



Killurin Landfill

2019 Updated Hydrogeological Risk Assessment



Report for:
Wexford County Council

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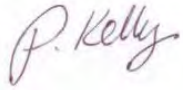

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1 INTRODUCTION

1.1 General Introduction

The following 2019 updated hydrogeological risk assessment is intended to satisfy the requirements of Environmental Protection Agency (EPA), relating to a waste management facility at Killurin, Co Wexford. EPA waste license reference no. W0016-2.

The EPA issued a corrective action for the landfill on the 30th July 2019 in relation to groundwater, which stated the following:

'Groundwater monitoring results for the facility indicate that leachate from the landfill is impacting on groundwater and the facility has been identified as a significant pressure to the environmental objectives of the associated groundwater body under the Water Framework Directive (WFD). The results indicate that the level of contamination is reducing with time'.

Corrective Action:

The licensee shall continue the groundwater monitoring programme at the facility. The licensee shall submit a groundwater monitoring report to the EPA annually which includes results for the previous 12 months, groundwater contour maps (shallow & deep), interpretation and trend analysis of the results and refer to the recommendations and compliance values set out in the report submitted to the EPA in accordance with condition 8.8.2 of the licence.

This report provides a response to this corrective action taking into account all groundwater quality data since the 2015 Hydrogeological Risk Assessment report for Killurin Landfill. It is considered to supersede the 2015 Risk Assessment report in its entirety.

1.2 Objectives

The following objectives were agreed with Wexford County Council:

- Review all available laboratory data, water level monitoring data and other relevant information between 2015 and 2019;
- Interpret all site data and develop an updated Conceptual Site Model (CSM) for the site;
- To assess the site's compliance with the Groundwater Regulations (S.I. No. 9 of 2010);
- To update the level of risk posed to sensitive receptors;
- Develop an updated interpretative Hydrogeological Risk Assessment Report for the landfill to include updated groundwater contour maps, trend analysis and recommendations in accordance with EPA requirements; and,
- Recommend suitable mitigation measures, if deemed necessary.

1.3 Methodology

This report was prepared in accordance with the following guidance documentation:

- Guidance on the Authorisation of Discharges to Groundwater, EPA, 2011;
- Guidance on the Management of Contaminated Land and Groundwater at EPA Licensed Sites (2013),
- Code of Practice Environmental Risk Assessment for Unregulated Waste Disposal Sites, EPA, 2007; and
- Hydrogeological Risk Assessments for Landfills and the Derivation of Groundwater Control and Trigger Levels, Environment Agency, 2003.

1.4 Sources of Information

The following sources of information were reviewed as part of this assessment:

- Wexford County Council (WCC) Killurin Landfill Annual Environmental Reports (AERs) between 2008 and 2019;
- 1:100,000 Geological Sheet 23, Bedrock Geology of South Wexford – Geological Survey of Ireland (GSI) – 1994;
- Extracts of historical 6" geological mapping field sheets;
- Historical site investigation reports;
- Historical site borehole logs;
- EPA inspector reports;
- Wexford Groundwater Protection Scheme;
- Geological Survey of Ireland (GSI) online databases and mapping;
- EPA online databases and mapping (<https://gis.epa.ie/EPAMaps/>);
- Irish soil information system online, Teagasc;
- Ordnance Survey of Ireland (OSI) historical mapping;
- Discussions with landfill manager;
- Water Framework Directive (WFD) water maps (<http://wfdireland.ie/maps.html>)
- Catchments.ie WFD Cycle 2 (<http://catchments.ie>);
- GSI, Groundwater Protection Schemes, 1999; and,
- Fitzsimons, V., Daly, D. and Deakin, J., 2003. GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination. Draft Report, Geological Survey of Ireland.

2 REVIEW OF PREVIOUS SITE ASSESSMENTS

A number of relevant historical reports were initially reviewed as part of this hydrogeological assessment for the site and are summarised below.

Report Title 1: Hydrological Report of the Proposed Landfill Site at Killurin, Co. Wexford, KT Cullen, 1984.

This report describes the results of a hydrogeological study undertaken to determine the suitability of the Killurin site as a landfill facility. The main results and conclusions are outlined below:

- The 11-acre site comprised 4.5 acres of a disused sand and gravel quarry with the remainder comprising unworked areas and mudflats along the River Slaney.
- The site was previously used as a landfill site for the disposal of domestic, industrial and “inert” wastes, including motor vehicles.
- A site topographical survey, a trenching programme and the drilling of three boreholes (BH1, BH2 and BH3) was undertaken at this time.
- The works identified:
- Overburden consisting of a complex sequence of glacial outwash deposits overlying bedrock comprising slates and grits;
- 4.2 to 12.4 metres of overburden between the quarry floor and bedrock; and,
- Groundwater present close to the quarry floor with some areas flooding in winter.
- The report concluded the following:
 - The site was suitable for development as a landfill facility, if properly managed;
 - Groundwater flow direction was towards the River Slaney and would not likely affect private water wells located to the north and east of the site; and,
 - There would be minimal impact on local groundwater quality, if appropriately managed.
 - A series of recommendations for the future use of the site as a landfill were provided.

Report Title 2: EPA Waste Licence Application Form – Disposal Activities (Landfill), 1997 - Submitted by Wexford County Council

Salient information within this application in relation to this hydrogeological assessment is as follows:

- Approximately 22,000 m³ of leachate was calculated to be produced annually from the proposed landfill.
- The application concluded that there is sufficient dispersion and dilution available in the underlying geology and hydrogeology to negate any possible environmental pollution. However no representative calculations were identified in the application to confirm this determination.
- The application specified that the site does not have a liner system but that cells were constructed using earth bunds and screens to prevent surface water run-off.
- A Leachate Management Plan was prepared to control leachate generation.
- Leachate monitoring was proposed via 12 existing boreholes (*i.e.* boreholes BH2 to BH8 and BH12 to BH16) within the waste body, drilled to the base of the waste body.
- An additional 7 boreholes (*i.e.* boreholes BH1, BH9, BH10, BH11, BH17 and BH19) were drilled to facilitate groundwater monitoring.
- No active leachate treatment was proposed to be undertaken. Leachate treatment by natural attenuation and the ‘dilute and disperse’ principal was considered to be appropriate for the site.
- Retention times within the subsoils and groundwater were confirmed to be difficult to estimate; however estimated calculations concluded that retention times were likely to be significant and in terms of weeks rather than days.
- The application concluded that the risk to groundwater was low based on the following:
 - A significant amount of attenuation was likely to take place within the sub-soils;
 - The retention times were likely to be significant;
 - The area is not classed as an important aquifer; and,
 - There are no water abstraction points downstream of the site.
- Surface water runoff from the site was proposed to enter the reed beds in a diffuse pattern.

- Soils in the area of the reed beds were confirmed to be saturated and marshy which was interpreted to provide an extremely high dilution factor for surface water entering the reed beds. Low flow rates within the Slaney River were utilised for an assimilative capacity assessment to demonstrate a low impact.
- Surface water monitoring points were established at the site *i.e.* locations SW1, SW2 and SW3.
- Continuous analysis of the River Slaney did not record a significant level of pollution in the area. Results were reported to demonstrate that no sudden drop in quality in the vicinity of the landfill was occurring. It was therefore concluded that leachate was being effectively “treated” at the site.

Report Title 3: Application to the EPA for a Waste Licence Review for Waste Disposal Activities at Killurin Landfill Site, 2002, Wexford County Council.

Salient information from the Waste Licence Review Application is as follows:

- The application for a waste licence review was to facilitate the vertical extension of the landfill at Killurin Landfill. It included an Annual Report in addition to an Environmental Management Plan.
- The Annual Environmental Report outlined a proposal to divert surface water away from landfilled parts of the facility along the northern and eastern boundaries in order to reduce the production of leachate. This was submitted to the EPA in July 2000 and subsequently completed in 2013.
- A phased leachate management plan was outlined and is summarised below:
 - The collection of data from the leachate interception pits to determine where the leachate was leaking from the site. Further information was provided by the UCC Aquatic Services Unit survey with results showing that the southern half of the boundary with the reed beds was receiving leachate inflow. The leachate was considered to be emanating from two discrete drainage channels; one in the vicinity of groundwater monitoring wells BH9 and BH10, and one adjacent to Leachate Borehole 5, located directly below the landfill gas flare compound where SW3 was discharging;
 - Limiting the hydraulic head of leachate within the waste body to 10 mOD, at the geographical centre of the land-filled area. It was anticipated that limiting the hydraulic head to 10 mOD would prevent the leachate migration northwards, against the groundwater flow of north east to south west. Leachate abstraction from two buried slotted tanks, surrounded by clean stone and an impermeable clay bund, was proposed in the western region of the site with disposal to Wexford Town wastewater treatment plant (WWTP);
 - Construction of an on-site leachate storage lagoon and the active extraction of leachate using submerged pumps and dedicated boreholes. The leachate in the storage lagoon would be sent to Wexford Town WWTP; and,
 - Construction of a leachate treatment plant adjacent to the storage tanks, with the possibility of discharge to the local reed beds as a polishing step before final disposal of the treated wastewater to the river. This phase was not granted permission by the EPA and the leachate continues to be tankered to Wexford Treatment Plant.

Report Title 4: Ground Investigation Report, IGSL Ltd., 2005.

The investigation included the following:

- Drilling of seven (7 no.) rotary boreholes with groundwater monitoring standpipe installations around the perimeter of the landfill – six (6 no.) of which are located along the south western site boundary and installed as groundwater monitoring wells (*i.e.* BR01 to BR07);
- Seven (7 no.) trial pits adjacent to the boreholes (TP1 to TP7);
- Ten (10 no.) gas monitoring standpipes using a window sampling terrier rig; and,

Report Title 5: Untitled Site Investigations, Killurin Landfill

Additional trial pit excavations were undertaken between 2001 and 2003 to identify the extent of contamination of the area between the landfill and the River Slaney. Little geological information was gathered from the excavations; however slotted standpipes were installed to the base of the pits and were labeled as GW1, GW9, GW10, GW17 to GW19, and GW21 to GW27. It would appear that these pits facilitated groundwater quality monitoring of the unconsolidated sand and gravel deposits only.

Report Title 6: Draft Report on the Geophysical Survey at Killurin Landfill, Apex Geoservices Ltd., 2005.

A geophysical survey along the southern region of the landfill site was undertaken in 2005. A summary of the interpretation of the resistivity profiles undertaken is outlined below:

- An upper 1-2 m of unsaturated sandy clay overlying 5-6 m of saturated sandy clay is present;
- The resistivity of the saturated sandy clay was lower than the normal range for this material indicating the presence of leachate in this material;
- Very low resistivities (2 – 12.5 Ohm-m) were detected indicating that zones of more concentrated leachate are also present;
- A deep low resistivity zone between wells GW22 and GW21 was considered to be potentially associated with more shaley bedrock with leachate appearing to migrate via a faulted or fractured zone; and, the resistivity rose again below 6 to 8 mbgl and this was interpreted as less permeable weathered slatey/shaley bedrock.

Report Title 7: Groundwater Remediation Assessment at Killurin Landfill, Co. Wexford, Fehily Timoney & Company. Ltd., 2006.

This remediation assessment concluded the following:

- Groundwater quality at the southwestern boundary of the site was declining, as a result of the rise in leachate levels at the landfill and high permeability pathways both in the bedrock and the overburden.
- The River Slaney was not being impacted significantly by the landfill.
- Leachate pathways were identified in the high-permeability parts of the glacial outwash deposits and in a fractured zone of the bedrock associated with a regional thrust fault. Contamination was greatest at depth within the thrust fault.
- The assessment revealed that contamination would continue to emanate from this area of the site for a considerable period, albeit at a greatly reduced rate after a fully engineered cap was completed. This was due to the base of the waste being interpreted as periodically saturated by a high natural groundwater table irrespective of the head of leachate within the waste body.

The assessment recommended on-going monitoring post full completion of the capping works.

Report Title 8: Killurin Landfill – Leachate Management Plant, March 2013.

This plan provides a review of the leachate management infrastructure at Killurin landfill and recommended a number of mitigation measures as detailed in Section 3.5.1. This report recommended the installation of new leachate extraction wells to replace the LB wells which are no longer operational and cannot be used for monitoring purposes.

Report Title 9: Killurin Landfill Hydrogeological Assessment, June 2015 and Addendum, December 2015.

A hydrogeological risk assessment of Killurin Landfill Site was undertaken by BlueRock Environmental Limited in 2015 based on previous investigation reports and monitoring data between 2004 and 2014. A summary of the conclusions is outlined below:

- A Conceptual Site Model (CSM) was developed based on available information and monitoring data and identified a number of source-pathway-receptor (SPR) linkages ranging from Low to Moderate risk to identified sensitive receptors. The SPR linkages of concern relate to:
 - The vertical migration of leachate from the unlined waste cells to the underlying aquifer; and,
 - The horizontal migration of contaminant plume off-site to the River Slaney and the mudflats.
- The site was considered to be partially compliant with the “prevent” or “limit” objective of the Water Framework Directive (WFD) and Groundwater Directive (GWD). The prevention of hazardous substances entering the groundwater system was not being met as per WFD requirements monitoring event in 2010. Limiting the ingress of non-hazardous substances was being met by the mitigation measures that were installed at the site *i.e.* leachate abstraction, landfill capping and the lining of surface water drains.
- A series of mitigation measures were proposed to address the data gaps at the site, to facilitate a more detailed understanding of the hydrogeological regime and to assess the risk posed to downgradient receptors.
- The existing groundwater and surface water monitoring network was considered to be predominantly suitable to meet the requirements of the Groundwater Regulations. Several additional investigation and monitoring locations and amendments to the existing frequency and suite of testing were recommended.
- It was concluded that the landfill site appeared to have a low level of impact on the River Slaney and the mitigation measures completed in conjunction with the proposed additional monitoring and investigation locations were deemed to be sufficient for the site to be compliant with the Groundwater Regulations.

