ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

24 September 2019

Shellharbour City Council
PO Box 155
Shellharbour Square
Shellharbour City Centre NSW 2529

Attention: **Joel Coulton**
Waste and Recovery Manager

Dear Joel,

August 2019 Quarterly Environmental Monitoring – Dunmore Recycling and Waste Disposal Depot, Dunmore, New South Wales.

1 INTRODUCTION

Environmental monitoring is undertaken on a quarterly basis at the Dunmore Recycling Waste Disposal Depot, Dunmore, NSW (the site), in accordance with Environment Protection Licence (EPL) No. 5984. The monitoring includes sampling groundwater bores, a leachate pond, surface water bodies, a dust gauge and landfill gas at the landfill surface to detect any potential impacts of land filling activities on the environment.

2 SCOPE OF WORKS

On 20 and 21 August 2019, groundwater, surface water, leachate, gas and dust samples were collected in and around the site.

During July 2019, four bores were reinstalled to replace bores destroyed during the redevelopment of buildings at Dunmore Resource and Recycling (DRR). It was intended to reinstall BH18 near its original location, however due to refusal on buried obstructions and concrete, the bore was relocated to the northwestern corner of the offices at DRR (BHA). Locations of the monitoring network is illustrated in **Figure 1** (**Appendix A)**

Groundwater samples were collected from nine monitoring bores (BH1c, BH2, BH3, BH4, BH13, BH14, BH16, BH20 and BH20s). At BH10 only the standing water level (SWL) was measured and no sample was taken. Surface water was collected from the leachate pond (LP1), three on site retention ponds (SWP1, SWP2, and SWP4) and Rocklow Creek at four points (SWC2, SWC_Up, SWC_Down and SWC_Down_2). Sampling was also taken at four recently reinstalled bores (BHA, BH12r, BH17r and BH19r). No sample was collected from BH15 as the access point was at the base of a steep and uneven slope and was inaccessible. No sample was taken at SWP5 as the retention pond was dry.

A dust gauge bottle was collected to the north of the site (DDG1) and a gas walkover of all site buildings and the landfill cap was also undertaken. Landfill gas was measured in the field using an Inspectra Laser Unit (ILU) and a GA5000 Landfill Gas Analyser (GA5000).

3 FIELD MEASUREMENTS

Prior to purging, monitoring bores were measured for SWL. During sampling, field measurements were taken including pH, electrolytic conductivity (EC), oxidation/reduction potential (ORP), dissolved oxygen and temperature. Colour and odour of water samples were also noted. Field measurements recorded for each location are presented in **Table 2** (**Appendix B**).

All sampling was undertaken in accordance with Environmental Earth Sciences NSW (2011) *Soil, Gas and Groundwater sampling manual*.

4 LABORATORY ANALYSIS

The following analyses were undertaken for site groundwater and surface water during the May 2019 monitoring event:

- groundwater – ionic balance (pH, total dissolved salts (TDS), sodium, calcium, potassium, magnesium, fluoride, chloride, ammonium, sulfate, bicarbonate, phosphate and nitrate), total organic carbon (TOC), biological oxygen demand (BOD), total and soluble iron, and soluble manganese;
- surface water (SWC_Up, SWC_Down and SWC_Down_2) – ionic balance, total and soluble iron, turbidity, nitrate, ammonium and bicarbonate;
- surface water (SWC2) – ammonium, nitrate, bicarbonate and total and soluble iron;
- surface water SWP1, SWP2 and SWP4 – ionic balance, total and soluble iron and turbidity;
- additional analyses for SWP4 – TOC and BOD; and
- leachate tank (LP1) – ionic balance, TOC, BOD, total and soluble iron, soluble manganese, turbidity, faecal coliforms and E. Coli.

Water samples and the dust sample were sent to Sydney Analytical Laboratories (SAL) for inorganic chemical analyses and to Sonic Healthcare for faecal coliforms and Escherichia coli (E. Coli) counts. All laboratories are NATA accredited for the methods used.

The inorganic laboratory results for groundwater and surface water are shown in **Table 3** and **Table 4** (**Appendix B**). Calculated ratios of principal ions are presented in **Table 5** (**Appendix B**).

5 RESULTS AND DISCUSSION

5.1 Groundwater flow

Inferred groundwater contours from the August 2019 standing water level (SWL) measurements are illustrated in **Figure 2** (**Appendix A**). These were calculated using SWLs from surveyed bores. Groundwater flow direction was towards Rocklow Creek in a southerly direction similar to previous monitoring events.

Cumulative rainfall for June 2019 (91.6 mm), July 2019 (20 mm) and August 2019 (37.2 mm) was 148.8 mm (BOM – Albion Park Wollongong Airport weather station) and slightly below 1999-2019 mean rainfall for this period of the year. Groundwater levels were slightly higher in all the wells monitored compared to May 2019 levels, with an average difference of +0.4 m AHD.

5.2 Groundwater

5.2.1 Groundwater sampling locations impacted by leachate

Field and laboratory results from the August 2019 sampling round, specifically from bores BH1c, BH2, BH3, BH12r, BH13, BH17, BH20 and BH20s displayed chemistry that can be related to leachate impact with high levels of potassium, ammonium and nitrate. Leachate interaction is demonstrated by elevated concentrations of non-native potassium (K^+), ammonium (NH_4^+-N) and nitrate (NO_3^-) relative to native sodium (Na+), calcium (Ca^{2+}) and magnesium (Mg^{2+}). This comparison is known as the leachate to non-leachate (L/N) ratio.

An L/N ratio >10 may be indicative of leachate impact depending on the combination with other indicators such as odour, colour, BOD and bicarbonate whereas a significant impact is likely to correspond with a ratio of >20 (**Table 5, Appendix B**).

Bore BH1c is located near the old unlined landfill cell and intercepts leachate within the cell. As such the chemical signature of this bore has historically contained elevated leachate indicators in comparison to other monitoring bores (**Schoeller plot BH1 a/b/c**, **Appendix C**). This continued during the current monitoring event and the groundwater was found to have a yellow brown colour and ammonia and sulfuric odour noted in combination with elevated TDS (4690mg/L), K^+ (250 mg/L) [resulting in low Ca/K (1.13)] and NH_4^+-N (330 mg/L) concentrations. The very low levels of dissolved oxygen (0.03 ppm, **Table 2**) and presence of soluble Fe^{2+} (2.1 mg/L) indicate an anaerobic environment and biochemical demand in response to microbial respiration. BOD has fluctuated since the bore was installed, ranging from 850 mg/L to 6 mg/L. BODs have remained at similar levels (6-25 mg/L) since August 2016 with a slight decreasing trend up to the May 2019 BOD concentration of 12 mg/L. Further evidence of microbial activity and respiration of nitrogen species in groundwater is elevated HCO_3^- resulting in a low Cl/HCO_3^- ratio of 0.36 (**Table 5**). This suggests some degradation of the leachate plume, and the organic nitrogen species therein, has occurred in this monitoring bore.

Bore BH2 is located down gradient from the old unlined landfill cell. Historically elevated levels of NH_4^+-N indicate some leachate impact at this location. NH_4^+-N concentration at BH2 showed an increasing trend since 2010 and reached its historical maximum in August

2017 and November 2017 (49 mg/L in both months). NH_4^+-N concentration increased slightly in the August 2019 monitoring round to a level of 42 mg/L (up from 39 mg/L in November 2018). Bicarbonate (HCO_3^-), Na^+ and Mg^{2+} concentrations in groundwater have shown an increasing trend since May 2008 (**Table 3** and **Schoeller plot BH2, Attachment C**). Calcium (Ca^{2+}) and potassium (K^+) concentrations slightly increased since the last monitoring round (**Table 3** and **Schoeller plot BH2, Attachment C**) in May 2019. Low oxygen and negative redox (**Table 2)** continue to suggest microbial respiration and therefore degradation of the leachate is occurring at this location. Additionally, a sweet odour was noted.

Groundwater from bore BH3 reported an increase in concentration of native ions (Na^+, Mg^{2+} K^+ and Ca^{2+}). Non-native nitrogen species increased in August 2019 with NH_4^+-N concentration rising to 41 mg/L from 27 mg/L in May 2019. NO_3^- recorded a decrease increase in concentration to 26 mg/L from 105 mg/L in the previous monitoring event (May 2019). The concentration of HCO_3^- also increased from 490 mg/L to 640 mg/L. The L/N ratio (30.21%) had decreased since the May 2019 monitoring round (60.29 %). It was reported and verified during the drilling of BH3 that old unconfined waste dumps were in the vicinity of bore BH3 (outside the designated cells near bore BH2).

Bore BH12_R was reinstalled in July 2019 to the southwest of the leachate tanks and south of the nightsoil stockpiles. This bore was installed to replace BH12 (monitoring point 9 of EPA license number 5984) following the development of the new facilities at Dunmore Resource and Recycling. Field observations recorded a negative redox (-4 mV). Groundwater was observed to be clear with no discernible odour recorded, however a strong odour was present associated with the green waste and compost stockpiles making it difficult to pick up any slight odours in groundwater. The chemical signature of the groundwater at this location is indicative of leachate impact (elevated TDS (1580mg/L), K^+(62 mg/L) (**Table 5, Appendix B**), which is in keeping with the migration of leachate from the main landfill to the southeast. When compared with historic data for BH12, concentrations of other landfill indicators such as Ca/K ratio had increased (9.28 in August 2019 compared to 1.07 in November 2016) and NH_4^+-N had decreased (1.50 mg/L in August 2019 compared to 12 mg/L in November 2016), indicative of degradation of the leachate plume. This is further supported by elevated concentrations of Fe (2.4 mg/L) and very low levels of dissolved oxygen (as low as -0.23 ppm) indicate an anaerobic environment and biochemical demand in response to microbial degradation.

BH17_R was installed in July 2019 to replace BH17b, following the development of the new facilities at Dunmore Resource & Recycling. Bore 17R is located to the east of the leachate tanks, which provides coverage to the eastern bounds of the site (**Figure 1**). Results compared with historical data from BH17 (**Schoeller plot BH17, Appendix C)** indicates that the chemical signature has reduced slightly since 2016 but remains broadly stable. The L/N ratio (14.64 %) is higher than the last recorded value of nearby bore BH17 (7.06%) but is consistent with values recorded in 2012. Negative ORP (-114 mV) and very low dissolved oxygen in addition to elevated concentrations of Fe (3.2 mg/L) and Mn (0.23 mg/L) are indicative of an anaerobic environment and high microbial activity. Further evidence of microbial activity and respiration of nitrogen species in groundwater is elevated HCO_3^- (545 mg/L) resulting in a low Cl/HCO_3^- ratio of 1.2 (**Table 5**). This indicates degradation of the leachate plume, and the organic nitrogen species therein.

Bore BH20 is located down gradient of the landfill, leachate ponds and shallow old landfill. This bore was positioned to assess the chemical characteristics on the boundary of the landfill site. Field observations at bore BH20 recorded a negative redox (-150 mV) with very slight cloudy brown water and a faint hydrogen sulphide odour. The L/N ratio (26.16%) in the August 2019 round had increased from the February 2019 value and was still considered significantly elevated. The TDS remained relatively low (970 mg/L) making the L/N susceptible to natural variations or fluctuations in chemistry. Chemical characteristics of the bore show groundwater is low in Na^+, with a moderate Ca/K and K/TDS ratio (**Table 5**). Ammonium levels remained elevated at 24 mg/L however other landfill indicators were low or absent.

Bore BH20s is located directly adjacent to BH20 but at a shallower depth. Screened intervals of BH20 and BH20s are 6.0-9.0 mBGL and 1.5-4.5 mBGL respectively. Similarly, this bore was positioned to compare the chemical characteristics on the boundary of the landfill site in order to locate potential transport pathways to Rocklow Creek. In August 2019, field measurements at bore BH20s recorded a positive redox (32 mV), indicative of an oxidative atmosphere. Groundwater very slightly light brown and a very faint odour was detected. NO_3^- concentrations increased slightly from 54 mg/L in May 2019 to 55 mg/L in August 2019. The L/N ratio (69.80 %) is elevated and is indicative of potentially high leachate impact at this site. TDS is relatively low (810 mg/L) making the L/N susceptible to natural variations or fluctuations in chemistry. Chemical characteristics of the bore show groundwater was low in Na^+, with a moderate Ca/K and K/TDS ratio (**Table 5**). As observed within BH3, the relatively high rainfall from March to June 2019 may have impacted the nitrogen species within BH20s, causing leaching of nitrogen species from the soil into the groundwater, resulting in elevated NO_3^- concentrations. Ammonium levels (1.2 mg/L) have increased significantly since February 2019 (0.1 mg/L) and remain lower than those seen at the deeper BH20 bore. It was previously thought that high nitrate levels in this shallower bore location was indicative of nitrification throughout the soil profile, however, continued monitoring at this location will be necessary to determine potential leachate transport pathways to Rocklow Creek.

5.2.2 Remaining groundwater sampling locations

During the May 2019 monitoring round, ionic chemistry indicated that bores BHA, BH4, BH13, BH14 and BH16 only displayed slight to no leachate influence. Chemical composition of each of these bores has been depicted in **Schoeller plots** in **Attachment C**.

BHA is located to the east of the landfill and to the south of the former BH18 and positioned to be hydraulically upgradient of the leachate plume migrating to the southeast. The L/N ratio was 9.45%, suggesting mild impact by leachate. A redox potential of 6 ppm and dissolved oxygen content of -0.27 ppm is suggestive of a slight oxidative to reducing environment. TDS is relatively low (790 mg/L) making the L/N susceptible to natural variation in groundwater chemistry. Both ammonium and nitrate levels were relatively low to moderate (0.4 mg/L and 9.8 mg/L respectively). In addition, groundwater was also low in Na^+ (76 mg/L) with an elevated Ca/K ratio (20.20) and moderate K/TDS ratio (1.77%) (**Table 5**, **Appendix B**). Bore BHA is strategically placed up gradient of landfilling activities and should be continually monitored to determine the background water quality.

The L/N ratio at bore BH4 continued to decrease in the August 2019 round (8.2%) from the November 2018 monitoring of 10.94 %. The L/N ratio at this location had not previously

exceeded 10% since May 2003. NH_4^+-N levels decreased from 8.9 mg/L to 6.70 mg/L however concentrations in nitrite (NO_2^-) decreased further from the low concentrations recorded in May (0.1mg/L in the August 2019 round from 0.23mg/L in May 2019), indicative of a decrease in the nitrification process and transformation of NH_4^+-N to NO_2^-. BH4 is placed on the border of the historic shallow landfill site and down gradient of landfilling activities. This area should be continually monitored to determine water quality in this area.

In addition to BH12R, Bore BH13 is in close proximity to a former night soil area (**Figure 1**). A slight residual leachate influence has been apparent at this location in the past. Analysis of chemical data from the August 2019 monitoring round shows an increase of L/N ratio of 15.59 % from 12.03 % in May 2019. Concentrations of NO_3^- continue to fluctuate; at 2.30 mg/L are comparable with the February 2019 monitoring round (3.10 mg/L), but still significantly lower than the November 2018 round (31.0 mg/L). Large fluctuations in NO_3^- have previously been observed in the historic data, however, chemical composition of the groundwater has generally remained consistent since monitoring began in 2002 (**Schoeller plot BH13**, **Attachment C**).

The L/N ratio at bore BH14 in the August 2019 round (6.3%) increased to its highest since May 2018 round (7.29 %). NO_3^- concentration increased slightly (3.6 mg/L) but remain significantly lower than historical values recorded at this location (105 mg/L in February 2017). NH_4^+-N concentrations increased slightly from 1.80 mg/L to 2.70 mg/L, exceeding the site criteria of 1.88 mg/L. Bore BH14 is strategically placed down gradient of landfilling activities and should be continually monitored to determine the water quality in this area given its history of leachate impact.

Bore BH16 is located in a swampy area, however on this occasion groundwater field observations recorded clear colour and no discernible odour. The sampled redox potential indicates a reducing environment (-128 mV), which may have an influence on the historical dominance of NH_4^+-N over NO_3^-. This round, NH_4^+-N concentrations remained stable at 0.2 mg/L. Groundwater sampling in May 2019 indicated limited to no leachate impact at BH16 despite a slightly elevated L/N ratio of 9.44 %, which had decreased from the May 2019 monitoring round (12.80%). Bore BH16 is located close to a drainage channel where offsite impacts can readily influence the chemical characteristics of the shallow groundwater and should continue to be monitored for fluctuations.

5.2.3 Groundwater site criteria exceedances

NH_4^+-N concentrations above threshold levels (1.88 mg/L) (ANZECC, 2000) were reported in groundwater from bores BH1c (330 mg/L), BH2 (42 mg/L), BH3 (41 mg/L), BH4 (6.7 mg/L), BH13 (3.0 mg/L), BH14 (2.7 mg/L), BH17R (9.6 mg/L), BH19R (5.5 mg/L) and BH20 (24 mg/L).

Nitrate (NO_3^-) was reported above guideline thresholds (10.6 mg/L) (ANZECC, 2000) at BH3 (105 mg/L), BH12R (130 mg/L) and BH20s (55 mg/L).

Iron (Fe) concentrations above threshold levels (0.3 mg/L, ANZECC, 2000) were reported at BH1c (2.1 mg/L), BH2 (1.2 mg/L), BH3 (0.35 mg/L), BH12R (2.4 mg/L), BHA (0.89 mg/L), BH14 (1.4 mg/L) and BH17R (3.2 mg/L).

