to provide greater clarity of the more recent fluoride and total cyanide measurements.

Coastal Zone, continued

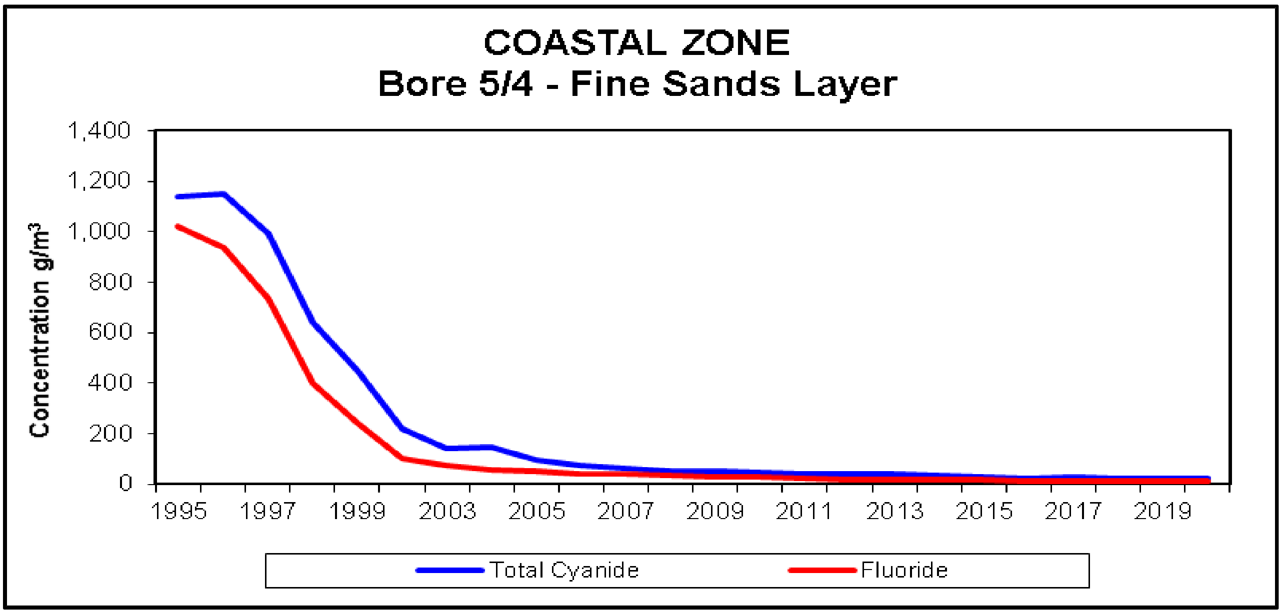


4.4.1.1 Comments on Cyanide & Fluoride in Bore D

Fluoride and total cyanide concentrations in coastal Bore D have recovered significantly since monitoring began in 1995. Fluoride has stabilised to near background levels where as the total cyanide level is above levels observed in bore 2/2. The total cyanide peak observed in the midshore bores for 2015 are also seen in coastal bore D. In August 2015 the underground discharge pipe was replaced as it was suspected to have broken in the coastal zone due to coastal erosion and or storm damage.

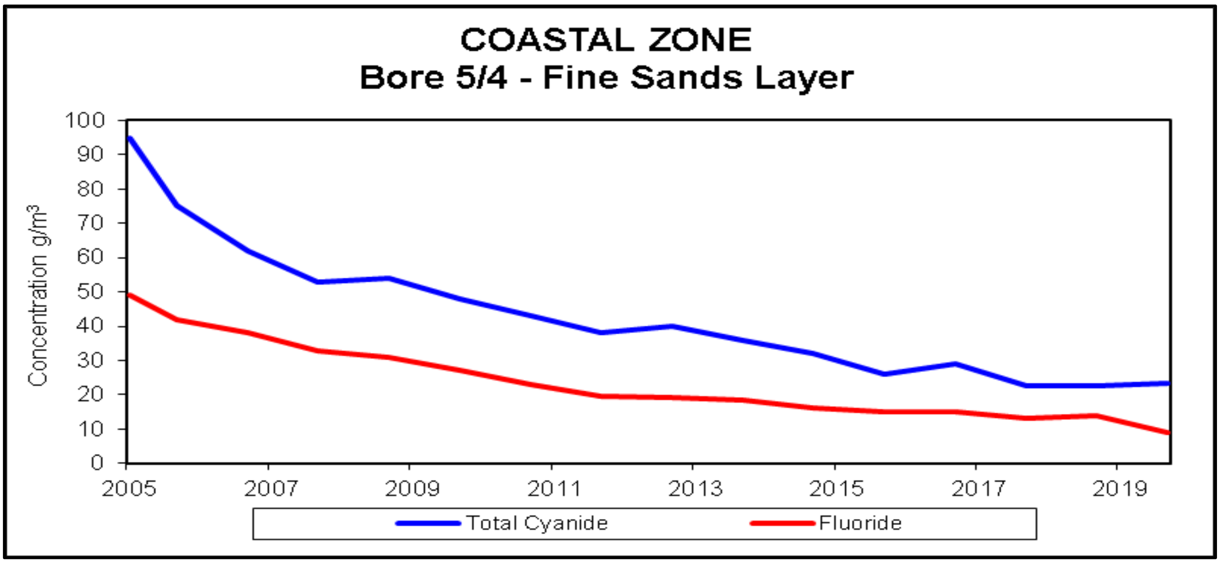
4.4.2 Results for Cyanide & Fluoride in Bore 5/4

The following graph shows the annual average concentration of total cyanide and fluoride measured in the groundwater samples from deep Bore 5/4 since 1995.



Coastal Zone, continued

The following graph shows the annual average concentration of total cyanide and fluoride measured in the groundwater from deep Bore 5/4 between 2005 and 2020.

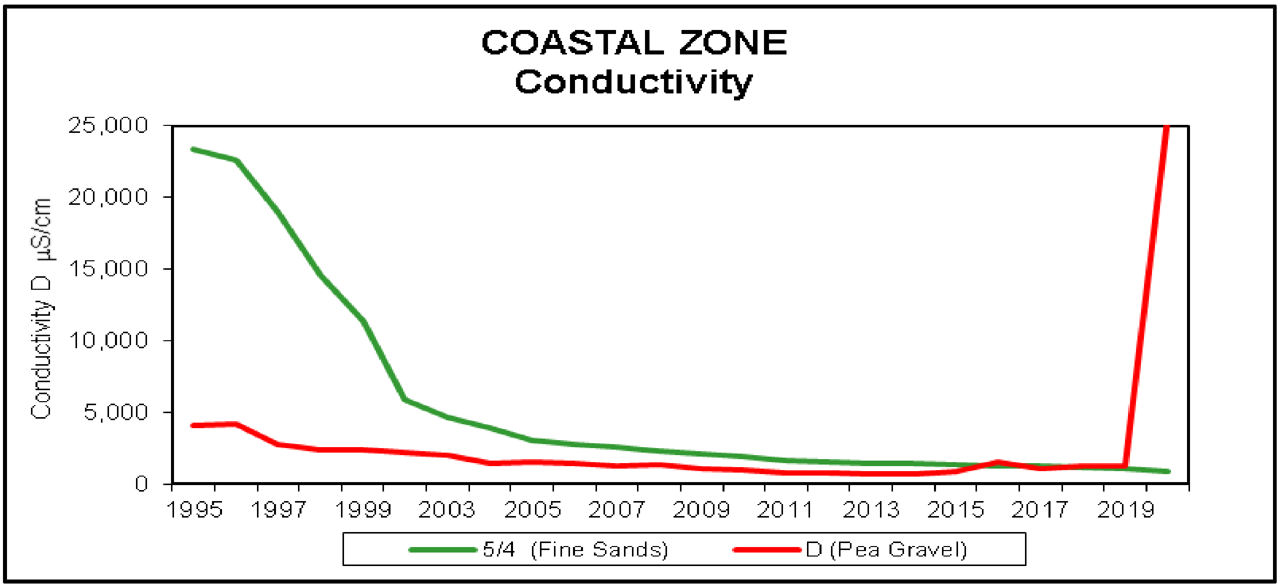


4.4.2.1 Comments on Cyanide & Fluoride in Bore 5/4

Fluoride and total cyanide concentrations of coastal bore 5/4 have recovered since monitoring began in 1995 and are continuing to decrease. Fluoride has reached the background level found in bore 2/2. Cyanide is still currently elevated compared to bore 2/2 and is similar in concentration to that in the up-gradient bore 4/10. Again, the concentration in the overlying pea gravel is much less than that in the deeper fine sands. This bore will continue to be monitored for seawater ingress as it is only currently 11 metres from the coast.

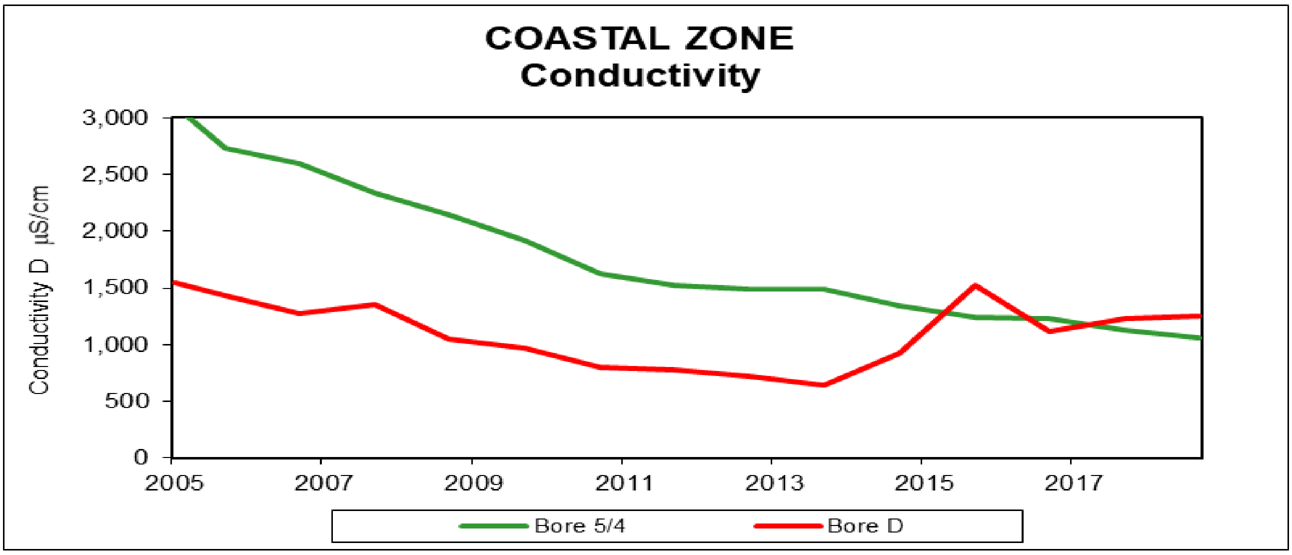
4.4.3 Results for Conductivity

The following graph shows the conductivity measured in groundwater sampled from Bores D and 5/4 since 1995.



Part of the same data as displayed in the graph above for year 2005 to 2020, is displayed in the following graph to provide greater clarity of the more recent conductivity measurements.

Coastal Zone, continued



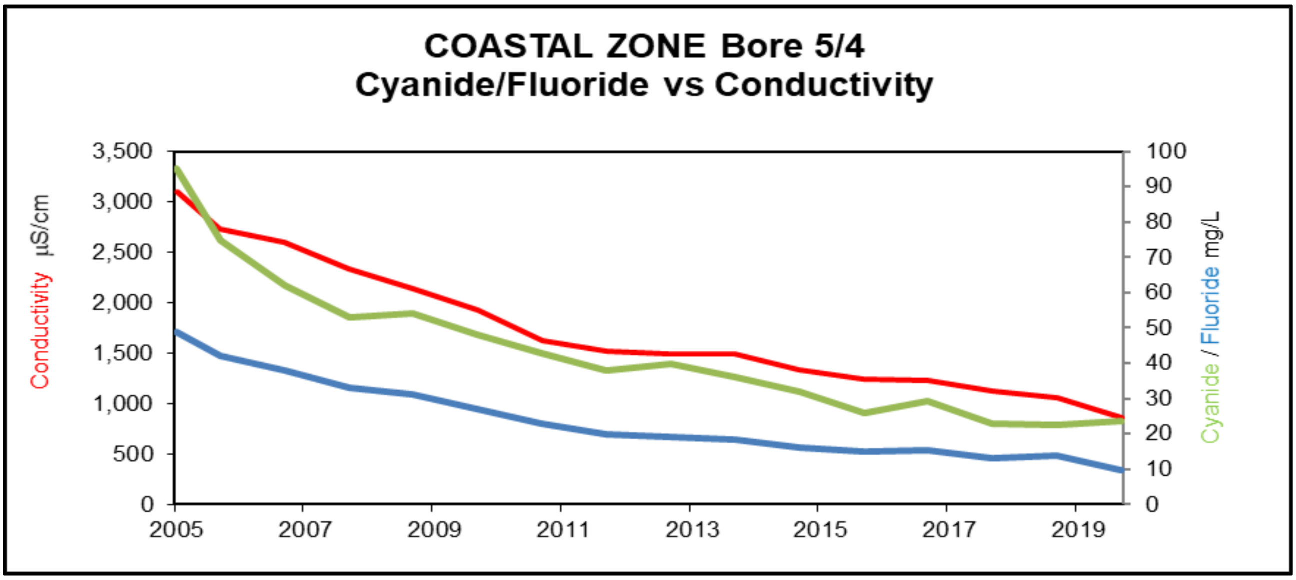
4.4.3.1 Comments on Conductivity

Monitoring at deep bore 5/4 in the fine sands layer demonstrates continued recovery over time. This bore is approximately 11 metres from the edge of the sand dunes to the beach. The conductivity is about 700 µS/cm greater than levels observed in the background bore 2/2 and 500 µS/cm above levels seen around the sewage field. This may be due to the start of sea water intrusion in this bore.

The shallow bore D has also recovered over time, however, this bore now contains largely seawater. This bore is now located only 5 metres from the edge of the sand dunes. The samples taken in June and August 2020 recorded conductivities > 45,000 µS/cm and fluoride at 2-1.6 mg/L (a drop from 15 mg/L in late 2019) indicating seawater intrusion has occurred due to coastal erosion. Monitoring at this bore has ceased as it is unsuitable for monitoring of groundwater in the coastal zone.

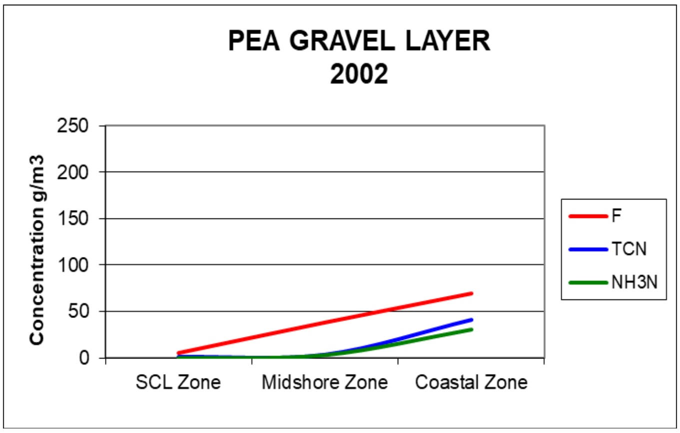
4.4.4 Trends for Coastal bore 5/4

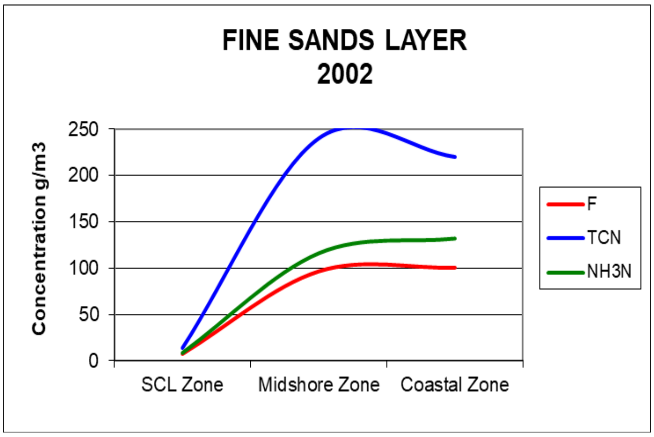
The cyanide and fluoride concentrations track reasonably well with conductivity for deep bore 5/4. Similar to what was observed for the SCL zone. See graphs below for detail.

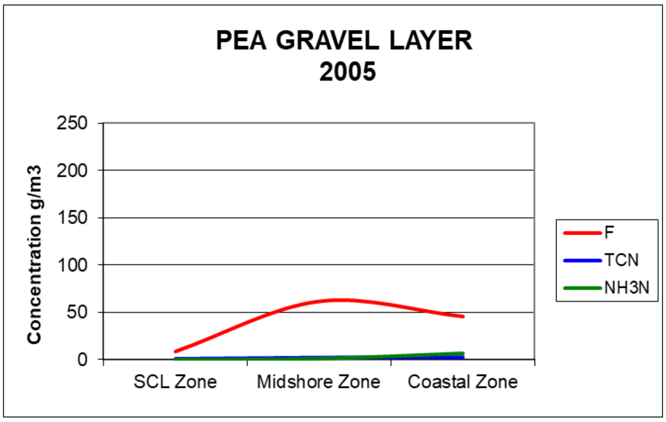


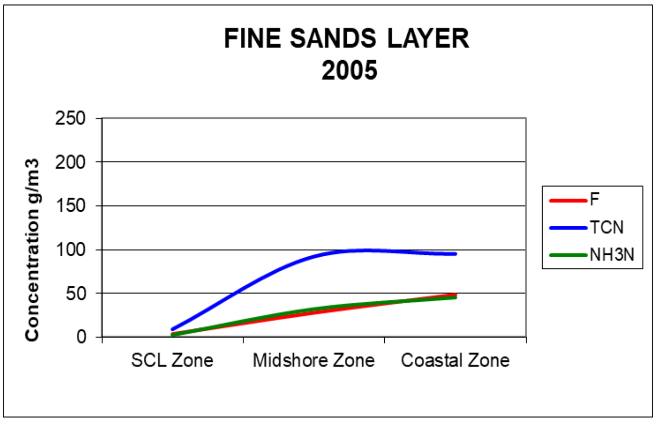
4.5 Comparison of Zones over Time

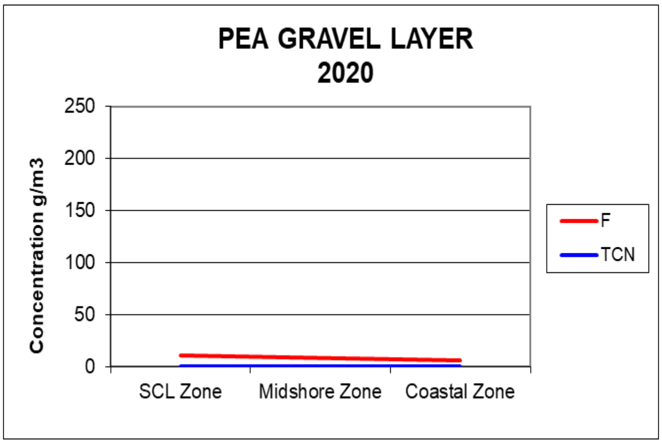
Comparison of Zones for the reporting years 2002, 2005 and 2020 are displayed below to show the general recovery of the groundwater over time.

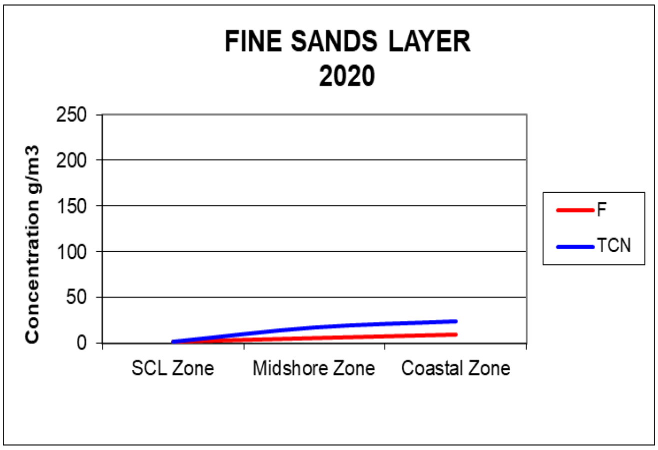












Both the pea gravel and find sand layers show great recovery from the 1990s groundwater contamination for all zones. The shallower pea gravel layers are showing less contamination than the fine sand layers which is expected due to the higher permeability in the pea gravel.

5 APPENDICES

Appendix A: ES Correspondence

R… onal House
C… ner Price St and North Rd
Invercargill,
New Zealand

SOUTHLAND REGIONAL COUNCIL

Private Bag 90116
Invercargill
Telephone (03) 215-6197
Fax (03) 215-8081

Our Reference: A277
Enquiries to :

11 October 1995

Site Services Manager
New Zealand Aluminium Smelter Ltd
Private Bag 90110
Invercargill

Dear Nicola

Cathode Pad Contaminant Plume, Options for Remediation

Following consideration of AquaFirma's report on the options for remediation of the cathode pad contaminant plume, the Council resolved on 11 October 1995 that NZAS be advised that:

(i) it is Council's opinion that the cathode pad contaminant plume be allowed to continue to recover by natural dispersion alone.

(ii) the monitoring regime recommended in the AquaFirma report should be implemented.

(iii) an annual report on results and possible alternative methods for remediation should be supplied to the Council each July.

The intention is that the need for any external audit of the annual report will be made at the end of each sampling year.

Thank you for your pro-activeness in this matter.

Yours faithfully

W J Tuckey
Director of Planning and
Resource Management
WJT:EHR

Managing Your Environment

Regional House
Corner Price St and North Rd
Invercargill,
New Zealand

SOUTHLAND REGIONAL COUNCIL

Private Bag 90116
Invercargill
Telephone (03) 215-6197
Fax (03) 215-8081

Our Reference: N015-012
Refer Accession No: 04782
Enquiries to: Ian Welsh

9 August 1999

The Manager
New Zealand Aluminium Smelters Ltd
Private Bag 90110
Invercargill

Dear Sir

Further to the Groundwater Reports, July 1999, regarding SCL Groundwater Report and the Diesel Bioremediation Report for 1999, I wish to confirm the following:

1. Council's Planning and Resource Management Committee has accepted staff recommendations made in the 4 August 1999 Planning and Resource Management meeting. A copy of the staff report and recommendations are enclosed.

2. The Committee also expressed its satisfaction at the responsible way in which NZAS had dealt with and progressed the matters.

Should you require more information or wish to discuss matters, please ask for Ian Welsh of this office.

Yours faithfully

JDR (James) Holloway
Environmental Compliance Manager

14 June 2002

environment SOUTHLAND
Te Taiao Tonga
Cnr North Rd & Price St
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Invercargill New Zealand
Phone 03 215 6197
Fax 03 215 8081
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Email service@envirosouth.govt.nz
Website www.envirosouth.govt.nz

Shaun O'Neill
Superintendent
Laboratory Services
New Zealand Aluminium Smelters Limited
Private Bag 90110
Invercargill

Our Reference: N015-028
Refer Accession No:
Enquiries to: James Holloway

Dear Shaun

SCL Groundwater Report

Thank you for the report on the results of the 2002 SCL groundwater monitoring. The report indicates further reduction in the contamination of groundwater and both the pea gravels and fine sand layers south of the storage pad.

We have noted that the graphical presentation of the data in the report has to be interpreted very carefully. While the report notes attenuation occurring at relatively constant rates, the discontinuous time intervals in sampling are not well represented in the graphs and the recovery rate of the groundwater may in fact be reducing over time.