3 SITE DESCRIPTION

3.1 Site Location

Killurin Landfill is a closed landfill located in the townland of Newtown Lower, Killurin, County Wexford, close to Deeps Bridge on the east side of a meander on the Slaney River. The site is approximately 11km northwest of Wexford Town and 15km south of Enniscorthy and has Irish Grid Coordinates 298000E, 126000N.

The site covers approximately 10.7 hectares, of which 4.9 hectares are landfill and the remainder is screen material.

The facility is located in a former sand and gravel quarry which was periodically used as a landfill during the 1970s and 1980s before it was purchased by Wexford County Council (WCC) in 1985. The council used the site as a landfill until 7th June 2008 and capping works were largely completed in 2011 with access road capping completed in 2014.

A site location map is included as Figure 1.

3.2 Topography

The topography of the general environs of the landfill is flat to undulating and is characterised by narrow wooded valleys. Elevations at the site range from a high of 15 mOD in the eastern region of the site close to the eastern edge to a low of very close to sea level in the mud flats along the River Slaney. Eastwards from the site, the land steadily rises to a local high point of 65 metres above sea level at Newtown Upper about 1km to the southeast of the site.

The site lies on a large meander in the Slaney River which is deeply entrenched into its present valley. The river valley is a major topographic feature in County Wexford and is for the most part rock lined and cut to a much lower sea level than exists at present. The Killurin meander can be described as an incised meander which developed as the course of the Slaney River changed in response to changes in sea level.

The waste body is capped in a dome-like fashion within the footprint of the site and extends to a maximum height of approximately 31 mOD.

3.3 Site Layout

The landfill site facility is currently closed and comprises a series of former unlined waste cells. All the waste body has been fully capped since 2014 with an access road surrounding the perimeter of the waste body (see Figure 2).

The site entrance, leachate storage and lagoon, wheelwash a former recycle and scrap metal area are all located in the northwestern region of the site. A landfill gas flare system was installed in the southcentral region of the waste body - see Figure 2.

3.4 Site History

Wexford County Council (WCC) purchased the Killurin site in 1985 which was a disused sand and gravel quarry that was already accepting material for waste disposal including domestic, industrial and "inert" wastes, including motor vehicles. The quarry was surveyed immediately prior to landfilling and this survey illustrated that the northern part of the site was the main extraction area, thinning to a narrow, extraction area that runs north-south on the centre of the site. Landfilling began in the mid-1980's at the northern end of the site; It was brought up to ground level in this area by the end of the 1980's and by the early 1990s (as evidence by a 1992 aerial photo) had advanced to the central portion of the site. The narrow band of worked out quarry was filled between this time period and the late 1990's, and thereafter landfilling occurred at various places above the original level of the site.

The council continued to use the site for landfilling purposes, and in 1997, submitted a Waste Licence Application to the EPA.

The waste licence was granted in 1999 with conditions covering the monitoring and protection of surface water and groundwater resources at the site and a maximum waste height of 25 mOD. In 2002, the council applied for a review of the licence to allow for a vertical extension of the landfill and this application was subsequently granted in 2003 to a maximum height of 31 mOD.

Landfilling continued until June 2008 and capping was largely completed in 2011. Capping of the landfill perimeter haul road was completed in 2014.

A series of non-compliances were issued to the facility in relation to groundwater and surface water exceedances. These refer to among other things, non-monitoring of leachate levels, uncontrolled leachate discharges, failure of capping works and failure to install leachate interception trenches.

Some initial capping of landfill slopes was carried out at the site prior to 1999. Further capping of the landfill footprint was progressed in five phases between 2004 and 2008. Additional work was carried out in 2010 to complete subsoil and topsoil application to the Phase 5 area.

3.5 Leachate and Surface Water Management

3.5.1 Leachate

Leachate management on the site consists of pumping via a piped collection system to on-site storage tanks prior to transfer to Wexford Town WWTP using sealed suction tankers. Leachate is extracted from bored wells in the landfill using pneumatic pumps that were installed in a number of phases from 2003 onward.

- 2003: A series of 13 no. submersible leachate pumps (W-series wells) were installed around the southern perimeter of the site.
- 2005 (January): Installation of 5 no. additional leachate pumps (W-series wells) were installed around the vertical extension perimeter to reduce leachate breakouts and control migration
- 2005 (July): An additional 16 no. pumps (*i.e.* A1 to A16) were installed within the vertical extension of the waste body in a bid to reduce the standing leachate head from the central portion of the site.
- Circa 2008: 12 no. leachate wells installed within the waste body (*i.e.* LB2 to LB8 and LB12 to LB15). These LB wells are no longer used for leachate depth monitoring. The well liners kinked due to differential settlement and are no longer suitable for monitoring purposes.
- 2014: 16 no. leachate wells (*i.e.* LE_12_01 to LE_12_16) installed in the landfill area above the access road to monitor leachate levels along the centre of the site. Pumps were installed in 8 wells in March 2014 (*i.e.* LE_12_1, 4, 7, 11, 12, 14, 15, & 16). These wells are considered the main leachate monitoring wells across the site (see Figure 3a).

A leachate cut-off drain was constructed around the perimeter of the vertical extension, for diversion to sumps around the perimeter. Historical leachate breakouts lower down the waste body were sealed with bentonite.

The waste licence application in 2002 for the site detailed a phased plan to manage the leachate at the site. Phases 1 to 4 were previously described in Section 2, Report Title 3.

- A review of existing leachate infrastructure was also undertaken as part of the Leachate Management Plan in 2013. The findings of this review are summarised as follows:
 - ✓ Significant depths of leachate existed in a number of wells;
 - ✓ Pumping had varied effects on leachate levels;
 - ✓ Pump rates were very varied, with some very high pump rates considered questionable;
 - ✓ Pump locations within wells were likely to be affecting discharge rates and should be checked and adjusted regularly; and,

- ✓ Depths of wells and depth to leachate did not always correlate (*i.e.* in some cases, the recorded depth to leachate was greater than the actual depth of the well).

There is currently no SCADA system at Killurin for control/management of the leachate collection and extraction system. The leachate quantities are measured using a docket system. This docket system is in turn supported by random weighbridge checks at Holmestown Waste Management Facility.

A number of mitigation measures were considered in 2013 as outlined below. It was proposed that completion of the capping at the site, combined with increased leachate extraction was the most appropriate mitigation measure for the site, and that monitoring should continue for at least 18 months post completion of capping before any decisions on further proposed mitigation measures were taken. The final capping works were completed in mid-2014.

- **Completion of Capping**

Capping of the entire site was fully completed, including the access ring road, in 2014. The impact of the final capping on the leachate generation at the site was estimated to reduce the volume of leachate generation by approximately 2,800 m³ per annum (a reduction of over 50% from the calculated volume for 2011).

- **Enhanced Pumping Regime**

Leachate extraction was considered to be effective in terms of reducing leachate levels across the site. A number of additional wells were recommended in selected locations to replace/assist existing wells. The proposed wells were generally located along the central spine of the landfill (*i.e.* the highest point of the waste body and generally maximum level of the leachate body) and over the floor of the original quarry.

- **Ongoing Monitoring**

It was proposed that a period of intense monitoring (*i.e.* monitoring/analysis of leachate levels, groundwater quality and leachate volumes extracted from site) be carried out for a period of 12 months after completion of all capping works and the installation of new wells. After 12 months, it was proposed that a review of the monitoring regime be carried out, with intensifications/relaxations as appropriate. Monitoring would then be continued for a further six months before any definitive assessment of the effectiveness of the regime was made.

3.5.2 Surface Water

Surface water management on the site consists of a series of gravity collection networks. The system is split generally into three zones, as follows:

- Zone 1: Landfill area above the access road on the landfill;
- Zone 2: Landfill area below the access road on the landfill; and,
- Zone 3: General site drainage from the hardstanding area at the site entrance.

Surface runoff from the Zone 1 side slopes discharges down the slopes to the existing access ring road. Sub-surface water from Zone 1 is collected in a piped toe drain (a 150 mm perforated uPVC pipe, in Type B filter material, wrapped with a filter drain) along the toe of the capped slopes. The subsurface drainage blanket laid on the engineered clay capping layer discharges to this toe drain. The toe drain discharges at the north and south of the landfill cap via silt traps. The northern discharge is piped through the entrance yard area to a headwall (constructed as part of the Phase C2 capping works) discharging to the reed beds adjacent to the Slaney, which is monitored as SW2. The southern discharge point is piped down the lower side slope and discharge to the Slaney at SW4.

Surface water from Zone 2 runs down the capped slopes to a drain at the base of the slope, along the northern and eastern landfill boundaries. These toe drains predate the capping works in this area and were constructed in 2001 (while the capping was installed in 2004). The drain is a lined drain typically comprising a 300mm O.D uPVC perforated pipe laid in a HDPE lined trench and backfilled with 2" drainage stone. These drains discharge to Slaney, either directly to the Slaney at SW4, or to the surface water stream on the eastern boundary of the site near SW1. The capping construction on these slopes

was constructed so that the GCL lapped with the HDPE, so that sub-surface discharge from these slopes also discharges to these drains. Surface water runoff from Zone 2 on the southern and western boundaries is via natural drainage to the surrounding lands.

Along with the toe drains constructed in 2001, additional drains were constructed along the existing haul road at that time, which discharged at SW3. These drains were decommissioned in 2003 and sealed, leaving SW3 redundant as a monitoring location. Run-off from hardstand areas (*i.e.* the old scrap metal storage area) discharge to the headwall at SW2 via an oil-water interceptor.

4 BACKGROUND GEOLOGY

4.1 Waste

Municipal waste deposition occurred at the Killurin site under council control since 1985. The waste comprised domestic, industrial and 'inert' waste material including motor vehicles. The original landfilling occurred in the northwestern region of the site before moving in an east to southeastern direction across the site. Some landfilling had already taken place at the then-operational sand and gravel pit. This landfilling was confined to the northwest corner of the site.

4.2 Overburden Geology

The Teagasc soil mapping for the western region of the site area is mapped as the Crosstown Soil Association which generally comprises luvisols derived from fine to coarse loamy drift with siliceous stones parent material. The east side of the site is mapped as the Seafield Soil Association which comprises rendzinas, brown podzolics, groundwater gleys and podzols derived from sandy stoneless drift (see Figure A, Appendix A).

The overburden geology of the Killurin area comprises unconsolidated overburden deposits and bedrock with complex sequences of glacial outwash deposits reported at the landfill site. This is mapped as Gravels derived from Lower Palaeozoic sandstones and shales (GLPSsS) (see Figure A2, Appendix A).

The 2005 Site Investigation summarised overburden conditions at the as follows:

- Brown and grey brown sandy gravelly CLAY with some cobbles;
- Brown very gravelly SAND or sandy Gravel with occasional cobbles;
- Brown slightly clayey gravelly SAND; and,
- Brown sandy SILT.

The 1985 KT Cullen investigation identified 9 metres of glacial outwash deposits at the site. The worked-out quarry was surveyed before development as a landfill took place and it surmised that the sand and gravel deposit was 'an elongated mound with its long axis parallel with the general valley direction'. The deposit was exploited along its long axis, with the quarry developing as a long sinuous quarry with a flat floor bounded on both sides by high ridges of unworked material.

Significant variability in the overburden composition was encountered as summarised above with the 2005 investigation which identified localised smaller, high permeability channels of sand and gravel penetrating the matrix of lower-permeability silts and clay overburden.

All available trial pit and borehole logs are provided in Appendix B and Appendix C.

4.3 Bedrock Geology

On a regional scale, the solid geology of Wexford is dominated by lower Palaeozoic rocks that traverse the site in a northeast-southwest axis. The three units that are interpreted to outcrop beneath the site, according to the GSI 1:100,000 memoir (Sheet 19, the Geology of Carlow-Wexford), are as follows:

- The Polldarrig Formation - Dark grey mudstones with thin quartzites;
- The Ballynacarrig Member - Pale grey quartzites in thin dark slates; and,
- The Newtown Formation - Grey-green greywacke and slates.

The geology of the site is presented in Appendix A (Figure B and B2).

The structural history of the area is reflected in the relatively large density of faults shown on the geological map. Thrust faulting and associated normal faults are evident in the region as a result of the Monian Orogeny (or mountain building event) which caused major deformation of the Wexford region in

the middle-Arenig (about 480 Ma). This type of event may lead to the development of major fracture zones around fault planes.

The 2005 Site Investigation results (see Table 4.1 below and Appendix B & C) summarised bedrock conditions at the site which comprised the following:

- Grey brown and grey blue, fine grained, thinly bedded SILTSTONE / GREYWACKE bedrock with subordinate units of mudstone.
- Weathering grades range from slightly to moderately weathered (and locally highly weathered) with the siltstone units less susceptible to the weathering process.
- Discontinuities are classed as being mainly very closely spaced with numerous sections of the drilling core designated as highly fractured or non-intact.

BH ID	Ground Level (mOD)	Total Depth (mbgl)	Total Depth (mOD) ¹	Depth to Bedrock (mbgl)	Depth to Bedrock (mOD)
BR01	10.69	13.40	-2.71	7.4	3.29
BR02	6.56	13.7	-7.14	10.5	-3.94
BR03	6.78	18.8	-12.02	-	-
BR04	6.48	20.0	-13.52	-	-
BR05	6.35	16.0	-9.65	9.0	-2.65
BR06	5.94	19.2	-13.26	-	-
BR07	5.81	12.5	-6.69	-	-

Note 1 mOD levels sourced from borehole logs within the 2005 SI Report.

Table 4.1 Bedrock Information

Bedrock core samples were recovered from boreholes BR01, BR02 and BR05 and are described as a moderately strong, thinly bedded fine to medium-grained greywacke. Comparison with the GSI description and classification suggests that these boreholes encountered the Newtown Formation of green-grey greywackes and slates. The solid core recover (SCR) for the site was relatively variable, with the upgradient borehole (BR01) recording more competent rock than BR02 and BR05; fracture spacing approached 25cm for BR05 and lower values for the other two cored holes.