5.3 Surface water monitoring

During the May 2019 monitoring round, samples from Rocklow Creek (SWC2, SWC_Up, SWC_Down and SWC_Down_2) and three surface water ponds (SWP1, SWP2, and SWP4) were collected. Results of surface water analysis (**Table 3** and **Table 4**) indicate that concentrations of ions were within the historical ranges. As surface water ponds are intended to retain any surface water migrating towards Rocklow Creek, the detection of chemical constituents that may be associated with landfill leachate are expected. Chemical composition of each of these monitoring points has been depicted in **Schoeller plots** in **Attachment C.**

NH_4^+-N levels detected at SWP1 (0.70 mg/L) increased since the previous monitoring event (0.3 mg/L). Ongoing minor leachate impact has been indicated by consistent L/N ratios > 10% and < 20%. Elevated concentrations of soluble iron and a negative redox potential are indicative of a reducing environment which may have contributed to historical low levels of dissolved oxygen and the production of NH_4^+-N.

Surface water sampled at SWP2 showed little to no leachate impact. The surface water pond collects runoff from around the site and potential impacts from site activities are often observed. NH_4^+-N concentration remained low at 0.10 mg/L however, fluctuating NH_4^+-N is common at this location with previous monitoring events ranging between 0.01 and 15 mg/L. NO_3^- concentrations had increased from the May 2019 monitoring round (0.10 mg/L) to 0.84 mg/L. All chemical parameters at this location are within historical ranges.

NH_4^+-N concentration at SWP4 decreased slightly from the May 2019 round from 3.2 mg/L to 2.10 mg/L, but remained above the trigger level of 1.88 mg/L. NO_3^- levels also increased significantly from 0.80 mg/L in May 2019 to 4.20 mg/L. The increase in NH_4^+-N and NO_3^- concentrations is indicative of a potential slowdown in the natural process of nitrification by which NH_4^+-N naturally attenuates. All chemical parameters at this location are within historical ranges and are considered representative of natural variation for surface waters.

The four surface water creek sites SWC2, SWC_Up, SWC_Down and SWC_Down_2 (**Figure 2**) were also sampled during the August 2019 sampling event. SWC_Down_2 was established in order to detect potential leachate impacts to Rocklow Creek originated from the eastern portion of the site (Environmental Earth Sciences NSW, 2017). SWC_Up, SWC_Down and SWC_Down_2 had high concentrations of TDS (ranging between 26,700 and 37,600 mg/L), notably Na^+ and Cl^- (**Table 3**); this is due to the tidal nature of these waters and differentiates them from landfill groundwater / surface water.

The low nutrient and L/N ratios within Rocklow Creek indicated that there was no leachate impact within Rocklow Creek. All surface water creek sampling sites (SWC2, SWC_Up, SWC_Down and SWC_Down_2) had concentrations of NH_4^+-N and NO_3^- below the ANZECC (2000) guidelines. All four sites will continue to be monitored to ensure leachate is not impacting upon the Rocklow Creek.

5.4 Monitoring of Leachate Tanks

The chemistry of leachate water at the Dunmore Recycling and Waste Disposal Depot is significantly different when compared to the surface and groundwater chemistry of non-leachate influenced bores. This is demonstrated through comparison of chemical data presented in **Table 3**. In particular, TDS, BOD, TOC, Na^+, NH_4^+-N, K^+, HCO_3^-, PO_4^{3-} and total

iron concentrations are generally elevated in leachate pond water compared to other monitoring bores (**Schoeller Plot LP1, Attachment 3**). Ionic ratios (**Table 5**) such as low Ca/K (0.60) and high Na/Ca (10.30) and L/N (83.51) ratios represent landfill leachate chemical characteristics. These chemical characteristics have been relatively stable over the past 10 years of monitoring.

Laboratory analysis recorded faecal coliforms and E. Coli during this round of 20 CFU/100 ml, a significant decrease on the concentrations of 170 CFU/100 ml and 140 CFU/100mL respectively reported in February 2019 (**Table 4**). Fluctuation in these concentrations in leachate tanks are common and thus dermal contact with these waters should continue to be avoided due to historic levels of elevated concentrations and the corresponding health concerns relating to high microbial counts.

5.5 Quality assurance/quality control

For quality assurance and quality control the following precision and reliability measures were calculated. The charge balance difference between the summed total of anions against cations (milli-equivalent units) was in the range of 0.79 % to 4.61 %. The results are a good indication that all major cations and anions present in the groundwater have been analysed and accounted for, providing confidence in the laboratory results obtained.

Field and laboratory practices were further evaluated by comparing the difference between field and laboratory pH and field measured electrical conductivity (EC) against laboratory total dissolved salts (TDS). The range of most relative percent difference (RPD) of field to laboratory pH measurements was typically between 3.77 % and 18.33%, with the exception of BH1c (156.78) and LP1 (200%). The relationship between the field determined EC and laboratory measured TDS relationship ranged between 0.52 and 0.77.

RPDs between the intra-laboratory duplicate and the primary sample taken at bore BH4 were all within the acceptable RPD criteria. Thus, the data is considered reliable (**Table 7**).

5.6 Gas monitoring

Landfill gas was measured in the field using an Inspectra Laser Unit (ILU) and a GA5000 Landfill Gas Monitor (GA5000). Measurements were taken within and around all buildings in a 250 m radius from the current landfill cell as well as across the landfill cap (gas walkover grids of the May 2019 round are presented in **Figure 3**).

Weather conditions observed during gas monitoring on 20 August, based on readings from the weather station at Albion Park (Wollongong Airport)[1] are summarised in **Table 1.**

Table 1: Weather conditions

Temperature (Min and Max)		Wind Speed and direction		Relative humidity	
8.8ºC	19.9ºC	W	76	9am	44%
				3 pm	33%

All readings were below the site-specific criteria outlined in EPL no. 5984 as the NSW EPA (2013) reporting threshold of 1.00 % v/v CH4 within onsite buildings and therefore pose no direct risk. All readings were below the threshold concentration for closer investigation and potential action (500 ppm or 0.05 % v/v, NSW EPA [2013], **Table 6**). Continued monitoring with both the GA5000 and ILU will be undertaken at quarterly monitoring events.

5.7 Dust

Dust deposition levels to the north of the site were 0.6 g/m^2/month total solids, which is below the accepted level of 4 g/m^2/month (Australian Standards AS3580.10.1 and AS2724.1). Dust deposition levels are within historical ranges and will continue to be monitored to assess the closest sensitive receptor, houses located to the north-west of site.

6 CONCLUSION AND RECOMMENDATIONS

Groundwater behaviour across the site since the commencement of quarterly monitoring in 1992 has been generally consistent. As the plume beneath the site is relatively stable, changes in leachate behaviour into the future are not expected to be significant. Changes to site conditions such as stockpile locations, new landfill cells, new retention ponds and other earth works could potentially impact leachate behaviour on site.

The August 2019 monitoring round found L/N ratios to be generally stable when compared to long-term trends. Decreases in leachate impacted bores were observed in BH3, BH20, BH14, due to decreases in nitrogen species concentrations. BH20s and BH16 recorded slight increases in L/N ratios.

[1] http://www.bom.gov.au/climate/dwo/201908/html/IDCJDW2001.201908.shtml, accessed 18 August 2019

Assessment of monitoring bores closest to Rocklow Creek, BH20 and BH20s, has detected the presence of leachate indicators despite the Rocklow Creek samples (SWC-Up, SWC-Down and SWC_Down_2), showing no affect. Although the historical data sets of these new bore locations are relatively limited, it appears that on-site activities are not significantly impacting Rocklow Creek. Surface water monitoring indicated that on site activities have had limited impact on water quality at locations SWP1, SWP2, SWP4 and SWP5. Assessment of Rocklow Creek sampling locations (SWC2, SWC-Up, SWC-Down and SWC_Down_2) reported no concentrations of NH_4^+-N and NO_3^- above the ANZECC (2000) trigger value.

Gas concentrations detected at all buildings assessed on site were below guidelines and therefore no action was required. It is recommended that monitoring continue with an FID or Inspectra Laser Unit and GA5000 Landfill Gas Monitor.

Depositional dust monitoring results continued to be below guidelines (Australian Standards AS3580.10.1 and AS2724.1) and will continue to be monitored to assess the impact that dust poses on nearby residential areas.

7 LIMITATIONS

This report has been prepared by Environmental Earth Sciences NSW ACN 109 404 006 in response to and subject to the following limitations:

1. The specific instructions received from Shellharbour City Council;
2. The specific scope of works is set out in PO117559 issued by Environmental Earth Sciences NSW for and on behalf of Shellharbour City Council.
3. May not be relied upon by any third party not named in this report for any purpose except with the prior written consent of Environmental Earth Sciences NSW (which consent may or may not be given at the discretion of Environmental Earth Sciences NSW);
4. This report comprises the formal report, documentation sections, tables, figures and appendices as referred to in the index to this report and must not be released to any third party or copied in part without all the material included in this report for any reason;
5. The report only relates to the site referred to in the scope of works being located at Dunmore Recycling and Waste Disposal Depot located at Buckley's Rd Dunmore, NSW;
6. The report relates to the site as at the date of the report as conditions may change thereafter due to natural processes and/or site activities;
7. No warranty or guarantee is made regarding any other use than as specified in the scope of works and only applies to the depth tested and reported in this report;
8. This report is not a geotechnical or planning report suitable for planning or zoning purposes; and
9. Our General Limitations set out at the back of the body of this report.

Should you have any queries, please do not hesitate to contact us on (02) 9922 1777.

For and on behalf of
Environmental Earth Sciences NSW

Author/ Project Manager
Elin Griffiths
Associate Environmental Scientist

Internal Reviewer
Stuart Brisbane
Senior Principal

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Attachments:

Appendix A – Figures

Appendix B – Tables

Appendix C – Schoeller Plots

Appendix D – Laboratory Transcripts

8 REFERENCES

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ENVIRONMENTAL EARTH SCIENCES GENERAL LIMITATIONS

Scope of services
The work presented in this report is Environmental Earth Sciences response to the specific scope of works requested by, planned with and approved by the client. It cannot be relied on by any other third party for any purpose except with our prior written consent. Client may distribute this report to other parties and in doing so warrants that the report is suitable for the purpose it was intended for. However, any party wishing to rely on this report should contact us to determine the suitability of this report for their specific purpose.

Data should not be separated from the report
A report is provided inclusive of all documentation sections, limitations, tables, figures and appendices and should not be provided or copied in part without all supporting documentation for any reason, because misinterpretation may occur.

Subsurface conditions change
Understanding an environmental study will reduce exposure to the risk of the presence of contaminated soil and or groundwater. However, contaminants may be present in areas that were not investigated or may migrate to other areas. Analysis cannot cover every type of contaminant that could possibly be present. When combined with field observations, field measurements and professional judgement, this approach increases the probability of identifying contaminated soil and or groundwater. Under no circumstances can it be considered that these findings represent the actual condition of the site at all points.

Environmental studies identify actual sub-surface conditions only at those points where samples are taken, when they are taken. Actual conditions between sampling locations differ from those inferred because no professional, no matter how qualified, and no sub-surface exploration program, no matter how comprehensive, can reveal what is hidden below the ground surface. The actual interface between materials may be far more gradual or abrupt than an assessment indicates. Actual conditions in areas not sampled may differ from that predicted. Nothing can be done to prevent the unanticipated. However, steps can be taken to help minimize the impact. For this reason, site owners should retain our services.

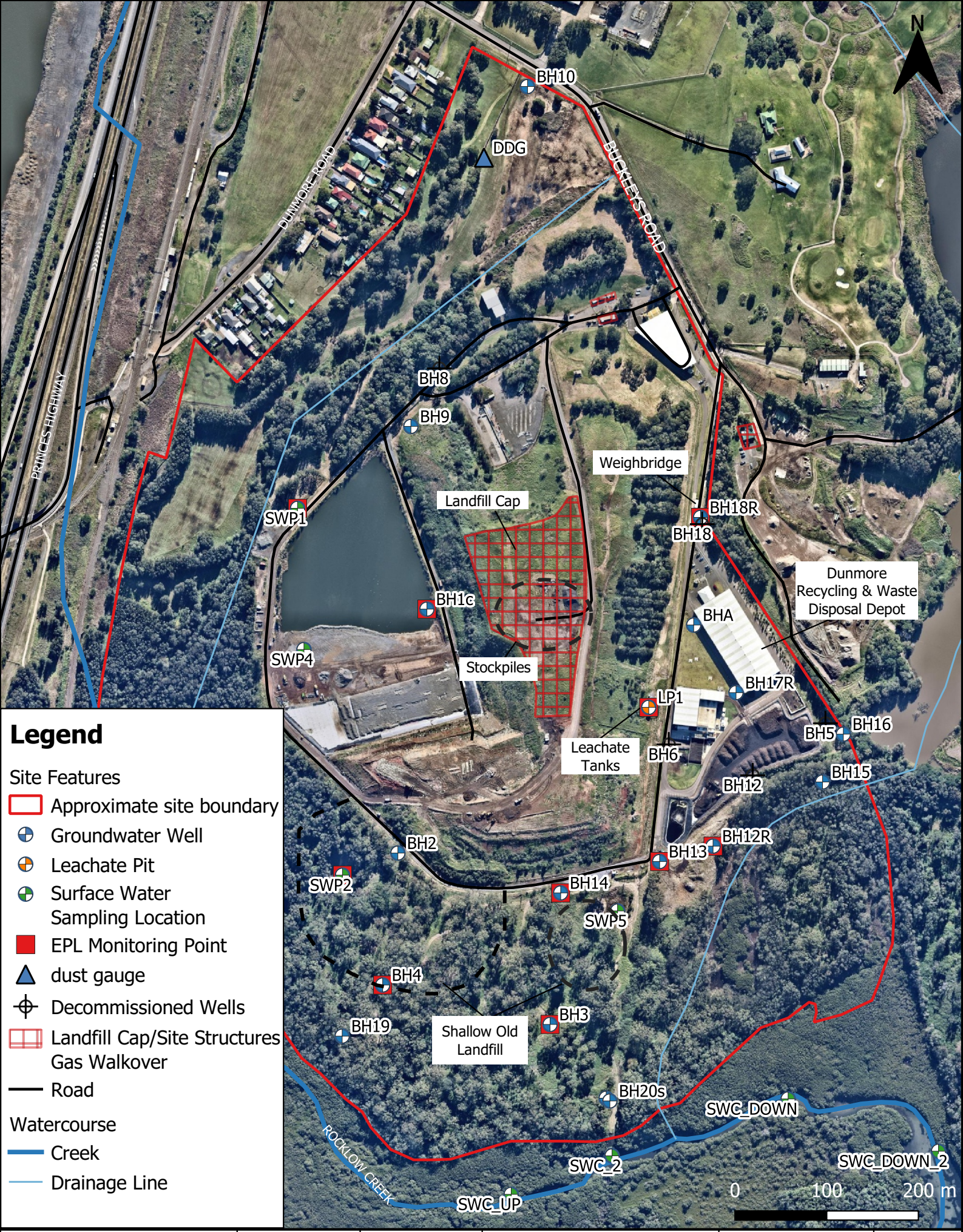
Problems with interpretation by others
Advice and interpretation is provided on the basis that subsequent work will be undertaken by Environmental Earth Sciences NSW. This will identify variances, maintain consistency in how data is interpreted, conduct additional tests that may be necessary and recommend solutions to problems encountered on site. Other parties may misinterpret our work and we cannot be responsible for how the information in this report is used. If further data is collected or comes to light, we reserve the right to alter their conclusions.

Obtain regulatory approval
The investigation and remediation of contaminated sites is a field in which legislation and interpretation of legislation is changing rapidly. Our interpretation of the investigation findings should not be taken to be that of any other party. When approval from a statutory authority is required for a project, that approval should be directly sought by the client.

Limit of liability
This study has been carried out to a particular scope of works at a specified site and should not be used for any other purpose. This report is provided on the condition that Environmental Earth Sciences NSW disclaims all liability to any person or entity other than the client in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by any such person in reliance, whether in whole or in part, on the contents of this report. Furthermore, Environmental Earth Sciences NSW disclaims all liability in respect of anything done or omitted to be done and of the consequence of anything done or omitted to be done by the client, or any such person in reliance, whether in whole or any part of the contents of this report of all matters not stated in the brief outlined in Environmental Earth Sciences NSW's proposal number and according to Environmental Earth Sciences general terms and conditions and special terms and conditions for contaminated sites.

To the maximum extent permitted by law, we exclude all liability of whatever nature, whether in contract, tort or otherwise, for the acts, omissions or default, whether negligent or otherwise for any loss or damage whatsoever that may arise in any way in connection with the supply of services. Under circumstances where liability cannot be excluded, such liability is limited to the value of the purchased service.