Given that there is variable reductions of contaminant concentrations in the pea gravel layer, it is recommended that a further "snap shot" be taken in three years. At that time, the graphical representation of data should be plotted against an accurate timeline to provide a better visual determination of the reduction in contaminants in the groundwater.

If you have any further questions, please contact me.

Yours faithfully

Warren Tuckey
Director of Environmental Management

air water coast land

Received
JON
15/02/06

14 February 2006

environment SOUTHLAND
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Shaun O'Neill
Superintendent, Laboratory Services
New Zealand Aluminium Smelters
Private Bag 90110
Invercargill

Our Reference: N015-028
Refer Accession No: 2005/23479

Dear Shaun

SCL Groundwater Report

Council has considered the monitoring results which you presented in the 2005 SCL Groundwater Report. They have accepted that contaminants below the SCL site are declining due to both dilution and transport to the CMA. There is no evidence that transport and discharge to the CMA through groundwater is having any measurable impact on the environment.

As a consequence of the report, Council have concluded that there is no further requirement to undertake monitoring of the SCL groundwater contamination, unless the SCL storage area is unsealed and opened to the environment.

If you have any questions, please contact me.

Yours sincerely

JDR (James) Holloway
Environmental Compliance Manager

air water coast land

Appendix B: 2020 Comparison of all Bores

The table below is detailing the average groundwater data obtained for 2020. Six samples for fluoride, pH and conductivity and two samples for free and total cyanide. Note sampling at bore D

		Ground Water Bores 2020 – Average Value								
Analyte	**Unit**	**2/2 (sand)**	**3/1**	**3/2**	**3/3**	**3A1 (sand)**	**4/5**	**4/10**	**5/4 (sand)**	**D**
Conductivity	µS/cm	350	449	408	386	458	562	651	885	41700
Fluoride	g/m^3	4.4	17.1	13.7	5.1	1.4	11.2	5.2	9.7	1.6
Total Cyanide	g/m^3	0.02	1.6	0.74	0.15	1.6	0.44	17	23.5	0.8
Free Cyanide	g/m^3	<0.01	0.17	0.1	<0.01	<0.01	0.01	0.04	0.04	<0.01
pH		7.4	8.6	8.3	7.7	9.3	9.1	10.2	9.9	8

ceased after August due to seawater contamination.

The table below is detailing the December 2020 ground water data obtained.

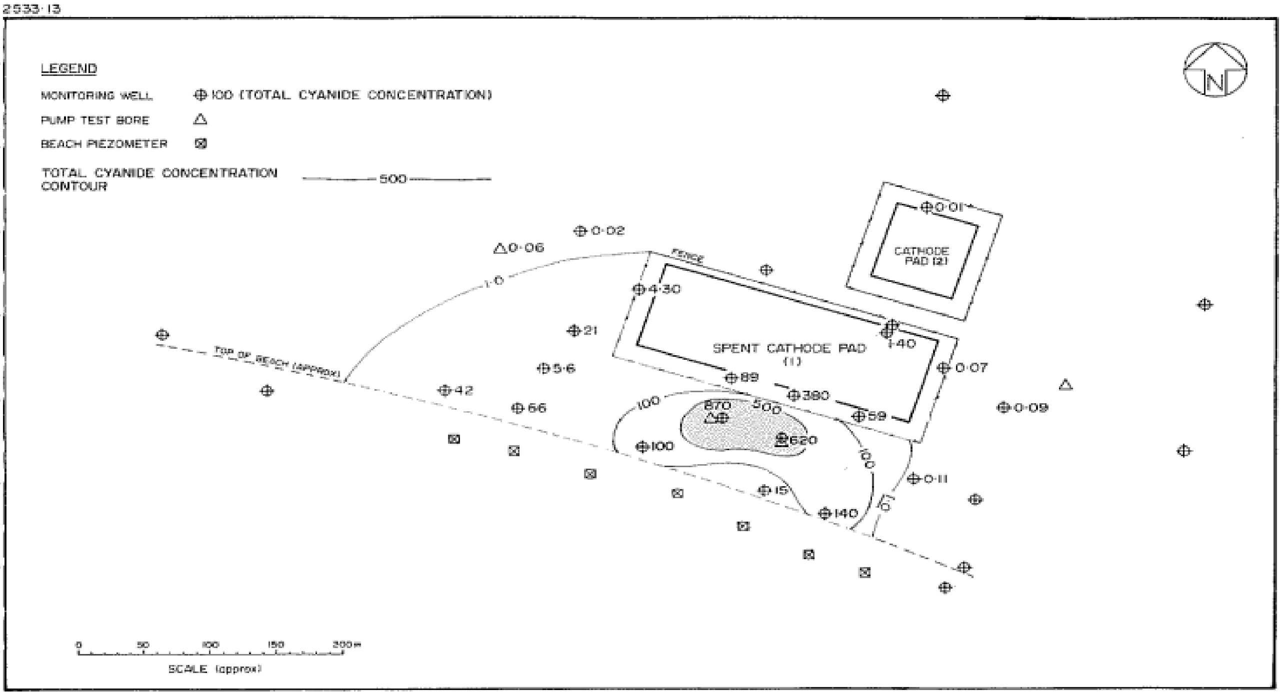
		Ground Water December 2020								
Analyte	**Unit**	**2/2 (sand)**	**3/1**	**3/2**	**3/3**	**3A1 (sand)**	**4/5**	**4/10**	**5/4 (sand)**	**4/1**
Conductivity	µS/cm	336	645	701	826	464	816	585	993	389
Fluoride	g/m^3	3.7	20	39	7	1.5	25	4.1	12	0.7
Total Cyanide*	g/m^3	0.015	2.8	1.1	<0.125	<0.25	0.675	12	24	0.808
Free Cyanide*	g/m^3	<0.01	0.013	<0.01	<0.01	<0.01	0.014	0.012	0.016	<0.01
pH		7.5	9	8.6	7.9	9.4	9.5	10.2	10.2	8.8

Total and free cyanide was last measured in August 2020.

Appendix C: 1992 SCL Pad Groundwater Investigations

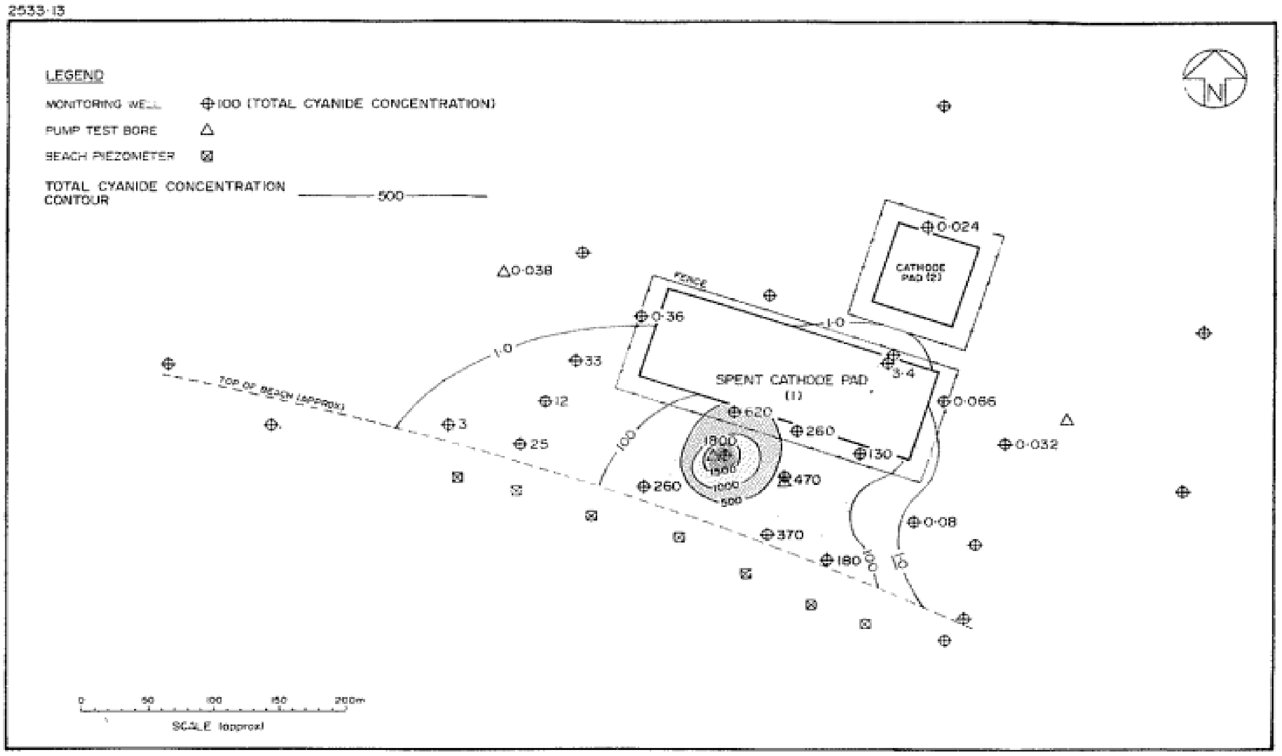
Reference: Groundwaters of Tiwai Peninsula Volume 1, Woodward-Clyde (NZ) Ltd, 1994

2533·13

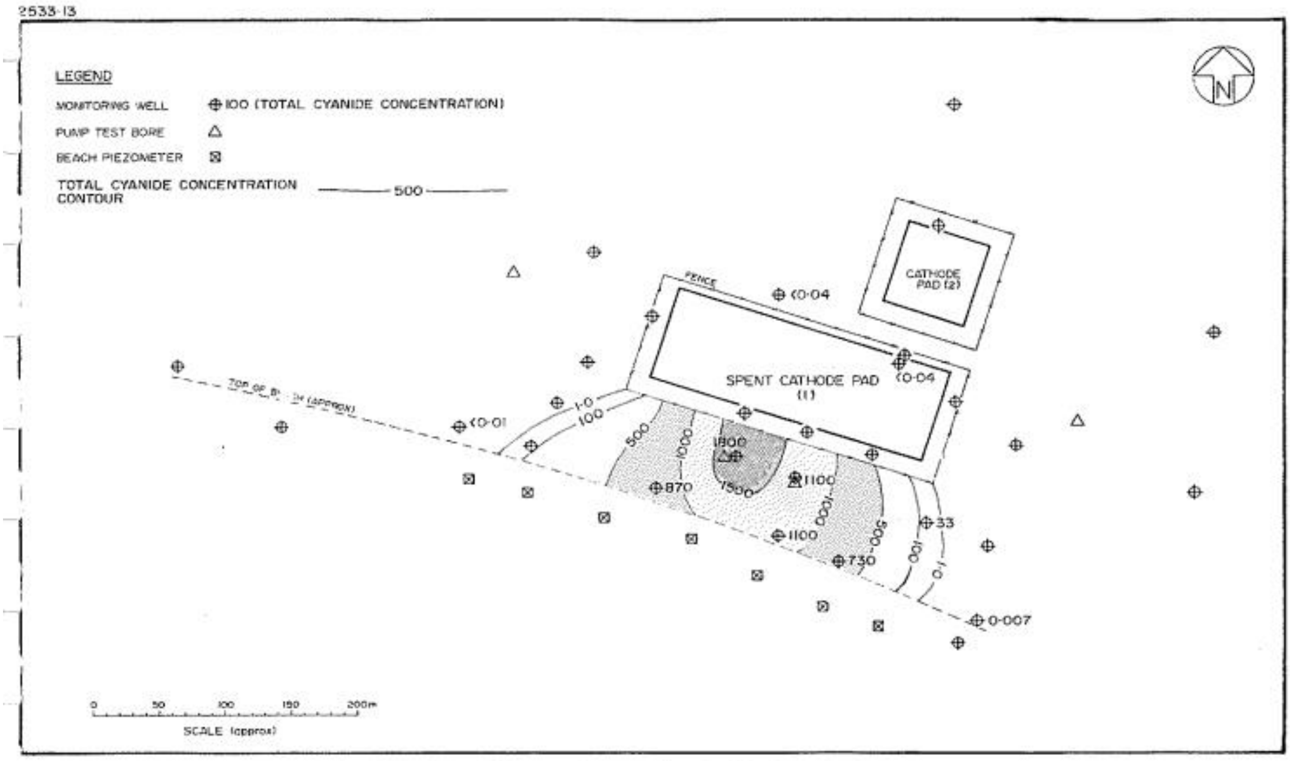


SPENT CATHODE PAD - TOTAL CYANIDE CONCENTRATIONS (g/m^3) IN SHALLOW PEA GRAVEL, JUNE 1992

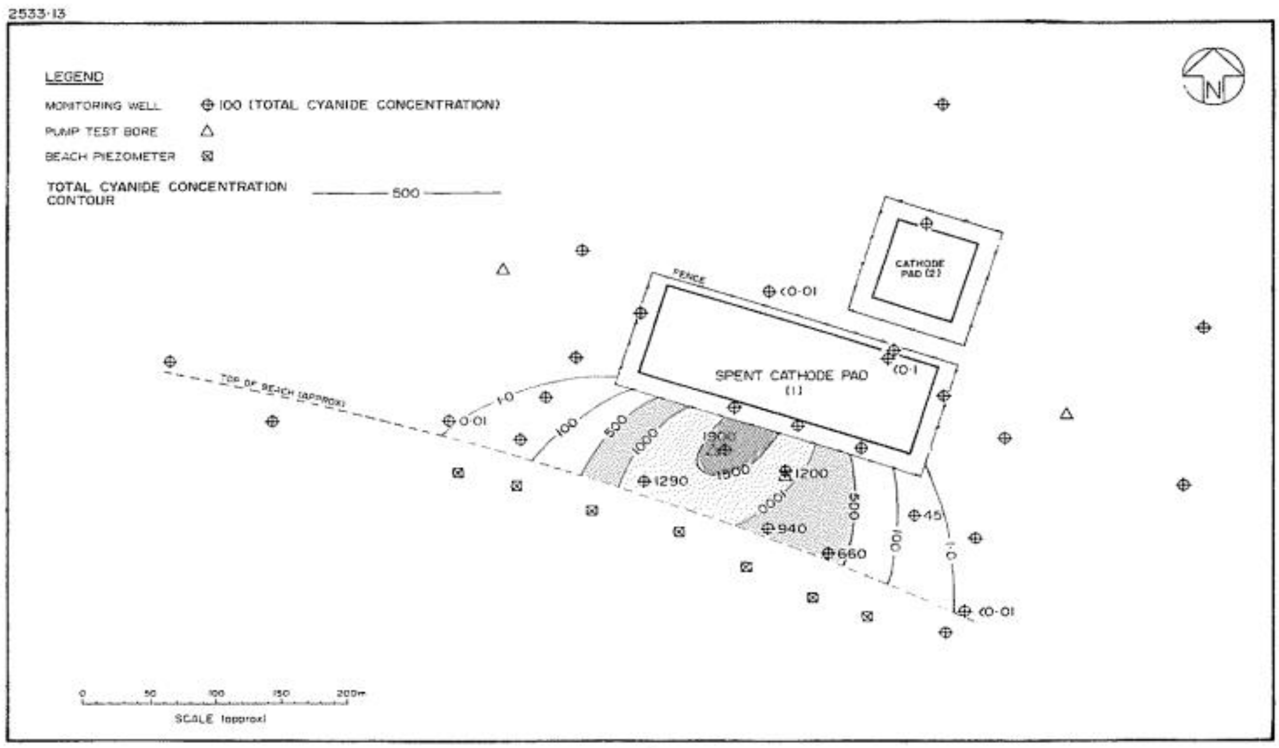
2533·13



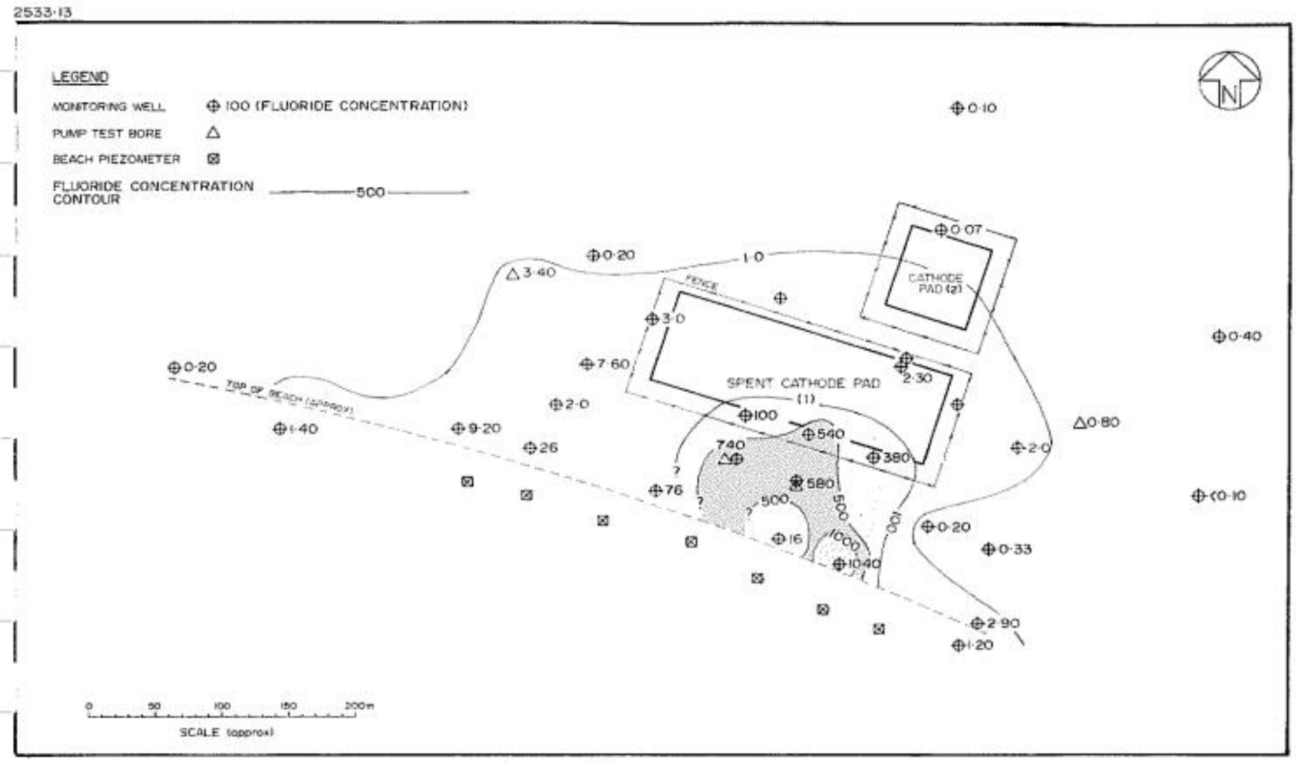
SPENT CATHODE PAD - TOTAL CYANIDE CONCENTRATIONS (g/m^3) IN SHALLOW PEA GRAVEL, OCTOBER 1992



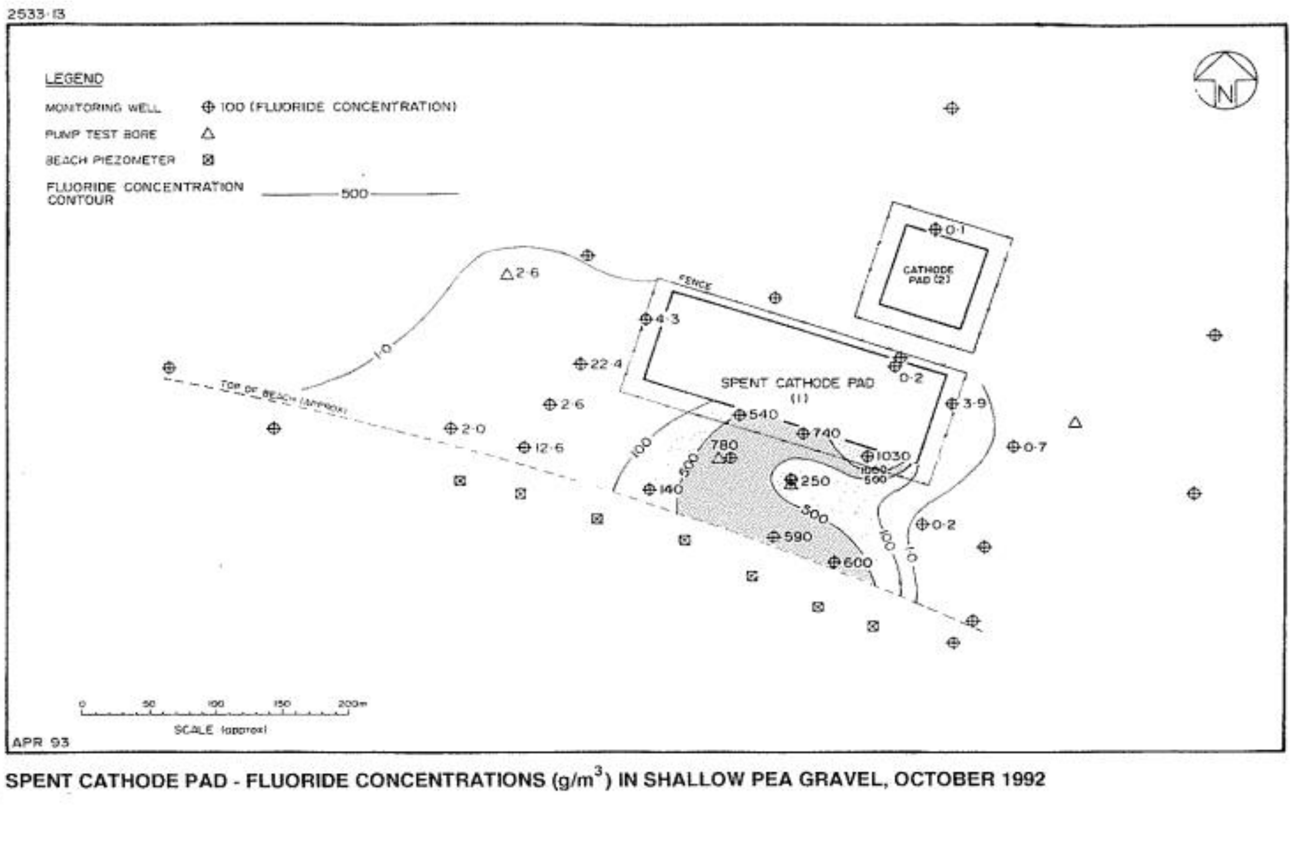
SPENT CATHODE PAD - TOTAL CYANIDE CONCENTRATIONS (g/m^3) IN DEEPER SANDS, JUNE 1992