Previous reports suggested that the waste did not lie directly onto bedrock. A review of the bedrock levels as part of this report confirmed that this was likely to be the case. The rock surface appears to be relatively level ranging between 8 and 11 metres below ground level.

A major fracture zone within the bedrock was revealed by the 2005 geophysical survey which correlated with the site investigation data and the regional fault pattern. A deep zone of leachate between monitoring wells GW21 and GW22 was interpreted to be moving down a faulted or fractured zone. The interpreted section of the geophysical survey between GW21 and GW22 is included in Appendix D.

4.4 Geological Interactions

The interaction between the geological units across the site were summarised as follows:

- A heterogeneous waste body forms the upper layer, is laterally discontinuous, and is interpreted to be up to 20 metres in thickness.
- Underlying the waste body is a complex series of glacial outwash deposits, comprising small localised channels of sand and gravel set in a matrix of silts and clays. The geophysical resistivity survey interpretation showed an upper 1-2 metres of unsaturated sandy clay followed by 5 to 6 metres of saturated sandy clay. In particular areas, the resistivity of the saturated sandy clay was lower than the normal range for this material indicating that some leachate is present in higher permeability channelized areas.

- The bedrock directly underlies the glacial outwash deposits and appears (by interpolating from older survey information and interpreted depths to bedrock) not to be in direct contact with the waste body. A major fracture in the bedrock was revealed by geophysical surveying (see Appendix D), and this correlates to more recent site investigation data and the regional faulting pattern. A deep zone of leachate between GW22 and GW21 was interpreted to be associated with leachate moving down a faulted or fractured zone. Other than at this deep leachate area, the resistivity rises again and was interpreted as less permeable weathered slatey/shaley bedrock.
- Average monthly gridded rainfall data was sourced from Met Éireann and is presented in Table 4.2.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(mm/yr)
2014	179.8	214.5	99.8	87	65.6	36.8	66.2	153.5	11	158.8	207.7	48.5	1329.2
2015	83.1	44.6	76.2	22.9	144.3	46.1	149.4	66.1	63.4	91.3	113	335.9	1236.3
2016	163.8	131	46	86.3	56	76.6	43	59.4	144.4	53.4	46.2	142	1048.1
2017	59.2	86.7	95.6	30.6	107.4	135.5	63.2	83	159.1	74.8	81.1	113.8	1090
2018	125.1	47.4	174.1	126.3	42.2	13.6	48.7	59.5	92.3	71.4	248.7	215.1	1264.4
2019	54.3	88.3	120.8	119.5	26.6	92.4	34.5	118.3	102.2	168.2	199	125.5	1249.6

Table 4.2 Monthly rainfall data (mm) from Taghmon (Kilgarvan), Wexford

The closest rainfall station to the site (with complete data) is at Taghmon (Kilgarvan) 9km to the south-west. The potential evapotranspiration (PE) in the south eastern river basin district is 450 to 500 mm/yr. These values are used as a best estimate of the site PE. Actual evapotranspiration (AE) is estimated by multiplying PE by 0.95, to allow for the reduction in evapotranspiration during periods when a soil moisture deficit is present (Water Framework Directive, 2004). Actual evapotranspiration is therefore 427.5 to 475 mm/yr. Taking an annual average rainfall volume of 1200 mm/year, the effective rainfall at Killurán Landfill will range between 725 and 772.5 mm/year.

4.5 Sensitive & Designated Areas

The Slaney River Valley is located to the west and south of the site and is categorised as a special area of conservation (SAC).

The River Slaney is listed as a Designated Salmonid River, under the EU Freshwater Fish Directive (78/659/EEC). The Slaney estuary is designated a candidate Special Area of Conservation (SAC [000781]) and supports several species listed in the European Habitats Directive (92/43/EEC). It is a Proposed Natural Heritage Area (pNHA) [000781]) and Special Protected Area (SPA [004076]).

The other main priority habitat located in proximity to the landfill site is the mudflats located between the landfill site and the river (*i.e.* 1140 Mudflats and sandflats not covered by seawater at low tide). The mudflats are considered to be an SAC, pNHA and SPA with significant polychaete communities that provide a food source for the birdlife associated with this habitat.

Other main considerations are River and Brook Lamprey which are qualifying interests for this habitat. Deterioration of the mud habitats is considered to be a significant impact. In terms of water quality, Salmon, Sea Lamprey and Otter are also QI species which rely on good water quality.

The Forth Mountain located to the south of the site has been categorised as a proposed natural heritage area.

There are no source protection areas mapped in the vicinity of Killurán Landfill. A number of private groundwater wells are present in the vicinity of the site as detailed in Section 6.7; however, these wells are not considered to be downgradient of the landfill site.

5 HYDROLOGY

5.1 Hydrological Features

The site is located within the Slaney & Wexford Harbour Catchment in Hydrometric Area no. 12. This catchment includes the area drained by the River Slaney and all streams entering tidal water between the Raven Point and Greenore Point, Co. Wexford. The northern part of the catchment is underlain by granite bedrock which runs southwest and forms the Blackstairs Mountains that mark the western boundary of the catchment. The southern part of the catchment is underlain by metamorphic rocks with a band of volcanic bedrock, running through the centre of the catchment. The River Slaney (and associated mudflats) is adjacent to the western boundary of the Killurin Landfill. The river is a major regional hydrological feature, draining a catchment of 1,980 km².

The Slaney rises in the Glen of Imaal near Lugnaquilla in the Wicklow Mountains. It flows in a westerly direction towards Stratford and then flows in a southerly direction through Baltinglass, Rathvilly and Tullow. It then continues in a south easterly direction through Bunclody and Enniscorthy and then southerly to Ferrycarrig where it turns east into Wexford Harbour and on into the sea. The total length of the river is 117 kilometres and it is tidal as far upstream as Enniscorthy.

The channel of the river is between 100 and 200 m wide as it passes the landfill. It is also estuarine in character at this location, as demonstrated by its semi-saline water chemistry, and the presence of estuarine flora.

The Lower Slaney Estuary (waterbody code IE_SE_040_0200) had an overall status of Moderate and overall risk of 1a (*i.e.* at risk). The river had a moderate status due to elevated levels of dissolved inorganic nitrogen (DIN) dissolved oxygen, Biochemical Oxygen Demand (BOD) and microalgae. These data are based upon the final River Basin Management Plan (2009 - 2015). The WFD cycle 2 indicates that the status of the Lower Slaney Estuary deteriorated from Moderate to Poor (2013 - 2018). The Lower Slaney Estuary is At Risk of remaining at Poor status and is impacted by excess nutrients, phytoplankton and deteriorated dissolved oxygen conditions.

All surface water features at the site is drainage channels to facilitate the dispersal of rainfall at the site and direct to the River Slaney. Details of the drainage system are previously described in Section 3.5.7.

The closest river gauging station is at Enniscorthy (15 km upstream) which reports a mean annual flow of 24.3 m³/sec between 1956 and 2019 (wfdireland.ie/HydroTool/). The lowest channel floor in the vicinity of the landfill site ranges between -4.59 and -9.7 mOD.

Consultations with the Office of Public Works (OPW) confirmed the lowest river channel floor between -9.7 and -4.6 mOD along the stretch of river adjacent to Killurin Landfill.

5.2 Hydrological Monitoring

3 no. River Slaney monitoring locations are monitored by the EPA - one upstream (S1) and two (S2 and S3) downstream. In addition, 4 no. landfill site surface water monitoring locations (*i.e.* SW1 to SW4) are presented in Figure 3.

The SW locations are located within an onsite surface water drain that is fed by surface water runoff from surrounding lands (including the landfill in the case of the downgradient points). The monitoring locations tend to be dry frequently, leading to a shortfall of monitoring data.

SW3 is the outfall located due south of the flare compound. This location has not been monitored for a number of years and is not identified as a monitoring location in the Schedule to the waste licence.

A number of historical monitoring events for SW2 appear to have been carried out at the incorrect location (*i.e.* between Q2 2012 and Q1 2014). Historic results for SW2 are treated with caution in light of this information. Subsequent monitoring events will be carried out at the correct location.

6 HYDROGEOLOGY

6.1 Aquifer Classification & Vulnerability

The bedrock aquifer underlying the site is named the Castlebridge A-A Groundwater Body (GWB) which is classified as a **Poorly Productive** (PI) aquifer. This GWB is mapped within the large Castlebridge A GWB (264 km²) and considered as a separate GWB due to the presence of the landfill. A PI classification means that the bedrock is generally unproductive except for local zones. Typical yields are generally only sufficient for domestic water supplies. There are no groundwater wells downgradient of the site between the site and the River Slaney.

Although not represented on GSI mapping, shallow groundwater is present within the sand and gravel deposits on the site. Groundwater flow is interpreted to flow in a southwesterly direction towards the River Slaney in both the overburden and bedrock horizons.

The geophysical survey carried out by Apex Geoservices in 2005 indicated that the faulted or fractured zone in the bedrock in the south west of the site may also be a water bearing.

6.2 Aquifer Vulnerability

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost groundwater. This means that vulnerability relates to the permeability and thickness of the subsoils. A detailed description of the groundwater vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination (Fitzsimons et al, 2003).

The aquifer vulnerability rating for the site is mapped by the GSI as high based on limited regional database information. Based on the site-specific geological information, the site vulnerability is considered to be **high** due to the presence of a highly permeable glacial outwash deposits across the site (Appendix A Figure C).

The high vulnerability rating and poorly productive (PI) classification gives a resource protection classification of PI/H, which is deemed acceptable (*i.e.* R2₁) subject to guidance in the EPA Landfill Design Manual or conditions of a waste licence.

EPA Landfill Site Design Manual (EPA, 1999):

(R2₁ = Acceptable subject to guidance in the EPA Landfill Design Manual or conditions of a waste licence. Special attention should be given to checking for the presence of high permeability zones. If such zones are present, then the landfill should only be allowed if it can be proven that the risk of leachate movement to these zones is insignificant. Special attention must be given to existing wells downgradient of the site and to the projected future development of the aquifer.

6.3 Groundwater WFD Status

Work completed for the Water Framework Directive assigned 'Status' to Ground Waterbodies (GWB). The Castlebridge North GWB (IE_SE_G_031) surrounds the waste facility, which is a designated GWB itself, namely Waste Facility (W0016-02) (IE_SE_G_032).

Ground Waterbody WFD Status 2013-2018 (<https://gis.epa.ie/EPAMaps/>) indicates that the Waste Facility (W0016-02) (IE_SE_G_032) is of 'Poor' status and at Risk of not meeting its objective for good status by 2027 due to elevated ammonia concentrations because of the facility. The Castlebridge North GWB (IE_SE_G_031) is of 'Good' status and is not 'at risk'.

6.4 Hydrogeological Monitoring

The hydrogeology of the site has been interpreted based on a number of historical site investigations undertaken across the site. A total of 17 no. trial pits were excavated on site to depths of between 3.8m and 5.2mbgl. A total of 22 no. boreholes / monitoring wells were drilled and excavated over the site for both determination of substrata and monitoring purposes. Borehole logs are missing for a number of boreholes (*i.e.* all shallow GW wells, and bedrock wells GBH1 and GBH2); however available bedrock borehole logs (*i.e.* BR01 to BR07) indicate total depths ranging between 13.4 and 20.5 mbgl. Borehole and trial pit logs are included as Appendix B and C. The current groundwater monitoring well network is highlighted within Table 6.1.

6.5 Groundwater Recharge

The GSI groundwater recharge maps indicate that the annual average recharge is 100 mm/year with a recharge cap of 513 mm/year. Effective rainfall is given as 603 mm/year.

BH	Level (mOD)		Drilled Total Depth (mOD)	Bedrock		Description	Screen Level (mbgl ⁵)	Screen Level (mOD)	Horizon
	Ground Level	Well head (mOD)		mbgl	mOD				
GW1	N/A	3.79	-1.91	-	-	Downgradient, northwest of landfill.	N/A ⁴	0.79 - 1.91	OB ¹
GW9	N/A	1.60	-0.50	-	-	Downgradient, south of landfill.	1.0 – 7.0	0.60 - 0.50	OB
GW10	N/A	1.85	0.35	-	-	Downgradient, south of landfill.	1.0 – 7.5	1.35 – 0.35	OB
GW11	N/A	22.40	13.25	-	-	Upgradient, southeast of landfill.	1.0 – 7.5	19.40 – 13.25	OB
GW17	N/A	11.36	5.76	-	-	North of landfill	-	8.36 – 5.76	OB
GW18	N/A	10.97	5.44	-	-	North of landfill	-	7.97 – 5.44	OB
GW19	N/A	13.08	7.62	-	-	North of landfill	-	12.58 – 7.62	OB
GW21	N/A	-	-	-	-	Downgradient, south of landfill.	-	-	OB
GW22	N/A	-	-	-	-	Downgradient, south of landfill.	-	-	OB
GW23	N/A	-	-	-	-	Downgradient, south of landfill.	-	-	OB
GW24	N/A	-	-	-	-	Downgradient, southwest of landfill.	-	-	OB
GW25	N/A	-	-	-	-	Downgradient, southwest of landfill.	-	-	OB
GBH1 ³	N/A	9.68	4.46	-	-	Upgradient, north of landfill.	-	6.68 – 4.46	BDRK ²
GBH2 ³	N/A	13.83	6.53	-	-	Upgradient, northeast of landfill.	-	10.83 – 6.53	BDRK
BR01	N/A	14.5	13.4	7.4	-	Upgradient, northeast of landfill.	8.4 – 13.4	-	BDRK
BR02	N/A	2.0	17.7	8.66	-	Downgradient, south of landfill.	11.7 – 17.7	-	BDRK
BR03	N/A	2.2	18.8	-	-	Downgradient, south of landfill.	12.8 – 18.8	-	BDRK
BR04	N/A	2.0	20.0	-	-	Downgradient, south of landfill.	14.0 – 20.0	-	BDRK
BR05	N/A	2.3	16.0	9.0	-	Downgradient, south of landfill.	8.5 – 16.0	-	BDRK
BR06	N/A	1.4	19.2	-	-	Downgradient, southwest of landfill.	13.2- 19.2	-	BDRK
BR07	N/A	1.2	20.5	-	-	Downgradient, southwest of landfill.	14.5 – 20.5	-	BDRK

Note 1 OB = Overburden Installations **Note 2** BDRK = Bedrock Installation **Note 3** = No borehole logs **Note 4** N/A = Not Available **Note 5** mbgl = metres below ground level

Table 6.1 Borehole & Monitoring Well Details

6.6 Third Party Wells

A number of dwellings in the area utilise private groundwater wells for agriculture and domestic water supply purposes in proximity to the site. These are located either up hydraulic gradient of the site or across the Slaney River and are presented in Appendix A Figure D. A summary of the wells identified are summarised in Table 6.2 below.