APPENDIX A: FIGURES



Legend

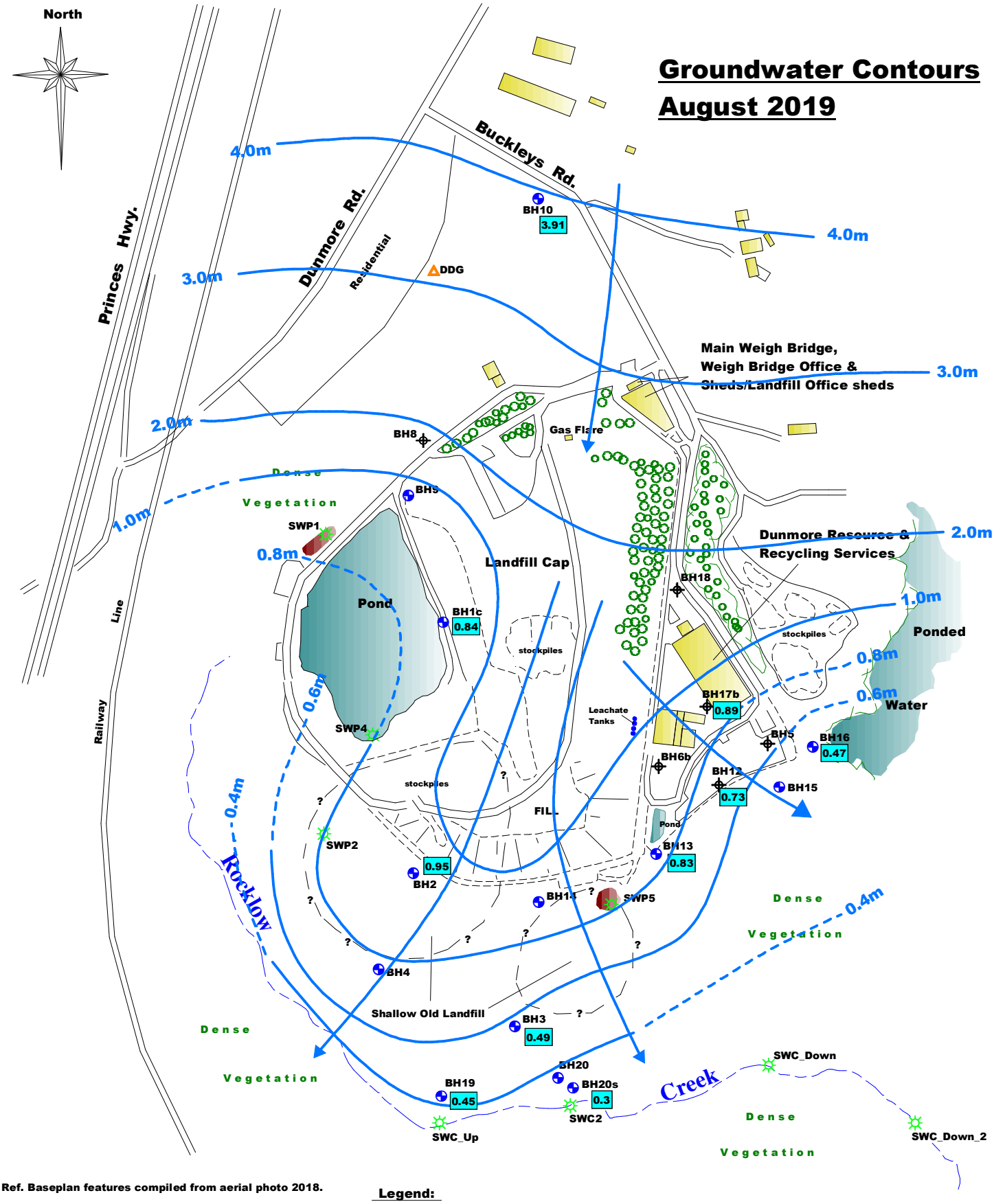
Site Features

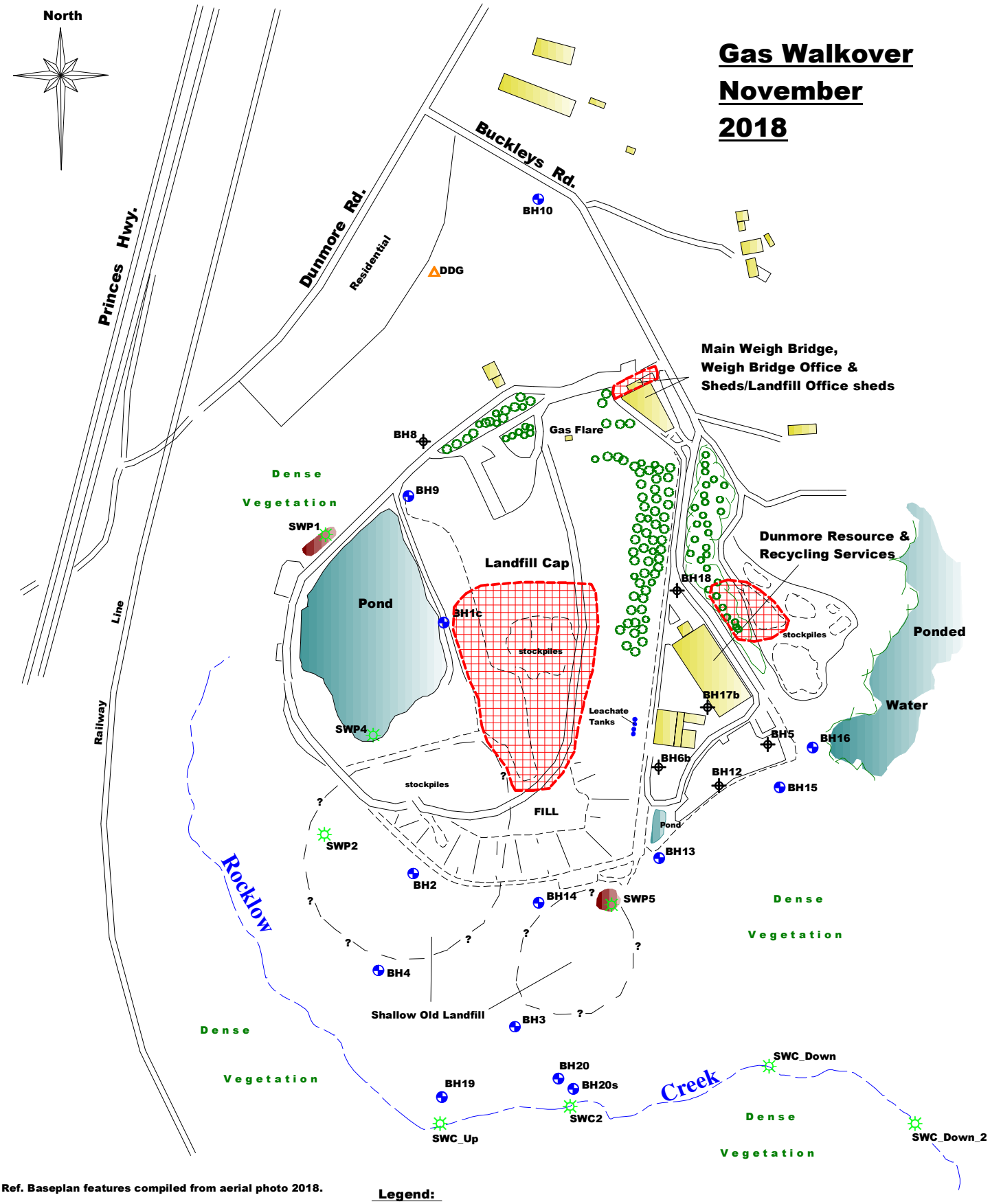
- Approximate site boundary
- Groundwater Well
- Leachate Pit
- Surface Water Sampling Location
- EPL Monitoring Point
- dust gauge
- Decommissioned Wells
- Landfill Cap/Site Structures
- Gas Walkover
- Road

Watercourse

- Creek
- Drainage Line

ENVIRONMENTAL EARTH SCIENCES CONTAMINATION RESOLVED	Drawn by: MN	Date: Sept. 2019	**Shellharbour City Council**	Figure No. 1
	Proj. Manager: EG	Scale: As shown	Dunmore, NSW	Site Layout
	Job No: 118109	Source: Nearmaps		


North
Groundwater Contours
August 2019
Princes Hwy.
Dunmore Rd.
Buckleys Rd.
Residential
4.0m
3.0m
2.0m
1.0m
0.8m
0.6m
0.4m
BH10
3.91
DDG
Main Weigh Bridge,
Weigh Bridge Office &
Sheds/Landfill Office sheds
Gas Flare
BH8
BH9
Dense
Vegetation
SWP1
Landfill Cap
Dunmore Resource &
Recycling Services
BH18
Pond
BH1c
0.84
stockpiles
Ponded
Water
Leachate
Tanks
BH17b
0.89
BH5
BH16
0.47
BH6b
BH12
0.73
BH15
SWP4
Railway Line
FILL
Pond
BH13
0.83
SWP2
BH2
0.95
BH14
SWP5
Rocklow
Creek
BH4
Shallow Old Landfill
BH3
0.49
BH20
BH20s
0.3
SWC2
BH19
0.45
SWC_Up
SWC_Down
SWC_Down_2
Ref. Baseplan features compiled from aerial photo 2018.
0
100
200
Scale (metres)
Legend:
Bore locations
Dust gauge locations
Surface water locations
Decommissioned bores
Inferred groundwater contour (m AHD)
Inferred flow direction
SWL (standing water level m AHD)
ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED
Client:
Shellharbour City Council
Title:
Groundwater Contours - August 2019
Location:
Buckleys Road, Dunmore, Shellharbour, NSW
Job No. 118109
Date: 19 Sept. 2019
Drawn by: TRJ
Proj. Man. MN
Scale: As shown
Figure 2



Ref. Baseplan features compiled from aerial photo 2018.

0 100 200

Scale (metres)

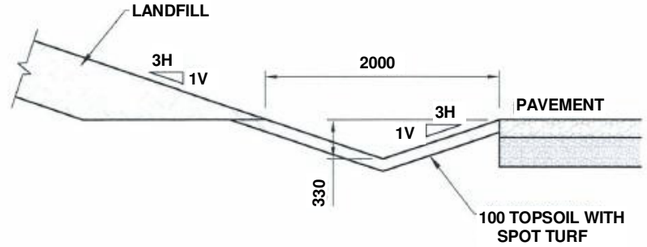
Legend:

- Bore locations
- Dust gauge locations
- Surface water locations
- Decommissioned bores
- Gas walkover

ENVIRONMENTAL EARTH SCIENCES CONTAMINATION RESOLVED	Title:	Gas Walkover	
	Location:	Buckleys Road, Dunmore, Shellharbour, NSW	
Client: Shellharbour City Council	Job No. 118077	Date: May 2019	Figure 3
	Drawn by: TRJ	Proj. Man. EG	Scale: As shown

Regional Locality Map

Ref. Based on updated aerial photograph 2018.



TYPICAL SECTION OF OPEN DRAIN

SCALE 1:50

Legend:

- licence boundary
- levee bank
- drainage layout
- approx. stormwater diversion drain
- approx. stormwater flow direction

0 100 200

Scale

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Title: Surface Water Runoff		
Location: Dunmore Recycling & Waste Disposal Depot, Shellharbour		
Client: Shellharbour City Council		Job number: 118109
Drawn by: TRJ	Scale: As shown	Source: See Ref.
Proj Man: EG	Date: May 2019	Figure 4

APPENDIX B: TABLES

Table 2: Field measurements – August 2019

Sample Location	SWL	pH (field)	EC (field)	ORP	Temp	DO	Odour	Colour
Units	m (dip)	---	mS/cm	mV	°C	ppm	---	---
BHA	3.285	6.45	1.2	6	17.9	-0.27	none	light cloudy brown
BH1c	3.44	6.87	6.98	-137	23.7	0.03	H2S	light amber
BH2	4.03	6.74	3	-1380	20.6	-0.22	mild sweet putrefied	dark grey green
BH3	3.25	7.27	2.12	-128	17.1	2.13	-	-
BH4	4.43	6.92	1.9	-122	17.1	-0.27	mild H2S to start	clear
BH12_r	4.47	6.53	2.4	-4	20.6	-0.23	none	clear
BH13	4.46	6.82	1.68	-8	19.3	1.45	none	clear
BH14	4.91	6.54	1.85	12	19.9	0.03	very mild sweet putrefied	clear
BH16	0.91	6.77	0.5	-128	13.2	1.73	none	clear
BH17r	3.56	6.61	2.25	-114	17.4	-0.27	none	light cloudy brown
BH19	4.65	6.99	1.79	-107	17	-0.15	none	light cloudy brown
BH20	2.375	7.29	1.53	-157	17.1	2.13	very mild H2S	very light brown
BH20s	2.375	7.24	1.2	32	15.5	-0.34	very mild H2S	very light brown
LP1	-	NT	-	-	-	-	-	-
SWP1	-	6.63	0.48	-74	10.7	1.9	none	none
SWP2	-	7.8	2.28	23	8.8	7.09	mild H2S	faint brown
SWP4	-	7.8	2.34	7	11.8	8	none	dark grey green
SWC2	-	7.22	3.6	62	11.9	3.92	none	clear
SWC-Up	-	7	42.6	107	11.1	3.37	none	clear
SWC-Down	-	7.44	42.7	92	10.9	7.1	none	clear
SWC_Down_2	-	7.75	45.2	100	11.5	9.47	none	clear

Notes:

SWL Standing Water Level, measured to the top of the monument or casing; RL – reference level; ORP = electron activity; EC= electrolytic conductivity --- not measured; N/A = Not applicable; DO = dissolved oxygen;

ENVIRONMENTAL EARTH SCIENCES
CONTAMINATION RESOLVED

Table 3: Water laboratory results – August 2019

Sample	pH	TDS	Na	Ca	K	Mg	NH_4-N	Cl	F	NO_3	NO_2	SO_4	HCO_3	PO_4	TOC	BOD	Sol. Mn	Sol. Fe	Tot. Fe
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
BH1c	7.2	4690	930	145	250	110	**330**	850	0.51	<0.1		35	4030	0.16	195	9	0.12	**2.1**	15
BH2	7.2	1800	345	180	48	74	**42**	400	0.28	<0.1		130	1180	<0.1	60	3	0.41	**1.2**	10
BH3	7.4	1120	135	165	33	31	**41**	290	0.2	26		87	640	<0.1	15	7	0.22	**0.35**	13
BH4	7.3	1140	155	205	26	40	**6.7**	220	0.15	<0.1	<0.1	150	720	<0.1	21	<2	0.19	0.2	4.5
BH12-R	6.9	1580	155	295	62	65	1.5	280	0.13	**130**		300	705	<0.1	16	<2	0.76	**2.4**	3.5
BHA	6.9	790	76	145	14	35	0.4	76	0.12	9.8		235	385	<0.1	21	<2	0.12	**0.89**	2.9
BH13	7.2	1050	105	180	46	44	**3**	88	0.23	2.3		255	675	<0.1	26	<2	0.23	0.18	1.6
BH14	6.9	1200	185	200	21	48	**2.7**	200	0.41	3.6		97	880	<0.1	30	<2	0.32	**1.4**	3.8
BH16	7.1	385	64	24	11	33	0.2	120	0.26	0.22		52	170	<0.1	19	2	0.09	0.22	4.9
BH17-R	6.9	1340	200	180	51	45	**9.6**	380	0.11	1.6		175	545	<0.1	26	<2	0.23	**3.2**	17
BH19-R	7.3	1060	190	155	22	39	**5.5**	230	0.11	<0.1		185	590	<0.1	24	<2	0.14	0.19	2.5
BH20	7.6	970	59	175	46	34	**24**	160	0.16	<0.1		225	465	0.18	20	<2	0.08	0.15	1.6
BH20s	7.7	810	37	120	82	41	1.2	52	0.15	**55**		200	410	<0.1	18	<2	0.06	0.07	0.09
LP1	7.9	11700	2390	160	590	145	**970**	2100	0.72	<0.1		120	9310	33	790	110	0.49	**4.6**	5.9
SWC2							1.4			0.18	0.23		240					0.2	0.35
SWP1	7.2	250	41	30	13	12	0.7	68	<0.1	0.18		10	145	0.24				**0.45**	5.6
SWP2	**8.1**	1270	295	95	29	51	0.1	330	0.14	0.84		180	565	<0.1				0.05	0.2

Sample	pH	TDS	Na	Ca	K	Mg	NH_4-N	Cl	F	NO_3	NO_2	SO_4	HCO_3	PO_4	TOC	BOD	Sol. Mn	Sol. Fe	Tot. Fe
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SWP4	**8.4**	1400	340	71	20	67	**2.1**	360	0.3	4.2		310	455	<0.1	35	4		0.04	0.17
SWC-UP	7.4	26700	7980	375	290	1000	0.8	14600	0.47	0.35		2100	235	<0.1				0.15	1
SWC-DOWN	7.7	37400	11400	440	425	1290	0.2	20600	0.49	0.18		2780	215	<0.1				0.24	0.75
SWC-DOWN_2	7.9	37600	11300	450	420	1380	<0.1	20700	0.48	<0.1		2860	200	<0.1				0.17	0.22
ANZECC 2000	**6.5-8.0**	**-**	**-**	**-**	**-**	**-**	**1.88***	**-**	**-**	**10.6#**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.3**	**-**

Notes:

Results and guidelines are expressed in mg/L

SWC_Do – SWC_Down;

NT- not analysed;

Guidelines levels from ANZECC (2000) – Australian and New Zealand guidelines for fresh and marine water quality for the protection of aquatic ecosystems;

* - guideline from freshwater trigger values as total NH4-N at different pH values - Table 8.3.7 of ANZECC (2000) - based on average laboratory pH of 7.3 from pH values presented above;