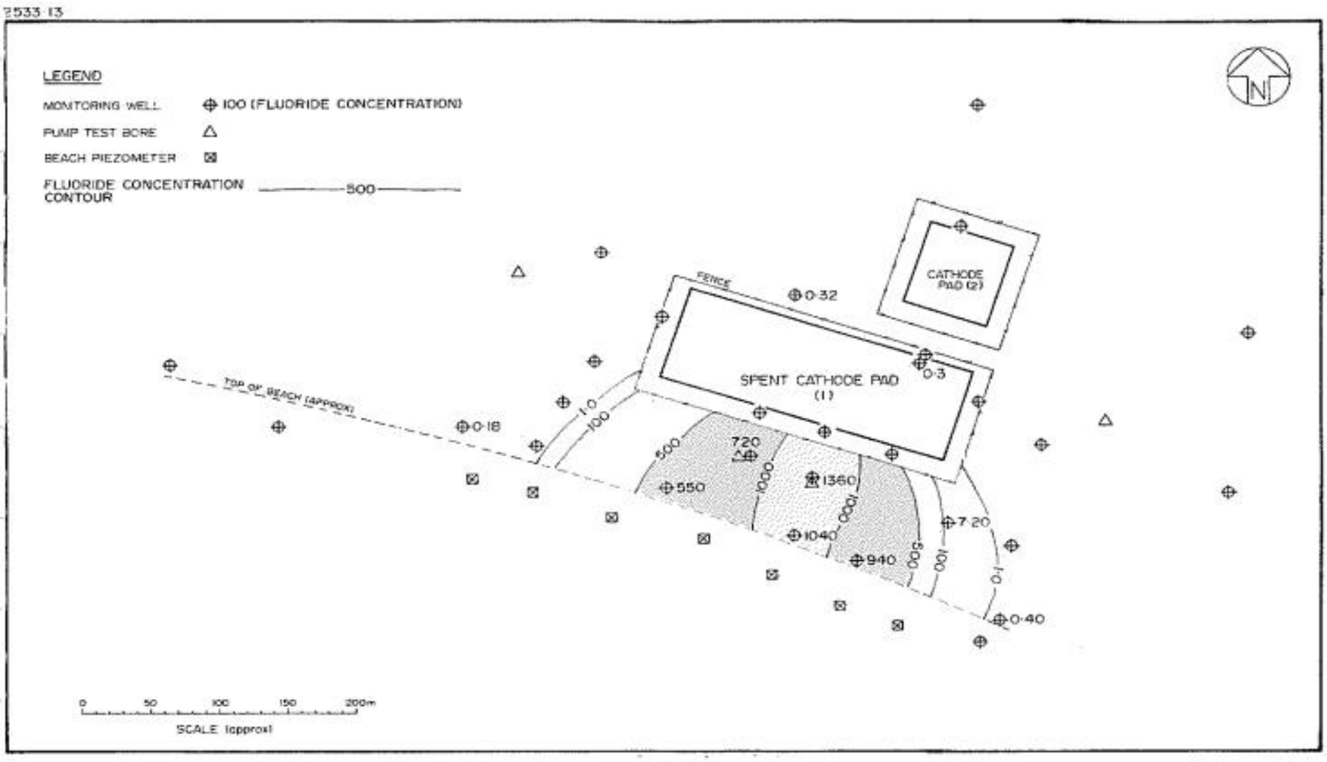
SPENT CATHODE PAD - TOTAL CYANIDE CONCENTRATIONS (g/m^3) IN DEEPER SANDS, OCTOBER 1992



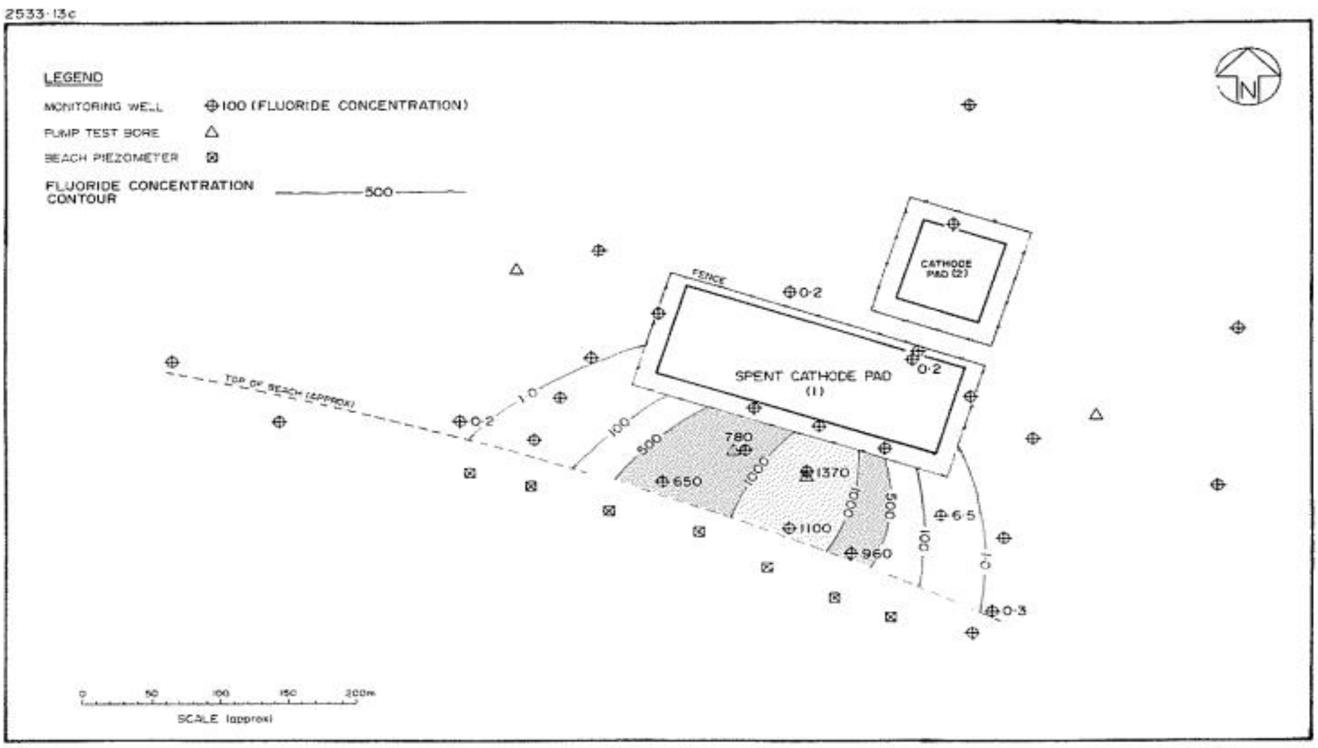
SPENT CATHODE PAD - FLUORIDE CONCENTRATIONS (g/m³) IN SHALLOW PEA GRAVEL, JUNE 1992



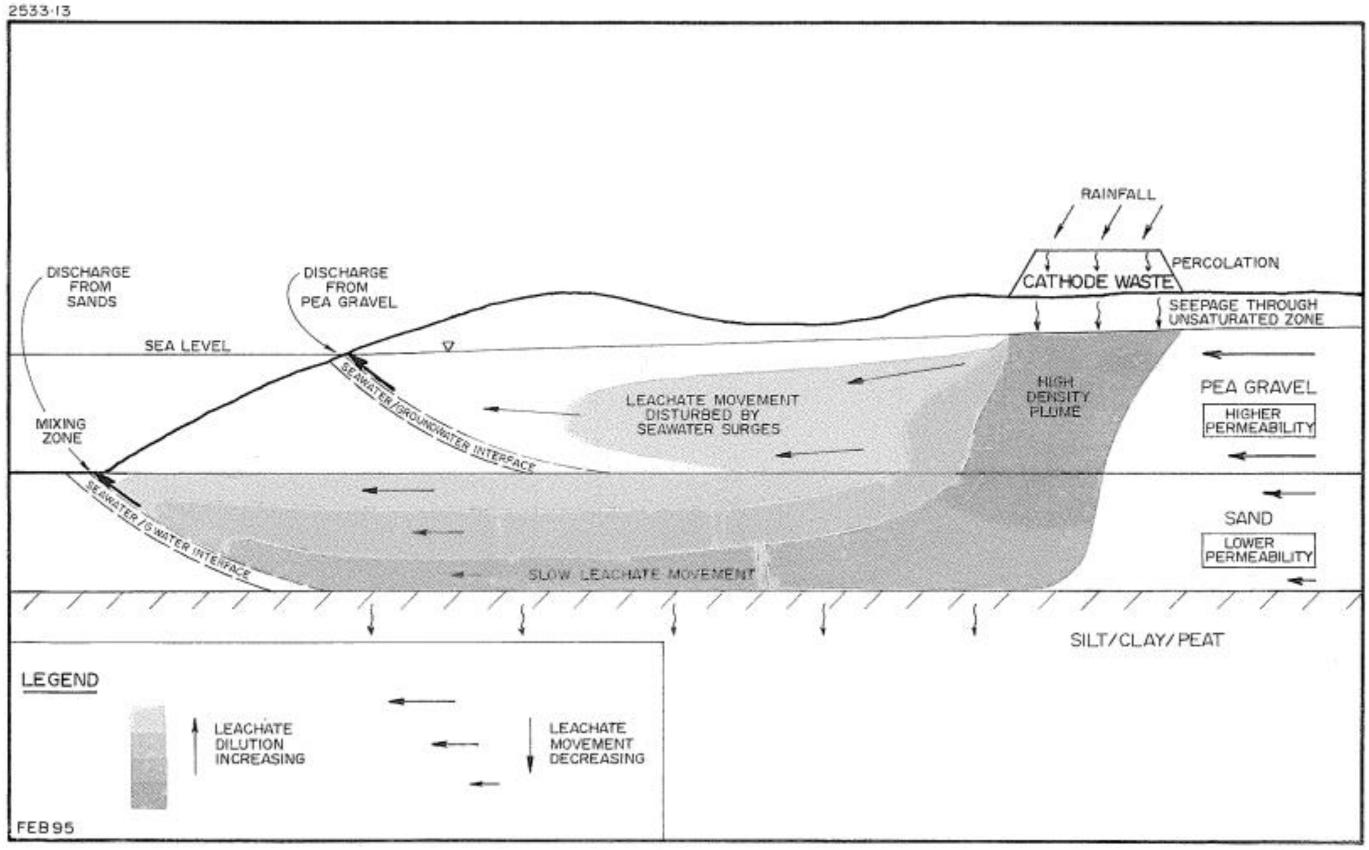
SPENT CATHODE PAD - FLUORIDE CONCENTRATIONS (g/m³) IN SHALLOW PEA GRAVEL, OCTOBER 1992



SPENT CATHODE PAD - FLUORIDE CONCENTRATIONS (g/m^3) IN DEEPER SANDS, JUNE 1992

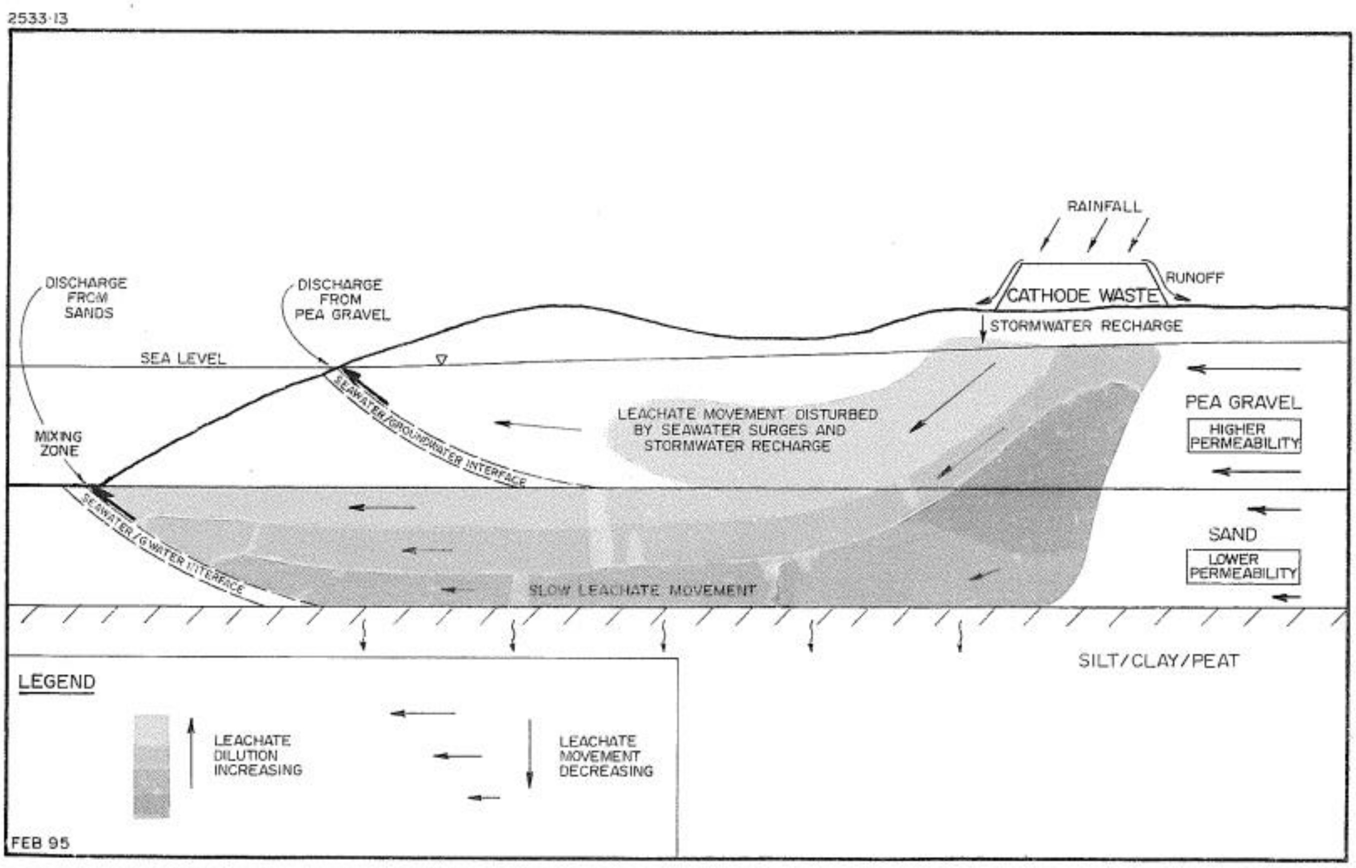


SPENT CATHODE PAD - FLUORIDE CONCENTRATIONS (g/m^3) IN DEEPER SANDS, OCTOBER 1992



CONCEPTUALISATION - PRE COVER - SPENT CATHODE PAD

Figure 13



CONCEPTUALISATION - POST COVER - SPENT CATHODE PAD

Figure 14

New Zealand Aluminium Smelters Ltd

NZAS Groundwater Monitoring Programme

Summary – March 2021.

Shaun O'Neill - Superintendent Closure Readiness, NZAS
3-26-2021

NZAS Routine Groundwater Monitoring.

Part1: Routine Groundwater Monitoring

NZAS has a comprehensive groundwater monitoring programme within the confines of the smelter boundary, at the NZAS landfill and on the wider Tiwai Peninsula. NZAS routinely monitors and reviews groundwater quality at these multiple locations. Results of this monitoring are routinely reported to Environment Southland for review.

Groundwater monitoring is undertaken for the following requirements:

- Resource Consents for Environment Southland (ES)
- Information for compliance to NZ Drinking Water Standards
- NZAS assurance of waste storage integrity
- NZAS assurance of wash-down operations.

The following locations are monitored and are depicted on site map 90-G-01050 (Page 3):

Landfill bores (19)

Groundwater monitoring data from 19 groundwater bores: A6, A20 – A24, A30, A31, A40, A41, A51 – A58, T1A. Data for this groundwater is reported in detail in Part 2 of this document.

SCL Pad bores (9)

Groundwater monitoring around the SCL pad. Comments regarding levels of contaminants are made in the annual report to ES, however, no actual data has been submitted since 2005 when ES advised in early 2006 that monitoring of the groundwater plume was no longer required as levels had attenuated by dissolution and movement of the plume seaward to Foveaux Strait. ES has requested SCL bore data from 2005 to 2020 and a report has been prepared for submission. One bore, which is located at distance from the SCL Pad, has recently collapsed due to coastal erosion and is planned for replacement in 2021.

Reco wash down sump bores (4)

The bores surround a water tank which collects water from an enclosed hard stand area where Reconstruction wash down shells and superstructures after they have been removed from Potlines. Monitoring for cyanide and fluoride contamination of groundwater has been ongoing to ensure any seepage to groundwater is detected. This area has historically had elevated concentrations due to minor cracking in the concrete tank. The tank was repaired in 2016 after leakage was detected and groundwater concentrations are now slowly decreasing.

Sentinel bores (8)

These bores are for monitoring of potential seawater ingress into the aquifer. They are required to be monitored if the annual production of metal exceeds 375,000 tonnes or if NZAS exceeds 3500 m^3/day for three continuous months. NZAS has routinely monitored these bores since 2005. One bore has been removed from service due to damage from seawater and another bore is showing seawater ingress most probably due to coastal erosion. These two bores are planned to be replaced in 2021.

SCL shed ports (14)

These ports are for monitoring of potential contaminants that may be leaching into the lining below the concrete floor of SCL #1. There are shallow ports and deep ports located close to the building.

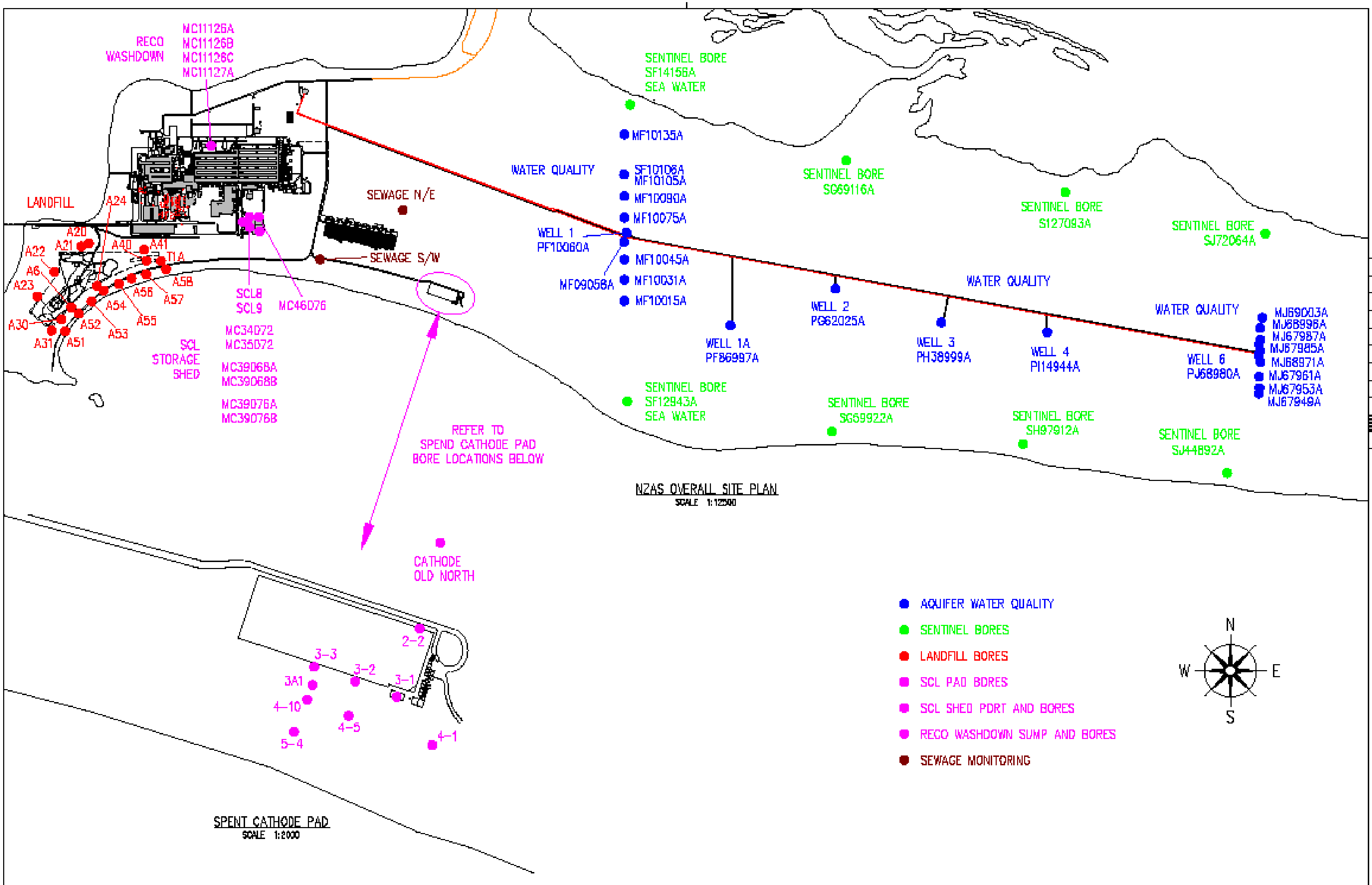
SCL shed bores (7)

These bores are for monitoring of potential contaminants that may be leach into groundwater surrounding the SCL sheds. They are located close to the building.

Aquifer/pumphouse water quality

Reporting of water quality under NZ Drinking Water Standards is no longer required under requirements of the NZ Drinking Water Standards 2018. However, NZAS continues to monitor for pH, fluoride, conductivity and total solids monthly. The presence of E-coli is also tested routinely.

The following drawing, 90-G-01050, depicts bores routinely monitored on Tiwai Peninsula.



DO NOT SCALE - IF IN DOUBT ASK

UNCONTROLLED DOCUMENT WHEN PRINTED, CHECK FOR LATEST VERSION ON-LINE

Pa

No.	DATE	REVISION	DRN	DES	APP	NOTES	REFERENCE DRAWINGS	DWG. No.	EQUIPMENT No.

AutoCAD

NEVILLE HALL

SHAUN O'NEILL

NZAS

SHAUN O'NEILL

NEW ZEALAND ALUMINIUM SMELTERS LIMITED

NZAS SITE
ENVIRONMENTAL BORE
MONITORED SAMPLE LOCATIONS
MARCH 2021

A1

SCALE	DWG. No.	REVISION
1 : 12500	90-G-01050	R- B

Part 2: NZAS Landfill Groundwater Monitoring Programme

The NZAS landfill was opened during construction of the smelter in the late 1960's and is consented for use by Environment Southland.

In 2003 Environment Southland publically notified that NZAS had sought an application for a consent to operate a landfill at Tiwai Point and that submissions from the public on the application could be made to Environment Southland.

In support of the NZAS application an Assessment of Environmental Effects (AEE) was submitted to Environment Southland which outlined the impact the landfill was and would have upon the local environment including the coastal marine area. The AEE included information from reputable independent scientific consultant organisations who concluded after comprehensive studies that "proposed and existing activities at the Tiwai Landfill are therefore unlikely to result in adverse environmental effects on the Bluff Harbour, or South Coast marine receiving environment."

The Resource Consent (Discharge Permit) No 202196 was issued by the Southland Regional Council (Environment Southland) on 8th December 2003 and states that NZAS is able to:

> *"To discharge contaminants onto or into land in circumstances which may result in those contaminants (or any other contaminants emanating as a result of natural processes from those contaminants) entering water; and to discharge contaminants from any industrial or trade premises onto or into land. The material for disposal is waste from NZAS and the material that is known as Haysom's dross."*

The Discharge Permit expires on 8 December 2023.

The Discharge Permit requires NZAS to monitor for a comprehensive range of analytes (substances) in groundwater at various locations and frequencies and report these results at six monthly intervals to Environment Southland. Additionally, all results from a calendar year are summarised in an Annual Report provided to Environment Southland by the 31st March of the year following. The Discharge Permit specifies no maximum concentration (level) of contaminates in groundwater originating from the landfill.

Surrounding the landfill are nineteen groundwater monitoring bores from which water samples are routinely analysed. As per the Discharge Permit results from eight bores are routinely reported to Environment Southland. To provide assurance that the data reported to Environment Southland is valid there are an additional eleven groundwater monitoring bores surrounding the landfill with results are reviewed by NZAS.

The landfill contains materials located in separate cells which enables potential removal and re-use at a later date. As cells become full they are closed, covered with locally sourced cover material and then periodically re-planted with native vegetation. New cells are then opened to replace closed cells.

Material stored at the landfill includes very fine carbon material that is unable to be utilised in the production of new anodes, double bagged man-made mineral fibres (e.g. glass wool) and asbestos, clean-fill of concrete and, construction / refractory bricks. The landfill also contains one cell of historic dross that is scheduled for commencement of removal in 2021 as production capacity becomes available by a third-party contractor. The landfill also contains a separate cell of Haysom's dross material.