GSI code	Distance from site	Usage	Depth (MoD)	Depth to bedrock (mOD)	Yield (m ³ /d)	Drill date
2911NWW017	0.49 km W of the site (across Slaney River)	Domestic	32	1.8	327.3	21/09/78
2911NWW021	0.88 km W of the site (across Slaney River)	Agricultural and domestic	50.6	-	65.5	-
2911NWW019	1.3 km SE of the site	Agricultural and domestic	49.1	-	5.5	18/05/66
2911NWW020	1.3 km SE of the site	Agricultural and domestic	48.8	-	6.5	Unknown

Table 6.2 Off-site Third-Party Wells

There are no known discharges to groundwater in the immediate vicinity of the site.

6.7 Permeability

Hydraulic conductivity (K) testing was undertaken within a number of monitoring wells (*i.e.* falling head tests) and from PSD test values from the 2005 site investigation. The following hydraulic conductivity levels were calculated:

Investigation ID	Depths (m)	K (m/sec)	Hydrostratigraphic Unit
TP2	1.2	2.5×10^{-3}	Sand & Gravels
TP3	2.5	9.6×10^{-6}	Sand & Gravels
TP4	1.0	1.28×10^{-5}	Sand & Gravels
TP5	1.9	4.8×10^{-6}	Sand & Gravels
TP7	1.9	2.7×10^{-4}	Sand & Gravels
Geometric Mean		5.25×10^{-5}	
BR03	-	8.3×10^{-7}	Bedrock
BR04	-	1.10×10^{-6}	Bedrock
BR05	-	7.3×10^{-7}	Bedrock
BR06	-	1.3×10^{-6}	Bedrock
Geometric Mean		9.65×10^{-7}	

Table 6.3 Hydraulic Conductivities

The hydrogeological properties of the waste material are typically difficult to predict but is likely to have a relatively low hydraulic conductivity and at the same time facilitate the flow of a significant quantity of leachate. Significant heterogeneities can exist due to the deposition methodology (*e.g.* thicker layers of daily cover may locally increase horizontal permeability). Therefore, the hydrogeological behaviour of a waste body is typically regarded as anisotropic, with high ratios of horizontal to vertical permeability.

The hydraulic conductivity levels were previously calculated from the Particle Size Distribution tests undertaken on the coarse-grained overburden using the Hazen method (see Table 6.3). It is noted that

the Hazen method becomes increasingly skewed as the grain size decreases and it is likely that these hydraulic conductivities are overly conservative with the likely value in the range of 10^{-4} m/sec.

It was reported that significantly elevated levels of hydraulic conductivity were noted in BR02 in comparison to the remaining bedrock monitoring wells. However, this data was not available for review as part of the compilation of this report. Assuming to be accurate, the increased conductivity is likely to be attributed to increased fracturing of the bedrock in this location and possibly associated with the fault-planes recorded on the geological map for the area and the geophysical survey.

6.8 Groundwater Levels & Flow Direction

- All groundwater levels recorded and associated graphs are provided in Appendix E. Note there are no groundwater levels recorded for boreholes GW11, GW17, GW18, GW19 or GW25.
- The original site assessment in 1985 interpreted a groundwater flow in a southwesterly direction towards the River Slaney at a relatively shallow gradient of approximately 0.1. Current groundwater levels confirm this flow direction. Groundwater levels and contours for August 2018 and December 2019 are presented in Figures 4 and 5.
- Groundwater seepages or strikes were encountered at various depths in Trial Pits TP2, TP3, TP4, TP5, TP6 and TP7, mostly as slight or small inflows. Depths to groundwater ingress ranged between 0.8 m (TP2) and 2.2 m (TP3).
- Groundwater strikes were also encountered in each of the rotary core boreholes ranging between 1.0 m (BR05) and 9.2 m (BR06).
- Groundwater levels have been recorded within 16 no. monitoring wells from March 2015 to December 2019 on various occasions. The levels, when recorded, provide a useful indication of seasonal variability in groundwater levels. Graphs of groundwater levels in both upgradient (Figure 6.1) and downgradient (Figure 6.2) monitoring wells are presented below and generally illustrate the following:
 - Groundwater levels remain broadly consistent over time, with only minor variations identified attributed to prevailing climatic conditions. During the drier months groundwater levels gradually decrease. During wetter periods where prolonged rain was recorded, levels of groundwater were noted to rise slightly over a number of months. It is noted that over time, groundwater levels within the downgradient wells recorded a slightly reducing trend over time i.e. within GW1, BR02, BR03, GW9, GW23 and GW24.
 - Groundwater within the overburden appears to be in hydraulic connection with the underlying bedrock and appears to act as a single groundwater unit across most of the site.
 - Although both wells are screened in the bedrock in proximity to each other, groundwater within GBH2 is consistently higher than groundwater levels within GBH1. Difference in levels range between 0.76 and 2.36 metres over time which may indicate varying permeability conditions in this area.
 - Groundwater or leachate discharge at the boundary of the landfill is likely to be occurring along preferential pathways that occupies a significant portion of the site.
 - Groundwater within both the overburden and bedrock is likely to be providing baseflow to the River Slaney. The effect of the reed beds between the waste body and the river on baseflow to the river remains unclear.

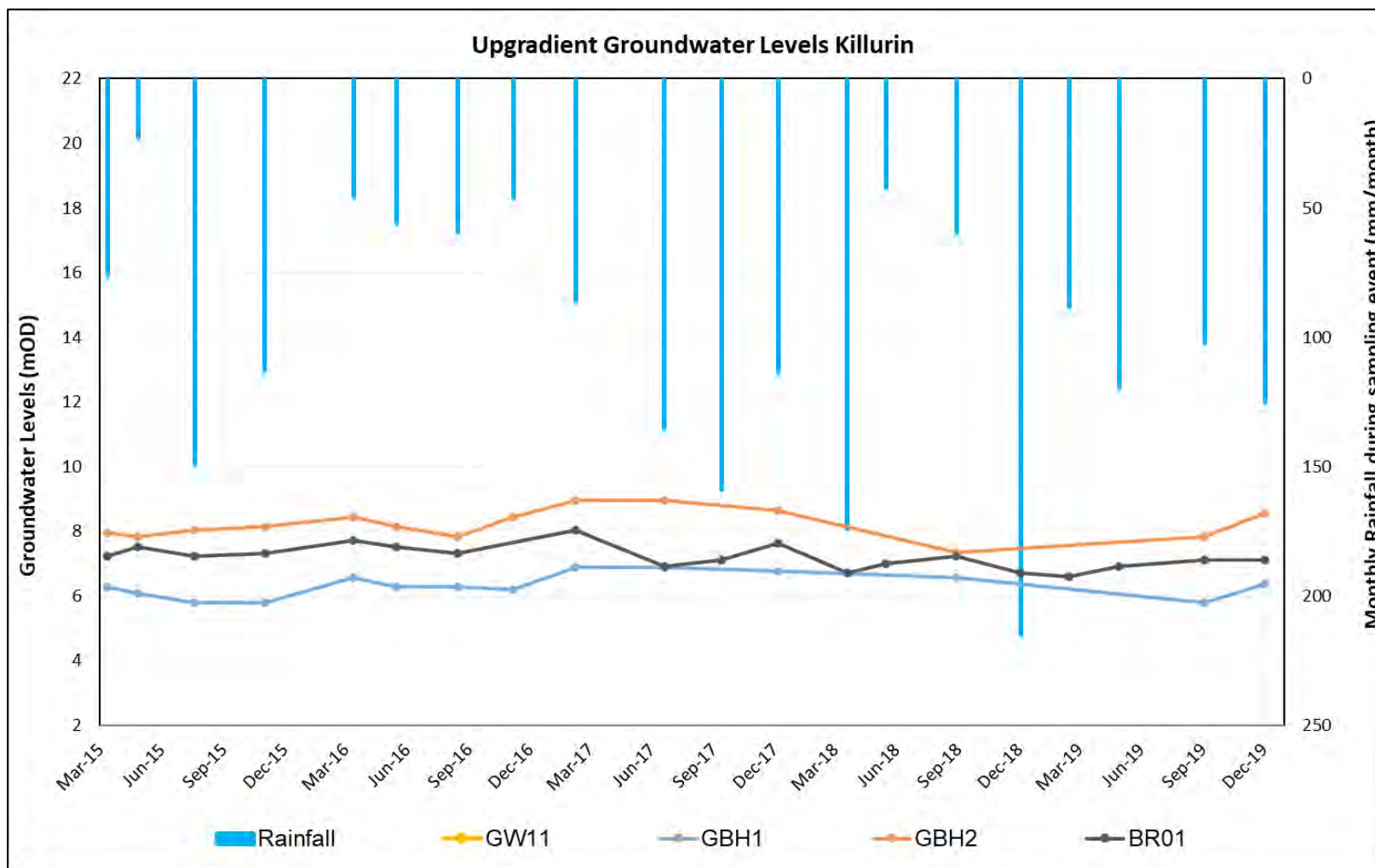


Figure 6.1 Upgradient Groundwater Levels

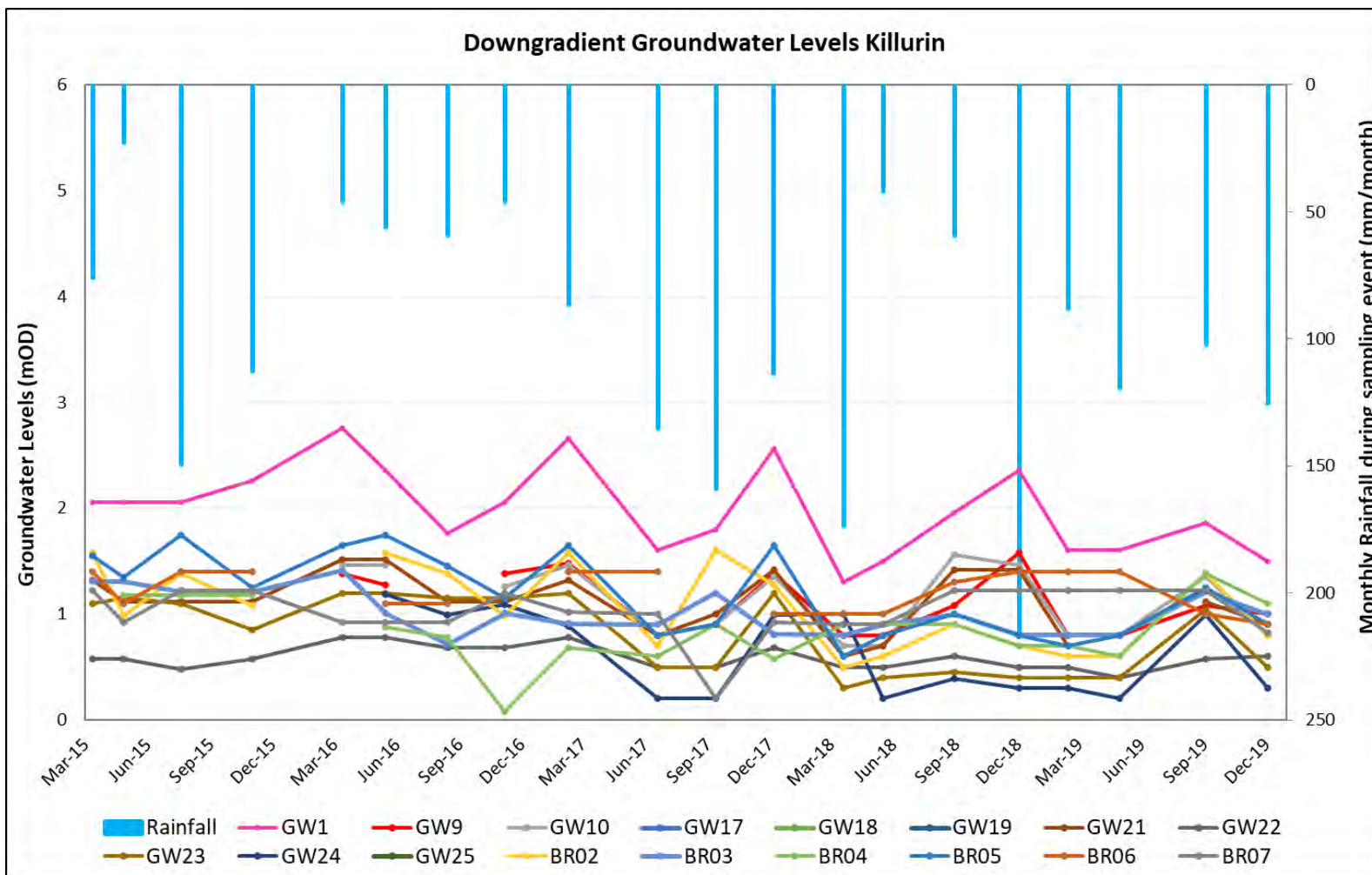


Figure 6.2 Downgradient Groundwater Levels

6.9 Leachate Levels

Leachate levels within the waste body were previously monitored on a monthly basis within 12 no. leachate wells installed within the waste body (*i.e.* LB2 to LB8 and LB12 to LB15). These LB wells are no longer used for leachate depth monitoring. The well liners kinked due to differential settlement and are no longer suitable for monitoring purposes.