- # - based on the recalculated trigger value for freshwater, Hickey 2013; and

values above the guidelines are **bolded.**

Table 4: Surface water results – August 2019

Sample	NH4-N	HCO3	Sol. Fe	Tot Fe	FCs	E. Coli
Units	mg/L	mg/L	mg/L	mg/L	CFU/100ml	CFU/100ml
LP1	1.4	240	0.2	0.35	20	20
SWC2	<0.1	<1	<0.01	<0.01	-	-
SWC-UP	-	-	-	-	-	-
SWC-Down	0.4	395	0.91	3.1	-	-
SWC_DOWN_2	0.8	235	0.15	1	-	-
SWP1	0.2	215	0.24	0.75	-	-
SWP2	<0.1	200	0.17	0.22	-	-
SWP4	2.1	455	0.03	0.2	-	-
ANZECC 2000	1.88*	---	0.3#	---	---	---

Notes:

--- = not analysed;

ND: not detected

FCs = faecal coliforms;

E. Coli = Escherichia coli;

Guidelines levels from ANZECC (2000) – *Australian and New Zealand guidelines for fresh and marine water quality for the protection of aquatic ecosystems*;

* = guideline from marine trigger values as total NH4-N at different pH values - Table 8.3.7 of ANZECC (2000) - Table 8.3.7 of ANZECC (2000) - based on average laboratory pH of 7.3 from pH values presented in Table 1;

= interim indicative working level presented in section 8.3.7 of ANZECC 2000 (based on Canadian derived guidelines); and

Values above the guidelines are **bolded.**

Table 5: Ratios of principal ions – August 2019

Bore	Na/Cl	Na/Ca	Mg/Ca	Ca/K	Cl/SO_4	Cl/HCO_3	K/TDS (%)	L/N (%)
BH1c	1.69	5.59	1.25	1.13	32.91	0.36	5.33	**48.95**
BH2	1.33	1.67	0.68	7.32	4.17	0.58	2.67	**15.04**
BH3	0.72	0.71	0.31	9.75	4.52	0.78	2.95	**30.21**
BH4	1.09	0.66	0.32	15.38	1.99	0.53	2.28	8.23
BH12-R	0.85	0.46	0.36	9.28	1.26	0.68	3.92	**37.57**
BHA	1.54	0.46	0.40	20.20	0.44	0.34	1.77	9.45
BH13	1.84	0.51	0.40	7.63	0.47	0.22	4.38	**15.59**
BH14	1.43	0.81	0.40	18.58	2.79	0.39	1.75	6.30
BH16	0.82	2.32	2.27	4.26	3.13	1.21	2.86	9.44
BH17-R	0.81	0.97	0.41	6.88	2.94	1.20	3.81	**14.64**
BH19-R	1.27	1.07	0.41	13.74	1.68	0.67	2.08	7.19
BH20	0.57	0.29	0.32	7.42	0.96	0.59	4.74	**26.16**
BH20s	1.10	0.27	0.56	2.85	0.35	0.22	10.12	**69.80**
LP1	1.75	13.02	1.49	0.53	23.71	0.39	5.04	**57.89**
SWP1	0.93	1.19	0.66	4.50	9.21	0.81	5.20	**16.72**
SWP2	1.38	2.71	0.89	6.39	2.48	1.01	2.28	6.79
SWP4	1.46	4.17	1.56	6.93	1.57	1.36	1.43	5.50
SWC-UP	0.84	18.55	4.40	2.52	9.42	106.93	1.09	3.11
SWC-DOWN	0.85	22.59	4.83	2.02	10.04	164.91	1.14	3.24
SWC-DOWN2	0.84	21.89	5.06	2.09	9.81	178.14	1.12	3.20

1. Notes:
   % indicates ratios are presented in percentage in that column; and
   L/N = leachate/non-leachate ratio ; [(K + NH4 + NO3 + NO2)/(Ca + Mg + Na)] x 100.

Table 6: Summary of gas analysis, CH_4 – August 2019

Location	GA 5000 V/V%	ILU V/V%
Landfill cap	0	0.00014
Main weigh bridge, weigh bridge office and landfill office sheds	0	0.00014
Dunmore Resource & Recycling Services	0	0.0001
GUIDELINES	1.25 % v/v / 0.05 % v/v	1.25 % v/v / 0.05 % v/v

Notes:

Results and guidelines are expressed in V/V %;

Guidelines are as per the NSW EPA (2012) reporting accumulation value of 1.25 % v/v CH4; and surface emission trigger value (500 ppm or 0.05 % v/v); and

Values above the guidelines are **bolded.**

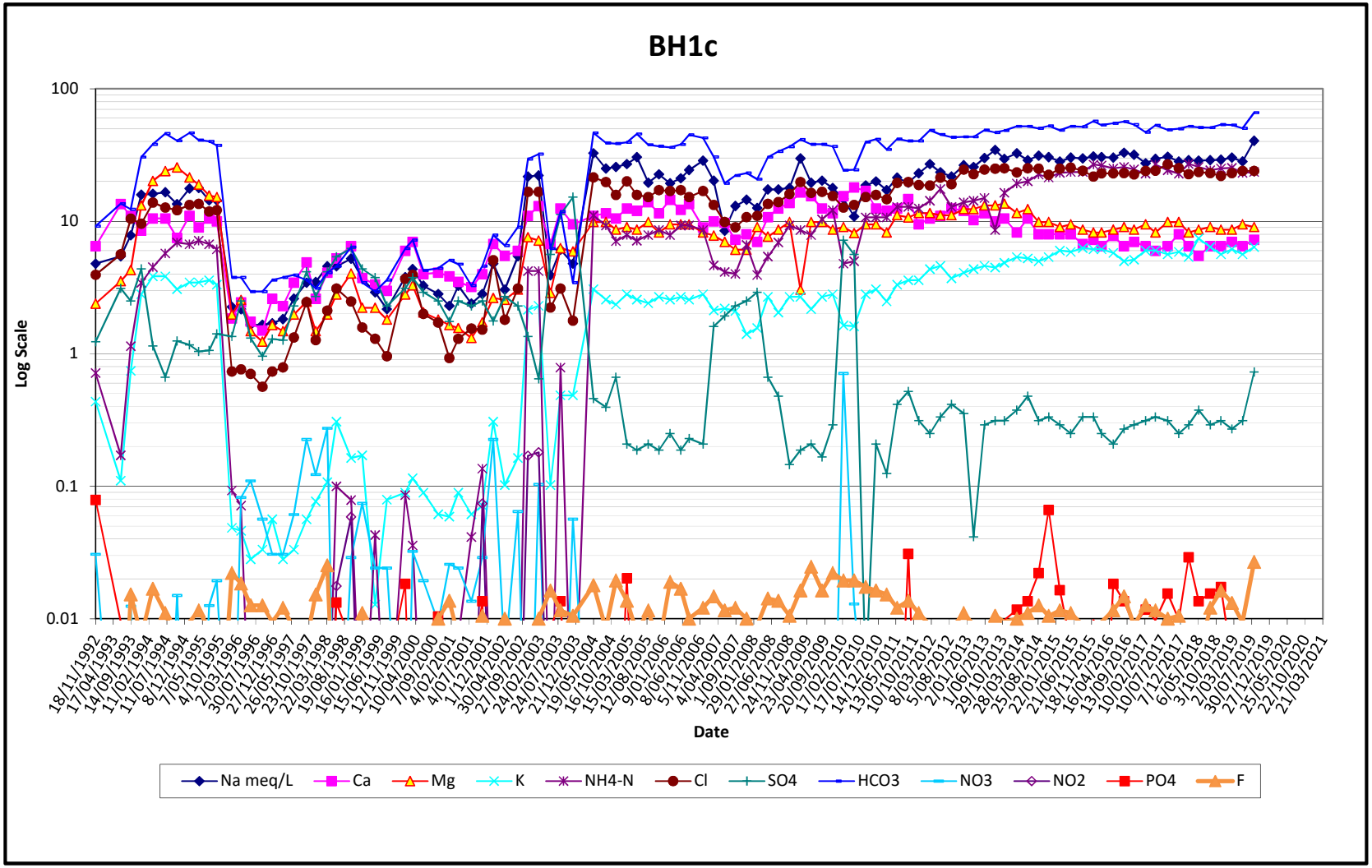
Table 7: Quarterly RPD Table – August 2019

Analytes	BH4	FD1	RPD(%)
pH	**7.3**	**7.3**	0.00
TDS	**1120**	**1120**	0.00
Na+	**155**	**150**	3.28
Ca++	**205**	**210**	2.41
Mg++	**40**	**42**	4.88
K+	**26**	**27**	3.77
NH4-N	**6.7**	**6.7**	0.00
Cl-	**220**	**220**	0.00
SO4--	**150**	**155**	3.28
HCO3-	**720**	**705**	2.11
NO3-	**<0.1**	**<0.1**	0.00
PO4---	**<0.1**	**<0.1**	0.00
F-	**0.15**	**0.10**	0.00
BOD	**<2**	**<2**	NC
Fe.D	**0.20**	**0.18**	10.53
Fe.T	**4.5**	**4.6**	2.20
Mn.D	**0.19**	**0.20**	5.13
TOC	**21**	**20**	4.88

Notes:

Results are expressed in mg/L;
NC: not calculated
RPD – Relative Percentage Difference
Values requiring further investigation are **bolded**.