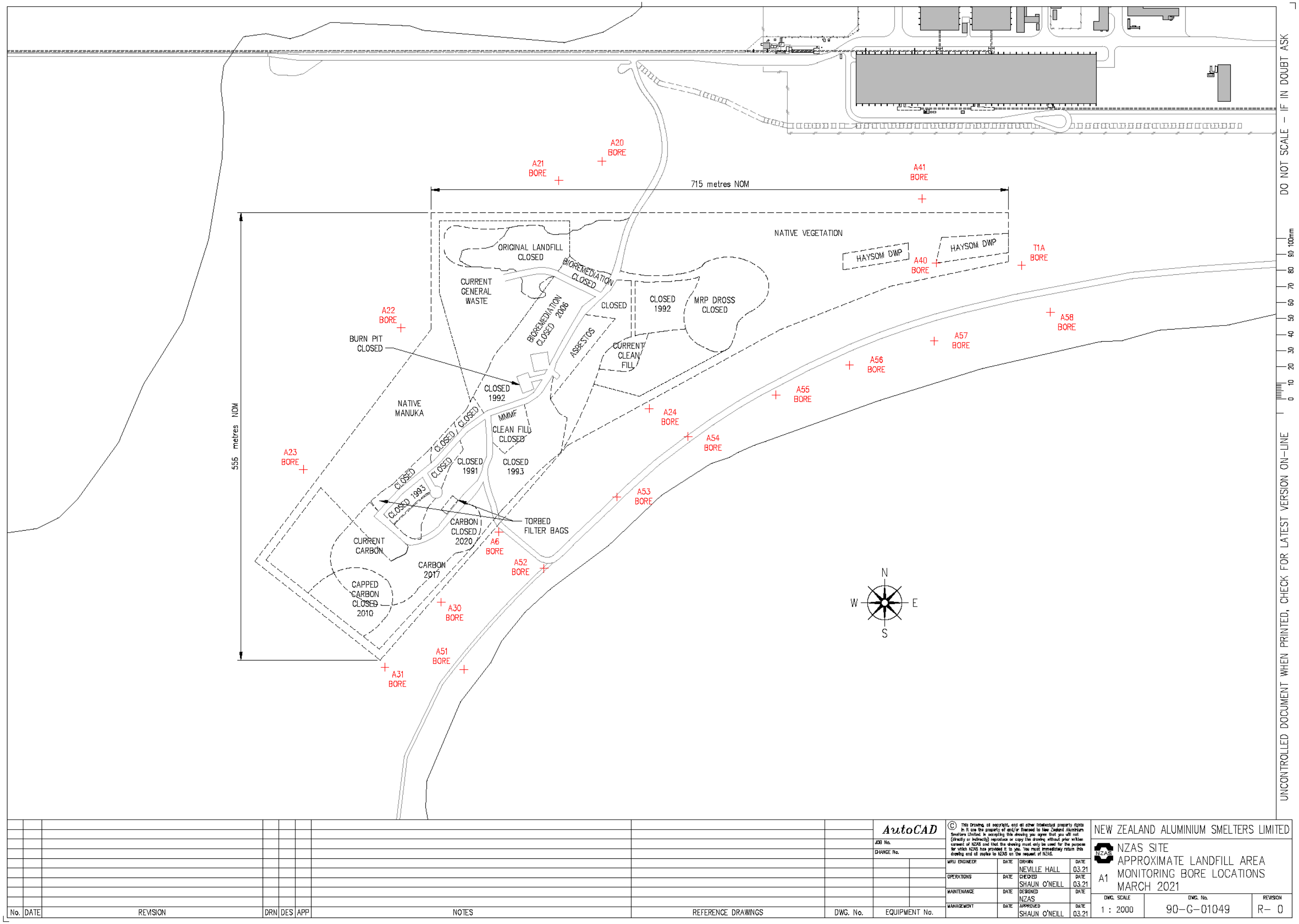
In 2009 the carbon cell and the Haysom's cell were covered with an impermeable geo-membrane to minimise leachate production from these two cells.

Where possible wooden pallets are returned to sender, or sent to a local company for dismantling and re-cycling. If this is not possible they are crushed and shredded on site and used as groundcover at the landfill.

All putrescible waste (i.e. from kitchens and lunch rooms) is sent off-site to the regional landfill.

Similar to municipal landfill, the NZAS landfill also contains general waste that is unable to be economically recycled or re-used.

Groundwater flow is generally southwards to Foveaux St. There is limited groundwater flow westwards and north to Bluff Harbour.


A20 BORE
A21 BORE
715 metres NOM
A41 BORE
556 metres NOM
NATIVE VEGETATION
ORIGINAL LANDFILL CLOSED
BIOREMEDIATION CLOSED
HAYSOM DWP
HAYSOM DWP
A40 BORE
T1A BORE
CURRENT GENERAL WASTE
CLOSED
CLOSED 1992
MRP DROSS CLOSED
A22 BORE
BIOREMEDIATION CLOSED 2006
ASBESTOS
A58 BORE
BURN PIT CLOSED
CURRENT CLEAN FILL
A57 BORE
A56 BORE
NATIVE MANUKA
CLOSED 1992
A55 BORE
A24 BORE
CLOSED
MMMF CLEAN FILL CLOSED
A54 BORE
A23 BORE
CLOSED
CLOSED
CLOSED 1991
CLOSED 1993
CLOSED
CLOSED 1993
A53 BORE
TORBED FILTER BAGS
CARBON CLOSED 2020
CURRENT CARBON
A6 BORE
CARBON 2017
A52 BORE
CAPPED CARBON CLOSED 2010
A30 BORE
A51 BORE
A31 BORE
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NEW ZEALAND ALUMINIUM SMELTERS LIMITED
NZAS SITE
APPROXIMATE LANDFILL AREA
MONITORING BORE LOCATIONS
MARCH 2021
A1
DWG. SCALE 1 : 2000
DWG. No. 90-G-01049
REVISION R- 0

Page

Groundwater at the landfill is monitored for an extensive range of analytes. The frequency of monitoring is dependent on the bore location and the analytes being sampled. The full range of analytes routinely analysed is:

- Temperature, pH, conductivity, alkalinity
- Carbon BOD5
- Total nitrogen, fluoride, sulphate
- A range of polycyclic aromatic hydrocarbons, total petroleum hydrocarbons,
- aluminium, iron, boron, manganese, nickel, potassium and vanadium,
- Kjeldahl nitrogen, nitrate and nitrite nitrogen,
- Weak dissociable cyanide.

In 2006 a comprehensive survey was undertaken in some bores for; calcium, magnesium, sodium, lithium, rubidium, phosphorus, sulphur, cyanide, silver, arsenic, barium, bismuth, cadmium, cobalt, chromium, cesium, copper, mercury, lanthanum, molybdenum, lead, antimony, selenium, strontium, thallium, tin, uranium and zinc.

Summary of Landfill Monitoring Results

Groundwater monitoring bores surrounding the landfill show there is leaching of contaminants from materials deposited at the landfill into the surrounding groundwater. Some bores are nominally 'upstream' of groundwater flow under the landfill while others are 'downstream' to monitor leachate levels.

The location of groundwater bores monitored in the NZAS landfill are displayed in site map (90-G-01049) given on Page 3.

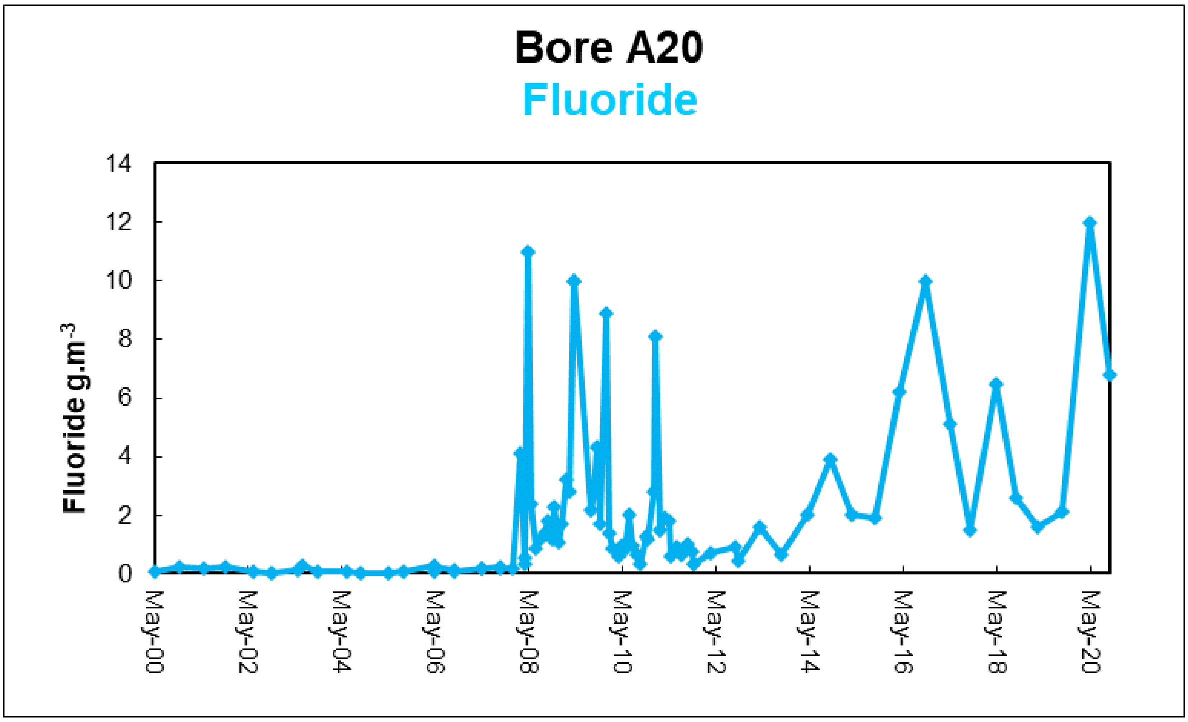
Background bores

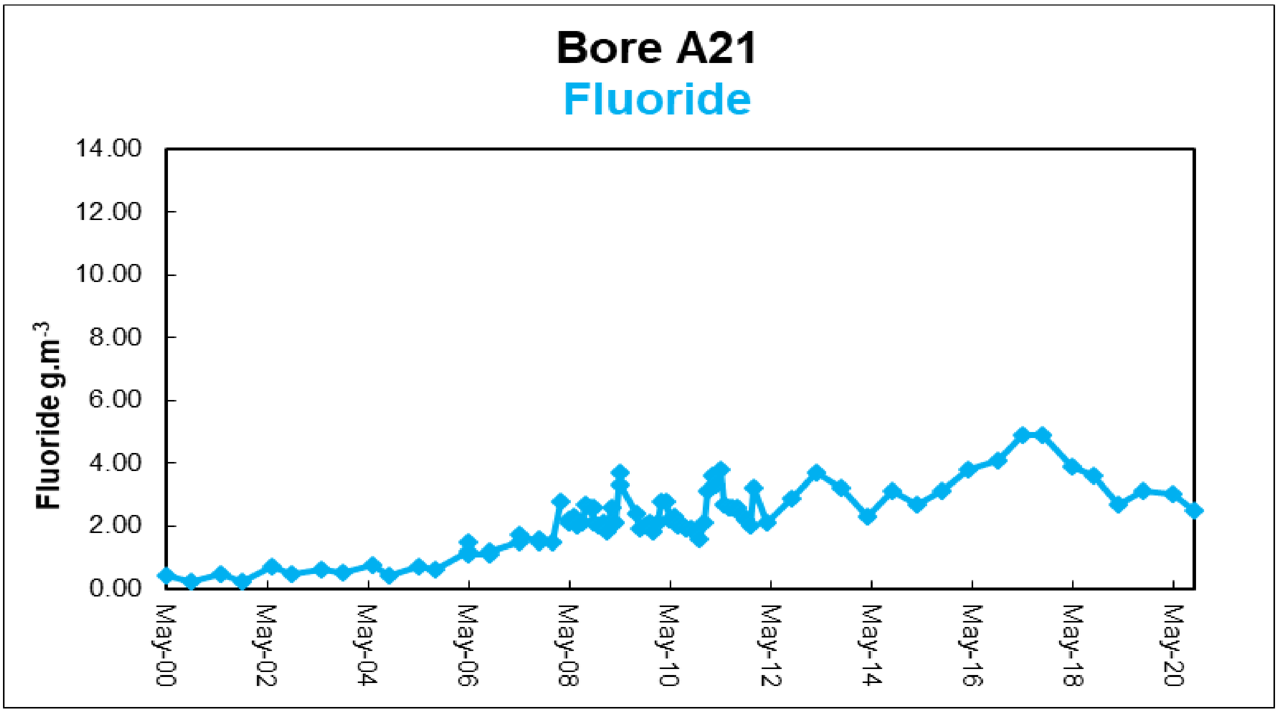
Fluoride levels have been chosen as an indicator for contamination in groundwater as fluoride is monitored in all bores.

Bores **A20**-**A23** and **A41** are all 'upstream' of groundwater flow and all indicate a limited influence of the landfill upon groundwater.

Bore **A20** and **A21** are located upstream of groundwater flow through the General, Clean fill and MRP dross piles.

Fluoride levels for bores **A20** and **A21** are displayed below.

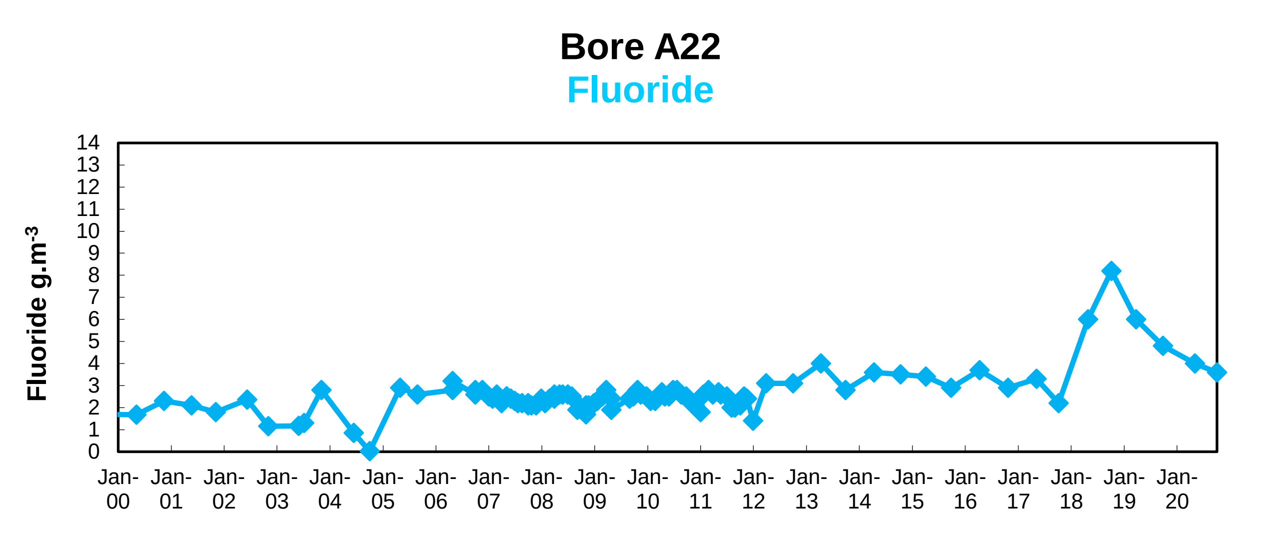




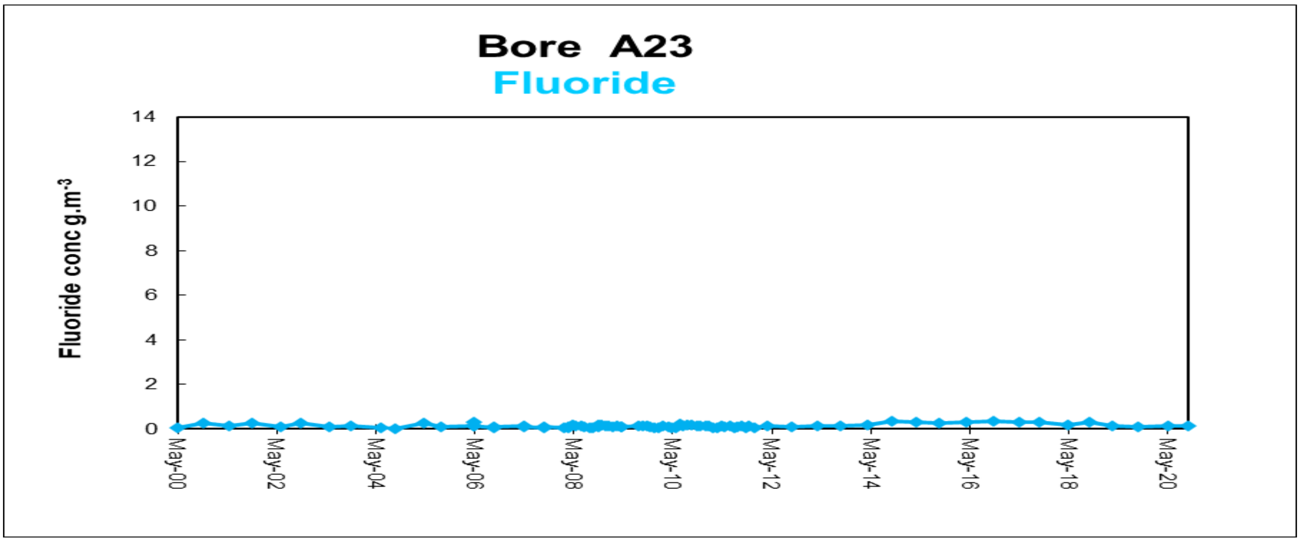
A 5-10 times increase in fluoride concentration in Bores **A20** and **A21** has been observed since 2007. The reason for fluoride increases in these bores is most likely due to a change in direction of groundwater flow resulting from changes in location where materials have been deposited in the Landfill, rather than being influenced by water from the nearby South drain.

Bore **A20** continues to be variable while small peaks in bore **A21** observed in 2008/2009, and in 2012, have reverted to a normal steady state of approximately <5 g/m^3.

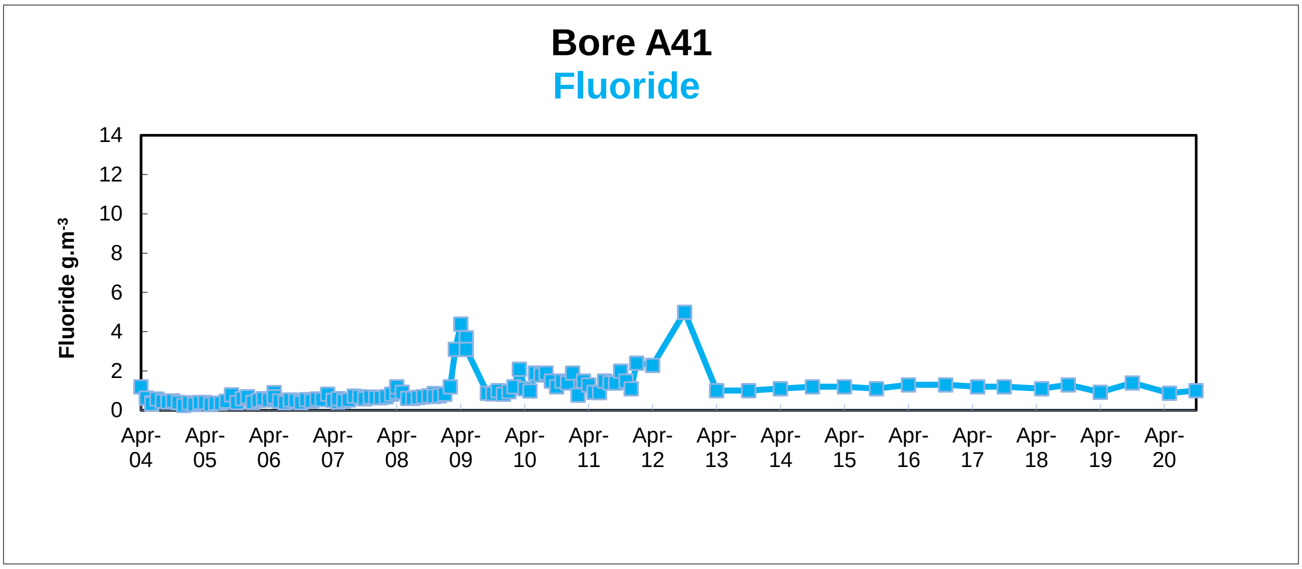
Bore **A22** is located southwestwards of the general pile and showing similar fluoride concentration to Bore **A21**.


Bore A22
Fluoride
Fluoride g.m-3
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20

Bore **A23** is located upstream (north) of the carbon piles. Typical fluoride values are less than 0.5 g/m³.



Bore **A41** is located upstream of Haysom's dross cell and continues to show low levels of fluoride.

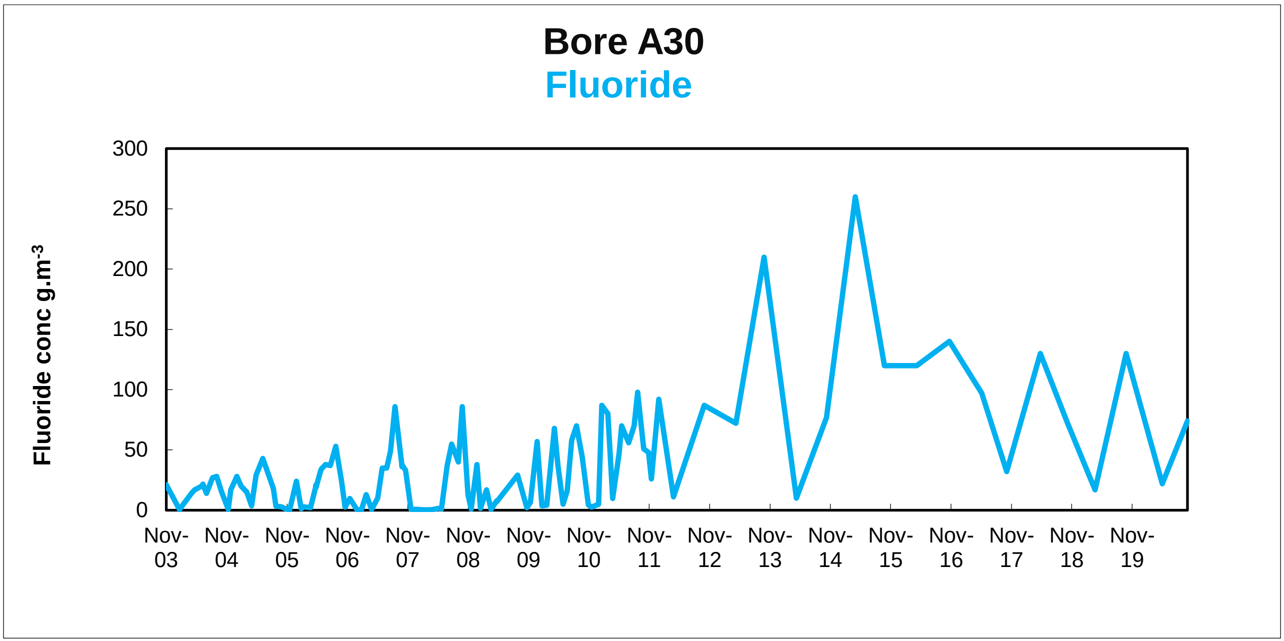


Downstream bores

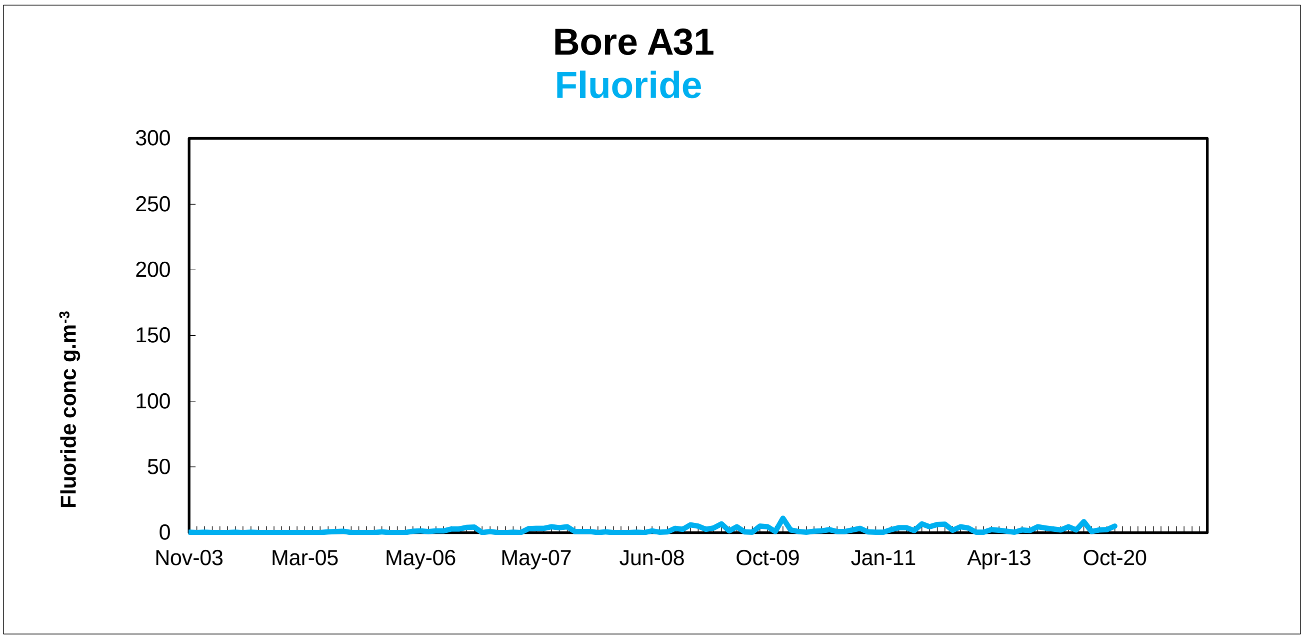
Bores **A30, A31, A6, A24, A40, T1A** and **A51-A58** are all 'downstream' of groundwater flow located between the landfill and Foveaux St. All bores indicate an influence of the landfill upon groundwater.