The historical range of recorded leachate levels between 2008 and 2014 (LB well series) is provided below in Figure 6.3.

The current leachate levels between 2014 and 2019 (LE well series) are presented on Figure 6.4 below. (also see Appendix E).

The current leachate monitoring wells (*i.e.* LE12-1 to LE12-16, A wells and W wells) locations are presented on Figure 3a. The leachate levels for September 2019 are illustrated on Figure 6.

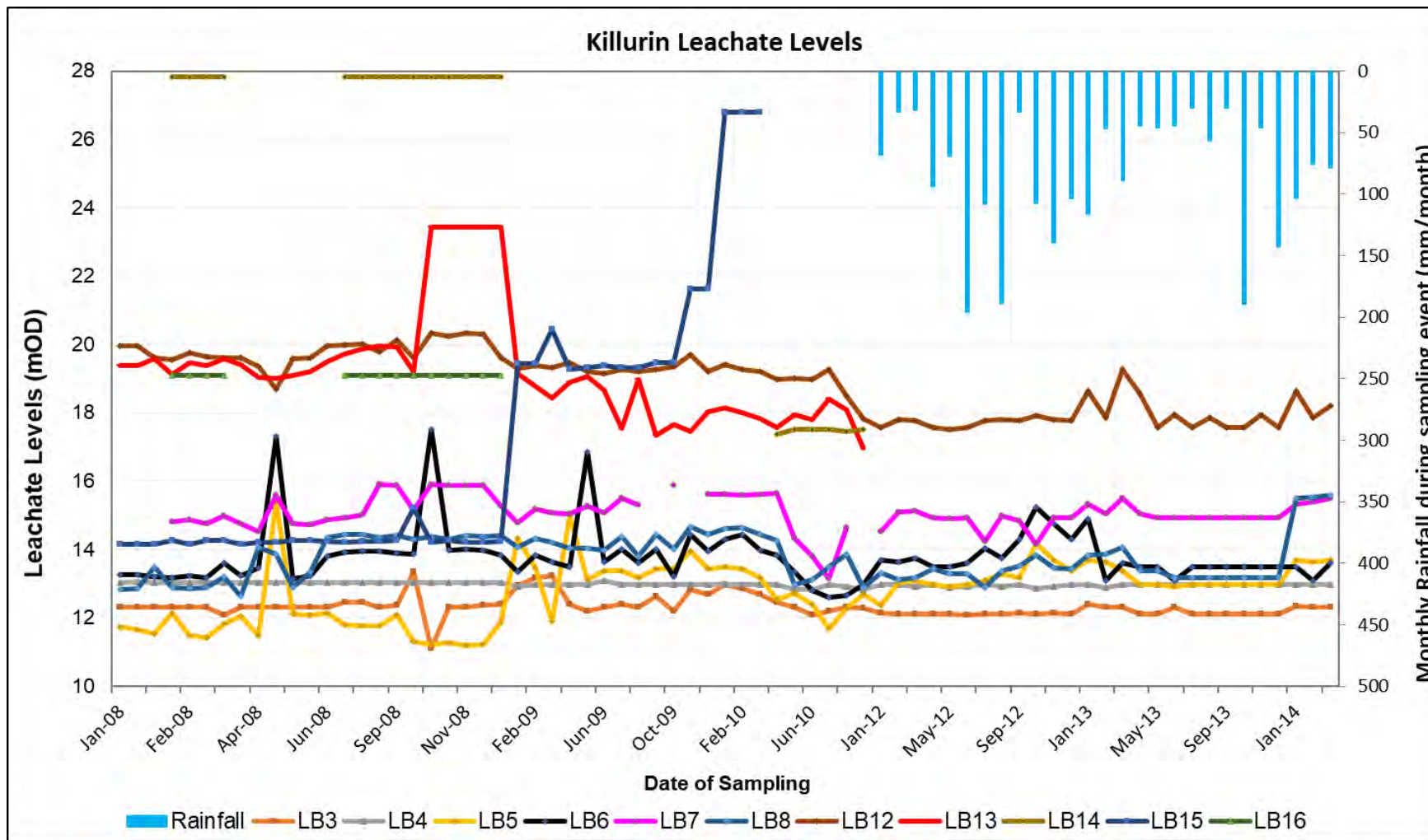


Figure 6.3 Historical Leachate Levels 2008-2014 (LB wells)

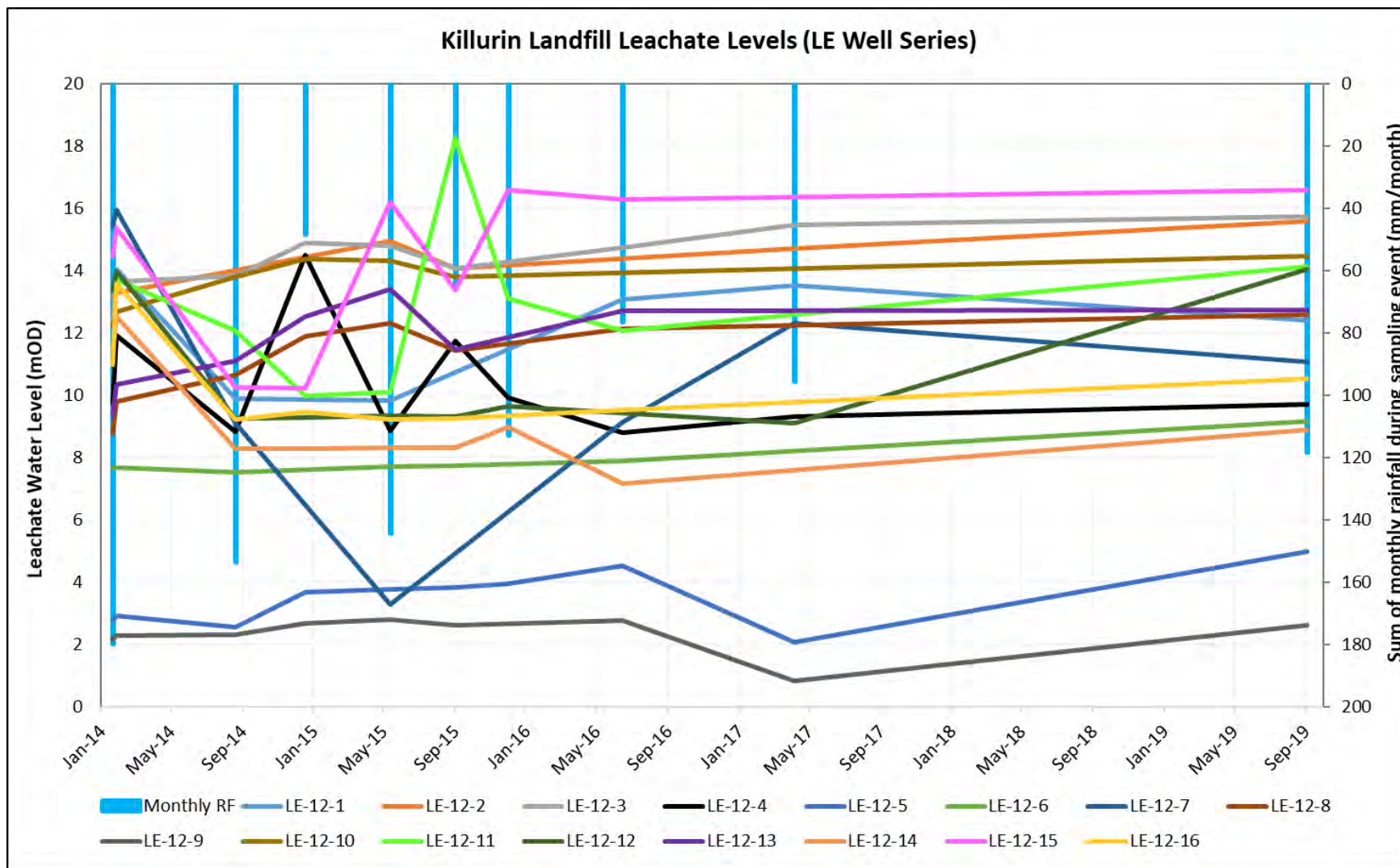


Figure 6.4 Current Leachate Levels (LE wells)

The recorded leachate levels suggest the following:

- Leachate levels within the current leachate monitoring wells have broadly ranged between 18.25 mOD (LE12-11, 01/09/2015) and 0.82 mOD (LE12-9, 05/04/2017). The highest levels are located in the central areas of the landfill coincident with the highest areas of waste deposition (*i.e.* top of the dome). The levels suggest that the leachate is broadly flowing radially from the centre of the waste mound
- The levels of leachate vary over distance and time within the waste body likely resultant from the effects of leachate abstraction from the waste body. Notable variations in levels were recorded between 2014 and 2016 with less 'spiked' levels recorded between 2016 and 2019.
- There are few leachate levels for 2017 and none for 2018. Based on the 2019 levels, several leachate levels appear have increased since 2016 within the landfill body; however, this may be resultant from the timing of when the dip was recorded between abstraction periods.
- No notable correlation between rainfall and leachate level variation was observed as expected most likely due to the capping effects of the landfill capping layer.
- The lower conductivity waste body in comparison to the underlying geological material appears to host a perched water body that reaches a significantly greater level than the surrounding areas. The leachate mound dominates the local groundwater flow pattern as is evident in Figure 6. The most recent review of leachate levels (*i.e.* September 2019) records a maximum of 20.4 mOD (*i.e.* A11) and a minimum of 2.6 mOD (*i.e.* LE12-9). Both these wells are on top of the mound.
- The lowest leachate levels were recorded within wells LE12-5 and LE12-9; however it is noted that these low-level leachate wells are in close proximity to wells with much higher leachate levels. This is likely to be due to the heterogeneous nature of the material within the waste body where compaction over time has resulted in locally and hydraulically discontinuous regions within the waste.

6.10 Conceptual Hydrogeological Regime

A conceptual understanding of the hydrogeological regime across Killurin Landfill is provided in Figure 7 and illustrates two groundwater bodies (*i.e.* within the waste body and a separate water body within the overburden/bedrock) that appear to be hydraulically connected. Groundwater within both the overburden and bedrock is likely to be providing baseflow to the River Slaney; however, the effect of the reed beds between the waste body and the river on baseflow to the river remains unclear.

The baseflow component to the River Slaney is considered to be predominantly via the overburden with a smaller proportion via the bedrock. This is interpreted by the recorded bedrock levels and channel floor levels of the proximate River Slaney.

Groundwater underlying the waste body is likely to be in contact with the waste body during periods of high rainfall thereby increasing the contaminant levels within groundwater at particular times of the year.

7 HYDROCHEMISTRY

Hydrochemical data was acquired from previous investigation and monitoring reports and Annual Environmental Reports (2014 - 2019) and databases supplied by Wexford County Council. The schedule of the waste licence requires the monitoring of certain parameters on either a monthly, quarterly or annual basis as outlined in Table 7.1.

Parameter	Surface Water Frequency	GROUNDWATER Frequency	LEACHATE Frequency
Visual Inspection	Weekly	Not Applicable	Not Applicable
Groundwater Level	Not Applicable	Quarterly	Not Applicable
Leachate Level	Not Applicable	Not Applicable	Weekly
Salinity	As agreed with the agency	As agreed with the agency	As agreed with the agency
Ammoniacal Nitrogen	Quarterly	Quarterly	Annually
BOD	Quarterly	Not Applicable	Annually
COD	Quarterly	Not Applicable	Annually
Chloride	Quarterly	Quarterly	Annually
Dissolved Oxygen	Quarterly	Quarterly	Not Applicable
Electrical Conductivity (EC)	Monthly	Monthly	Annually
Odour/Visual Inspection	Not Applicable	Monthly	Annually
pH	Monthly	Monthly	Annually
Total Suspended Solids	Quarterly	Not Applicable	Not Applicable
Temperature	Quarterly	Quarterly	Quarterly
Boron	Annually	Annually	Annually
Cadmium	Annually	Annually	Annually
Calcium	Annually	Annually	Annually
Chromium (total)	Annually	Annually	Annually
Copper	Annually	Annually	Annually
Cyanide (total)	Not Applicable	Annually	Annually
Fluoride	Not Applicable	Annually	Annually
Iron	Annually	Annually	Annually
Nickel	Annually	Annually	Annually
Lead	Annually	Annually	Annually
List I/II organic substances	Once-off	Annually	Once-off
Magnesium	Annually	Annually	Annually
Manganese	Annually	Annually	Annually
Mercury	Annually	Annually	Annually
Potassium	Annually	Annually	Annually
Sulphate	Annually	Annually	Annually
Sodium	Annually	Annually	Annually
Total Alkalinity	Annually	Annually	Not Applicable
Total Phosphorus or Orthophosphate	Annually	Annually	Annually
Total Oxidised Nitrogen	Annually	Annually	Annually
Total Organic Carbon	Not Applicable	Quarterly	Not Applicable
Residue on Evaporation	Not Applicable	Annually	Not Applicable

Arsenic	Annually	Annually	Annually
Barium	Annually	Annually	Annually
Selenium	Annually	Annually	Annually
Silver	Annually	Annually	Annually
Phenol	Annually	Annually	Annually
Zinc	Annually	Annually	Annually

Table 7.1 Water Quality Monitoring Parameters

In order to identify temporal trends, leachate, groundwater and surface water quality results were graphed over time for the selection of parameters for which data had been collected on a monthly, quarterly or annual basis (see Appendix F and Appendix G).

In keeping with the source-pathway-receptor concept, the data was interpreted under the following sub-sections:

- Source = Leachate quality
- Pathway = Groundwater quality
- Receptor = Groundwater & Surface water quality

Groundwater and on-site surface water monitoring points used to analyse water quality at various locations are outlined in Figure 3.

7.1 Leachate Quality Results

Leachate quality is monitored on an annual basis from the leachate collection tank on site.