APPENDIX C: SCHOELLER PLOTS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PO4
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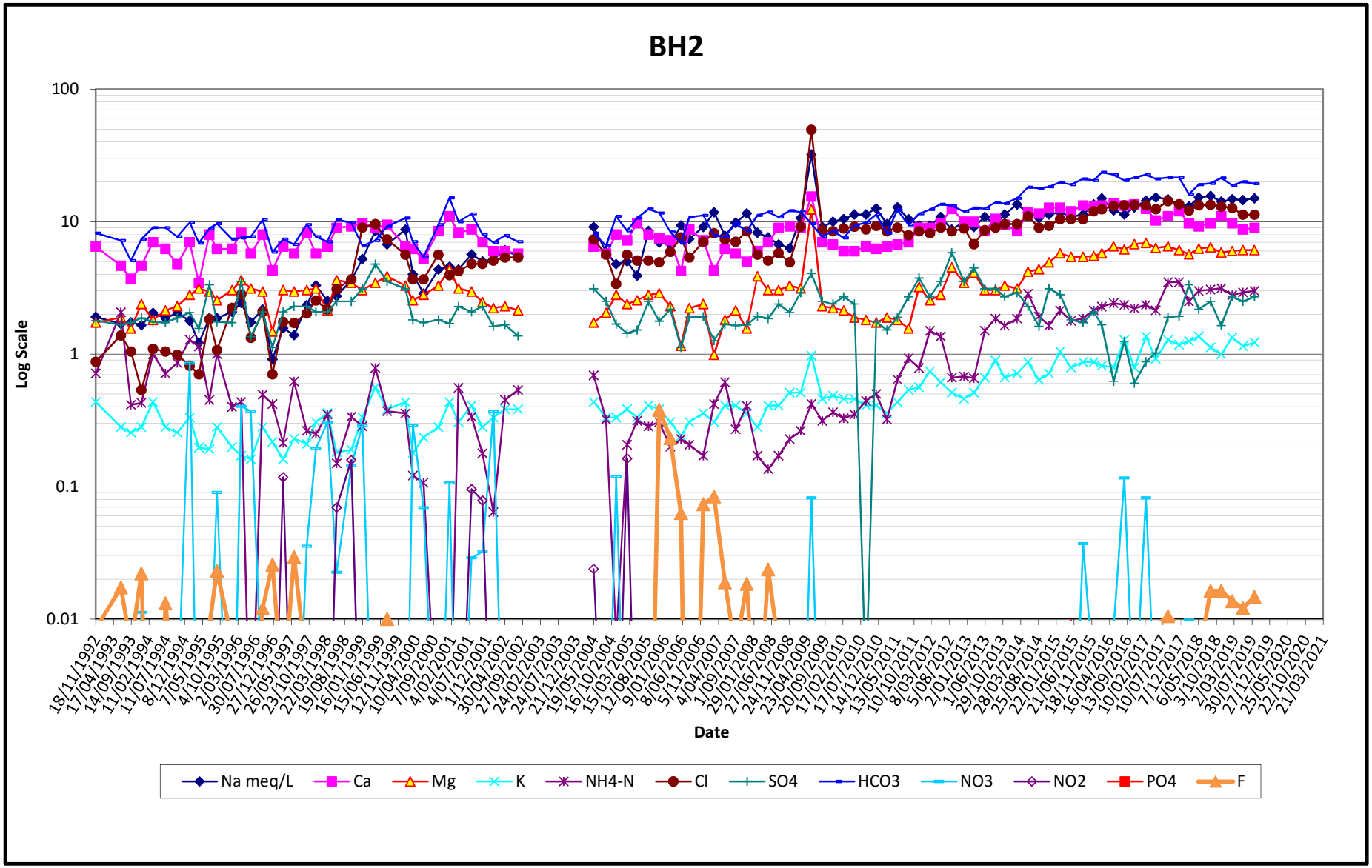
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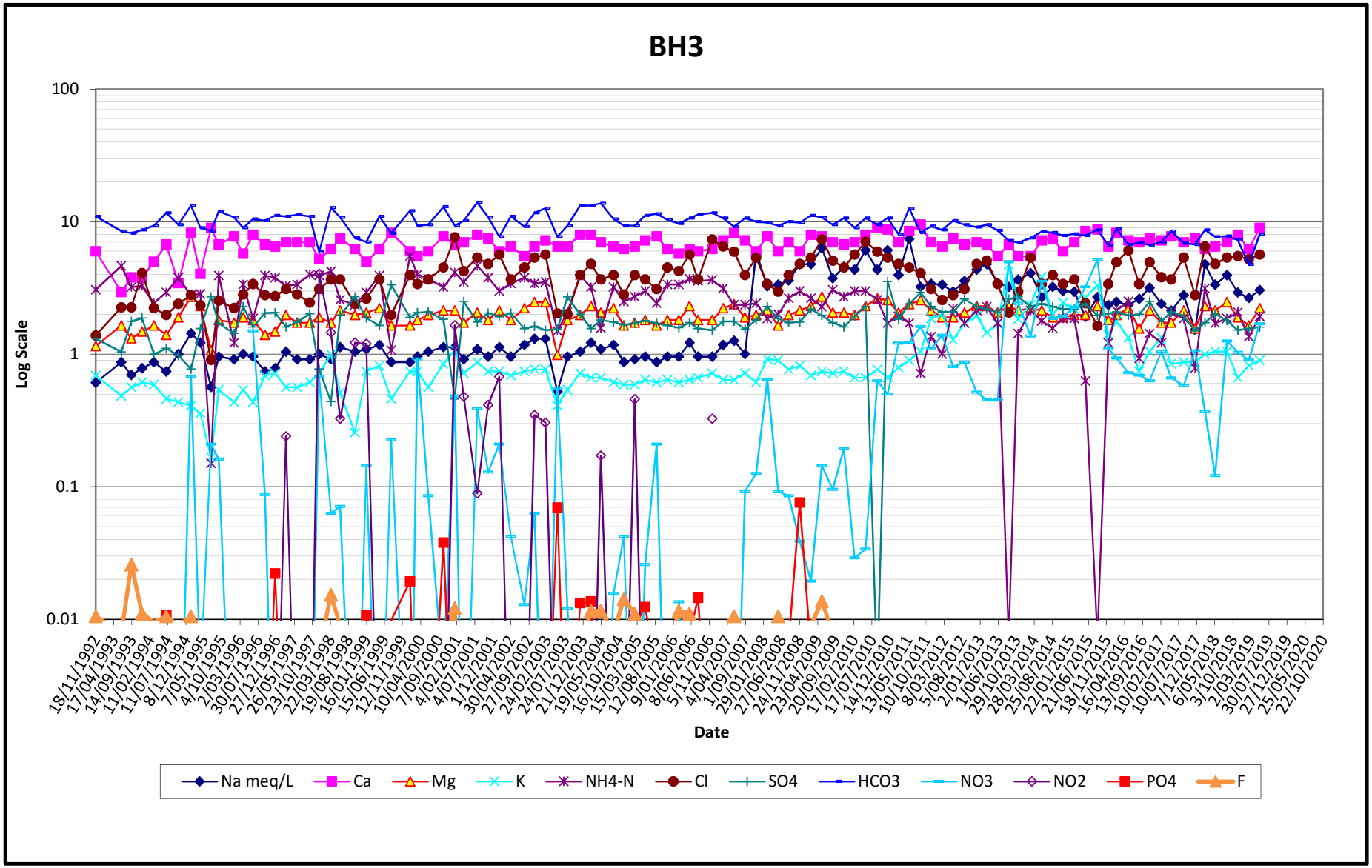
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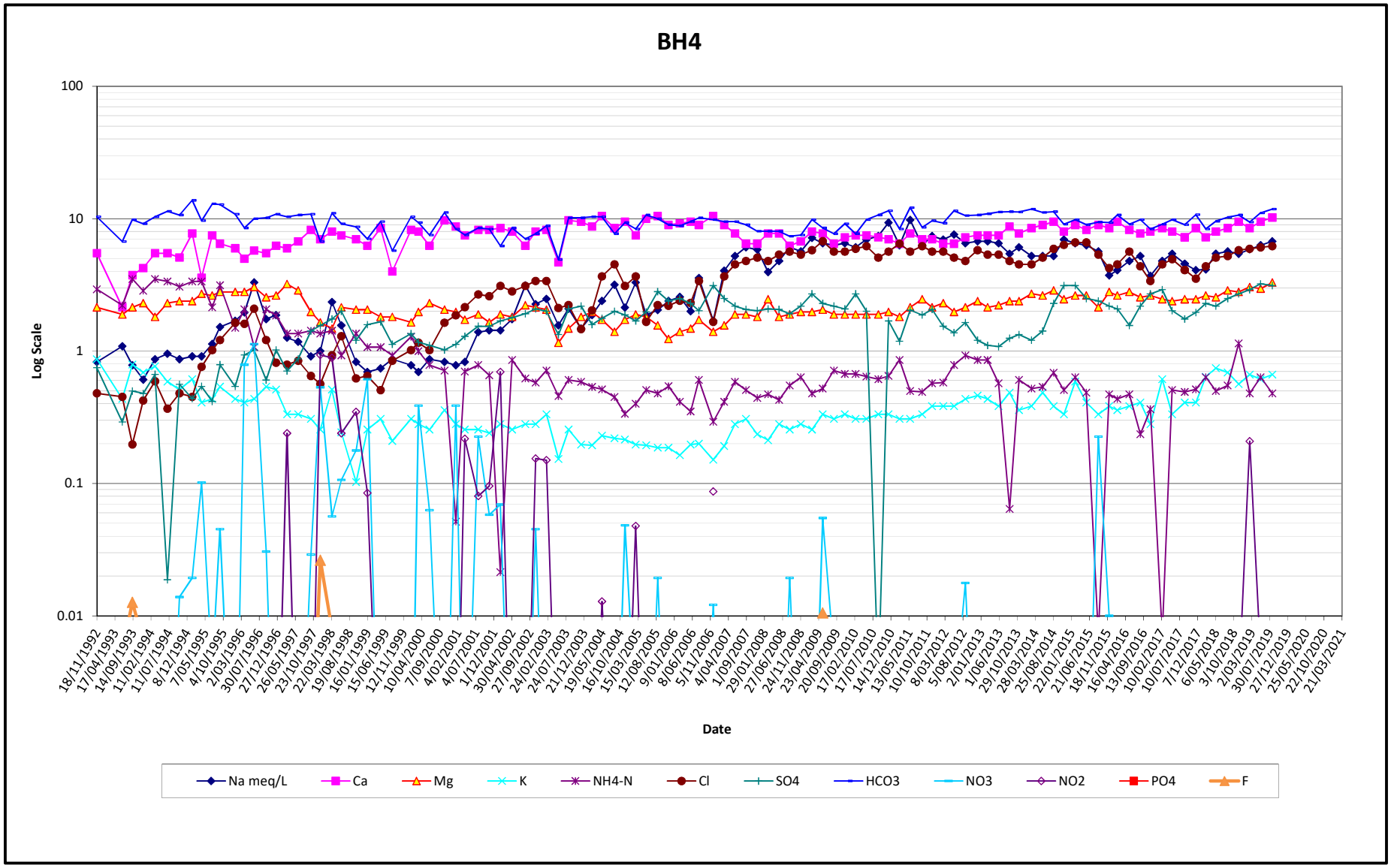
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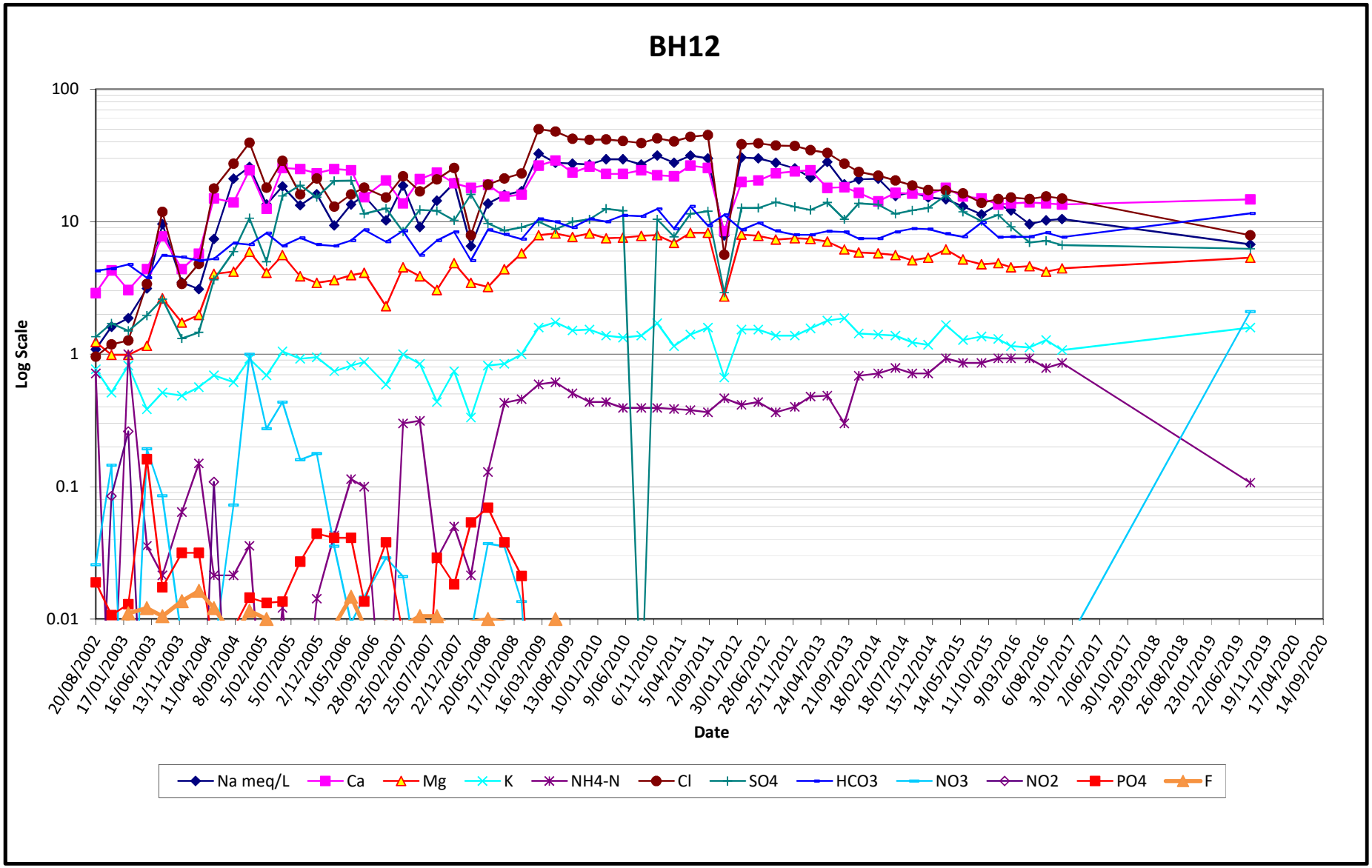
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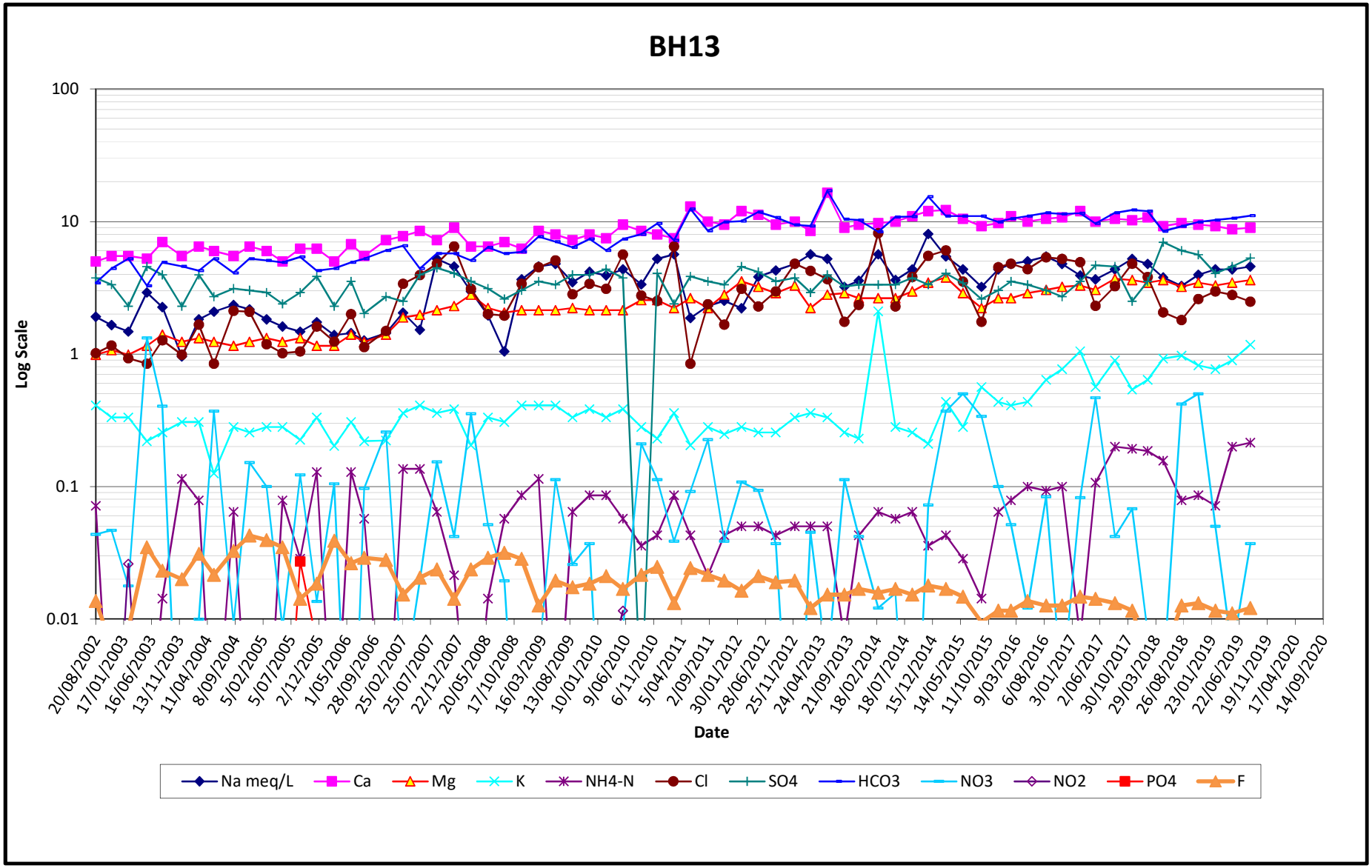
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NO2
PO4
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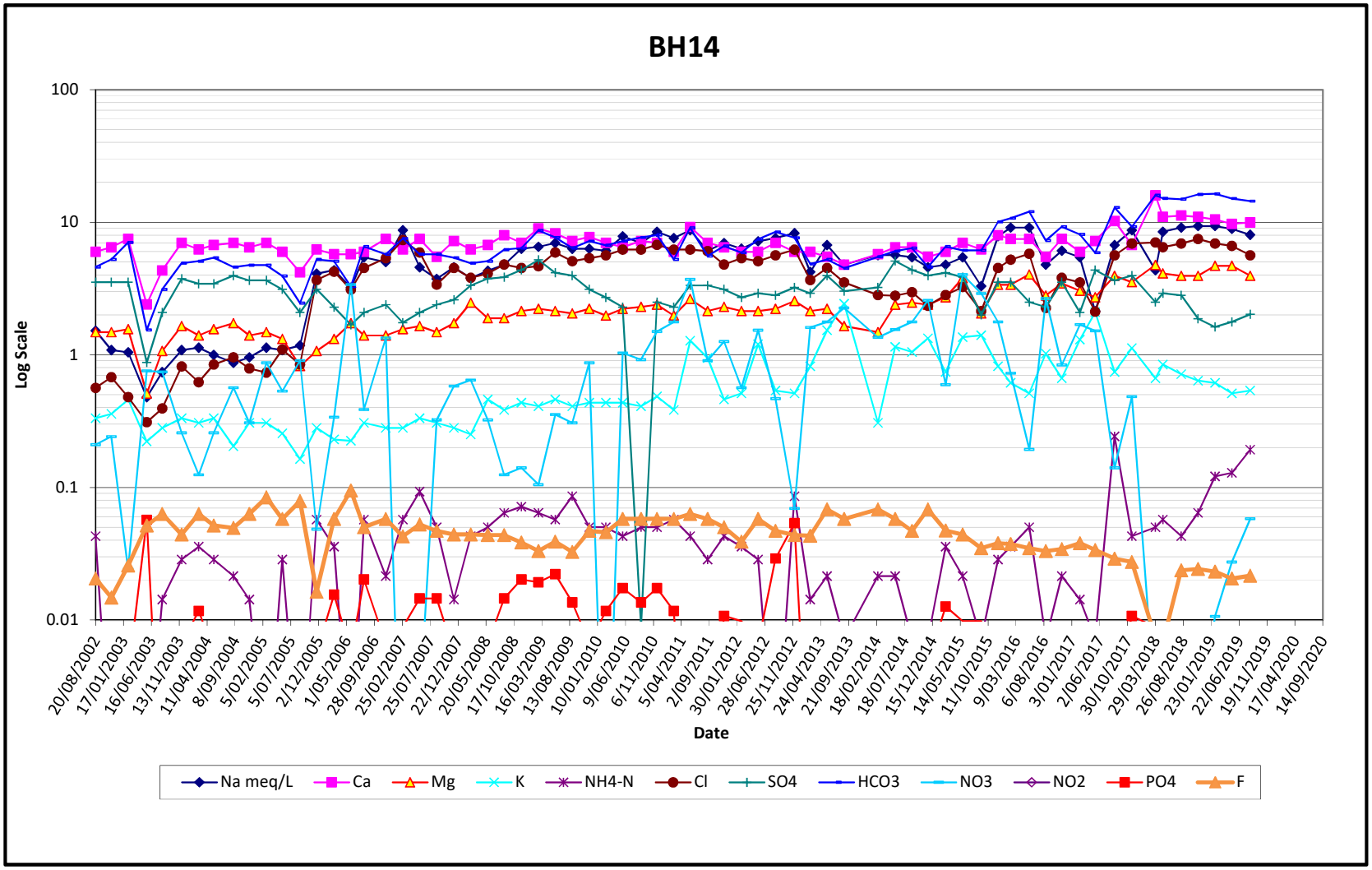
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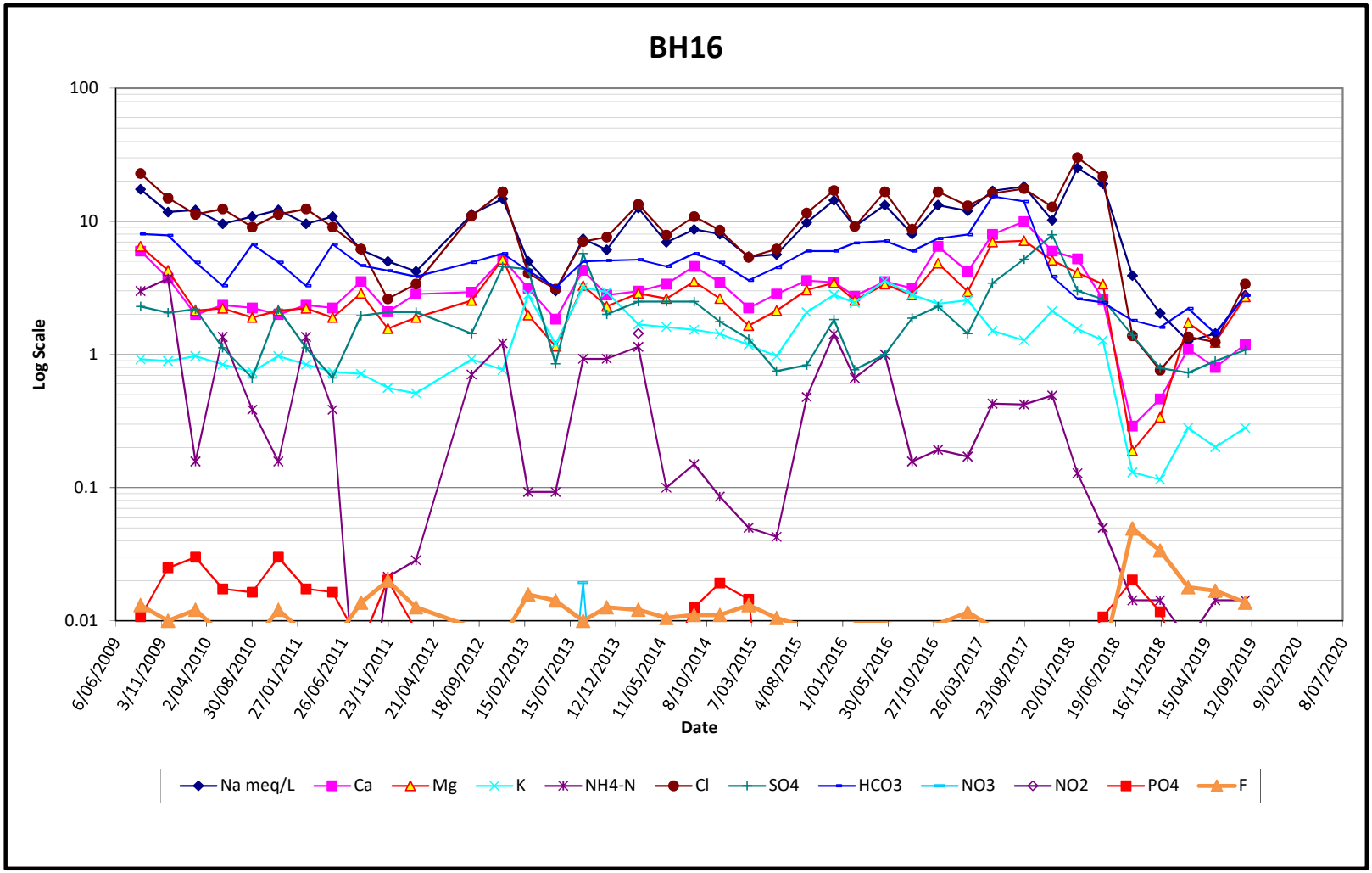