Bore **A30** and A**31** are located downstream of the carbon piles. The carbon piles contain small amounts of waste alumina and bath which contain leachable fluoride.

Bore **A30** is directly south of carbon piles which are not currently capped. This is likely to be the cause of the elevated fluoride levels observed in this location. Additionally, there are newer carbon deposits upstream of the capped carbon pile as well as fluoride rich alumina coated discarded torbed filter bags that are highly likely to contribute to the long-term increase in the fluoride levels at this bore.

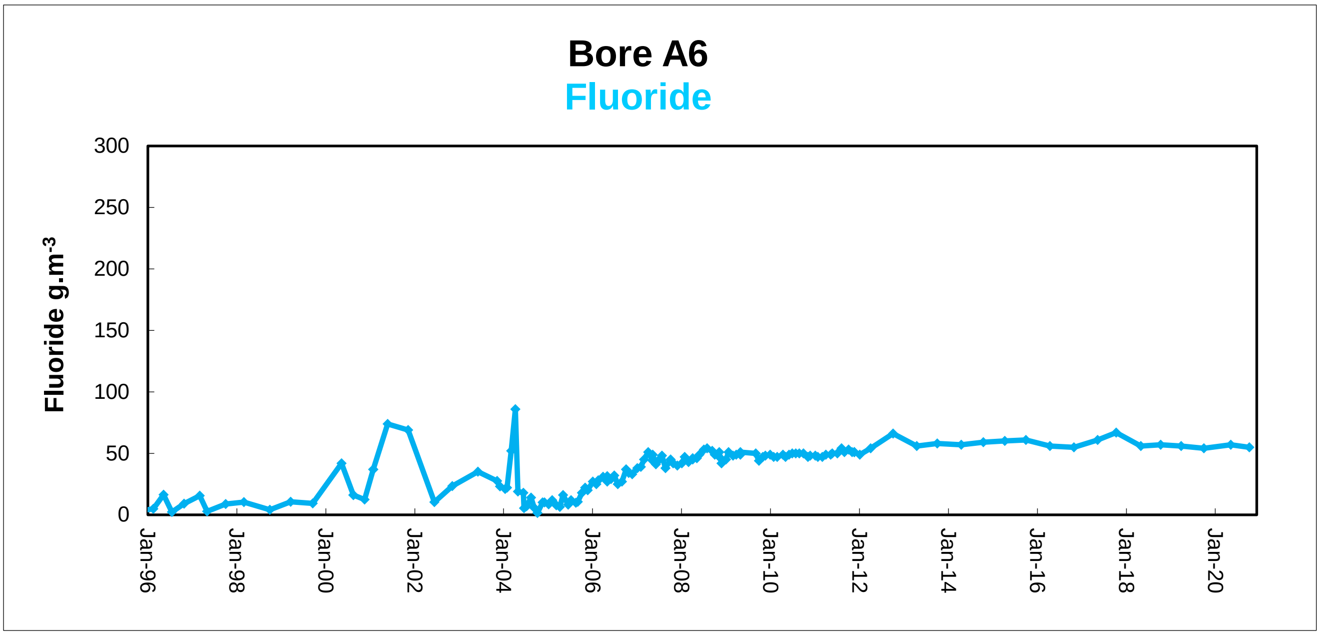


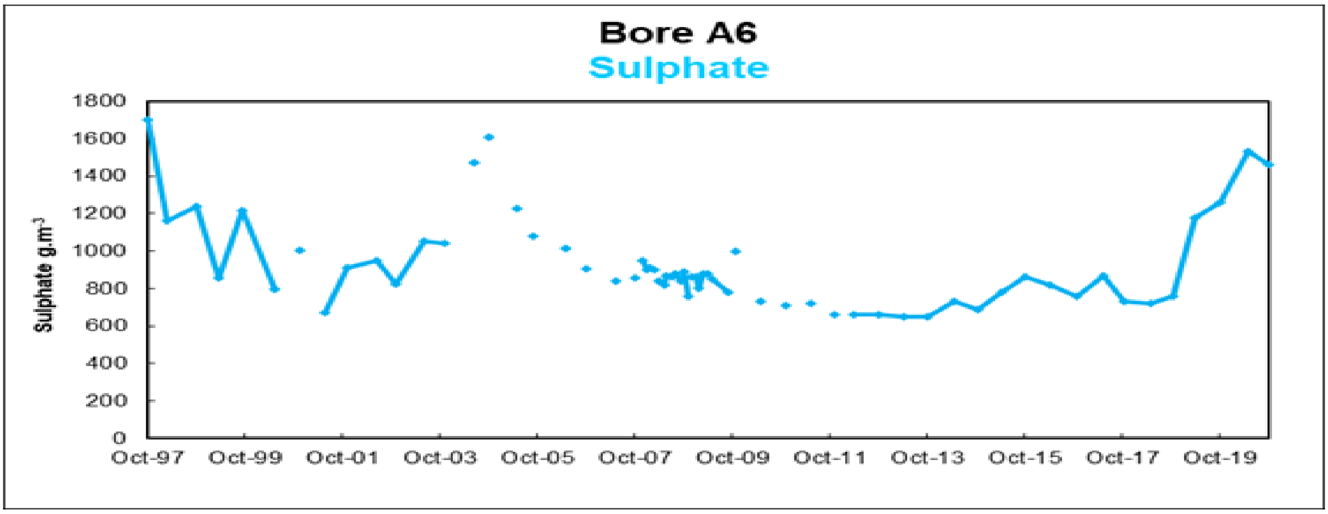
Bore **A31** is in the corner of the landfill south of the capped carbon pile. Levels are similar to back ground levels seen in bores north of the landfill.



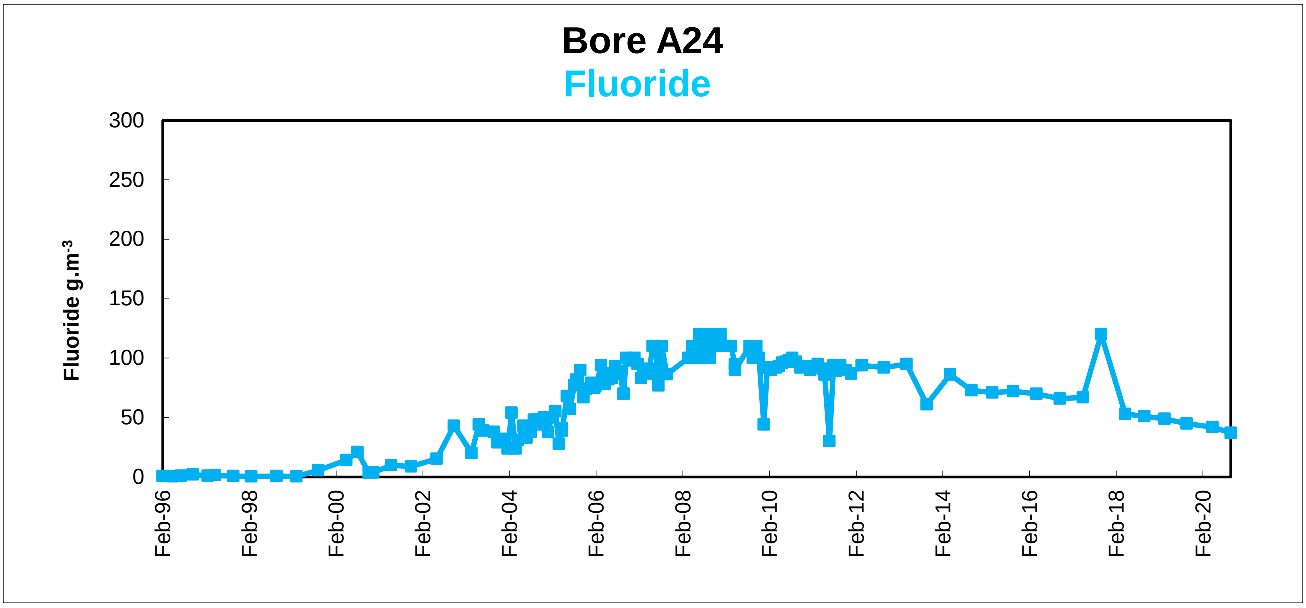
Bore **A6** is located north of Bore **A30** but not directly associated with any active waste piles. The level of fluoride contamination in this location is likely to be due to historical deposits of dross or bath.

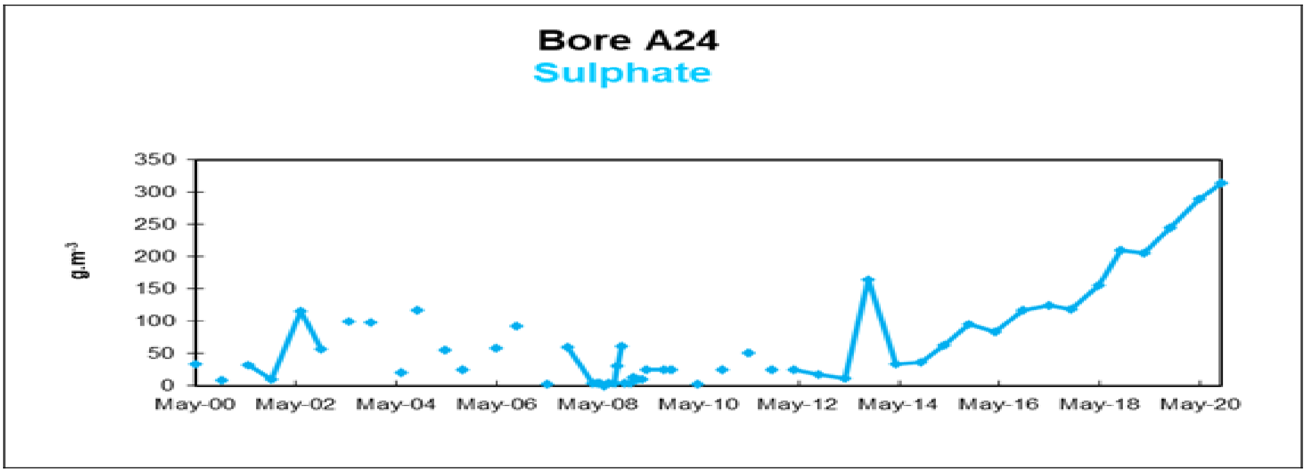
There was a five-fold increase in fluoride between 2005 and 2008. Fluoride levels have now stabilised at levels slightly less than what is seen in Bore **A30**. Sulphate levels in upstream bores are generally less than 50 g/m^3 indicating significant historical leaching of sulphate into groundwater as measured by Bore **A6.**



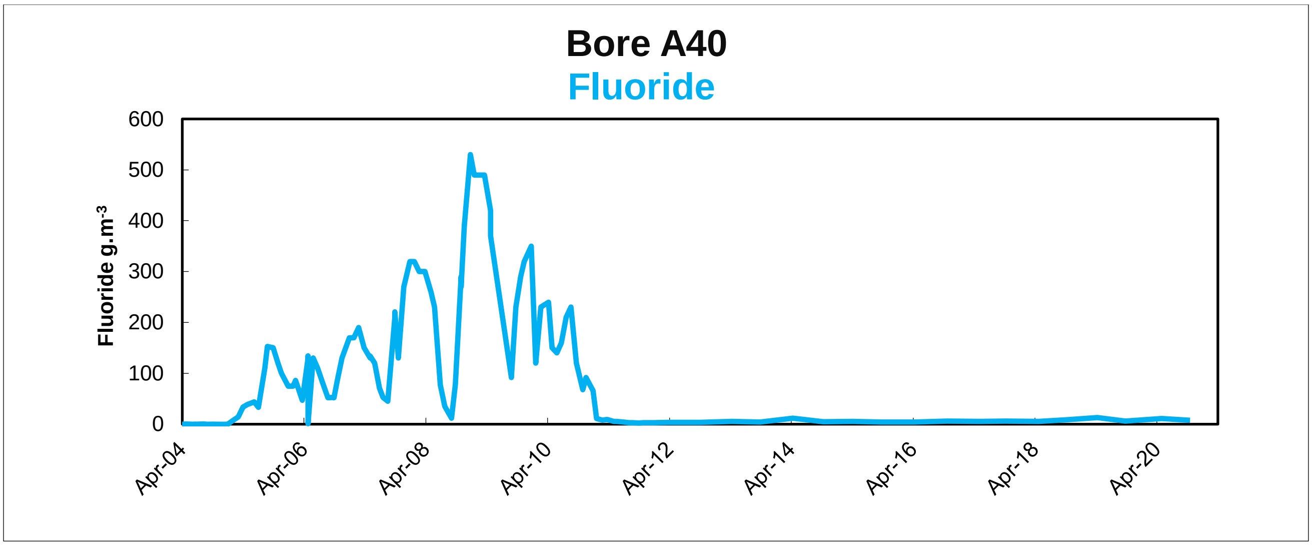


Bore **A24** is located downstream of the open cell of MRP dross. Levels of fluoride in this bore are steadily decreasing while sulphate is increasing. Sulphate levels in this bore started to increase in mid-2014 and continue to do so. Given the high concentrations in Bore **A6**, the elevated levels in Bore **A24** (see below) this may be due to the same source of sulphate as in Bore **A6**. Further work is required to identify the root cause of the high sulphate.





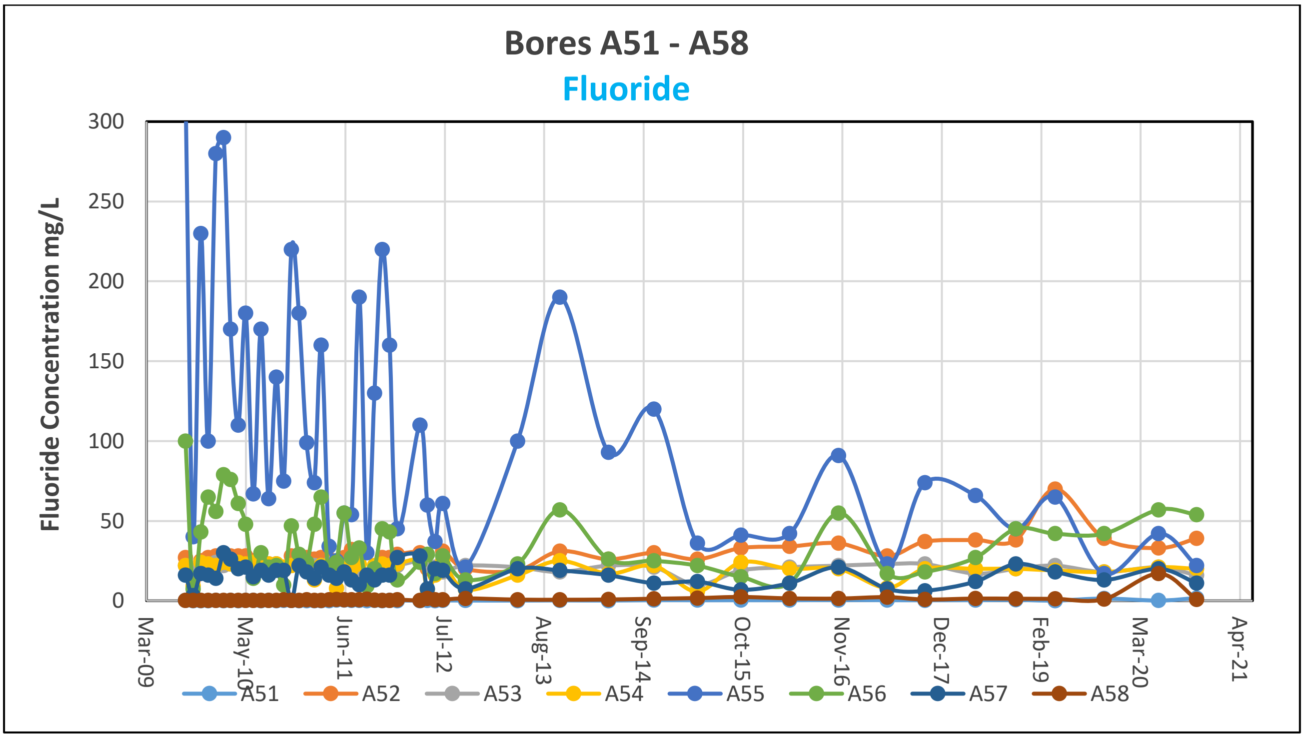
Bore **A40** is located is located south of the Haysom's dross. This material was deposited there around 2002/2003 and this is the reason why high fluoride values are observed at the start of the monitoring period. The leachate in this cell has steadied to a value under 10 g/m^3 indicating minimal high fluoride leachate occurring after capping with an impermeable membrane in 2009. Fluoride levels are now similar to values seen in background bores.



Coastal Bores A51-58

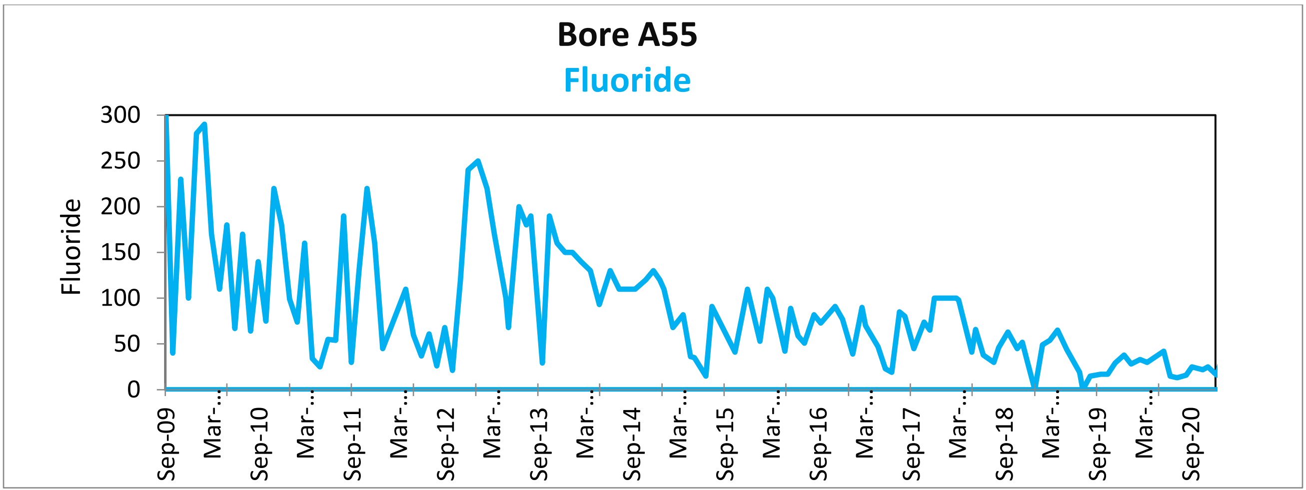
In 2009 eight coastal bores were installed as elevated fluoride levels were observed south of the landfill (Bores **A30**, **A31** and **A6**) and due to historical issues relating to Haysom's dross leaching to groundwater. A large part of the carbon pile was capped in 2009 to stop the leachate entering groundwater from one carbon pile. The location of these bores can be viewed below.

Elevated fluoride levels were observed in six of the eight coastal bores upon installation in 2009. There has been a general decrease in fluoride, or otherwise stable levels of fluoride, since that time.

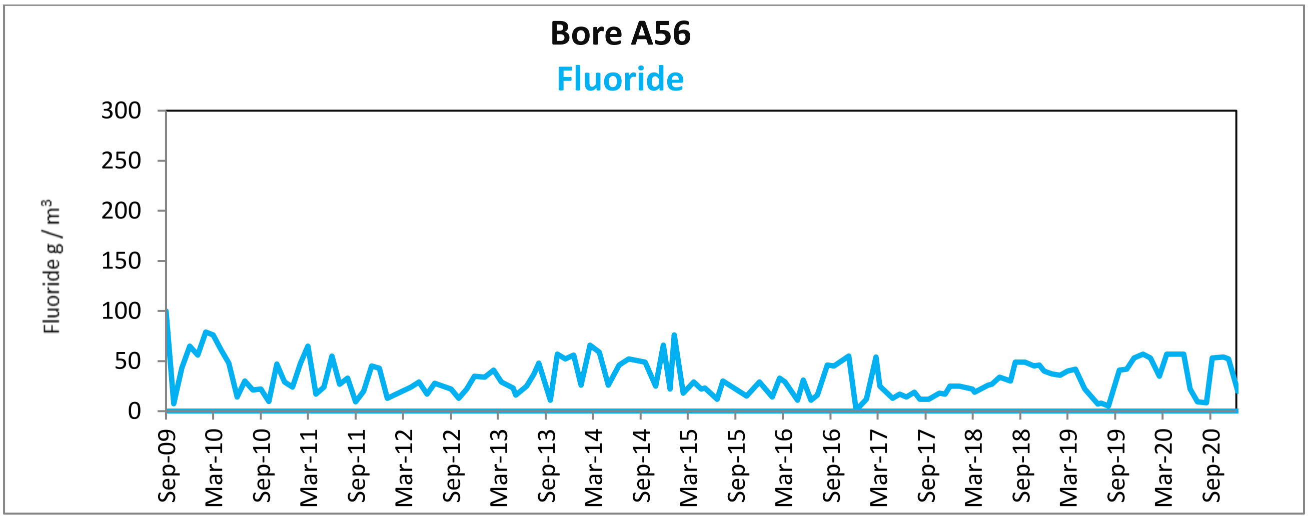


The fluoride levels from the other coastal bores are displayed in the graph below. (Note: mg/L = g/m^3).