Leachate quality can vary during the lifetime of landfill sites depending on the phase of decomposition. In terms of the overall suite of parameters analysed, raw leachate results from the landfill have been compared to “Typical Leachate Composition of 30 Samples from UK/Irish Landfills accepting mainly Domestic Waste” (Landfill Operational Practices).

On-going monitoring of leachate quality from the collection tank prior to pumping to the leachate storage tanks is maintained at the facility. The most recently reviewed annual monitoring data (*i.e.* Q3 2019) demonstrated that the concentrations have decreased or remained stable for the majority of the leachate quality parameters compared to those obtained for the previous reporting period (2018). Iron shows an increasing trend from 2016 to 2019 from 1.52 to 6.01 mg/l.

The quality is generally indicative of a landfill in the methanogenic stage of decomposition of organic compounds *i.e.* conversion of organic compounds to landfill gas and the leachate test results are provided below in Table 7.2.

Parameter	Level	Parameter	Level
Temperature °C	15.4	Cadmium µg/l	<0.08
Ammonia mg/l N	249	Calcium mg/l	124
BOD mg/l O2	34	Chromium µg/l	8.59
COD mg/l O2	251	Sodium mg/l	269
Chloride mg/l Cl	378	Copper µg/l	5.4
Conductivity µS/cm	4140	Iron mg/l	6.01
Fluoride mg/l F	<0.5	Lead µg/l	0.292
Mercury ug/l	<0.01	Magnesium mg/l	61.7
Total Oxidised Nitrogen mg/l N	5.46	Manganese µg/l	386
Ortho-Phosphate mg/l P	<0.02	Zinc µg/l	12.6
pH	7.4	Nickel µg/l	28.7
Sulphate mg/l SO4	5.8	Cobalt µg/l	nm
Boron µg/l	1130	Selenium µg/l	nm
Potassium mg/l	187	Molybdenum µg/l	nm
Antimony Ng/l	nm	Thallium µg/l	nm
Arsenic Ng/l	nm	Uranium µg/l	nm
Barium Ng/l	nm	Vanadium Ng/l	nm
Beryllium Ng/l	nm	Nitrite mg/l N	nm
Aluminium Ng/l	nm		

*Note: nm 'no monitoring' in 2019. For previous result see Appendix F.

Table 7.2 Leachate Quality Results 2019

A review of leachate quality between 2015 and 2019 within the existing leachate monitoring wells was undertaken (see Appendix F).

The following leachate wells (40 no.) were sampled between 2015 and 2019 for the parameters Temperature, Ammonia, Chloride, Conductivity, pH, COD and BOD:

A1, A2, A3, A4, A5, A7, A8, A9, A10, A12, W1, W5, W10, W12, W13, W27, W31, W33, W34-W45 and LE-12-1/2, LE12-4, LE12-7, LE12-11/12, LE-12-14/15/16.

A summary of the leachate trend data is provided in tables and graphs in Appendix F. The main findings of the leachate review are as follows:

- Leachate concentrations of Ammoniacal Nitrogen over time appear to be broadly reducing over time within 23 no. wells. Steady state trends were recorded within 7 wells and slightly increasing trends within 8 no. wells. Of the remaining 2 wells, well A3 has no data available between 2015 and 2019 and well LE12-2 has one recorded elevated level in May 2015 (i.e. 1,786 mg/l) and no subsequent data recorded since.
- Leachate concentrations of Chloride over time appear to be reducing within 17 no. wells. Steady state trends were recorded within 14 no. wells and increasing trends recorded within 3 no. wells and stable with a slightly increasing trend in 5 no. wells. Currently, the wells with rising Chloride trends appear to be as a result of spikes recorded in 2019 and include W5, W34, W35 & W37. A summary of the chloride trend data is provided in Appendix F.
- Conductivity levels over time are reducing in 20 no. wells, increasing in 7 no. wells, are stable in 6 no. wells and are stable with a slightly increasing trend in 5 no. wells. Currently the wells with rising trends are W34, W35, W36, W43, LE12-4, LE12-7 and LE12-14. Wells W1 and W5 on the northern boundary are stable but had spikes in 2018/19 which resulted in an upward trend. With the exception of LE12-14, which is near W1 and W5, the wells with rising trends are located in the southern area between the landfill and the river (Figure 3a). As with Chloride, the rising trend in W34, W35 & W37 appear to be as a result of spikes recorded in 2019. A summary of the conductivity trend data is provided in Appendix F.
- Sampling from the 10 no. A-wells, located within the vertical extension of the waste body, recorded stable to slightly rising Ammoniacal Nitrogen trends in wells A2 and A8 (it is noted that

the last sampling date was Oct-16), and stable to slightly rising Chloride concentrations in wells A4, A8, A9 and A10. The remaining wells exhibit reducing or stable trends.

- Four (4 no.) of the 17 no. W-wells, located around the southern perimeter of the waste body, were recorded with increasing Ammoniacal Nitrogen trends over time (i.e. W27, W34, W35, W36). Three (3 no.) of the W-wells were recorded with increasing Chloride levels and these trends correlate with the Ammoniacal Nitrogen trends in similar wells (i.e. W34, W35, W36). The W wells along the norther perimeter show the highest ammonia levels of the W series, however the trends are noisy and appear to be stable or reducing (wells W 1,5,10,12,13).
- Of the 9 LE wells, located within the original waste body and north of the access road, Ammoniacal Nitrogen and Chloride levels are reducing within 5 no. wells. Well LE12-11 has fewer data than most and was last monitored in Oct-16. Well LE12-2 was only sampled once in May-15 and recorded elevated levels of Ammoniacal Nitrogen (1,786 mg/l) and Chloride (2,280 mg/l).
- The above trends within the A-wells and W-wells are based on a monitoring period between 2015 and 2019. The capping works were completed in 2014 and therefore the trends take into account the effects of the full landfill cap installed across the waste body. The trend analysis undertaken indicates that the leachate strength is broadly reducing over time with slightly increasing trends in a notably smaller proportion of wells. These slightly increasing trends are not unexpected based on the heterogeneous nature of the waste material and are expected to reduce over time.
- No notable correlation between leachate quality and rainfall events is evident from the chemical data.
- It is noted that the wells with increasing trends are predominantly located in the eastern region of the waste body. Leachate concentrations appear to be greatest in the central region of the landfill. Lower strength leachate was recorded in wells close to the perimeter of the waste body (with the exception of wells W34 to W36).
- Notably lower levels of chloride and ammoniacal nitrogen in comparison with other wells were recorded within wells LE-12-7 and W1 which suggests a possible influence from the underlying groundwater body.
- The strength of the leachate appears to be significantly lower within the tanks in comparison to the leachate wells which suggest that dilution of the leachate is occurring through mixing stronger leachate with weaker leachate in the extraction system.
- Based on the EPA IGVs¹ and the GTVs², within the leachate collection tank, several elevated parameters were recorded from 2015 to 2019 (see Appendix F) and include:
 - Aluminium, Ammonia, Arsenic, Boron, Chromium, Copper, Conductivity, Chloride, Iron, Magnesium, Manganese, Nickel, Nitrite, Orthophosphate Potassium, Sodium, Zinc
 - The levels appear to be reducing over time with the exception of Iron which was 3.8 mg/l in 2015 and 6.01 mg/l in 2019.

¹ EPA Interim Guideline Values

² European Communities Environmental Objectives (Groundwater) Regulations 2010/16

7.2 Groundwater Quality

As required under the Waste Licence, groundwater monitoring program is undertaken within both upgradient and downgradient wells at the site *i.e.* wells GW1, GW9, GW10, GW11, GW21, GW22, GW23, GW24, GW25, GBH1, GBH2, BR01, BR02, BR03, BR04, BR05, BR06 and BR07.

The groundwater monitoring wells are installed within both the bedrock (BR) and overburden (GW and GBH) wells. In the following subsections and in accordance with previous monitoring rounds, the following parameters are discussed:

- Ammoniacal Nitrogen;
- Chloride;
- Electrical Conductivity (EC); and,
- Total Organic Carbon (TOC).

Ammoniacal Nitrogen is utilised as the key parameter in examining groundwater quality. Due to the estuarine nature of the site and the presence of the extensive reed beds, the suite of typical parameters (*e.g.* Electrical Conductivity, Total Organic Carbon and Chloride) suitable for groundwater quality assessment is relatively limited.

All groundwater quality data and graphs are provided in Appendix F.

A summary of the upgradient and downgradient graphs for Ammoniacal Nitrogen are provided below in Figure 7.1 to Figure 7.3 for ease of reference. All groundwater results were compared with the EPA Interim Guidelines Values (IGVs) and the EC Environmental Objectives (Groundwater) Regulations 2010 (S.I. No. 9 of 2010) and amended in 2016 (S.I. No.366 of 2016) which are referred to as GTVs (*i.e.* Guideline Threshold Values).

7.2.1 Upgradient Monitoring Wells

Monitoring wells BR01, GBH1, GBH2 and GW11 were interpreted as upgradient monitoring locations relative to the waste body. GW1 was originally interpreted to be upgradient of the site and screened within the overburden. However, as detailed in Section 7.1, the presence of the leachate mound appears to have impacted on the groundwater quality in this well and it is therefore is no longer considered to be representative of upgradient groundwater quality conditions.

No chemical analysis was undertaken within monitoring wells GW17, GW18, GW19, GW26 or GW27 as they have been consistently dry since 2002.

- **BR01 (bedrock well)**

The GTV for **Ammoniacal Nitrogen** is (*i.e.* 0.175 mg/l). Levels of Ammoniacal Nitrogen recorded between 2015 and 2019 below the GTV and ranged between <0.01 and 0.029 mg/l. One isolated significant exceedance was recorded in BR01 in December 2018 (*i.e.* 35.7 mg/l). It is unclear if the level is a reporting error by the laboratory as all subsequent levels returned to background levels in subsequent monitoring events. It is noted that the laboratory limit of detection was <0.2 mg/l for nine rounds which is slightly above the GTV. The levels are generally considered to be representative of upgradient groundwater quality to the site.

TOC levels recorded a positive detection (1.2 mg/l) in Mar-15 and since then all levels were recorded below the laboratory LOD (<1.0 & <3.0). **pH** levels typically remain neutral (*i.e.* between 6.8 and 8.3) with one isolated reduced level 6.4 detected. **EC** levels remain relatively consistent over time (ranging between 561 and 619 μ S/cm). **Chloride** levels remain consistent over time with no exceedance above the GTV (*i.e.* 187.5 mg/l) recorded to-date.

- **GBH1 & GBH2 (bedrock wells)**

Elevated levels of **Ammoniacal Nitrogen** above the GTV of (0.175 mg/l) were recorded on a number of occasions within bedrock monitoring wells GBH1 and GBH2 between 2015 and June 2019. Isolated and elevated levels ranged between 0.26 and 24 mg/l before returning to background levels. These

detections suggest the presence of a pathway between the waste body and the bedrock aquifer; however, the levels are generally stable over time and have been predominantly below the GTV during this more recent period of time. It is again noted on several occasions the laboratory limit of detection was <0.2 mg/l which is above the GTV).

- **GW11 (overburden well)**

Monitoring data for GW11 is limited to 4 no. rounds from March-15 to March-16. All detections of **Ammoniacal Nitrogen** within this monitoring period were recorded below the GTV (Appendix F). Slightly elevated and isolated levels were occasionally detected ranging between 0.15 and 0.44 mg/l between 2006 and 2008 with no elevated detections recorded since.

7.2.2 Downgradient Monitoring Wells

A description of all groundwater quality is provided in the following sections. The data has been graphed as presented in Figure 7.1 to Figure 7.3 and Appendix F.

- **GW1 (overburden well)**

Elevated levels of **Ammoniacal Nitrogen** were recorded between 2008 and 2014 ranging between 6.0 and 9.5 mg/l. The current levels from 2015 to 2019 range between 7.05 and 12.4 mg/l. These levels represent an impact from landfill leachate with broadly steady state conditions recorded since completion of the capping works in 2014.

The remaining parameters analysed (*i.e.* **TOC, Chloride, pH and EC**) have remained broadly steady with occasionally slight increases during the monitoring period to-date.

- **GW9 (overburden well)**

Consistently elevated levels of **Ammoniacal Nitrogen** were recorded within this monitoring well ranging between 6.4 and 20.7 mg/l. The levels are still consistently elevated but demonstrate a generally downward trend over time.

The remaining parameters analysed (*i.e.* **TOC, Chloride, pH and EC**) have remained broadly steady with occasionally slight increases during the monitoring period to-date with no obvious impact from landfill leachate.

- **GW10 (overburden well)**

Slightly and occasionally elevated levels of Ammoniacal Nitrogen were recorded within GW10 over time with no obvious trend apparent. The levels suggest the well is partially impacted by the leachate body and is also likely to be also affected by the proximity to the extensive and adjacent reed beds. Two exceedances of 1.1 and 8.8 were recorded between 2015 and 2019. (It is noted on several occasions the laboratory limit of detection was <0.2 mg/l which is above the GTV. The remaining parameters analysed (*i.e.* **TOC, Chloride, pH and EC**) remain low and stable.

- **GW21 (overburden well)**

Consistently elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within this monitoring well with levels ranging between 13 and 63 mg/l between 2015 and 2019. The levels remain consistently elevated but have been steadily reducing since February 2008 with the most recent level recorded at 24 mg/l in October 2019. The remaining parameters analysed (*i.e.* **TOC, Chloride, pH and EC**) are within normal range and exhibit a steady or reducing trend over time.

- **GW22 (overburden well)**

Consistently elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within this monitoring well with levels recorded between 42 and 67 mg/l between 2015 and 2019. The levels have been steadily reducing over time but remain elevated in 2019 at a level of 47.7 mg/l. The remaining parameters analysed (*i.e.* **TOC, Chloride, pH and EC**) are within normal range and exhibit a steady or reducing trend.