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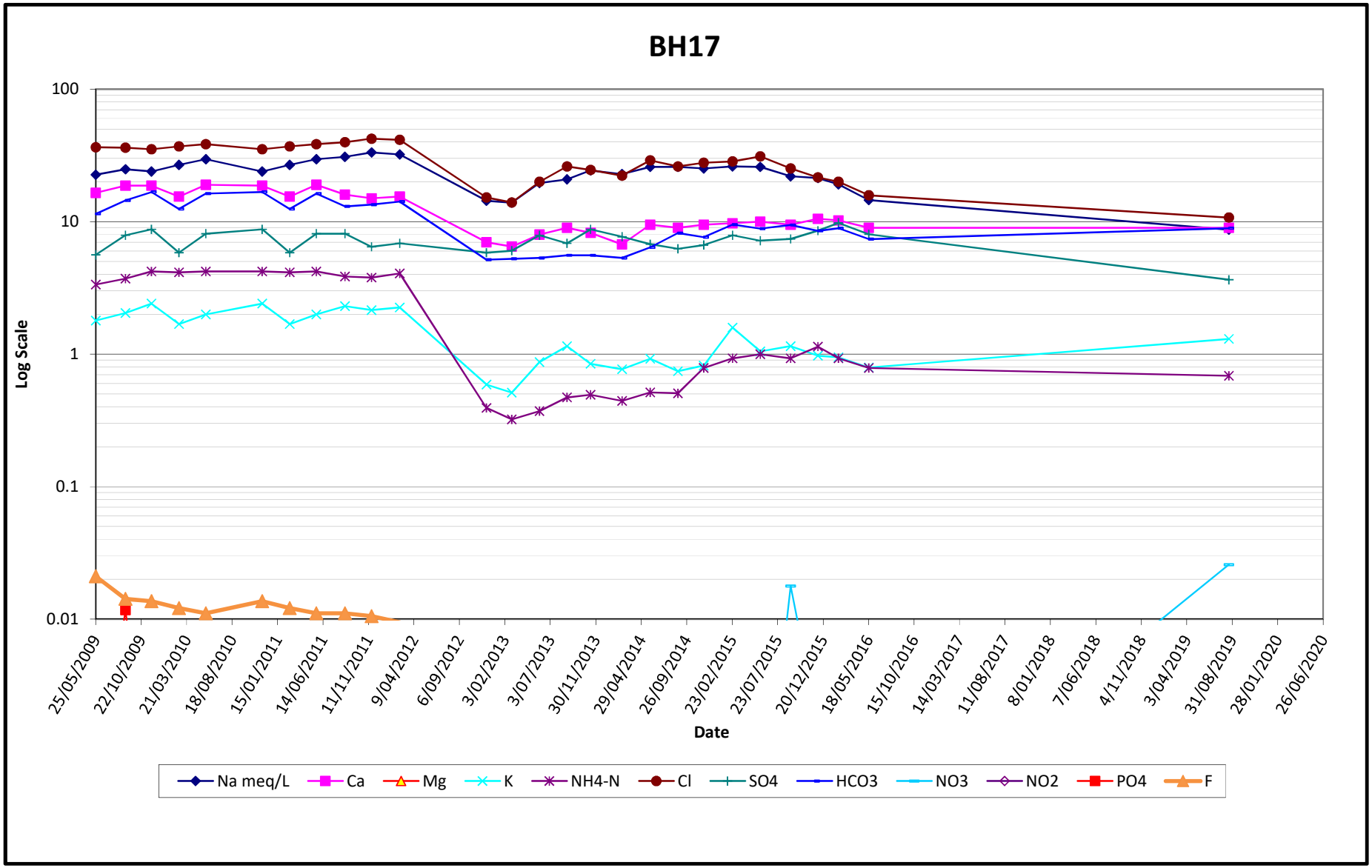
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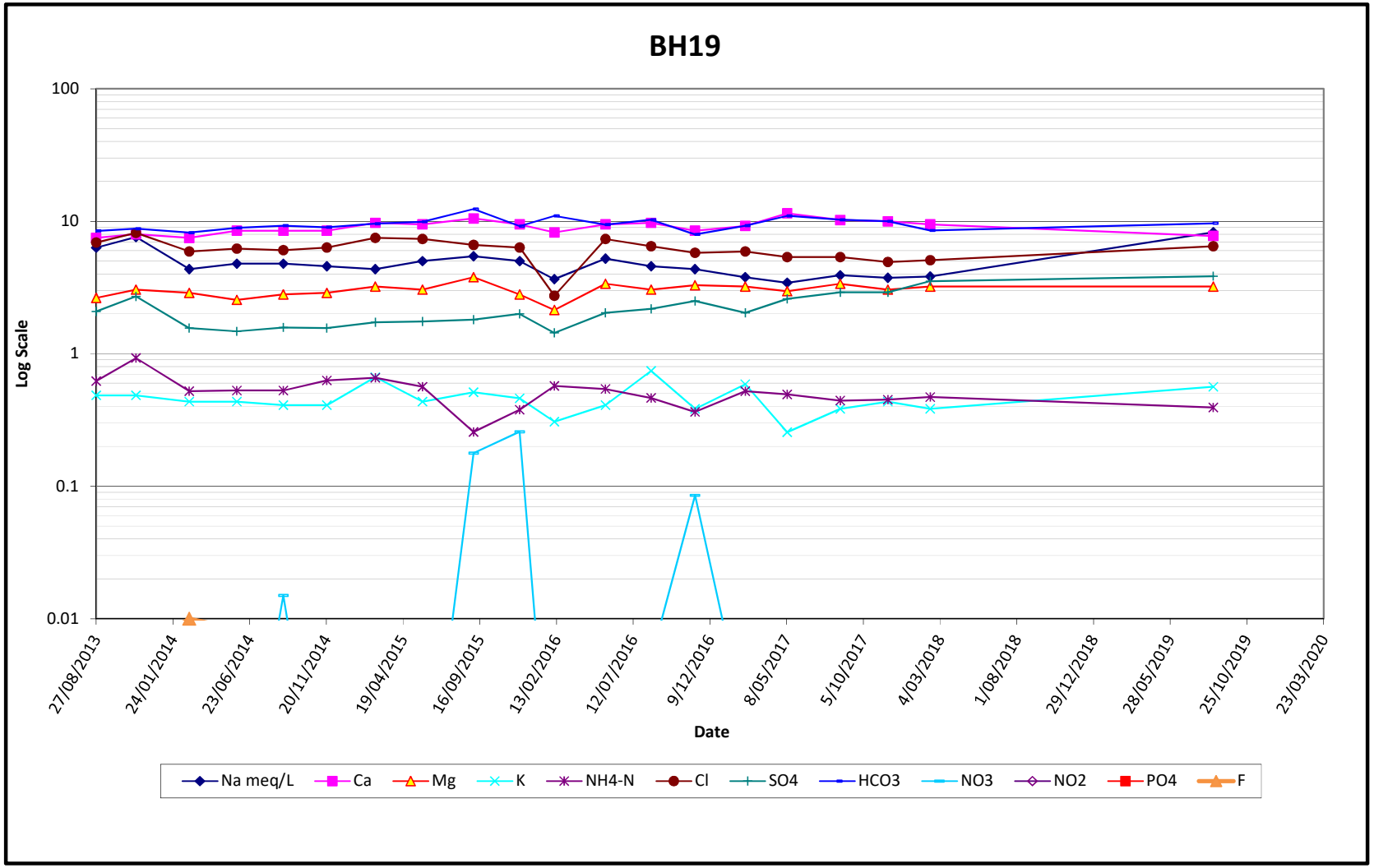
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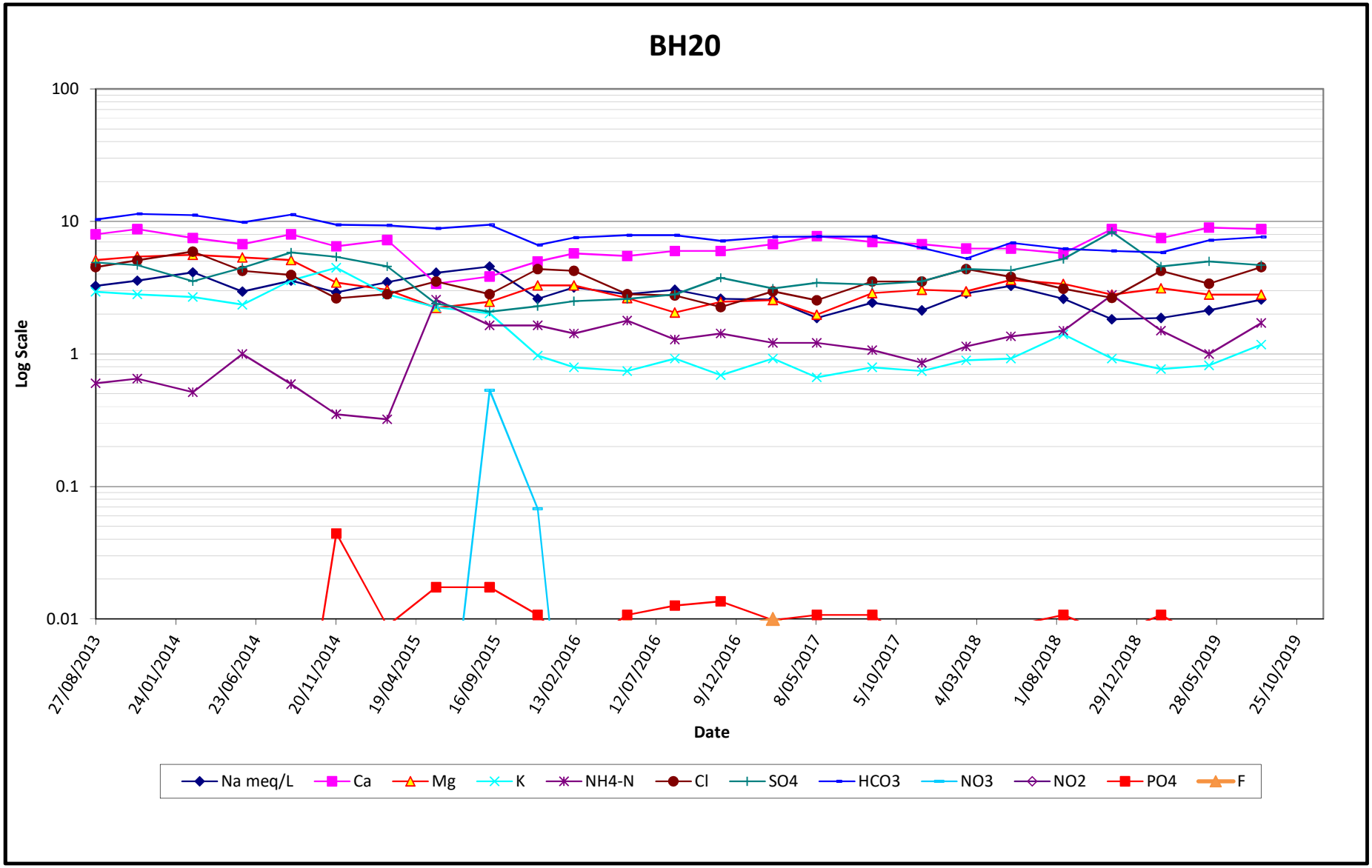
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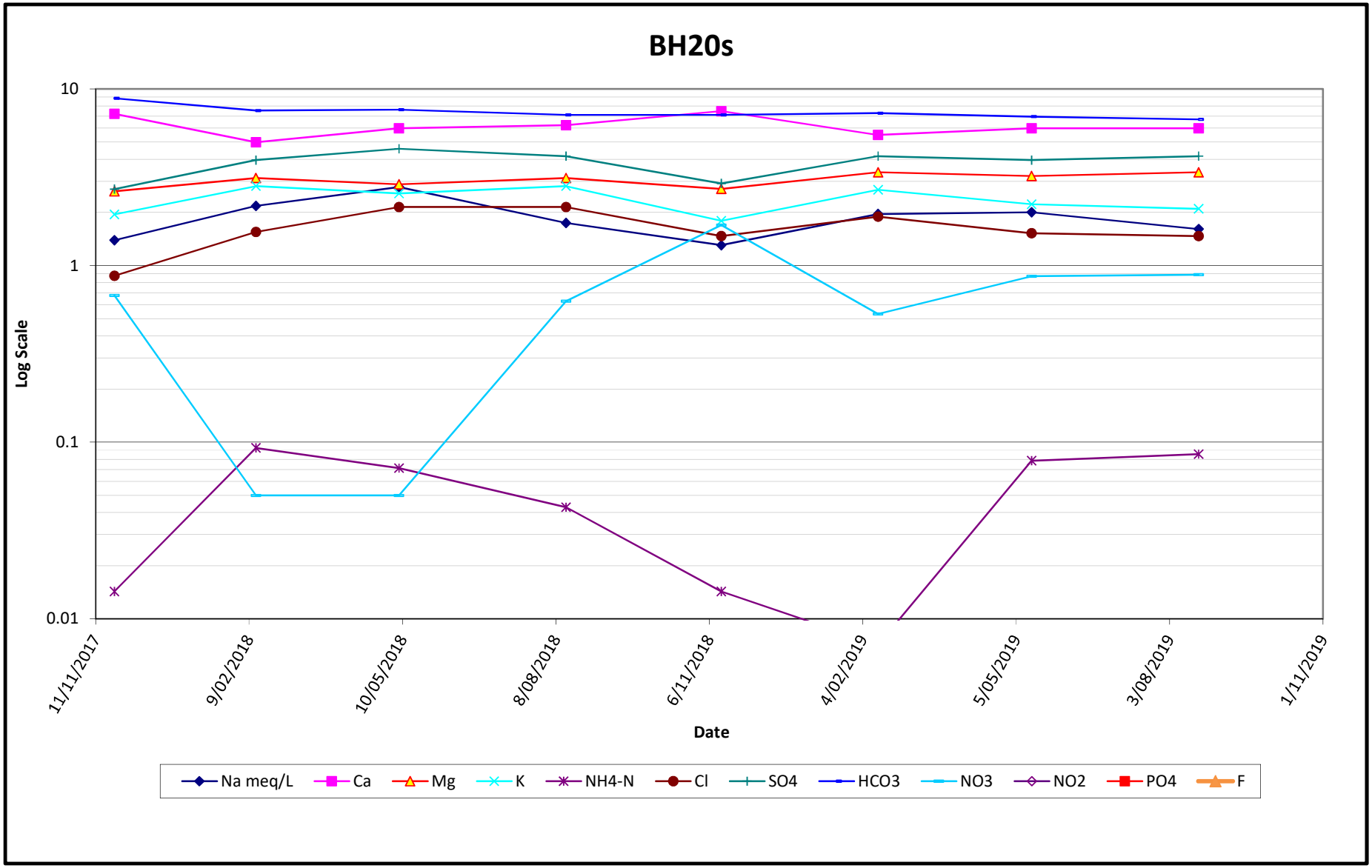
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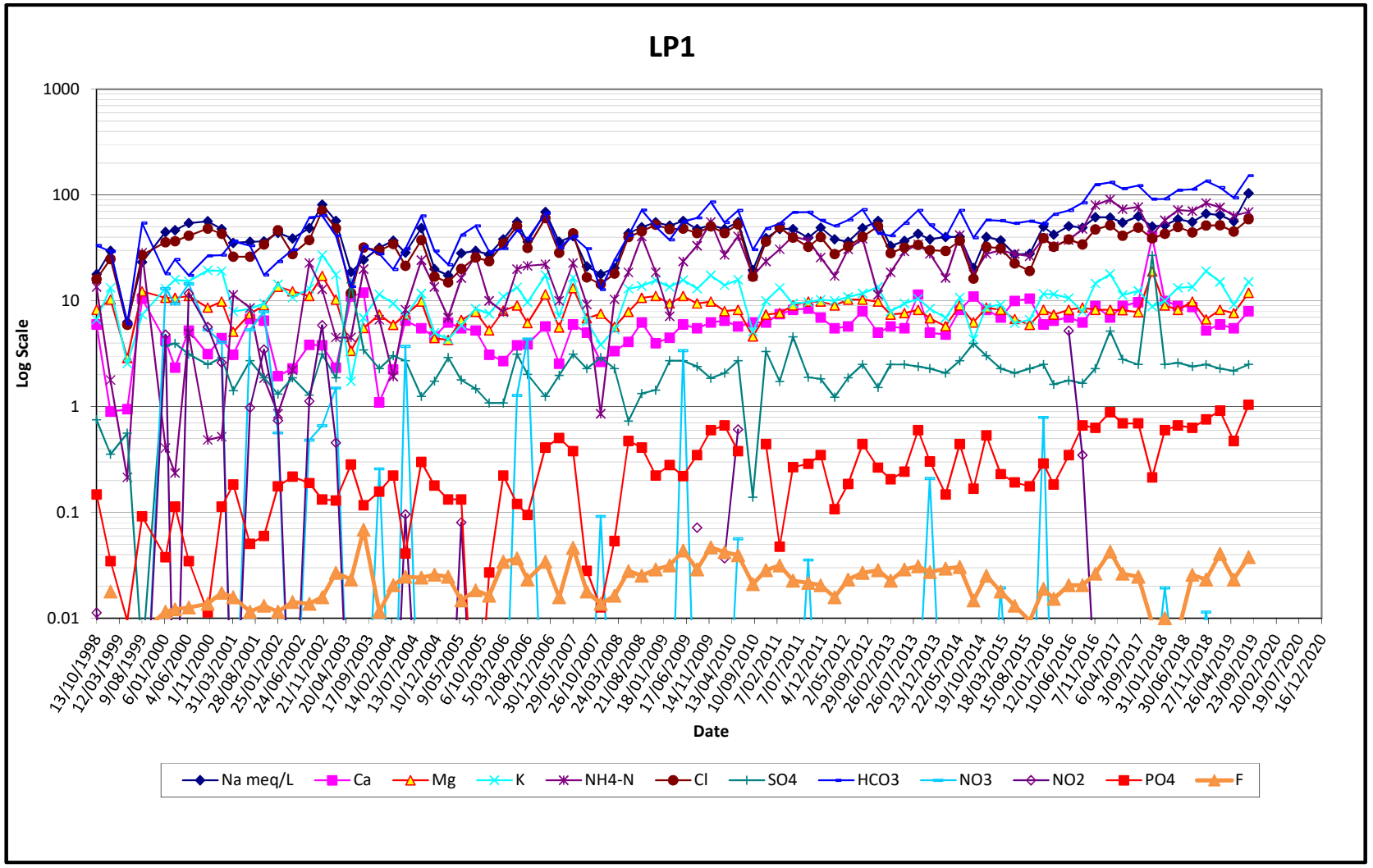
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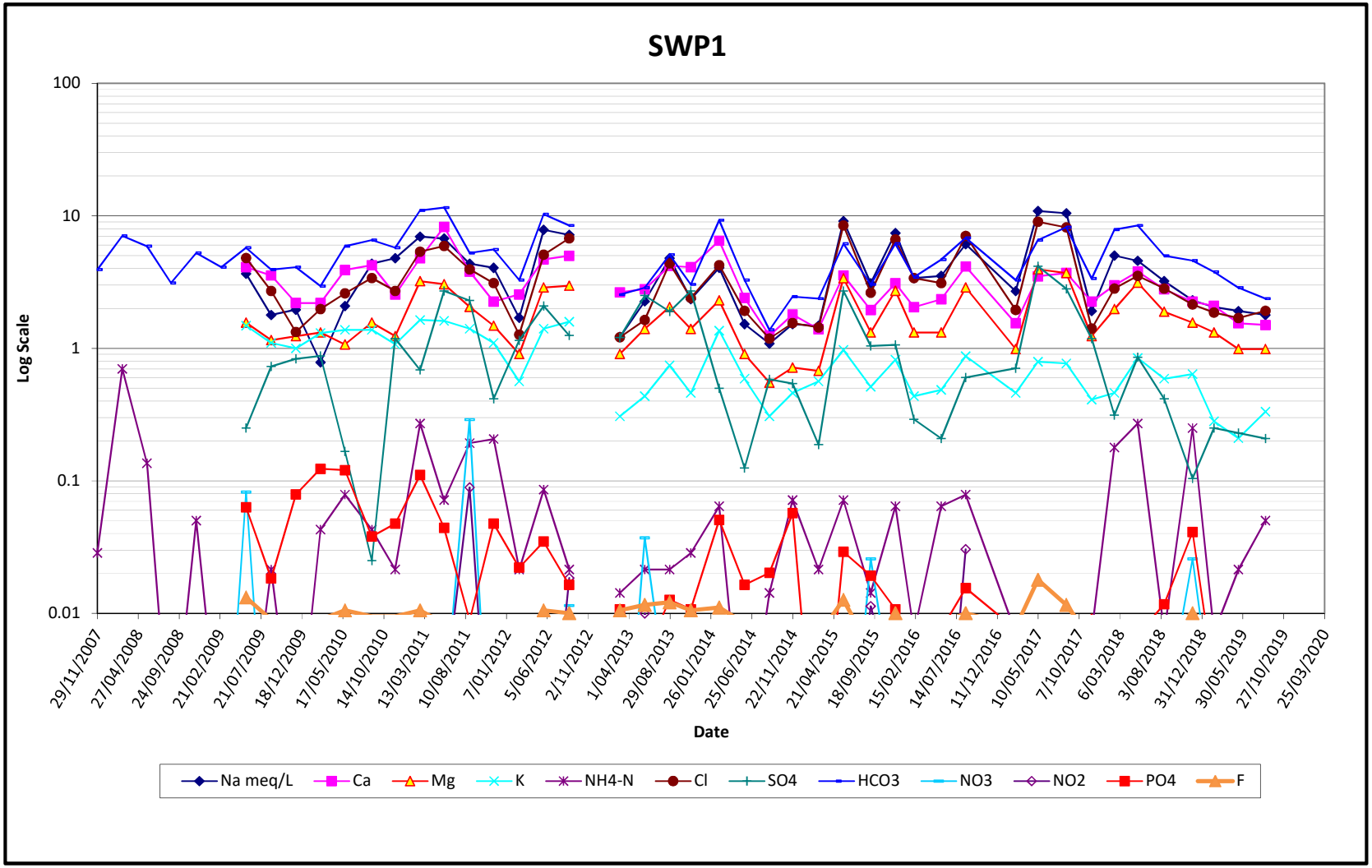
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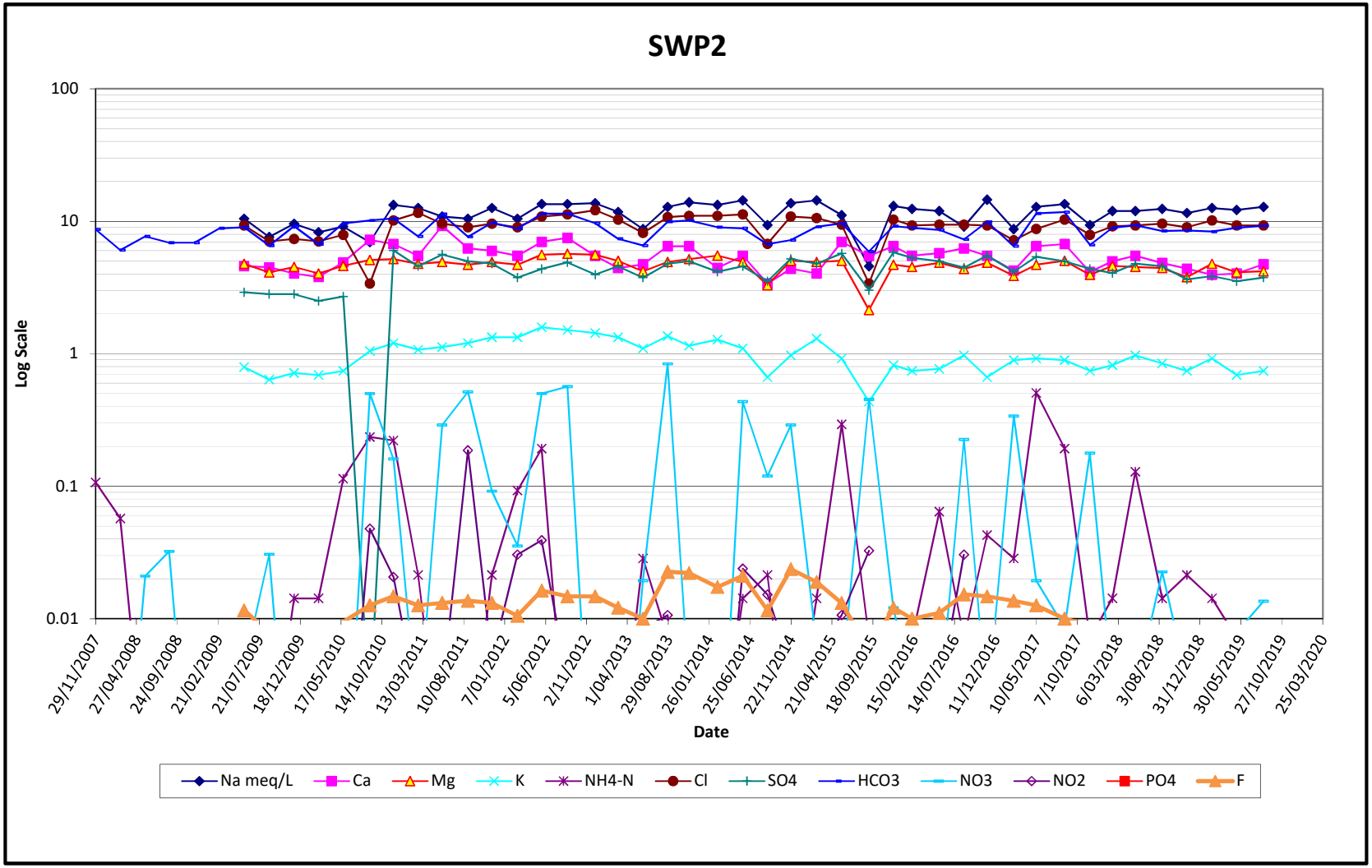
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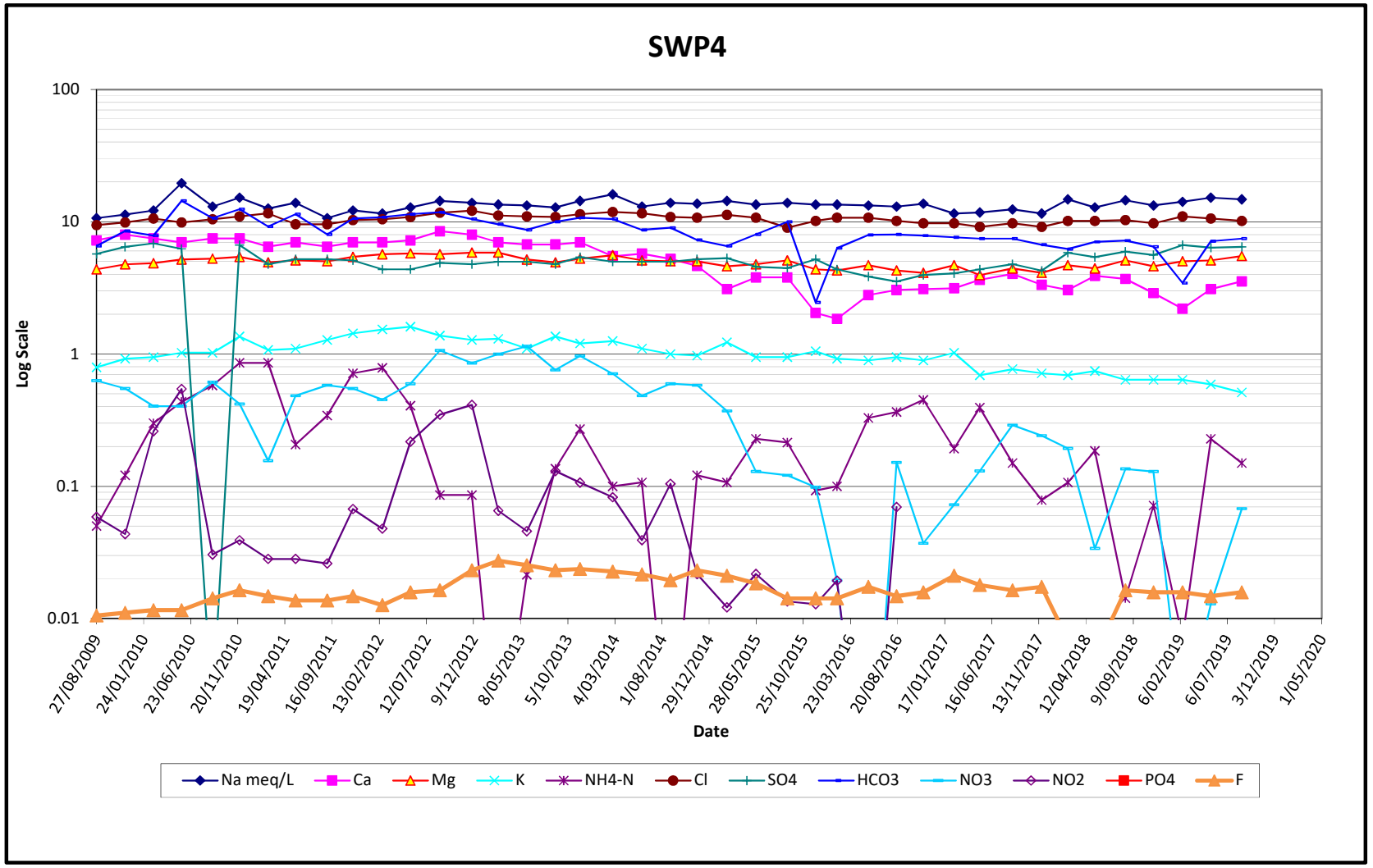
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Date
Na meq/L
Ca
Mg
K
NH4-N
Cl
SO4
HCO3
NO3
NO2
PO4
F