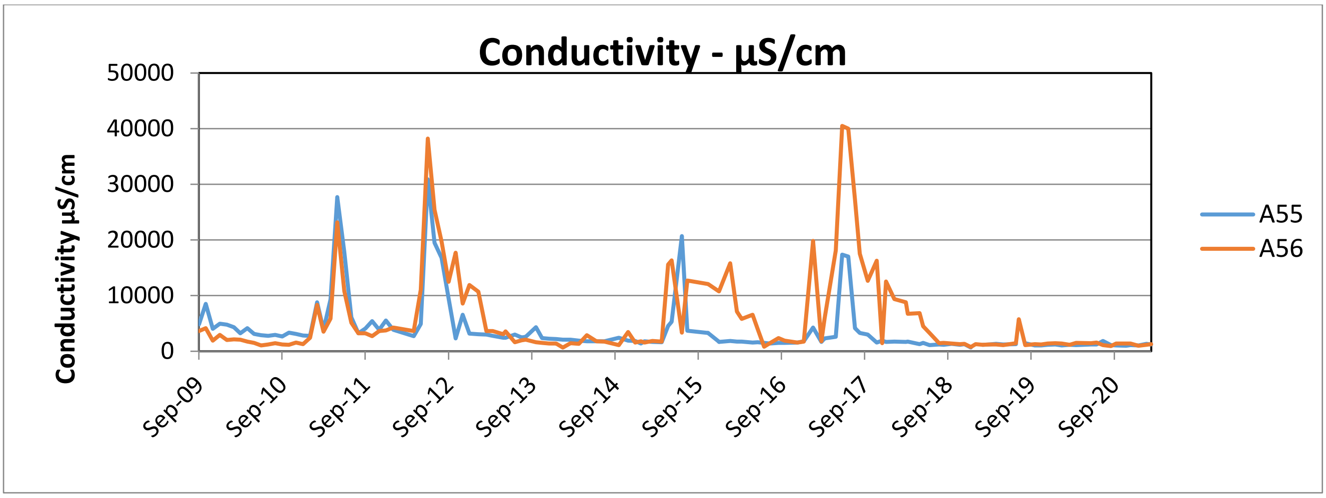
Bore **A55** south of the MRP dross pile has shown the greatest decrease in fluoride concentration over the last 10 years.



The adjacent Bore **A56**, located between the MRP area and the Haysom's cell is stable although still showing elevated fluoride levels indicative of leaching of fluoride from either of these two areas.



Conductivity is another indicator for potential contamination. Large spikes in conductivity are seen on several occasions which do not match the elevated fluoride levels. This is likely to be due to seawater ingress into the bore. Conductivity of seawater is approximately 50,000 µS/cm. The fluoride concentration in seawater is 1.3 g/m^3 so if there was seawater intrusion into the bores there would be a minor but observable contribution to fluoride from the seawater. However, no correlation is observed and the absence of this correlation is not clear.



Additional Information

The following data (inserted MS Excel file) is a full summary of monitoring data obtained from sampling groundwater surrounding the landfill since the mid 1990's. During this time new bores have been established to provide assurance of groundwater leachate concentrations.

Memorandum

7 April 2021

To	New Zealand Aluminium Smelters Ltd		
Subject	**NZAS Closure Preliminary Study** Sampling and Analysis Quality Plan Summary	Job no.	12533899 / CAL.11
Document No.	12533899-2200-CS-MEM-0001 CAL.11.2200-H-MMO-00001	Rev.	0

1. Introduction

1.1 Background

Rio Tinto are in the process of undertaking a Closure Preliminary Study (PS) for the New Zealand Aluminium Smelters Ltd (NZAS) site located at 1429-1530 Tiwai Road, Awarua (the 'Site').

GHD has been commissioned to complete a Contaminated Sites work package which is part of the broader Preliminary Study. This includes a phased approach enabling increasing data collection and knowledge. The first phase involved a review of the existing environmental information of the Site including the NZAS Contaminated Sites Register, completion of a Site inspection and interviews with NZAS staff. The purpose was to identify areas of interest associated with potentially contaminating activities so that a Detailed Site Investigation (DSI) could be designed. The DSI stage of the PS involves the collection of samples from various environmental media (soil, sediment and groundwater).

The initial review identified a number of potential contaminant sources across the site. The source areas were grouped into 13 zones and the initial review assessed the likely transport pathways and receptors.

A DSI was recommended in order to further characterise the potential contamination in the underlying soil and groundwater across the Site. This will be used to inform Rio Tinto and NZAS of potential risks to human health and the environment. The DSI report is in progress and is being completed as per the requirements of Regulation 3 of the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NESCS).

1.2 Designing the DSI

A further visit to the site was undertaken in order to assess suitable locations to collect samples. The location of a sampling point involves a number of considerations which are based on gaining close proximity of the potential contaminant source to be investigated but must also consider:

- access/egress issues for sample collection machinery such as drill rigs and excavators;
- health and safety considerations, including, but not limited to:
  - the presence of live underground utility services;
  - working in operational areas of a Smelter site;
  - site permitting requirements;
  - specific contaminant precautions required for sampling staff (e.g. correct personal protective equipment and methods for sample collection);

– local working area considerations (e.g. working safely near water); and

- in addition to targeting specific contaminant sources, obtaining a broad coverage of sampling points across the site by sampling locations for general coverage.

The DSI field work comprised soil, sediment and groundwater sampling. This memorandum contains a description of the sampling areas, methodology and analysis undertaken. A separate DSI report is in preparation and will be provided to Environment Southland in accordance with Rule 46A (a) of the proposed Southland Water and Land Plan[1].

1.3 Sampling Limitations

Although over 200 individual locations and 400 samples were collected, there are areas of the Smelter which were unable to be sampled under the current operational environment due to access restrictions and health and safety constraints. These were primarily the electrical switchyards to the east of the Smelter and the main potline buildings. The electrical switchyards are covered by Transpower's designation and are not controlled by NZAS. Both areas contain a network of high voltage cabling and the potlines run 24 hours a day with machinery transporting hot molten metal around the potlines. Sampling of both areas would involve drilling through a thick concrete floor and the use of sampling machinery. The risk was considered to be too great to undertake sampling in these areas under the current operational environment and the locations were highlighted for sampling during a future decommissioning phase. Where sampling within the area was unable to be achieved, groundwater monitoring wells were installed around the outside/periphery of these areas to identify evidence of contaminant plumes potentially emitting from these locations. These newly installed groundwater monitoring wells will supplement the existing network and provide a good representation of contamination transport through groundwater should contamination exist.

The DSI is designed to assess the Smelter and some areas of infrastructure to the east of the Smelter. The DSI does not include additional testing and sampling of the NZAS Landfill to the south west, as the types of material contained within the landfill are already known. The disposal to landfill is a consented activity with discharges of leachate to groundwater being actively monitored by NZAS as a consent requirement. The hydrogeology of the landfill and its contaminant profile has been considered in the PS outside of the contaminated sites investigation.

1.4 Objective

This summary of the Sampling and Analysis Quality Plan (SAQP) details the DSI methodology.

1.5 Scope

The scope of the document is to:

- Provide sampling methodology for the collection of soil, sediment and groundwater samples;
- Identify contaminants of concern and analysis to be undertaken; and
- Detail quality assurance / quality control procedures.

[1] Proposed Southland Water and Land Plan – Part A – April 2018

1.6 Assumptions

The SAQP and methodology were developed with consideration given to the following assumptions:

- The information that was used to compile the SAQP was sourced from NZAS Environmental Archive Room and that provided by Rio Tinto.
- The observations made during the investigation are representative of the activities that have occurred or are occurring in or adjacent to the Site (such as the land use assessments included in the historical review).

2. Sampling Locations & Rationale

2.1 Proposed Sampling Summary

A targeted sampling approach was applied to the Site, focussed on the areas of the Site where current or historical activities have occurred with the potential to contaminate soils and groundwater.

A total of 210 sampling locations were selected across the area of investigation, concentrated in areas where the majority of historical activities have occurred. Sampling methods were selected to assess the levels of contaminants at various depths across the Site.

- **Hand Dug Samples** – Samples were collected from near surface and at the base of the excavation. Only a surface sample was collected in the majority of hand sample locations due to the excavation methodology and underlying strata.
- **Test Pits** - Samples were collected from near surface and at the base of excavations (approximately 1 m bgl).
- **Machine Bores** - Samples were collected from near surface and at the groundwater interface. Additional samples were collected from the soil profile when a change in lithology or evidence of contamination was observed.
- **Monitoring Wells** - Samples were collected from near surface, one at approximately 1.5 m bgl and one at the groundwater interface**.**

When visual or olfactory evidence of contamination was encountered during works, additional samples were collected targeting this contamination.

Duplicate samples were collected for quality purposes during the works at a rate of 1 duplicate per 14 samples. Refer to Section 5 for further detail.

2.2 Sampling by Area

The Site has been broken down into 13 Investigation Zones based upon current and historical activities. Each Zone has been named according to the activity occurring or geographical location. Refer to Figure 1 within Appendix A for the locality of each Zone of investigation.

Within each zone are a number of identified potential sources of contamination which are identified on the NZAS Contaminated Sites Register (the Register). See Figure 2 within Appendix A for the Register locations and Appendix B for the sampling rationale at each location. See Figures 3 – 10 for soil sample locations.

2.2.1 Zone A - Peninsula

Zone A incorporates the area to the east of the plant. Key features within this area are:

- Current and former Spent Cell Liner (SCL) Pads;
- Sewage discharge field;
- Effluent Treatment Plant and outfall; and

- Eastern portion of the Tiwai Peninsula.

Refer to Table 1 within Appendix B for investigation type and sample analysis within Zone A.

2.2.2 Zone B – Re-processing Facility

Zone B incorporates the laydown area within the vicinity of the re-processing facility and includes the following key features:

- Diesel above ground storage tank (AST);
- Bagged Goods Store;
- Between Bagged Goods Store and SCL Sheds;
- Cooling Towers – All;
- SCL Crushing Building - Laydown area ; and
- SCL Sheds - Laydown area.

Refer to Table 2 within Appendix B for investigation type and sample analysis within Zone B.

2.2.3 Zone C – Southern Yard Area

Zone C incorporates the yard area to the south of the Potlines. Key features within this area are

- Aluminium - finished product storage;
- Stores underground petrol/diesel tanks;
- Salvage Yard;
- Canteen (South) car park (former fuel storage tank);
- Bath Plant;
- Metal Products - Diesel & Heavy Fuel Oil (HFO) Day Tanks;
- Current Fire Practice;
- Cell Repair - Diesel spill;
- Mobile Equipment Workshop;
- Foam Drum Store;
- Waste Oil - East of SCL Shed No.2;
- Straddle Carrier Warehouse - diesel AST and former laydown;
- Main Diesel Tank AST;
- Steam Cleaning Pad - Garage Area; and
- Former Foam Store.

Refer to Table 3 within Appendix B for investigation type and sample analysis within Zone C.

2.2.4 Zone D – Solid Storage

Zone D incorporates the Solid Storage area within the south western of the Smelter. Key features within the area include:

- SCL Shed No.2;
- South West SCL Container Area and Laydown;
- South Drain;
- T1 Towers; and
- Wharf Conveyor & Pipeline.

Refer to Table 4 within Appendix B for investigation type and sample analysis within Zone D.

2.2.5 Zone E – Liquid Storage

Zone E incorporates the Liquid Storage area within the western part of the Smelter. Key features within the area include:

- Pitch Bulk Tanks;
- Former Foam Spraying; and
- HFO tank.

Refer to Table 5 within Appendix B for investigation type and sample analysis within Zone E.

2.2.6 Zone F - Carbon

Zone F incorporates the Carbon Processing area within the west of the Smelter. Key features within the area include:

- Carbon Area - Drain overflow;
- Carbon Bake;
- Carbon Bake Furnace (CBF) - HFO day tanks; and
- Green Carbon.

Refer to Table 6 within Appendix B for investigation type and sample analysis within Zone F.

2.2.7 Zone G - Stack

Zone G incorporates the area surrounding the stack within the central area of the site. Key features within the area include:

- Dry Scrubbers/ Torbeds;
- Delining Building; and
- Former Electro Static Precipitator (ESP) drum storage area.

Refer to Table 7 within Appendix B for investigation type and sample analysis within Zone G.

2.2.8 Zone H – Reduction

Due to health and safety and operational restrictions, no sampling is to occur within the reduction area whilst the smelter is operational.

Four monitoring wells are being installed in surrounding Zones to identify groundwater contamination emitting from the Reduction area.

2.2.9 Zone I – Administration

Zone I incorporates the area centred on the gatehouse within the north west area of the site. Key features within the area include:

- NW corner yards - historical used brick storage and current new brick store; and
- West Drain.

Refer to Table 8 within Appendix B for investigation type and sample analysis within Zone I.

2.2.10 Zone J – CCG Area

Zone J incorporates the area surrounding the contractor's laydown yards within the northern area of the site. Key features within the area include:

- SCL Container Yard;
- Reduction – external laydown areas;
- CCG Hangar;
- CCG Buildings; and
- North Drain

Refer to Table 9 within Appendix B for investigation type and sample analysis within Zone J.

2.2.11 Zone K – Northern Yards

Zone J incorporates the area surrounding the CCG laydown yards within the northern area of the site. Key features within the area include:

- Washdown Diesel AST;
- Reconstruction (washdown); and
- Sewage Treatment Plant - Concrete wash area.

Refer to Table 10 within Appendix B for investigation type and sample analysis within Zone K.

2.2.12 Zone L – East Gate

Zone L incorporates the area to the east of the reduction area. Key features within the area include:

- Cooling towers;
- Power Supply - Switch yards discharge to ground;
- East Gate - Waste CBF bricks;

- Compressor House 1; and
- Gravel winning area - East Yards.

Refer to Table 11 within Appendix B for investigation type and sample analysis within Zone L.

2.2.13 Zone M – Landfill

Zone M incorporates the NZAS landfill. No additional soil investigation was undertaken within this area as there is extensive knowledge of the nature of the fill material.

2.3 **General Site Contaminant Coverage**

A number of common activities have occurred historically across the site which may have deposited contaminants into the environment.

The exception are the gravel areas that are believed to have had extensive herbicide use as weed control and whilst not included on the contamination register, where these locations coincide with proposed sample locations, laboratory analysis for herbicides was undertaken.

3. Field Methodology

3.1 Fieldwork Documentation

Field activities were recorded including any observations made at each sample location. Specifically, they included:

- Date;
- Personnel undertaking the work;
- Sample method;
- Description of the lithology of the excavation;
- Description of any contamination encountered (or lack thereof);
- Unique sample identification;
- Headspace reading taken by a Photo-ionisation detector (PID);
- Coordinates of sample location;
- Purge records (groundwater sampling only); and
- Any Quality Assurance/Quality Control sampling undertaken.

3.2 Soil Sampling

Soil sampling was undertaken under the following procedures:

- All field work was carried out in compliance with the project specific Job Safety and Environmental Analysis (JSEA) plan;
- Latitude 46 Ltd issued NZAS work and excavation permits and monitored health and safety compliance of all project workers throughout works;
- Underground services in the vicinity of the sampling locations were initially assessed by consulting Site supplied service plans. All sampling locations were then scanned using a Cable Avoidance Tool and Ground Penetrating Radar by Subsurface Service Locators and all locations were approved by a GHD Technical Director who issued a GHD ground penetration permit prior to excavation. Separately NZAS inspected each investigation location and issued ground disturbance permits for all excavation undertaken onsite;
- A PID was used to field screen samples for volatile contaminants at all locations;
- The test pits were excavated using a 5 tonne mechanical excavator;
- Hand dug samples were collected by either shovel or hand auger direct into sample jars. Between each location, the shovel or hand auger was washed with deionised (DI) water;
- Test Pit samples were collected by hand from the bucket of the excavator ensuring soil sampled has not been in contact with the bucket itself. A fresh pair of nitrile gloves were used for each separate sample collection;

- Soil bore and monitoring well installation soil samples were collected as hand grab samples from the recovered drill core. Where possible, samples were collected from the interior of the core that is generally less disturbed. A fresh pair of nitrile gloves were used for each separate sample collection; and
- Samples were placed into laboratory supplied containers and then placed in an iced chilly bin and couriered to Analytica Laboratories in Hamilton under standard GHD chain of custody procedures.

3.3 Sediment Sampling

Sediment samples were collected using a split spoon sampler, hand auger or shovel at two depth intervals in the drain sediments. One at between 0 and 0.1 m below sediment surface and the other from approximately 0.5 and 0.6 m into the drain sediments. Between samples, the sampling equipment was washed with DI water to prevent cross contamination.

3.4 Monitoring Well Installation

Monitoring wells were installed using a drill rig with direct push, push-tubes for sample recovery. Soil samples from monitoring wells were collected from near surface, at approximately 1.5 m bgl and at the groundwater interface. Groundwater was encountered at approximately 3.2 m bgl with the wells screened approximately 2 m above and below the water table. Wells were finished with flush mounted covers within the Smelter Domain and stand up covers within the vegetated area to the south of the Smelter Domain.

3.5 Groundwater Gauging

A groundwater dip round was undertaken of all groundwater monitoring wells prior to the commencement of sampling. An interface meter was inserted into each monitoring well to record the depth to groundwater in metres below top of casing (m btoc). The interface probe was decontaminated between each monitoring well. Where the interface probe indicated the presence of non-aqueous phase liquid, a single use disposable bailer was inserted into the monitoring well to confirm presence / absence of non-aqueous phase liquid.

3.6 Groundwater Sampling Methodology

3.6.1 Monitoring Wells

Groundwater samples were collected from the sixteen new monitoring wells and thirteen selected existing monitoring wells in accordance with GHD standard procedures.

The new monitoring wells were installed to target areas of potential contamination and to create a “ring” around the smelter to identify contaminants within groundwater.

Post installation, all new monitoring wells were developed by purging three well volumes of groundwater from each well and then a stabilisation period of two weeks was allowed prior to groundwater sampling.

A selection of existing monitoring wells within Area C and across the wider site were selected for sampling to compliment the newly installed monitoring well network.

See Figures 3 and 11 within Appendix A for the locality of monitoring wells sampled.

3.6.2 Sample Collection Methods

A low flow peristaltic pump was used to purge and sample the wells and an inline water quality meter was used to collect pH, temperature, dissolved oxygen and electrical conductivity data during purging and sampling. During sample collection, samples were collected by disconnecting the tubing prior to the inline water quality meter.

3.7 **Sample Labelling & Handling**

All samples were given a unique identification code during field works.

Soil samples were labelled using the following methodology:

Area _ Investigation Method _ Sample Number _ Sample Depth

For example, a sample collected from Test Pit 1 in Zone A at a depth of 0.1 m bgl was labelled "A_TP_1_0.1".

All samples were dispatched to the laboratory under chain of custody procedures using laboratory supplied courier stickers.

3.8 **Laboratory Reporting**

The laboratory reports were issued in accordance with IANZ requirements and include:

- The Chain of Custody forms including arrival temperature and sample condition;
- Analytical results of the samples;
- Results of any laboratory undertaken quality control analysis (in-house duplicates); and
- Extraction method (where undertaken) and dates in accordance with holding times.

3.9 **Equipment Required**

The following field equipment was required in aid of sample collection:

- **Auger and Shovel –** in select locations, samples were collected by the utilisation of hand tools. All tools were decontaminated with DI water between sample locations;
- **Split Spoon Sampler** – to obtain sediment samples from multiple depths within the sediment profile;
- **Photo Ionisation Detector** – to record volatile organic compounds headspace readings in parts per million (ppm);
- **Interface Probe** - to measure the static water level within each monitoring well and identify any non aqueous liquid (if present);
- **Water Quality Meter (YSI ProPlus)** – to collect field water parameters during sample to aid assessment of aquifer stabilisation prior to sampling; and
    - **Peristaltic Pump** – to pump groundwater through dedicated tubing for collection.

3.10 Calibration

All field equipment used for data collection was calibrated prior to the commencement of field works by the supplier. A specialist supplier provided all rental equipment and supplied calibration certificates with rental equipment and the results of calibration testing when equipment was returned.

3.11 Waste Disposal

3.11.1 Soil

No soil was removed from site as part of the DSI investigation.

In high traffic areas, test pits were backfilled with native soils to approximately 500 mm below ground level and with dunite AP40 (or equivalent) to surface and compacted with a plate compactor. The excess soil produced from this process was disposed of in the NZAS landfill under NZAS supervision.

The soil bores were backfilled with excavated material and reinstated with concrete and asphalt as needed. The monitoring wells were reinstated with concrete and flush tobies. Any excess soil from the soil bores or monitoring wells was collected and disposed of in the NZAS landfill under NZAS supervision.

3.11.2 Groundwater

All purged groundwater collected as part of the groundwater sampling process was collected into 20 litre containers and disposed of by NZAS onsite.

Memorandum

4. Analytical Suite and Analysis Methods

4.1 Soil

The following analytes were selectively tested for from 210 locations across the site with analysis undertaken by Analytica Laboratories. For a sample location specific breakdown, please refer to the tables within Appendix B.

- Fluoride
  - Subcontracted to Analytical Research Laboratories. A New Zealand based IANZ accredited laboratory owned by Ravensdown.
  - Samples dried and passed through 2 mm sieve. ½ g of soil taken and fused with NaOH at >600°C. The sample is dissolved and passed through a tube with an ion selective electrode. McQuaker and Gurney, Jan 1977. Analytical Chemistry Vol. 49 No.1 Page 53-56. Determination of Total Fluoride in Soil and Vegetation Using an Alkali Fusion / Selective Ion Electrode Technique.
- Total Cyanide
  - Water extraction followed by acid distillation, distillate measured by colourmetric analysis. (APHA 4500-CN C - Modified - Discrete Analyser - Online Method).
- Heavy Metals (10 elements: B, As, Be, Cd, Cu, Cr, Hg, Ni, Pb and Zn) + Co, V & Al
  - Samples dried and passed through a 2 mm sieve followed by acid digestion and analysis by ICP-MS. In accordance with in-house procedure based on US EPA method 200.8.
- Chloride (1:5 Water Extraction - NEPM Australia)
  - 1:5 water extraction (NEPM, Schedule B3, Laboratory Analysis of Potentially Contaminated Soil, 2011) followed by filtration and Ion Exchange Chromatography analysis - (APHA 4110 B Online Edition).
- TPH C7-C36 (NZ Standard)
  - Solvent extraction, silica cleanup, followed by GC-FID analysis. (C7-C36). (In accordance with in-house procedure based on US EPA 8015).
  - Note: Benzene, Toluene, Ethyl benzene, Xylene (BTEX) are included in the VOC suite. Investigation has focussed on more on PAH associated with diesel use as limited petrol use occurred onsite.
- Polycyclic Aromatic Hydrocarbons (PAH)
  - Solvent extraction, silica cleanup, followed by GC-MS analysis. Reported for the USEPA priority 16 PAH compounds including Acenaphthene, Acenaphthylene, Anthracene, Benz[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[g,h,i,]perylene, Benzo[k]fluoranthene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno[1,2,3-c,d]pyrene, Naphthalene, Phenanthrene and Pyrene.
  - Benzo[a]pyrene TEQ (LOR): The most conservative TEQ estimate, where a result is reported as less than the limit of reporting (LOR) the LOR value is used to calculate the TEQ for that PAH.
  - Benzo[a]pyrene TEQ (Zero): The least conservative TEQ estimate, PAHs reported as less than the limit of reporting (LOR) are not included in the TEQ calculation.