- **GW23 (overburden well)**

Consistently elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded ranging between 22 and 47 mg/l with a downward trend evident between 2016 and 2019. The levels are still consistently elevated above the GTV but appear to have stabilised at approximately 30 mg/l. The remaining parameters analysed (*i.e.* **TOC, chloride, pH and EC**) are within normal range and exhibit a steady or reducing trend.

- **GW24 (overburden well)**

Consistently elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within this monitoring well with levels ranging up to 94 mg/l. It is noted that these levels represent a significantly lower level than historically recorded with levels up to 380 mg/l previously detected. However, the trend is upward since 2015.

The recent levels recorded remain elevated between 23 and 94 mg/l and continue to exhibit elevated spikes over time. **TOC and pH** are within the normal range. **Chloride and EC** exhibit occasional elevated spikes and the increasing trend is due to large spikes in 2018. The chloride and EC have returned to baseline levels in 2019.

- **GW25 (overburden well)**

Elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded over the monitoring period ranging between 1.2 and 79.3 mg/l with wide variations recorded over time. The current levels remain consistent and represent a downward trend over time but only slightly elevated ranging between 1.7 and 3.5 mg/l in 2019. **TOC and pH** are within the normal range. **Chloride and EC** exhibit occasional elevated spikes and the increasing trend is due to large spikes in 2018. The chloride and EC reduced back to baseline levels in early 2019 before spiking again at lower levels to 2018.

The levels recorded between 2015 and 2019 represent a steady state trend over time.

- **BR02 (bedrock well)**

Elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within this monitoring well ranging between 19 and 25 mg/l. The levels remain consistently elevated over time; however, they represent a broadly steady state trend over time. **TOC and pH** are within the normal range. **Chloride and EC** levels recorded within this well appear to represent a slightly increasing trend but remain low and significantly below the GTV.

- **BR03 (bedrock well)**

Elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within this monitoring well ranging between 67 and 86 mg/l. The levels remain consistently elevated over time but have been steadily reducing since 2015. **TOC** spiked at 27 mg/l in 2016 but displays a decreasing trend over time. **pH** levels are within the normal range. **Chloride and EC** levels display a downwards trend and are below the GTV.

- **BR04 (bedrock well)**

Elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within this monitoring well ranging between 21.5 and 52 mg/l. The levels remain consistently elevated over time but have been steadily reducing since 2015. **EC, chloride, and TOC** levels are low and display a downward trend over time. **pH** levels are within the normal range.

- **BR05 (bedrock well)**

Elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within BR05 ranging between 82 mg/l and 67.2 mg/l since 2015. **EC, chloride, and TOC** levels are low and display a downward trend over time. **pH** levels are within the normal range.

- **BR06 (bedrock well)**

Elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within BR06 ranging between 2.71 and 10.8 mg/l between 2015 and 2019. The levels are still consistently but slightly elevated and represent a steady state trend over time. **TOC and pH** are within the normal range. **Chloride and EC** levels recorded within this well appear to represent a slightly increasing trend but are at moderate levels and below the GTV.

- **BR07 (bedrock well)**

Slightly elevated levels of **Ammoniacal Nitrogen** above the GTV were recorded within BR07 ranging between 0.13 and 0.3 mg/l between 2015 and 2019. The levels appear to be consistently reducing over time since 2015. (It is noted on several occasions the laboratory limit of detection was <0.2 mg/l)

The Chloride levels is higher than the other downgradient bedrock wells, but it is consistently reducing and is currently below the GTV. A significant spike in conductivity was observed in Apr-19 (14658 us/cm) which does not correlate with the other parameters. This spike was removed from the graph, the moderate EC levels display a reducing trend over time. **TOC and pH** are within normal ranges.

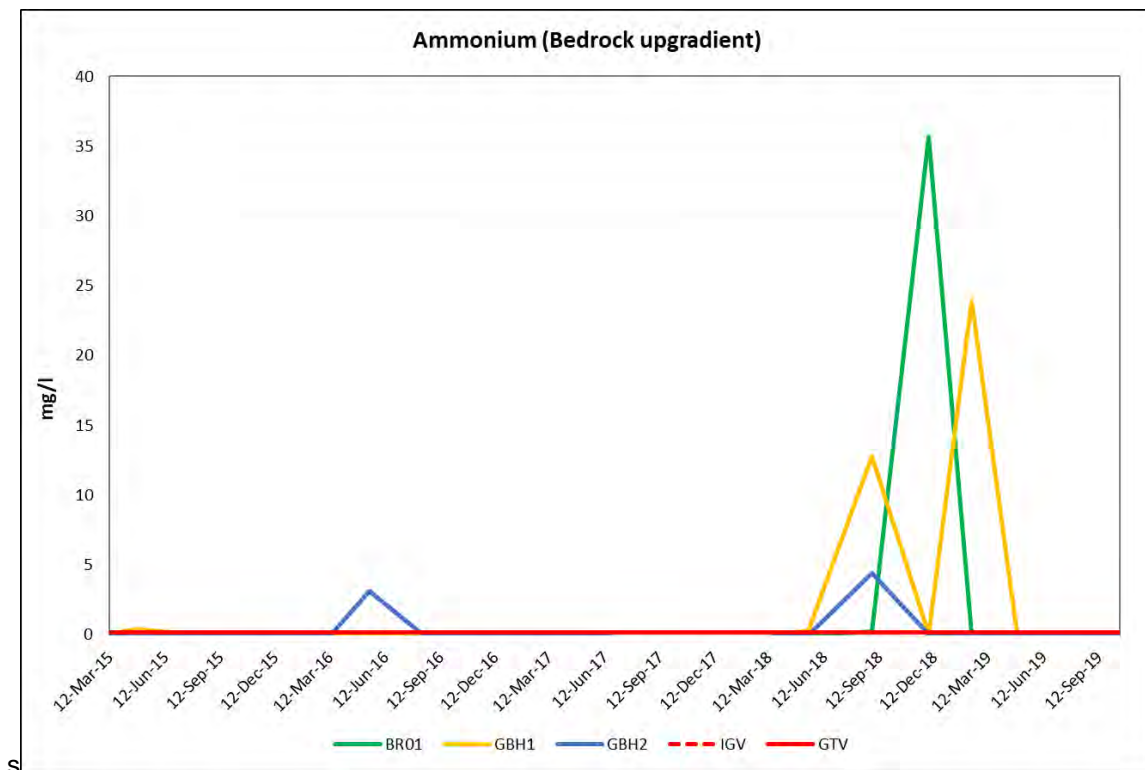


Figure 7.1 Upgradient Ammoniacal Nitrogen Levels (Bedrock)

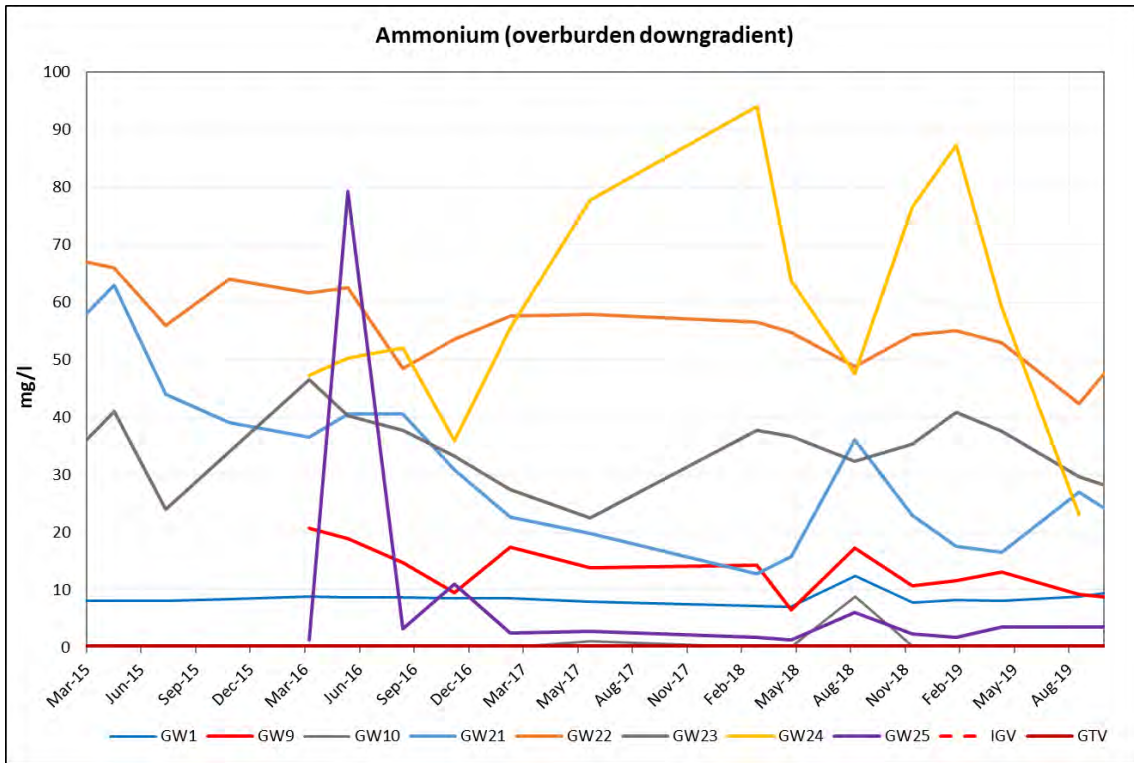


Figure 7.2 Downgradient Ammoniacal Nitrogen Levels (Overburden)

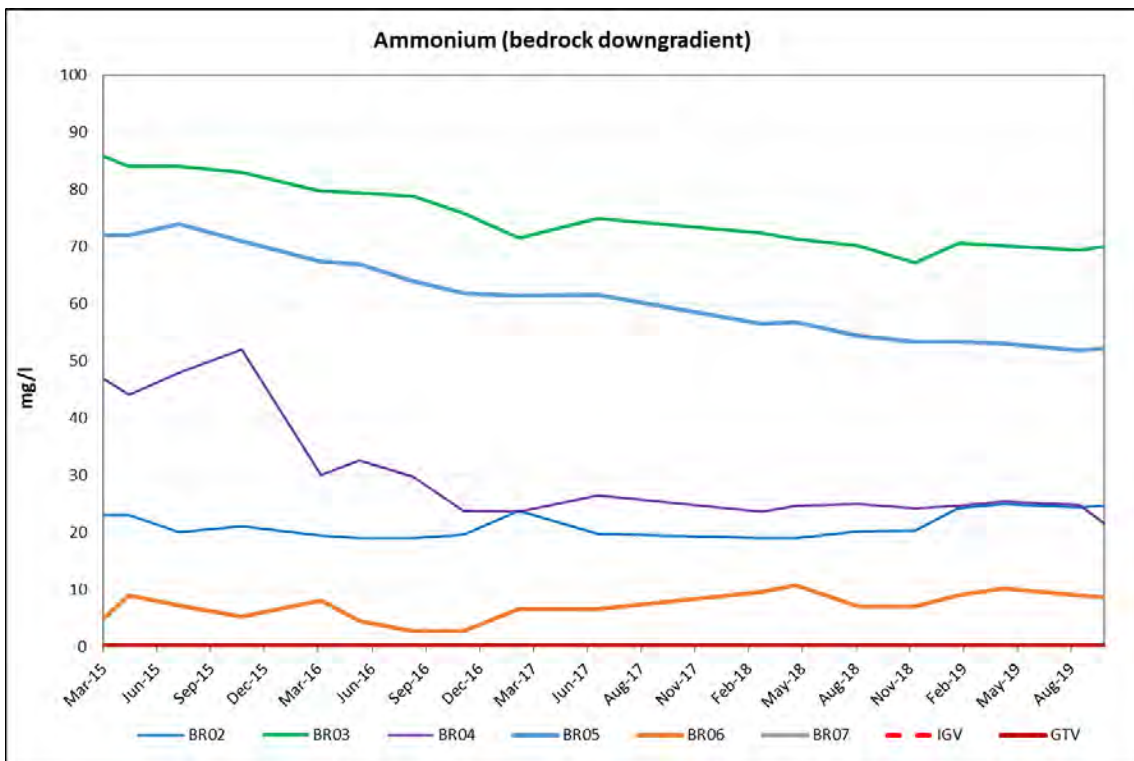


Figure 7.3 Downgradient Ammoniacal Nitrogen Levels (Bedrock)

7.2.3 Groundwater Data Summary

The following observations were made on completion of a review of all available groundwater quality data for the site (2015 – 2019 period) and are summarised in Table 7.3 below:

- The main parameter of note that is considered most representative of leachate, given the proximity of the site to an estuarine water body and an extensive reed bed habitat, is Ammoniacal Nitrogen. Other parameters such as EC, Total Organic Carbon and Chloride are likely to be partially impacted by the reed beds in the southern region of the site and less effective in identifying landfill leachate.
- Upgradient bedrock monitoring wells demonstrate an occasional impact from the waste body (i.e. Ammoniacal Nitrogen and TOC spikes) above the GTVs but generally have recorded levels below the GTVs. Chloride and EC are reducing over time and are consistently recorded below the GTVs.
- Off-site overburden well, GW11 (115m to the southeast of the landfill) does not record an impact from the landfill waste body.
- An impact by the waste body on groundwater in the downgradient monitoring wells is evident with no obvious difference in concentrations between overburden and bedrock wells. The impact from the leachate appears to be focused in the southwestern region between BR02 and BR05 with the highest concentrations of Ammoniacal Nitrogen in an area between BR03 and BR05 (i.e. ranging between 52 and 70 mg/l in October 2019). Leachate impacts were also detected in shallow well GW24 (23mg/l) with significantly lower levels recorded in GW25, BR06 and BR07 (i.e. ranging between 0.02 and 8.7mg/l in October 2019). A schematic of the levels recorded in October 2019 is presented in Figure 8.
- The Ammoniacal Nitrogen levels in GW1 appear to have stabilised with no obvious upward or downward trend apparent since 2015. This shallow overburden well is not considered to be an upgradient well, rather a side gradient well that has been partially impacted by the waste body.
- The highest levels of Ammoniacal Nitrogen recorded in 2019 were generally recorded within monitoring wells GW21 to GW24 and BR02 to BR05 located along the southwestern boundary of the waste body. The elevated levels of Ammoniacal Nitrogen ranged between 21.5 and 70.0 mg/l.
- Contaminant level trends within overburden groundwater monitoring wells continue to improve over time with the levels either static or consistently reducing over time - Ammoniacal Nitrogen levels in particular. The levels of Ammoniacal Nitrogen demonstrate a downward or steady state trend over time, with the exception of monitoring well GW24 which has no obvious trend and fluctuated between 94 and 23 mg/l with the lowest level recorded in 2019.
- The contamination levels recorded within GW25 spiked in May-16 and then reduced significantly and are now stable ranging between 1.7 and 3.5 mg/l in 2019. Levels within GW10 indicate that the well is only partially impacted by leachate with occasional elevated levels recorded.
- Contaminant level trends within downgradient bedrock monitoring wells BR05 and BR03 appear to be reducing steadily over time. The elevated levels within BR02, BR04, and BR06 are relatively static since 2016. BR07 has the lowest levels of ammonia of the downgradient bedrock monitoring wells, the levels range between 0.02 and 0.3 mg/l, after a spike in 2018 the levels are again low and reducing although remain above the GTV.
- Table 7.3 provides a summary of the contaminant levels within each well and a predicted date of achieving the GTV standard or lower based on identified downward trend analysis. The extrapolated trends are presented in Appendix F.