APPENDIX D: LABORATORY TRANSCRIPTS

SYDNEY
ANALYTICAL
LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
Fax: (02) 9838 8919
A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

ENVIRONMENTAL & EARTH SCIENCES

PO BOX 380
NORTH SYDNEY 2059

ATTN: E.GRIFFITHS

JOB NO:	SAL27330
CLIENT ORDER:	118109
DATE RECEIVED:	23/08/19
DATE COMPLETED:	06/09/19
TYPE OF SAMPLES:	WATERS
NO OF SAMPLES:	23

NATA Accredited for compliance with ISO/IEC 17025 Testing

.....
Issued on 06/09/19
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		21/08/19	20/08/19
SAMPLES		BH1c	BH2
pH		7.2	7.2
Total Dissolved Solids	mg/L	4690	1800
Biochemical Oxygen Demand	mg/L	9	3
Total Organic Carbon	mg/L	195	60
Iron (Total)	mg/L	15	10
Iron (Dissolved)	mg/L	2.1	1.2
Manganese (Dissolved)	mg/L	0.12	0.41

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	930	40.455	345	15.008
Calcium Ca++	145	7.236	180	8.982
Potassium K+	250	6.400	48	1.229
Magnesium Mg++	110	9.053	74	6.090
Ammonia (Total)	330	23.562	42	2.999
TOTAL CATIONS		86.706		34.308
Chloride Cl-	850	23.970	400	11.280
Fluoride F-	0.51	0.027	0.28	0.015
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	35	0.728	130	2.704
Bicarbonate HCO3-	4030	66.092	1180	19.352
Phosphate PO4---	0.16	0.005	<0.1	
TOTAL ANIONS		90.822		33.351

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		20/08/19	20/08/19
SAMPLES		BH3	BH4
pH		7.4	7.3
Total Dissolved Solids	mg/L	1120	1140
Biochemical Oxygen Demand	mg/L	7	<2
Total Organic Carbon	mg/L	15	21
Iron (Total)	mg/L	13	4.5
Iron (Dissolved)	mg/L	0.35	0.20
Manganese (Dissolved)	mg/L	0.22	0.19

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	135	5.873	155	6.743
Calcium Ca++	165	8.233	205	10.230
Potassium K+	33	0.845	26	0.666
Magnesium Mg++	31	2.551	40	3.292
Ammonia (Total)	41	2.927	6.7	0.478
TOTAL CATIONS		20.429		21.409
Chloride Cl-	290	8.178	220	6.204
Fluoride F-	0.20	0.011	0.15	0.008
Nitrate NO3-	26	0.419	<0.1	
Sulphate SO4--	87	1.810	150	3.120
Bicarbonate HCO3-	640	10.496	720	11.808
Phosphate PO4---	<0.1		<0.1	
Nitrite NO2-			<0.1	
TOTAL ANIONS		20.914		21.140

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		20/08/19	21/08/19
SAMPLES		BH13	BH14
pH		7.2	6.9
Total Dissolved Solids	mg/L	1050	1200
Biochemical Oxygen Demand	mg/L	<2	<2
Total Organic Carbon	mg/L	26	30
Iron (Total)	mg/L	1.6	3.8
Iron (Dissolved)	mg/L	0.18	1.4
Manganese (Dissolved)	mg/L	0.23	0.32

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	105	4.568	185	8.047
Calcium Ca++	180	8.982	200	9.980
Potassium K+	46	1.178	21	0.538
Magnesium Mg++	44	3.621	48	3.950
Ammonia (Total)	3.0	0.214	2.7	0.193
TOTAL CATIONS		18.563		22.708
Chloride Cl-	88	2.482	200	5.640
Fluoride F-	0.23	0.012	0.41	0.022
Nitrate NO3-	2.3	0.037	3.6	0.058
Sulphate SO4--	255	5.304	97	2.018
Bicarbonate HCO3-	675	11.070	880	14.432
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		18.905		22.170

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		21/08/19	20/08/19
SAMPLES		BH16	BH20
pH		7.1	7.6
Total Dissolved Solids	mg/L	385	970
Biochemical Oxygen Demand	mg/L	2	<2
Total Organic Carbon	mg/L	19	20
Iron (Total)	mg/L	4.9	1.6
Iron (Dissolved)	mg/L	0.22	0.15
Manganese (Dissolved)	mg/L	0.09	0.08