  - Benzo[a]pyrene toxic equivalence (TEQ) is calculated according to 'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health'. Ministry for the Environment. 2011. (In accordance with in-house procedure).
- Semi Volatile Organic Compounds (SVOC)
  - Solvent extraction followed by GC-MS analysis. (In-house based on US EPA 8270).
- Organochlorine Pesticides (OCP)
  - Samples are extracted with hexane, pre-concentrated then analysed by GC-MSMS.
  - (Chlordane (sum) is calculated from the main actives in technical Chlordane: Chlordane, Nonachlor and Heptachlor). (In accordance with in-house procedure).
- Asbestos - Semiquantitative method (BRANZ Method)
  - Sample analysis performed using polarised light microscopy with dispersion staining in accordance with AS4964-2004 Method for the qualitative identification of asbestos in soil samples.
- Polychlorinated Biphenyls (PCB)
  - Samples are extracted with hexane, pre-concentrated then analysed by GC-MSMS. The TEQ, expressed as 2,3,7,8-TCDD equivalence, is calculated based on TEF values outlined in "Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health", MFE 2011. (In accordance with in-house procedure).
- Volatile Organic Compounds (VOC)
  - Methanol extraction in accordance with US-EPA 5030A, analysis via GCMS with headspace sample introduction. (In-house procedure based on US EPA Method 5021).
  - As noted above, includes analysis for BTEX
- Sulphate-S (1:5 Water Extraction - NEPM Australia)
  - 1:5 water extraction (NEPM, Schedule B3, Laboratory Analysis of Potentially Contaminated Soil, 2011) followed by Ion Exchange Chromatography analysis (APHA 4110 B - Online Edition).
- PFAS Extensive List of 31 (including Gen-X and FOSAA) - Trace Method to 1 ppb in Soil
  - The extraction method is based on a weak basic ammonia solution in methanol using sonication to improve extraction followed by graphite carbon black SPE clean up. Heavily labelled internal standards are included to allow an internal standardisation calibration protocol. Final analysis of the extracts is performed by LCMSMS. In accordance with in-house procedure based on ASTM Method D7968-17a (2017).
- Basic Soil Test (pH, Olsen P, Ca, Mg, K, Na, bulk density, CEC and base saturation)
  - Subcontracted to Analytical Research Laboratories

4.2 Groundwater

A total of 29 groundwater monitoring wells were sampled during field works. The following analytes were selectively tested for:

- Fluoride

- Subcontracted to Watercare Laboratory Services - 0.45 um filtration followed by Ion-Selective Electrode/Flow Analysis. APHA 4500-F G (online edition).

- Acid Dissociable Cyanide
  - Acid distillation, distillate measured by colourmetric analysis. (APHA 4500-CN C - Modified - discrete Analyser - Online edition).
- Heavy Metals (10 elements: B, As, Be, Cd, Cu, Cr, Hg, Ni, Pb and Zn) + Co, V & Al
  - Samples were analysed as received by the laboratory using ICP-MS following an acid digestion. In house procedure based on US EPA method 200.8.
- Chloride
  - Analysis by Ion exchange chromatography following sample filtration. (APHA 4110 B - Online edition).
- TPH/PAH (NZ Standard)
  - TPH - Solvent extraction, silica cleanup, followed by GC-FID analysis (C7-C36). MFE Petroleum Industry Guidelines. (In accordance with in-house procedure based on US EPA 8015).
- PAH - Liquid-liquid extraction with hexane, florisil cleanup with analysis by GC-MS.
  - Benzo[a]pyrene TEQ (LOR): The most conservative TEQ estimate, where a result is reported as less than the limit of reporting (LOR) the LOR value is used to calculate the TEQ for that PAH.
  - Benzo[a]pyrene TEQ (Zero): The least conservative TEQ estimate, PAHs reported as less than the limit of reporting (LOR) are not included in the TEQ calculation.
  - Benzo[a]pyrene toxic equivalence (TEQ) is calculated according to 'Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health'. Ministry for the Environment. 2011. In accordance with in-house procedure.
- SVOC (PAH/OCP/Pesticides)
  - Dichloromethane extraction followed by GC-MS analysis. (In-house method based on US-EPA 8270).
- Polychlorinated Biphenyls (PCB)
  - Samples are extracted with hexane, pre-concentrated then analysed by GC-MSMS. In house method. The TEQ, expressed as 2,3,7,8-TCDD equivalence, is calculated based on TEF values outlined in "Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health", MFE 2011.
- VOC
  - GCMS analysis with headspace sample introduction (In accordance with US EPA Method 5021).
  - As noted above, includes analysis for BTEX.
- Sulphate
  - Analysis by Ion exchange chromatography following sample filtration. (APHA 4110B - Online edition).
- PFAS Extensive List of 31 (including Gen-X and FOSAA) - Trace Method to 1 ppb in water
  - The whole PFAS container is extracted and the sample container rinsed with extraction solution. The sample is pre-concentrated by SPE using a mixed mode reversed phase/weak anion exchange phase. Heavily labelled internal standards are added at the start of the extraction and absolute

recoveries reported. Final analysis of the extracts is performed by LCMSMS using an internal standardisation calibration protocol. In accordance with in-house procedure.

- Major anions and cations (calcium, magnesium, sodium, potassium, sulphate, chloride, bicarbonate, carbonate and alkalinity);
  - Redox parameters (field filtration for dissolved metals (0.1 micron filters), total and dissolved iron, total and dissolved manganese, total sulphur);
- Organic load analytes (carbonaceous biochemical oxygen demand); and
- Inorganic nitrogen contaminants (nitrate-N, nitrite-N and ammoniacal-N)

In addition, field physical parameters (pH, electrical conductivity, temperature and oxidation reduction potential (ORP)) were collected and recorded upon the field purging sheets.

Memorandum

5. QA/QC Control Sampling

5.1 Quality control procedures

GHD quality assurance/quality control (QA/QC) procedures to assess data quality were maintained throughout the project. All laboratory analysis was undertaken by IANZ accredited laboratories. The QA/QC programme undertaken as part of the assessment by GHD included the following:

- Use of appropriately qualified and trained staff;
- Preservation of samples with ice during transport from the field to the laboratory;
- Transportation of samples to the laboratory with accompanying chain-of-custody documentation;
- Compliance with sample holding times; and
- Review of results of field duplicate samples.

5.2 Duplicates

5.2.1 Soil

Field soil duplicates involved the collection of primary and duplicate samples at a ratio of 1:14, stored in separate containers and submitted for analysis to the laboratory as separate samples for QC purposes. The duplicate samples were selectively analysed for fluoride, cyanide, metals, VOC and TPH/PAH only.

5.2.2 Groundwater

Field groundwater duplicates involved the collection of primary and duplicate samples at a ratio of 1:5, stored in separate containers and submitted for analysis to the laboratory as separate samples for QC purposes. The duplicate samples were selectively analysed for fluoride, cyanide, metals, TPH/PAH and PFAS.

5.2.3 Relative percentage difference

A quantitative measure of the accuracy of the check analyses results obtained was made using calculated relative percentage difference (RPD) values. The RPD values were calculated using the following equation.

$$\text{RPD (\%)} = \frac{\langle Co - Cs \rangle}{\left\langle \frac{Co + Cs}{2} \right\rangle} \times 100$$

Where Co = concentration obtained from the original sample

Cs = concentration obtained from the duplicate sample

The usual acceptance criteria within the CLMG (No.5) for RPDs is between 0 and 40% in soils. However, a large percentage differential can occur particularly in soils due to the following:

- A small analytical differential between two samples based on the low levels of detection from the primary and duplicate soil sample; and
- Samples analysed in soil collected from non-homogenous (heterogeneous) soil profile.

The relative percentage difference (RPD) values for the duplicate samples collected were analysed during this investigation.

5.2.4 Trip and Rinsate Blanks

Rinsate blanks were collected daily on any groundwater sampling equipment utilised at multiple locations and laboratory supplied trip blanks accompanies all groundwater samples.

6. DSI Reporting

A DSI report is currently being completed in accordance with Regulation 3 of the NESCS which includes reference to the Contaminated Land Management Guidelines. This will be provided to the regulator, Environment Southland in accordance with Rule 46A (a) of the proposed Southland Water and Land Plan[2].

7. Limitations

This document has been prepared by GHD for New Zealand Aluminium Smelter Ltd (NZAS Ltd) and may only be used and relied on by NZAS Ltd for the purpose agreed between GHD and NZAS Ltd as set out in this report.

GHD otherwise disclaims responsibility to any person other than NZAS Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

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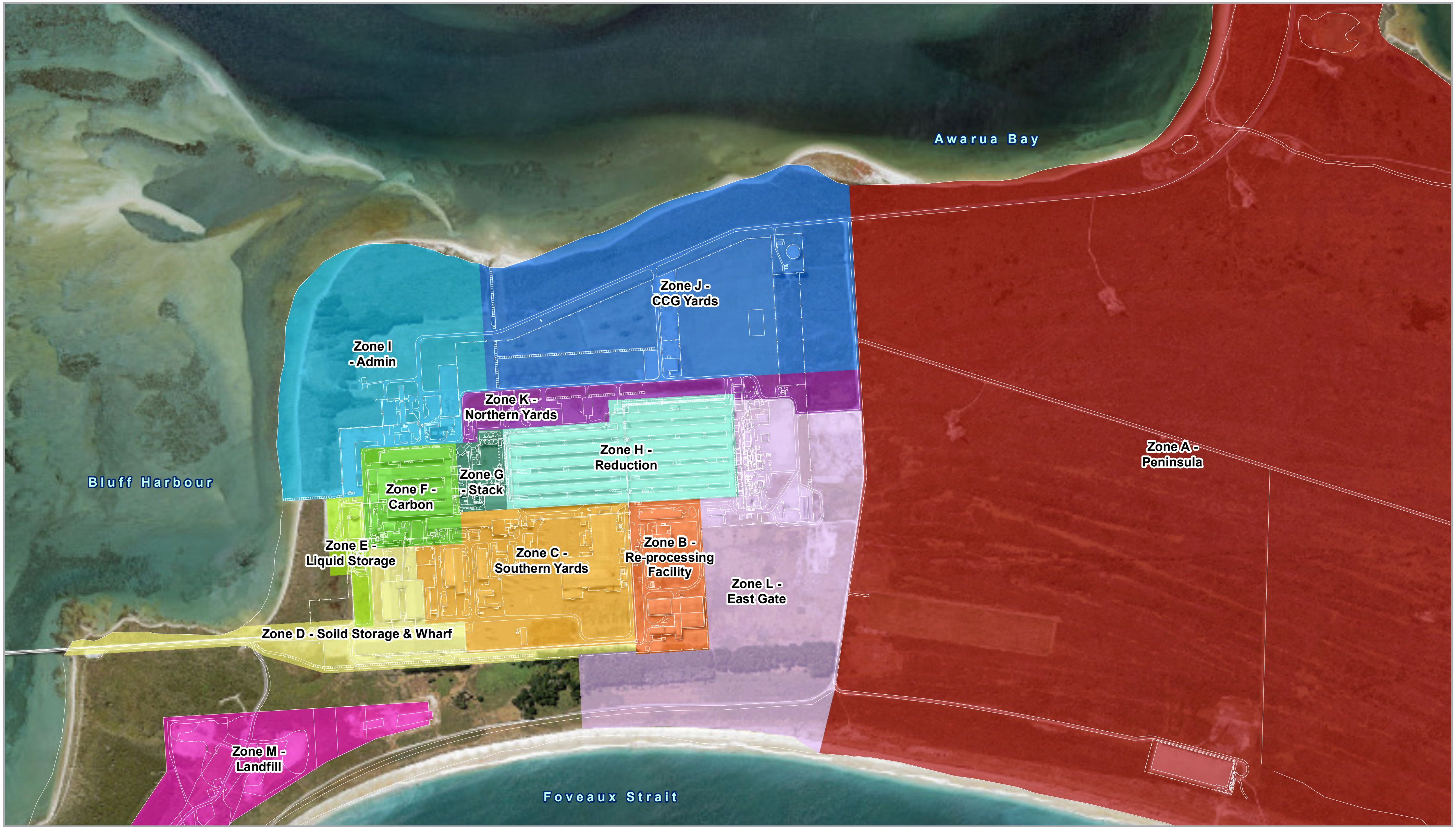
Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

[2] Proposed Southland Water and Land Plan – Part A – April 2018

Appendix A – Figures



LEGEND

- Zone A - Peninsula
- Zone B - Re-processing Facility
- Zone C - Southern Yards
- Zone D - Soild Storage & Wharf
- Zone E - Liquid Storage
- Zone F - Carbon
- Zone G - Stack
- Zone H - Reduction
- Zone I - Admin
- Zone J - CCG Yards
- Zone K - Northern Yards
- Zone L - East Gate
- Zone M - Landfill

Paper Size ISO A4

0 200 400

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

Rio Tinto
NZAS Preliminary Closure Study
SAQP Summary Report

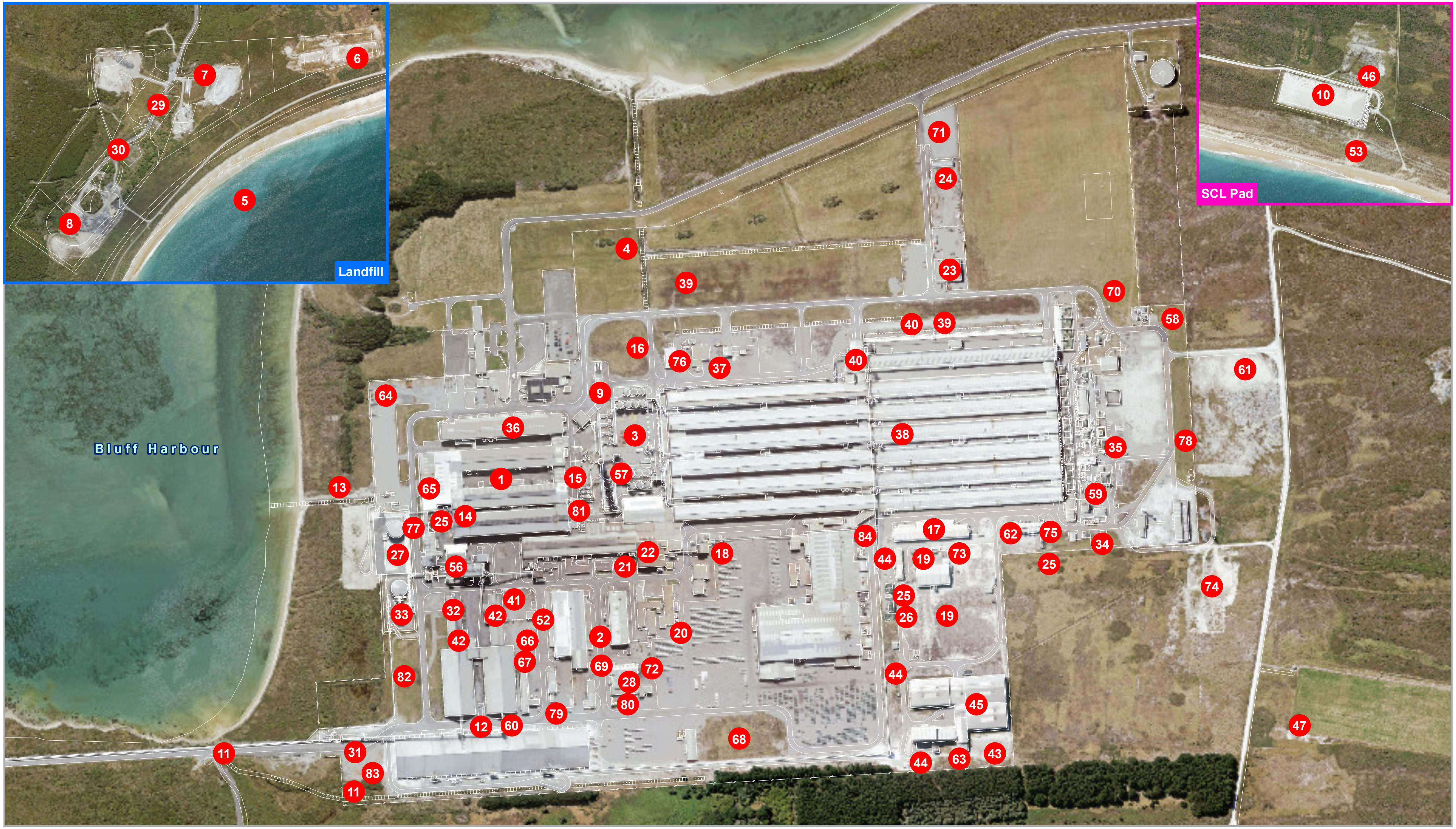
Project No. **12535044**
Revision No. **A**
Date **07 Apr 2021**

Investigation Zone Layout

FIGURE A1

G:\51\12535044\GIS\Maps\Deliverables\12535044_Z007_InvestigationZones.mxd

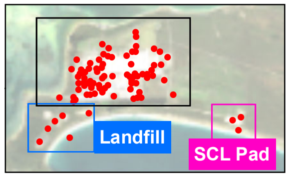
Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman



LEGEND

Site layout

Contamination site



Paper Size ISO A4

0 100 200

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

Rio Tinto
NZAS Preliminary Closure Study
SAQP Summary Report

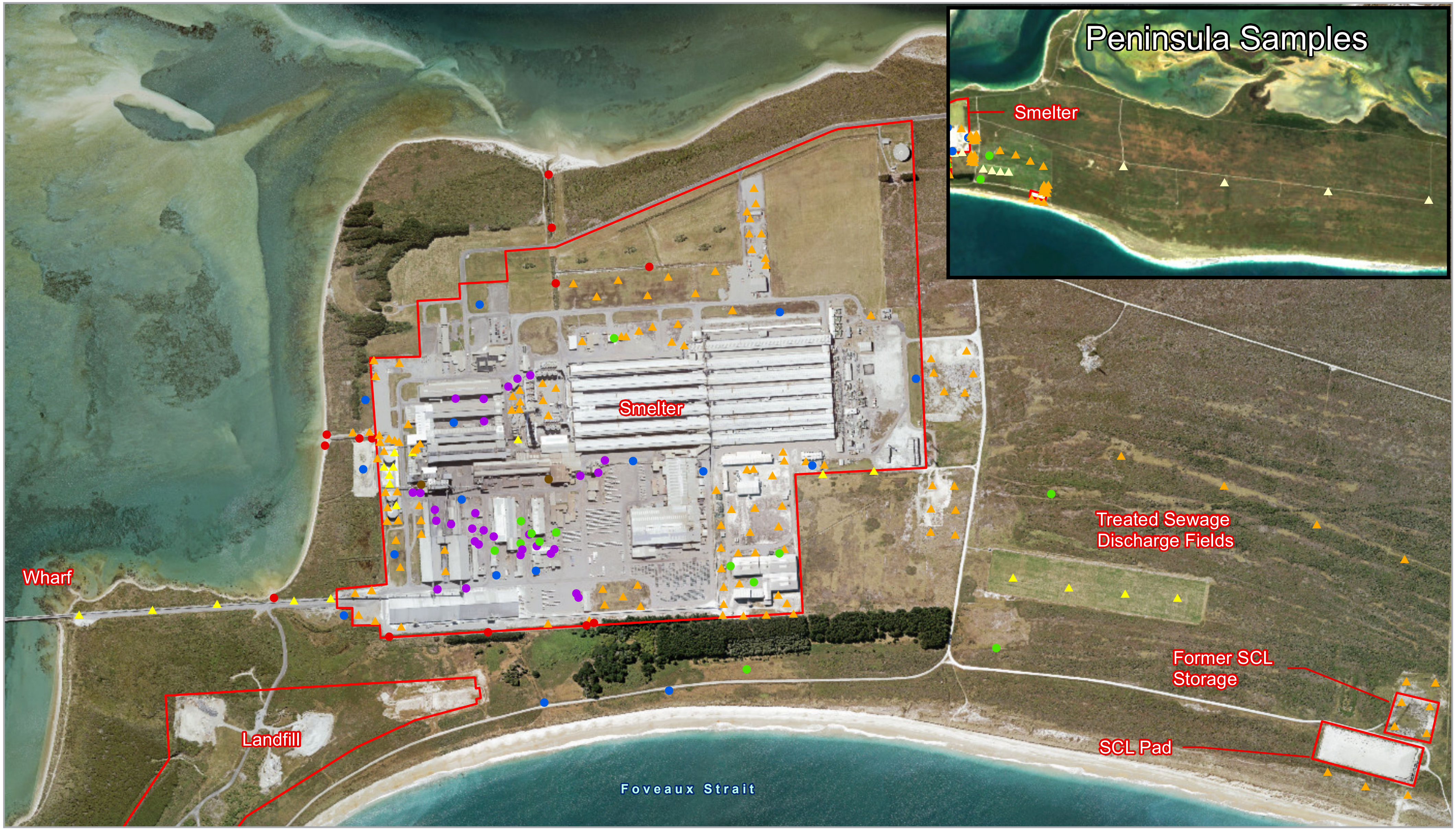
Contamination Register

Project No. **12533899**
Revision No. **A**
Date **20 Nov 2020**

FIGURE A2

N:\NZ\Christchurch\Projects\51\12535044\GIS\Maps\Deliverables\SAQP\12535044_SAQP002_ContaminationRegister.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: jrprice



LEGEND

- Monitoring Well - Not Installed
- Sediment Sample
- Hand Auger
- Test Pit
- Machine Soil Bore
- Monitoring Well
- Existing Monitoring Well
- Key Site Feature

0 200 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

GHD

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NZAS Preliminary Closure Study
SAQP Summary Report

All Sample Locations

Project No. **12535044**
Revision No. **A**
Date **25 Mar 2021**

FIGURE A3

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z004_Full_Sample_Coverage.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman

LEGEND

● Machine Soil Bore

0 50 100
Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

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NZAS Preliminary Closure Study
SAQP Summary Report

Soil Bore Locations

Project No. 12535044
Revision No. A
Date 25 Mar 2021

FIGURE A4

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z007_Soil_Bores_Samples.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman

LEGEND

▲ Test Pit

Paper Size ISO A4

0 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

Rio Tinto
NZAS Preliminary Closure Study
SAQP Summary Report

East Area
Test Pit Sample Locations

Project No. **12535044**
Revision No. **A**
Date **25 Mar 2021**

FIGURE A5

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z005_Test_Pits_Samples_East.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman

LEGEND

▲ Test Pit

Paper Size ISO A4

0 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

GHD

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NZAS Preliminary Closure Study
SAQP Summary Report

North Area
Test Pit Sample Locations

Project No. **12535044**
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Date **25 Mar 2021**

FIGURE A6

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z005_Test_Pits_Samples_North.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman

LEGEND

▲ Test Pit

Paper Size ISO A4

0 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

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NZAS Preliminary Closure Study
SAQP Summary Report

West Area
Test Pit Sample Locations

Project No. 12535044
Revision No. A
Date 25 Mar 2021

FIGURE A7

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z005_Test_Pits_Samples_West_Zone.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman

LEGEND

Hand Auger

0 200 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

N

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NZAS Preliminary Closure Study
SAQP Summary Report

East Area
Hand Auger Sample Locations

Project No. **12535044**
Revision No. **A**
Date **25 Mar 2021**

FIGURE A8

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z006_Hand_Auger_Samples_East_Zone.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman

LEGEND

Hand Auger

0 200 400
Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

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NZAS Preliminary Closure Study
SAQP Summary Report