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	64	2.784	59	2.567
Calcium Ca++	24	1.198	175	8.733
Potassium K+	11	0.282	46	1.178
Magnesium Mg++	33	2.716	34	2.798
Ammonia (Total)	0.2	0.014	24	1.714
TOTAL CATIONS		6.994		16.990
Chloride Cl-	120	3.384	160	4.512
Fluoride F-	0.26	0.014	0.16	0.008
Nitrate NO3-	0.22	0.004	<0.1	
Sulphate SO4--	52	1.082	225	4.680
Bicarbonate HCO3-	170	2.788	465	7.626
Phosphate PO4---	<0.1		0.18	0.006
TOTAL ANIONS		7.272		16.832

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		20/08/19	20/08/19
SAMPLES		BH20s	BHA
pH		7.7	6.9
Total Dissolved Solids	mg/L	810	790
Biochemical Oxygen Demand	mg/L	<2	<2
Total Organic Carbon	mg/L	18	21
Iron (Total)	mg/L	0.09	2.9
Iron (Dissolved)	mg/L	0.07	0.89
Manganese (Dissolved)	mg/L	0.06	0.12

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	37	1.610	76	3.306
Calcium Ca++	120	5.988	145	7.236
Potassium K+	82	2.099	14	0.358
Magnesium Mg++	41	3.374	35	2.881
Ammonia (Total)	1.2	0.086	0.4	0.029
TOTAL CATIONS		13.157		13.810
Chloride Cl-	52	1.466	76	2.143
Fluoride F-	0.15	0.008	0.12	0.006
Nitrate NO3-	55	0.886	9.8	0.158
Sulphate SO4--	200	4.160	235	4.888
Bicarbonate HCO3-	410	6.724	385	6.314
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		13.244		13.509

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		20/08/19	20/08/19
SAMPLES		BHA DUP	BH12-R
pH		7.0	6.9
Total Dissolved Solids	mg/L	800	1580
Biochemical Oxygen Demand	mg/L	<2	<2
Total Organic Carbon	mg/L	22	16
Iron (Total)	mg/L	3.1	3.5
Iron (Dissolved)	mg/L	0.91	2.4
Manganese (Dissolved)	mg/L	0.12	0.76

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	72	3.132	155	6.743
Calcium Ca++	150	7.485	295	14.721
Potassium K+	15	0.384	62	1.587
Magnesium Mg++	36	2.963	65	5.350
Ammonia (Total)	0.4	0.029	1.5	0.107
TOTAL CATIONS		13.993		28.508
Chloride Cl-	75	2.115	280	7.896
Fluoride F-	0.11	0.006	0.13	0.007
Nitrate NO3-	9.5	0.153	130	2.093
Sulphate SO4--	240	4.992	300	6.240
Bicarbonate HCO3-	395	6.478	705	11.562
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		13.744		27.798

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		20/08/19	20/08/19
SAMPLES		BH17-R	BH19-R
pH		6.9	7.3
Total Dissolved Solids	mg/L	1340	1060
Biochemical Oxygen Demand	mg/L	<2	<2
Total Organic Carbon	mg/L	26	24
Iron (Total)	mg/L	17	2.5
Iron (Dissolved)	mg/L	3.2	0.19
Manganese (Dissolved)	mg/L	0.23	0.14

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	200	8.700	190	8.265
Calcium Ca++	180	8.982	155	7.735
Potassium K+	51	1.306	22	0.563
Magnesium Mg++	45	3.704	39	3.210
Ammonia (Total)	9.6	0.685	5.5	0.393
TOTAL CATIONS		23.377		20.166
Chloride Cl-	380	10.716	230	6.486
Fluoride F-	0.11	0.006	0.11	0.006
Nitrate NO3-	1.6	0.026	<0.1	
Sulphate SO4--	175	3.640	185	3.848
Bicarbonate HCO3-	545	8.938	590	9.676
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		23.326		20.016

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		20/08/19	21/08/19
SAMPLES		FD1	LP1
pH		7.3	7.9
Total Dissolved Solids	mg/L	1120	11700
Biochemical Oxygen Demand	mg/L	<2	110
Total Organic Carbon	mg/L	20	790
Turbidity	NTU		50
Iron (Total)	mg/L	4.6	5.9
Iron (Dissolved)	mg/L	0.18	4.6
Manganese (Dissolved)	mg/L	0.20	0.49
E.Coli	cfu/100mL		20
Faecal Coliforms	cfu/100mL		20

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	150	6.525	2390	103.965
Calcium Ca++	210	10.479	160	7.984
Potassium K+	27	0.691	590	15.104
Magnesium Mg++	42	3.457	145	11.934
Ammonia (Total)	6.7	0.478	970	69.258
TOTAL CATIONS		21.630		208.245
Chloride Cl-	220	6.204	2100	59.220
Fluoride F-	0.10	0.005	0.72	0.038
Nitrate NO3-	<0.1		<0.1	
Sulphate SO4--	155	3.224	120	2.496
Bicarbonate HCO3-	705	11.562	9310	152.684
Phosphate PO4---	<0.1		33	1.043
TOTAL ANIONS		20.995		215.481

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		21/08/19	21/08/19
SAMPLES		SWP1	SWP2
pH		7.2	8.1
Total Dissolved Solids	mg/L	250	1270
Turbidity	NTU	27	6.4
Iron (Total)	mg/L	5.6	0.20
Iron (Dissolved)	mg/L	0.45	0.05

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	41	1.784	295	12.833
Calcium Ca++	30	1.497	95	4.741
Potassium K+	13	0.333	29	0.742
Magnesium Mg++	12	0.988	51	4.197
Ammonia (Total)	0.7	0.050	0.1	0.007
TOTAL CATIONS		4.652		22.520
Chloride Cl-	68	1.918	330	9.306
Fluoride F-	<0.1		0.14	0.007
Nitrate NO3-	0.18	0.003	0.84	0.014
Sulphate SO4--	10	0.208	180	3.744
Bicarbonate HCO3-	145	2.378	565	9.266
Phosphate PO4---	0.24	0.008	<0.1	
TOTAL ANIONS		4.515		22.337

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		21/08/19	21/08/19
SAMPLES		SWP4	SWC2
pH		8.4	
Total Dissolved Solids	mg/L	1400	
Biochemical Oxygen Demand	mg/L	4	
Total Organic Carbon	mg/L	35	
Turbidity	NTU	10	4.3
Iron (Total)	mg/L	0.17	0.35
Iron (Dissolved)	mg/L	0.04	0.20

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	340	14.790		
Calcium Ca++	71	3.543		
Potassium K+	20	0.512		
Magnesium Mg++	67	5.514		
Ammonia (Total)	2.1	0.150	1.4	
TOTAL CATIONS		24.509		
Chloride Cl-	360	10.152		
Fluoride F-	0.30	0.016		
Nitrate NO3-	4.2	0.068	0.18	
Sulphate SO4--	310	6.448		
Bicarbonate HCO3-	455	7.462	240	
Phosphate PO4---	<0.1			
Nitrite NO2-			0.23	
TOTAL ANIONS		24.146		

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION			21/08/19		21/08/19
SAMPLES			SWC-UP		SWC-UP DUP
pH			7.4		7.5
Total Dissolved Solids	mg/L		26700		26600
Turbidity	NTU		21		21
Iron (Total)	mg/L		1.0		0.97
Iron (Dissolved)	mg/L		0.15		0.17
		mg/L	meq/L	mg/L	meq/L
Sodium Na+		7980	347.130	8030	349.305
Calcium Ca++		375	18.713	370	18.463
Potassium K+		290	7.424	295	7.552
Magnesium Mg++		1000	82.300	1020	83.946
Ammonia (Total)		0.8	0.057	0.8	0.057
TOTAL CATIONS			455.624		459.323
Chloride Cl-		14600	411.720	14200	400.440
Fluoride F-		0.47	0.025	0.49	0.026
Nitrate NO3-		0.35	0.006	0.40	0.006
Sulphate SO4--		2100	43.680	2140	44.512
Bicarbonate HCO3-		235	3.854	235	3.854
Phosphate PO4---		<0.1		<0.1	
TOTAL ANIONS			459.285		448.838

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		21/08/19	21/08/19
SAMPLES		SWC-DOWN	SWC-DOWN 2
pH		7.7	7.9
Total Dissolved Solids	mg/L	37400	37600
Turbidity	NTU	14	2.2
Iron (Total)	mg/L	0.75	0.22
Iron (Dissolved)	mg/L	0.24	0.17

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	11400	495.900	11300	491.550
Calcium Ca++	440	21.956	450	22.455
Potassium K+	425	10.880	420	10.752
Magnesium Mg++	1290	106.167	1380	113.574
Ammonia (Total)	0.2	0.014	<0.1	
TOTAL CATIONS		634.917		638.331
Chloride Cl-	20600	580.920	20700	583.740
Fluoride F-	0.49	0.026	0.48	0.025
Nitrate NO3-	0.18	0.003	<0.1	
Sulphate SO4--	2780	57.824	2860	59.488
Bicarbonate HCO3-	215	3.526	200	3.280
Phosphate PO4---	<0.1		<0.1	
TOTAL ANIONS		642.299		646.533

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

DATE OF COLLECTION		21/08/19	21/08/19
SAMPLES		FD2	BLANK
pH		8.5	7.3
Total Dissolved Solids	mg/L	1420	<1
Biochemical Oxygen Demand	mg/L		<2
Total Organic Carbon	mg/L		<1
Turbidity	NTU		<0.2
Iron (Total)	mg/L	0.20	<0.01
Iron (Dissolved)	mg/L	0.03	<0.01
Manganese (Dissolved)	mg/L		<0.01

	mg/L	meq/L	mg/L	meq/L
Sodium Na+	340	14.790	<0.1	
Calcium Ca++	69	3.443	<0.1	
Potassium K+	21	0.538	<0.1	
Magnesium Mg++	68	5.596	<0.1	
Ammonia (Total)	2.1	0.150	<0.1	
TOTAL CATIONS		24.517		
Chloride Cl-	370	10.434	<1	
Fluoride F-	0.35	0.018	<0.1	
Nitrate NO3-	4.2	0.068	<0.1	
Sulphate SO4--	300	6.240	<2	
Bicarbonate HCO3-	455	7.462	<1	
Phosphate PO4---	<0.1		<0.1	
Nitrite NO2-			<0.1	
TOTAL ANIONS		24.222		

LABORATORY DUPLICATE REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

Sample Number	Analyte	Units	MDL	Sample Result	Duplicate Result	%RPD
BHA	pH		0.1	6.9	7.0	1
SWC-UP	pH		0.1	7.4	7.5	1
BHA	TDS	mg/L	1	790	800	1
SWC-UP	TDS	mg/L	1	26700	26600	0
BHA	Sodium	mg/L	0.1	76	72	5
SWC-UP	Sodium	mg/L	0.1	7980	8030	1
BHA	Calcium	mg/L	0.1	145	150	3
SWC-UP	Calcium	mg/L	0.1	375	370	1
BHA	Potassium	mg/L	0.1	14	15	7
SWC-UP	Potassium	mg/L	0.1	290	295	2
BHA	Magnesium	mg/L	0.1	35	36	3
SWC-UP	Magnesium	mg/L	0.1	1000	1020	2
BHA	Chloride	mg/L	1	76	75	1
SWC-UP	Chloride	mg/L	1	14600	14200	3
BHA	Fluoride	mg/L	0.1	0.12	0.11	8
SWC-UP	Fluoride	mg/L	0.1	0.47	0.49	4
BHA	Nitrate	mg/L	0.1	9.8	9.5	3
SWC-UP	Nitrate	mg/L	0.1	0.35	0.40	13
BHA	Sulphate	mg/L	2	235	240	2
SWC-UP	Sulphate	mg/L	2	2100	2140	2
BHA	Bicarbonate	mg/L	1	385	395	3
SWC-UP	Bicarbonate	mg/L	1	235	235	0
BHA	Phosphate	mg/L	0.1	<0.1	<0.1	0
SWC-UP	Phosphate	mg/L	0.1	<0.1	<0.1	0
BHA	Ammonia	mg/L	0.1	0.4	0.4	0
SWC-UP	Ammonia	mg/L	0.1	0.8	0.8	0
BHA	BOD	mg/L	2	<2	<2	0
BHA	TOC	mg/L	1	21	22	5
SWC-UP	Turbidity	NTU	0.2	21	21	0

LABORATORY DUPLICATE REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

Sample Number	Analyte	Units	MDL	Sample Result	Duplicate Result	%RPD
BHA	Fe (Total)	mg/L	0.01	2.9	3.1	7
SWC-UP	Fe (Total)	mg/L	0.01	1.0	0.97	3
BHA	Fe Dissolved	mg/L	0.01	0.89	0.91	2
SWC-UP	Fe Dissolved	mg/L	0.01	0.15	0.17	13
BHA	Mn Dissolved	mg/L	0.01	0.12	0.12	0

Acceptance criteria:

RPD <50% for low level (<10xMDL)
RPD <20% for medium level (10-50xMDL)
RPD <10% for high level (>50xMDL)
No limit applies at <2xMDL

MDL = Method Detection Limit

All results are within the acceptance criteria

ANALYTICAL REPORT

JOB NO: SAL27330
CLIENT ORDER: 118109

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory, in accordance with APHA Standard Methods of Water and Wastewater 22nd Edition, or other approved methods listed below:

4500B	pH
2540C	Total Dissolved Solids
3500B	Sodium Na+
3111B	Calcium Ca++
3500B	Potassium K+
3111B	Magnesium Mg++
4500D	Chloride Cl-
4500C	Fluoride F-
4500F	Nitrate NO3-
4110B	Sulphate SO4--
2320B	Bicarbonate HCO3-
4500F	Phosphate PO4---
4500G	Ammonia (Total)
4500B	Nitrite NO2-
5210B	Biochemical Oxygen Demand
5310C	Total Organic Carbon
2130B	Turbidity
3111B	Iron (Total)
3111B	Iron (Dissolved)
3111B	Manganese (Dissolved)

E.Coli/Faecal Coliforms Determined by BARRATT & SMITH (4034)
Report No.: W1918325

SYDNEY
ANALYTICAL
LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
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A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

ENVIRONMENTAL & EARTH SCIENCES

PO BOX 380
NORTH SYDNEY 2059

ATTN: E.GRIFFITHS

JOB NO: SAL27330B

CLIENT ORDER: 118109

DATE RECEIVED: 23/08/19

DATE COMPLETED: 06/09/19

TYPE OF SAMPLES: DUST GAUGE

NO OF SAMPLES: 1

NATA Accredited for compliance with ISO/IEC 17025 Testing

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Issued on 06/09/19
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL27330B
CLIENT ORDER: 118109

SAMPLES	ASH CONTENT g/m2/mth	COMBUSTIBLE CONTENT g/m2/mth	INSOLUBLES CONTENT g/m2/mth	SOLUBLES CONTENT g/m2/mth
DG1	0.3	0.2	0.5	0.1
MDL	0.1	0.1	0.1	0.1
Method Code	S14	S17	S15	S16
Preparation	P7	P7	P7	P7

ANALYTICAL REPORT

JOB NO: SAL27330B
CLIENT ORDER: 118109

SAMPLES	TOTAL SOLIDS CONTENT g/m2/mth	PARTICULATES CONTENT g/m2/mth	FUNNEL DIAMETER mm	TIME EXPOSURE days
DG1	0.6	<0.1	150	100
MDL	0.1	0.1		
Method Code	S8	S19		
Preparation	P7	P7		

Sampling Dates: 14/05/19-22/08/19

ANALYTICAL REPORT

JOB NO: SAL27330B
CLIENT ORDER: 118109

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory.

P7	Analysis performed on sample as received (total contents)
S14	Total Ash Content - AS3580.10.1
S17	Total Combustibles Content - AS3580.10.1
S15	Total Insoluble Solids Content - AS3580.10.1
S16	Total Soluble Solids Content - AS3580.10.1
S8	Total Solids Content - AS3580.10.1
S19	Total Particulates Content - AS3580.10.1

SONIC
FOOD & WATER TESTING

MICROBIOLOGY FINAL REPORT

CERTIFICATE OF ANALYSIS

W1918325
[]

SYDNEY ANALYTICAL LABS
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147

Lab Number:	299896124
Customer Reference Number:	118109
Site:	SHELLHARBOUR LP1
Sample Type:	WATER
Sample Notes:	
Date and Time of Collection:	21/08/19,1050
Date and Time of Testing:	24/08/19,0800
Collected By:	The Client
Tested:	As Received

TESTS	RESULTS	UNITS
FAECAL COLIFORM COUNT:	20	most probable number per 100ml
ESCHERICHIA COLI COUNT:	20	most probable number per 100ml

METHODS

* Thermotolerant (Faecal) Coliform Count - Australian Standard 4276.6 by Most Probable Number Method.
* Escherichia coli Count - Australian Standard 4276.6 by Most Probable Number Method.

The time between collection and the commencement of testing should not exceed 24 hours. Samples tested outside this time may have their results compromised.

END OF REPORT

Signed:. Date:27/08/19

T.Morgan	K.McClenahan	H.Sialepis	L.Vanhoff	P.Campora	R.Bhatt	N.Mecsery	S.Leelakrishnan
Laboratory Manager	Quality Manager	Technical Officer	Technical Officer	Scientific Officer	Scientific Officer	Technical Officer	Scientific Officer

NATA WORLD RECOGNISED ACCREDITATION
Accreditation No. 4034
Accredited for compliance with ISO/IEC 17025 – Testin