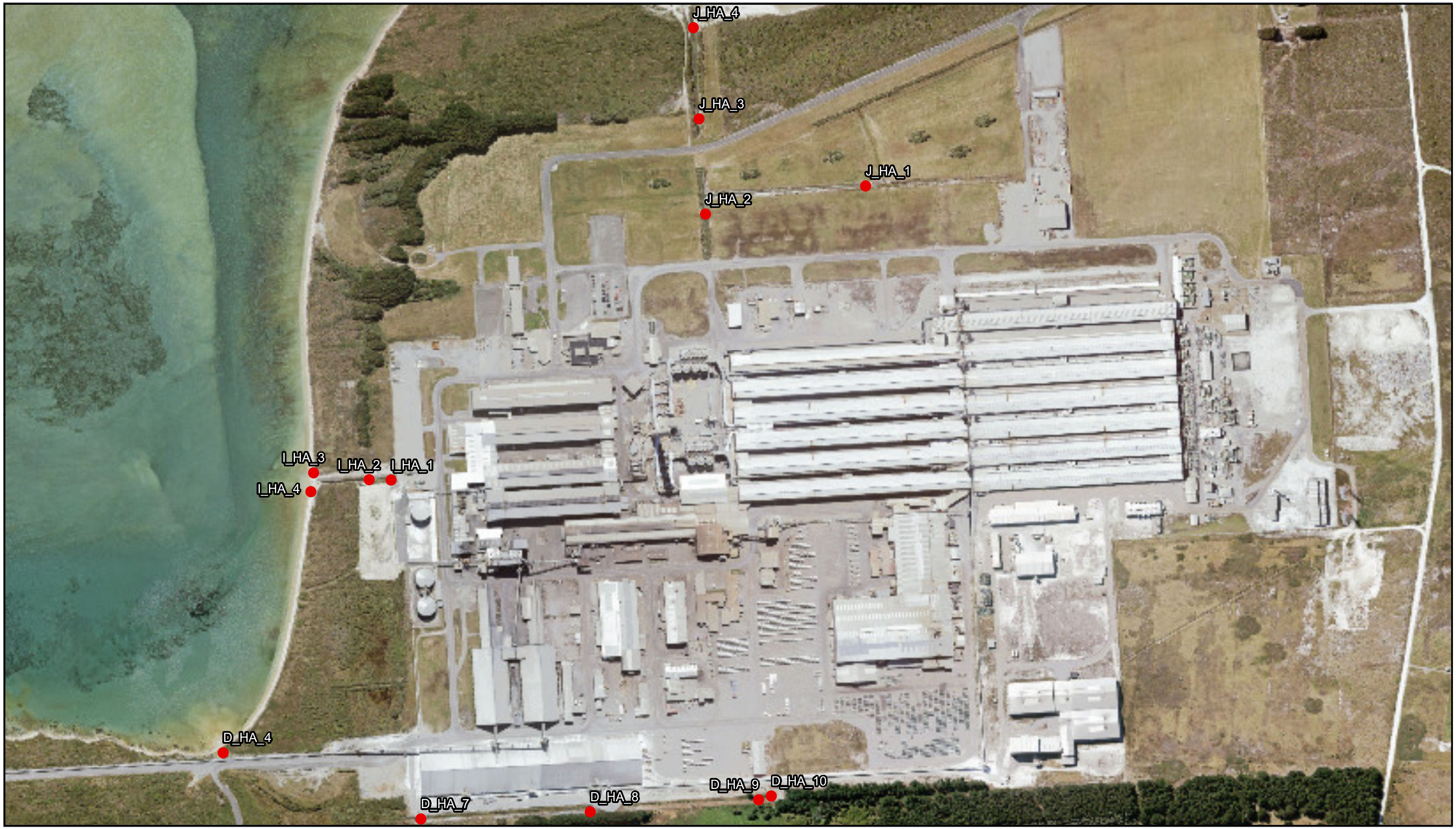
West Area
Hand Auger Sample Locations

Project No. **12535044**
Revision No. **A**
Date **25 Mar 2021**

FIGURE A9

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z006_Hand_Auger_Samples.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman



LEGEND

● Sediment Sample

0 200 400

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

Rio Tinto
NZAS Preliminary Closure Study
SAQP Summary Report

Project No. **12535044**
Revision No. **A**
Date **25 Mar 2021**

Sediment Sample Locations

FIGURE A10

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z006_Sediment_Samples.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman

LEGEND

- Monitoring Well - Not Installed
- Monitoring Well
- Existing Monitoring Well

Paper Size ISO A4

0 100 200

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: NZGD 2000
Grid: NZGD 2000 New Zealand Transverse Mercator

GHD

Rio Tinto
NZAS Preliminary Closure Study
SAQP Summary Report

Project No. **12535044**
Revision No. **A**
Date **25 Mar 2021**

Monitoring Well Locations

FIGURE A11

G:\51\12535044\GIS\Maps\Deliverables\Figures_for_Reports\12535044_Z005_Monitoring_Well_Samples.mxd

Data source: General Topo - LINZ 2020; Aerial imagery - LINZ 2020 (Sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand licence); Site layout - NZAS. Created by: chillman

Memorandum

Appendix B – Zone Contamination Register

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analysis
xx	Zone A Peninsula	Peninsula	4 Testpits 4 Hand Augers	Testpits to assess any fallout from the stack Hand Augers for baseline sampling of the surrounding environment	Fluoride, metals* and basic soil suite#
10	Zone A Peninsula	SCL Pad (Encapsulated)	No Sample points - Covered under Hazardous Materials Assessment	-	-
46	Zone A Peninsula	SCL Storage area	6 Test Pits	Old SCL storage area to the North of the SCL encapsulation. Material removed 1992. Potential for contamination of ground.	Fluoride, cyanide, metals, asbestos and basic soil suite#
47	Zone A Peninsula	Sewage Treatment Field	4 Hand Augers	Sewage treatment plant and disposal field. Potential for contamination of heavy metals, chemical and nutrients to ground water.	Fluoride, metals and basic soil suite#
53	Zone A Peninsula	Treated effluent plant and outfall	3 Test Pits	Treated effluent plant and outfall to the east of the SCL encapsulation area. Treated effluent consists of cathode, superstructure, bar washings, anode burn off washings, drain cleanings, leachate from the SCL encapsulation and any groundwater that is recovered from under the SCL sheds. Consented activity. Potential leak from facility to ground. Some pipes brought above ground in 2006.	Fluoride, cyanide, metals*, TPH/PAH and basic soil suite#

Notes

* See Section 4.1 of the SAQP for a full list of metal analytes

See Section 4.1 of the SAQP for a breakdown of the basic soils suite

xx - Not a Contamination Register Item

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analysis
17	Zone B Re-processing Facility	Bagged Goods Store	2 Test Pits	Storage and handling of dusty materials such as AlF3 and soda ash. Material escaping outside the building potentially contaminating sealed or gravelled areas outside the building. South of building waste material have been stored there over time	Fluoride, metals*, TPH/PAH and basic soils suite#
19	Zone B Re-processing Facility	Between Bagged Goods Store and SCL sheds	6 Test Pits	Pot bottoms and dross used to be stored outside on concrete pad / gravel between Bagged Goods Store and new SCL sheds. Dross to ground. Only pot bottoms stored here between 1994 and 1997. Potential for contamination of ground and groundwater. During 70's and 80's other waste materials were stored here.	Fluoride, cyanide, metals*, TPH/PAH and asbestos
25	Zone B Re-processing Facility	Cooling towers - All	2 Test Pits	All cooling towers on-site. Use of biocides. Potential contamination of ground under and around the towers from overspray of water.	Fluoride and Chloride
43	Zone B Re-processing Facility	SCL Crushing building - Laydown area	4 Test Pits	Storage of old roof louvres from Reduction on gravel south of the SCL sheds. Awaiting compacting/crushing. Fluoride rich dust potentially contaminating the storage ground. No louvres on the ground in Jan 2009. Site will be used again when next lot of roof louvres are to be replaced. None stored there between Jan 2009 and May 2019.	Fluoride, cyanide, metals*, asbestos, OCP and basic soils suite#
44	Zone B Re-processing Facility	SCL sheds - Laydown area	6 Test Pits	Storage of pot bottoms for further processing. Fluoride and cyanide rich dust potentially contaminating the storage ground.	Fluoride, cyanide, metals*, asbestos and basic soils suite#
45	Zone B Re-processing Facility	SCL Sheds 1,2,3	3 Test Pits	Storage of SCL in nearby buildings and alumina dust on ground.	Fluoride, cyanide, metals*
73	Zone B Re-processing Facility	Re-processing Facility Diesel AST	3 Test Pits	Bunded diesel AST. Diesel AST in good condition. Some evidence of ground disturbance adjacent due to yard discharges.	Metals*, TPH/PAH and asbestos

Notes

* See Section 4.1 of the SAQP for a full list of metal analytes

See Section 4.1 of the SAQP for a breakdown of the basic soils suite

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analysis
2	Zone C - Southern Yards	Cell Repair - Diesel spill	2 Soil Bores	In 1991/92 there was a significant diesel spill at NZAS. Some product recovered and rest left to remediate naturally. Permission was given from Environment Southland stop monitoring after 2006 review concluded that site would have remediated naturally by 2015. Final monitoring performed in 2006 and reported to ES.	Fluoride, cyanide, metals*and TPH/PAH
18	Zone C - Southern Yards	Bath Plant	3 Soil Bores 1 Monitoring well	Processing of bath. Material escaping containing fluoride rich dust. Potential for contaminating ground outside facility.	Fluoride, cyanide and metals*
21	Zone C - Southern Yards	Canteen (South) car park	1 Monitoring Well - refusal at 0.5 m bgl (well not installed)	To the west of the Rodding building. Diesel tank (55,000L) installed in 1971 and HFO tank (50,000L) installed in 1981 servicing Rodding. Tanks removed in early 90's. Potential for contaminated ground in this area.	Fluoride, cyanide, metals* and TPH/PAH
28	Zone C - Southern Yards	Mobile Equipment Workshop	Covered by Item 72 and 80	Asbestos from building material is stored in double lined bags at a designated area of the landfill. Area is sign posted. Facia boards from building removed during 2007/8 are deposited here. Current cell has capacity for further waste. Potential for contamination of ground.	Covered by Item 72 and 80
41	Zone C - Southern Yards	Salvage Yard	3 Soil Bores 1 Monitoring Well	Potential for leak of oils, solvents and paints stored for recycling to ground underneath sealed bunded area. Housekeeping in this area has improved greatly during 2008.	Fluoride. Cyanide, metals*, TPH/PAH, SVOC, asbestos and basic soils suite#
52	Zone C - Southern Yards	Stores - Underground petrol/diesel tanks	2 Soil Bores	Underground storage tanks for petrol (13000 & 18000L capacity). Contamination of petrol in surrounding ground. Tanks were removed in 2003. Diesel tank removed in 1996.	TPH/PAH, VOC and metals*
66	Zone C - Southern Yards	PFAS Drum Store	1 Soil Bore	Drummed storage of PFAS chemicals No evidence of leakage but no sampling undertaken.	PFAS
67	Zone C - Southern Yards	Waste Oil - E of SCL 2	1 Soil Bore	Waste oil and washdown area Potential ground contamination identified and not sampled previously	TPH/PAH
68	Zone C - Southern Yards	Straddle Carrier Warehouse - diesel AST and former laydown	5 Testpits 2 Soil Bores	Bunded diesel AST. Area around bowser shows ground staining. Area to immediate east was historical contractor and laydown area.	Fluoride, cyanide, metals*, TPH/PAH, asbestos and basic soils suite#
69	Zone C - Southern Yards	Main diesel tank AST	2 Soil Bores (1 not installed due to excavation refusal)	Bunded diesel AST Located in south central area of workshops. Has staining around diesel bowser pump.	TPH/PAH and SVOC
72	Zone C - Southern Yards	Steam Cleaning Pad - Garage Area	2 Soil Bores	Waste oil area Potential ground contamination identified and not sampled previously	TPH/PAH
79	Zone C - Southern Yards	Former Foam Store	1 Monitoring Well	Fire - PFAS Foam Use	PFAS
84	Zone C - Southern Yards	Metal Products - Diesel & HFO Day Tanks	1 Monitoring Well	Diesel AST	TPH/PAH
80	Zone C - Southern Yards	Current Fire Practice	1 Monitoring Well	Fire Training Area	PFAS

Notes

* See Section 4.1 of the SAQP for a full list of metal analytes

See Section 4.1 of the SAQP for a breakdown of the basic soils suite

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analyte
11	Zone D Solid Storage	South Drain	2 Test Pits 5 Hand Dug	South Drain - open stretch of drain. Aluminium and metal rich sediment in drain. Sediment removed on "as needs" basis.	Fluoride, cyanide, metals*, TPH/PAH and PFAS
12	Zone D Solid Storage	T1 Towers	2 Soil Bores	T1 towers were painted with lead based paint several years ago. After sandblasting in 2006 some lead paint still remains on the structures. Structures were repainted with lead free paints to contain the lead. Lead rich garnet collected from ground for disposal. No contamination of ground under structure expected.	Fluoride and metals*
31	Zone D Solid Storage & Wharf	Wharf Conveyor & Pipeline	2 Test Pits 5 Hand Dug	Conveying pencil pitch to storage via wharf conveyor. Potential contamination of ground and water under belt.	Fluoride, metals*, TPH/PAH and basic soils suite#
42 (32)	Zone D Solid Storage	SCL Shed #2	5 Test Pits 3 Soil Bores	Part of the pitch store was used for storage of SCL. SCL was removed in 2005 to make room for Wolsley alumina. Since then butt bath, butts and green scrap. Since 2008 coke has been stored there. Potential for contamination of ground through cracks in floor and walls.	Fluoride, cyanide, metals*, TPH/PAH, asbestos and basic soils suite#
60	Zone D Solid Storage	SCL Shed #3	Covered by Item 12	Bulk Garnet stored in this area.	-
83	Zone D Solid Storage	SW SCL Container Area and Laydown	3 Test Pits 1 Monitoring Well	Gravel area of SCL Containers and adjacent laydown area.	Fluoride, cyanide, metals*, TPH/PAH, asbestos and basic soils suite#

Notes

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See Section 4.1 of the SAQP for a breakdown of the basic soils suite

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analyte
33	Zone E Liquid Storage	Pitch Bulk Tanks	5 Test Pits (2 of which were hand dug) 1 Hand Dug	Pitch tanks, surrounding bunded area and associated equipment (scrubbing and liquid pitch line from wharf). Unknown if any spills have occurred in those areas. Potential for contamination of ground.	TPH/PAH, asbestos,basic soils suite# and PFAS
82	Zone E Liquid Storage	Former Foam Spraying	2 Test Pits 1 Monitoring Well	Grass area Anecdotal evidence of PFAS foam spraying from former fire chief	Fluoride, metals* and PFAS
77	Zone E Liquid Storage	HFO Tank - Fire	1 Test Pit (hand dug due to access)	Historical fire in this area which may have been extinguished with PFAS containing fire fighting foams.	Metals*, TPH/PAH and PFAS
27	Zone E Liquid Storage	HFO tank	4 Test Pits 5 Hand Dug 1 Monitoring Well	HFO main tank, surrounding bunded area and associated equipment (wharf line, oil farm and the CBF day tanks). Oil spills have occurred in bunded area and from supply line to Carbon. Oil/ water separator used when pigging the HFO line. Oil collected in sump and recycled. Potential site of HFO contamination. Bund was upgraded in 2014 no signs of oil contamination in the earth walls or bottom.	Metals*, TPH/PAH, asbestos, basic soils suite# and PFAS

Notes

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See Section 4.1 of the SAQP for a breakdown of the basic soils suite

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analyte
1 & 36	Zone F Carbon	Carbon - Green and Bake	3 Soil Bores 1 Monitoring Well	Forming and baking of anodes. Green Carbon and Carbon Bake buildings. Leak of material from cracks in buildings and ducts and fume to ground under and around buildings contaminating soil and groundwater.	Fluoride, metals* and TPH/PAH
14	Zone F Carbon	CBF - HFO day tanks	3 Test Pits 1 Hand Dug	Ground contaminated with HFO from leaking pipe on CBF4 return line on ring main onto ground. Occurred on 24 Sept 2006. Gravel was removed and sent to NZAS's Landfill for remediation.	Fluoride, metals*, TPH/PAH, SVOC, asbestos and VOC
56	Zone F Carbon	Green Carbon	2 Soil Bores 1 Monitoring Well (not installed due to access restrictions for drill rig)	2008 South of Heat transfer fluid (HTF)building. Leak from underground pipe. 4000 litres were lost over 12 or more months.	Metals*and TPH/PAH
65	Zone F Carbon	Carbon Area - Drain overflow	1 Test Pit	Drain which overflowed onto surrounding grass Potential ground contamination identified and not sampled previously	Fluoride, Metals*, SVOC and TPH/PAH

Notes

* See Section 4.1 of the SAQP for a full list of metal analytes

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analyte
3	Zone G Stack	Dry Scrubbers/ torbeds	4 Test Pits 1 Soil Bore 1 Hand Dug	Dry scrubbing system to scrub fluoride from the exhaust gasses from Reduction. Fluoride rich alumina occasionally spills onto ground via failed pipes. Contamination of the ground by the dry scrubbers. High levels of fluoride found in stormwater sumps by delining building. High Fluoride level in sump water by torbed substation	Fluoride, cyanide, metals*, asbestos, basic soils suite# and sulphate
9	Zone G Stack	Reconstruction	2 Soil Bores	Delining building and surrounding ground (including sumps) contaminated with SCL and pitch from the cells when jack hammering or transporting structure in and out of building. Delining was previously done on-line.	Fluoride, cyanide, metals*, TPH/PAH and basic soils suite#
15	Zone G Stack	Electro Static Precipitator (ESP) - to the east of the CBFs.	5 Test Pits	The ESP was used as part of the bake process prior to decommissioning CBF3. Tar from this process was stored in drums outside on the ground for a number of years. Material was removed from the site early 2006 and recycled. Changed rating on Aug17 when solid pitch was found in gravel when trenches were excavated to upgrade compressed air line by CBF2.	Fluoride, cyanide, metals*, TPH/PAH and asbestos

Notes

* See Section 4.1 of the SAQP for a full list of metal analytes

See Section 4.1 of the SAQP for a breakdown of the basic soils suite

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analyte
13	West Drain	Zone I West Yards	2 Test Pits 4 Hand Dug	West Drain - open stretch of drain. Metals, aluminium and PAH rich sediment in drain. Sediment removed on "as needs" basis	Fluoride, cyanide, metals*, TPH/PAH, basic soils suite# and PFAS
64	NW corner yards - former brick storage and current new brick store	Zone I West Yards	3 Test Pits 1 Monitoring Well	Former area of brick storage now also new brick storage Potential ground contamination identified and not sampled previously	Fluoride, cyanide, metals*, TPH/PAH and basic soils suite#

Notes

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See Section 4.1 of the SAQP for a breakdown of the basic soils suite

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analyte
4	Zone J CCG	North Drain	4 Hand Dug	North Drain - open stretch of drain. Fluoride, aluminium and metal rich sediment in drain. Sediment removed on "as needs" basis	Fluoride, cyanide, metals*, asbestos and PFAS
23	Zone J CCG	CCG Buildings	5 Test Pits	Storage of various chemicals and oil filled equipment in the CCG buildings. Not all sources have been bunded in the past. Potentially some could have spilled inside building then flowed outside to ground or via cracks in floor. In 2009 larger quantities of paint and oil are stored in locked container outside. Chemicals have spill trays. Small containers are stored inside the building.	Fluoride, cyanide, metals*, TPH/PAH, asbestos and basic soils suite#
24	Zone J CCG	CCG Hangar	2 Test Pits	Bath stored in bags. Shed not totally water proof. Potential for leakage to ground outside the hangar.	Fluoride, cyanide, metals*, asbestos and basic soils suite#
39	Zone J CCG	Reduction	8 Test Pits 1 Monitoring Well	Asbestos was removed from the old ductwork and multicyclones stored on an area to the North of Reco. Potential for contamination of ground.	Fluoride, cyanide, ,metals*, TPH/PAH, asbestos and basic soils suite#
71	Zone J CCG	SCL Containers - CCG Area	2 Test Pits	SCL containers stored in this area which has a gravel surface. Also being used for transformer cleaning during visit.	Fluoride, cyanide, metals*, TPH/PAH, asbestos and PCBs

Notes

* See Section 4.1 of the SAQP for a full list of metal analytes

See Section 4.1 of the SAQP for a breakdown of the basic soils suite

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analysis
37	Zone K Northern Yard	Reconstruction (washdown)	6 Test Pits	Material on cells removed from Reduction is washed off. Water is collected in under ground storage tank. Water then transferred via tanker for treatment to the Treated Effluent Plant when tank is full. Potential contamination of ground around tanks/wash area. Tanks were steam cleaned and sealed with a liquid membrane in Feb 2008. Dividing wall rotated 90deg. April 2008: 500 litres overflowing from tanker onto ground.	Fluoride, cyanide, metals*, TPH/PAH, asbestos and basic soils suite#
40	Zone K Northern Yard	Reduction	2 Test Pits 1 Monitorng Well	On an unsealed area to the North of the Reduction line 3, cell bottoms were cut up outside centre passage. Potential for contamination to ground.	Fluoride, cyanide, metals*, TPH/PAH, asbestos and basic soils suite#
58	Zone K Northern Yard	Sewage Treatment Plant - Sewerage Leak	Covered by Item 70	-	-
70	Zone K Northern Yard	Sewage Treatment Plant - Concrete wash area	1 Test Pit	Former concrete truck washdown area Area indentified by NZAS as being potential hot spot that should be investigated.	Metals*, SVOC, basic soils suite# and sulphate
76	Zone K Northern Yard	Washdown Diesel AST	1 Test Pit	Diesel AST and bowser some ground staining Potential ground contamination identified and not sampled previously.	TPH/PAH

Notes

* See Section 4.1 of the SAQP for a full list of metal analytes

See Section 4.1 of the SAQP for a breakdown of the basic soils suite

Contamination Register ID	Zone	Location	Sample Points	Rationale	Analysis
25	Zone L East Gate	Cooling towers - All	1 Test Pit	All cooling towers on-site. Use of biocides. Potential contamination of ground under and around the towers from overspray of water.	Metals* and sulphate
34	Zone L East Gate	Power Supply - Switch yards discharge	2 Hand Augers	Discharge of storm and process water to infiltration area south of switchyard. Consented activity. Potential contamination of ground and groundwater.	Fluoride, cyanide, metals*, TPH, VOC, SVOC, asbestos, PCB and basic soils suite#
61	Zone L East Gate	East gate - Waste CBF bricks	6 Test Pits	Waste CBF bricks stored on gravel awaiting disposal. First lot removed in 2015. 2015-2016 rebuilt bricks still there.	Fluoride, cyanide, metals*, TPH/PAH and asbestos
62	Zone L East Gate	Compressor House 1	1 Test Pit 1 Monitoring Well	Oil separator tank overflowed in Jan 2020 and spilt unto gravel. Surface oil removed but some oil penetrated into the gravel 5-10cm deep.	Fluoride, cyanide, metals*, TPH/PAH, VOC and SVOC
74	Zone L East Gate	Gravel winning area - East Yards	6 Test Pits	Former area of spoil dumping from Potline construction Area that has taken spoil from potline construction. Used for gravel winning but noted areas of fill in gravel face.	Fluoride, cyanide, metals*, TPH/PAH and asbestos
75	Zone L East Gate	Unknown AST - Water Treatment Chemicals	Covered by item 62	Hydrocarbon Waste Water AST	Covered by item 62
78	Zone L East Gate	Historic Transformer Fire	1 Monitoring Well	Exact location of fire undefined however monitoring well installed in this general area to identify any PFAS in groundwater and supplement a gap within the monitoring well network.	Metals*, TPH/PAH, PCB and PFAS (only groundwater samples taken in this location)

Notes

* See Section 4.1 of the SAQP for a full list of metal analytes

See Section 4.1 of the SAQP for a breakdown of the basic soils suite