Well	Details / Trends	Predicted approx. date to achieve GTV
Bedrock Well		
BR01 (upgradient)	With the exception of the spike in Dec-18, the levels are stable and improving over time.	Already achieved
GBH1 (upgradient)	Occasional elevated spikes, generally stable over time and frequently below the GTV.	Already achieved
GBH2 (upgradient)	Occasional elevated spikes, generally stable over time and frequently below the GTV.	Already achieved
BR02	Generally stable / slightly increasing trend over time with minimal improvement since 2014.	Upward
BR03	Quality significantly elevated but reducing slowly, static since 2018.	2030+
BR04	Consistently elevated but quality is steadily improving over time.	2023
BR05	Consistently elevated but quality steadily improving over time since 2012.	2029
BR06	Consistently elevated, quality static since 2015. Displays an increasing trend.	Upward
BR07	Quality improving over time since 2014.	2021
Overburden Well		
GW1	Quality remains static since November 2008.	Upward
GW9	Consistently elevated but quality steadily improving over time.	2024
GW10	Quality static below GTV with occasional exceedance.	Already achieved
GW21	Consistently elevated but quality steadily improving since 2008.	2022
GW22	Consistently elevated but steadily reducing over time and currently stable since 2010.	2030+
GW23	Consistently elevated but steadily reducing over time	2030+
GW24	Consistently elevated but quality steadily improving albeit with elevated spikes. Displays an increasing trend.	Upward
GW25	Current levels are still consistently elevated but are low and reducing over time.	2022

Table 7.3 Summary of Groundwater Quality results (2015 – 2019)

7.3 Surface Water Quality

The surface water regime on site consists of a series of open and piped drains on-site and is monitored at 4 no. locations (SW1 to SW4) within the site footprint and 3 no. locations within the River Slaney (S1, S2 & S3).

The objective of surface water monitoring programme is to screen for environmental pollution due to facility operations. Surface water monitoring is monitored on a quarterly basis using grab sampling techniques.

Surface water monitoring data is available from 2015 to 2019 (on-site) and 2015 to 2018 River Slaney. All data is summarised and graphed in Appendix G.

The results were compared with the Waste Licence (Suspended Solids) and the EC Environmental Objectives (Surface Water) Regulations (SI 272 of 2009). The river is tidal in the vicinity of the landfill and continue to be tidal north as far as Enniscorthy.

There are no data for SW3 which was dry during all sampling events. The sampling locations on the site are SW1, SW2, and SW4. The on-site locations SW1 to SW4 are presented on Figure 3.

The monitoring locations in the River Slaney are S1, S2 and S3. S1 is located upstream of the landfill, monitoring location S2 is slightly upstream of the landfill and monitoring location S3 is located downstream of the landfill. All are located within the tidal zone of the river estuary (see Figure 7.4).

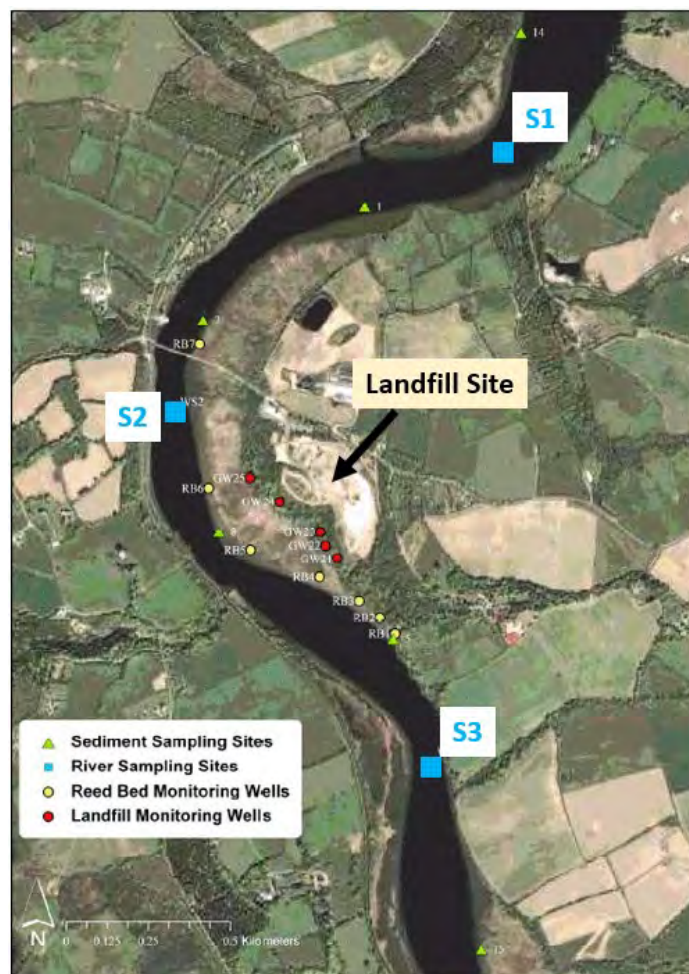


Figure 7.4 River Slaney Sampling Sites

7.4 Surface Water Quality Discussion

7.4.1 On-site Surface Water Drains Sampling Results

- Historically, Ammonia levels within the on-site surface water drains have tended to be highest within SW2 and this remains to be the case. Ammonia levels demonstrate a rising trend since 2015 within SW2 with spikes of up to 3.4 mg/l indicating an impact from the waste body.
- Ammonia levels are notably lower within in SW1 and SW4 but consistently above the EQS of 0.02 mg/l. The levels within SW1 and SW4 monitoring locations are frequently below the Good Status quality objective (mean, MAC levels) set out in SI 272/2009 with one exceedance noted.
- Chloride levels within all sampling locations ranged between 15 and 165 mg/l (i.e. below the EQS).
- Electrical Conductivity levels ranged between 236 and 872 us/cm (below the EQS). Levels within SW2 displays a slightly increasing trend while SW1 and SW3 levels display a reducing trend.
- The sampling locations on the site record some variability in the levels of BOD. SW1 is generally below the limit for High status waters but has 3 No. exceedances (3 – 7 mg/l), while SW2 is frequently above (3 – 7mg/l) the estuarine waters limit. SW4 is generally below the quality objective for High status waters except in 2017 a result of 17mg/l was recorded and in two rounds the laboratory LOD was <5mg/l which is above the quality objectives and should be considered the minimum value.
- The waste licence (Schedule C.4) sets the limit for suspended solids at the discharge points agreed with the Agency as 35 mg/l. Levels of suspended solids at the discharge points generally fall below this limit, with two outliers noted in 2017 in SW1 (70.4 mg/l) and in SW2 (44.3 mg/l).

7.4.2 River Slaney Water Quality Results

- The recorded levels of Ammonia at S1, S2 and S3 in the River Slaney between 2015 to 2019 ranged as follows:
 - S1 (0.02 to 0.12mg/l),
 - S2 (0.016 to 0.13mg/l), and
 - S3 (0.04 to 0.65mg/l).

S3 displays a rising trend which is currently above the EQS of 0.02 mg/l and the drinking water threshold of 0.3 mg/l. No data for 2019 has been provided to-date.

- The monitoring locations in the Slaney estuary recorded high variations in both Chloride and EC levels likely attributed to the tidal influence within the estuary. The Chloride levels ranged between 15 and 24,000 mg/l with the greatest levels recorded in S3. Similarly, in relation to EC levels, a range of between 15 and 24,000 mg/l were recorded with the greatest levels recorded in S3.
- The sampling locations monitored within the River Slaney recorded BOD results generally below the EQS limit for transitional waters, with outlier peaks recorded in July 2016 and June 2018 only. It is noted that the BOD levels downgradient of the landfill were recorded slightly higher than those upgradient of the landfill in June 2018 only.

7.4.3 Surface Water Quality Summary

In summary, the quality of the on-site surface water discharging from Killurin landfill site is likely to be impacted by the waste body. Ammonia levels in SW2 are increasing while SW1 and SW4 are stable and low but consistently above the surface water 2009 EQS standard.

Within the River Slaney, the downstream ammonia levels within S3 are frequently greater than the upstream sample locations (i.e. S1 & S2) and could potentially indicate a possible impact by the landfill in addition to surrounding agricultural runoff. The most recent levels of Ammonia recorded downstream at S3 were elevated at 0.41 mg/l above the threshold for EQS, DWR and 'Good' WFD status thresholds as per 2009 Surface Water Regulations.

It is noted that surface water sampling within the landfill site is undertaken by Wexford County Council on different occasions to the EPA sampling within the River Slaney and therefore a direct comparison of surface water runoff with river quality is not possible based on available information.

7.5 Dilution Effect in the River Slaney

An estimate of the assimilative capacity of the River Slaney has been made by comparing the ammoniacal nitrogen load presently estimated to be discharging from the landfill site via groundwater flux and the actual concentration measured in the river.

Leachate discharge from the site can be described by Darcy's Law equation:

$$Q = KiA$$

where:

- Q = Groundwater flux across the site that is discharging into the river (m³/day)
- K = the hydraulic conductivity of the conducting units – in this case the greatest value between the overburden and the bedrock is utilised as a conservative measure (i.e. 2.7×10^{-4} m/sec) – see Table 6.3.
- I = the hydraulic gradient utilising highest recorded gradients as a conservative measure (i.e. 0.035). Calculated maximum gradient of 0.035 recorded in 2017 (between BR01 and BR04) between 2015 and 2019.
- A = the area over which contaminant flow is occurring i.e. 240 metre length (i.e. approx. distance between BR02 and GW24) and 5-metre-deep vertical plane across approximately 50% of the section via preferential pathways.

A conservative groundwater flux calculation results in a daily groundwater throughput of 980 m³/day (i.e. 0.0113 m³/sec).

The mean annual for within the River Slaney of 24.3 m³/sec was recorded at the Enniscorthy EPA river gauging station between 1956 and 2019. Based on this mean flow (see Section 5.1) within the River Slaney of the dilution effect in the estuarine river is estimated at 2,143 times.

A conservative assimilative capacity assessment of the groundwater flux towards the river was undertaken using the following parameters:

Predicted Concentration in river = $C = (C1 \times Q1) + (C2 \times Q2) / (Q1 + Q2)$, where:

C1 = Average concentration in river upstream (0.07 mg/l)

C2 = Concentration of Highest recorded Groundwater Contaminant of Ammoniacal Nitrogen

Q1 = Mean flow in river = 24.3 m³/sec

Q2 = Interpreted groundwater flux along vertical plane between BR02 and GW24 (i.e. 600 m²)

The predicted impacted in the river from the groundwater flux was calculated to be 0.09 mg/l. It is noted that no dedicated EPA standard for estuarine river water bodies for Ammonia is available with the exception of salmonid water regulations (1988). These regulations have a threshold level for total ammonium as NH₄ of < 1 mg/l (95th %ile).

Using the 0.75%TV Threshold Value + 25% increase of permitted headspace EPA calculation, achieving the full 25% headspace level would require a groundwater flux concentration along the south and southwestern site boundaries of 4,000 mg/l. This is significantly above the highest recorded concentration of 90 mg/l in this area

It therefore appears that the current conservatively calculated contaminant flux to the river from the landfill body would have a low effect on the quality of the River Slaney. It is also noted that the dilution effects ignore the further reducing effects of the reed beds between the landfill site and the river.

8 UPDATED HYDROGEOLOGICAL CONCEPTUAL SITE MODEL

The preliminary source-pathway-receptor approach is now revisited to facilitate a hydrogeological conceptual model of the site. A cross-sectional profile of the site is presented in Figure 7.

8.1 Source Areas

- The raw leachate results from the landfill are within the maximum and minimum concentrations of typical landfill leachate in Ireland. The strength of the leachate appears to be significantly lower within the leachate tanks in comparison to the leachate wells which suggest that dilution of the leachate is occurring through mixing stronger leachate with weaker leachate in the extraction system.
- Leachate concentrations appear to be greatest in the south-central and south-eastern regions of the landfill with lower strength leachate recorded in wells close to the perimeter of the waste body.
- Hazardous and Non-Hazardous substances as per the EPA Classification Non-Hazardous substances in groundwater (2010) were detected in the leachate at the site as follows:
 - ✓ Ammoniacal Nitrogen;
 - ✓ Boron;
 - ✓ Zinc;
 - ✓ Nickel; and,
 - ✓ Chromium.

The entire landfill waste body has been fully capped with an engineered liner and therefore the generation of leachate is primarily from the degradation of the waste body itself rather than the effect of rainfall ingress. Some leachate is likely to be generated where groundwater may interact with the waste body at particular times of the year.

8.2 Pathways

- The hydrogeological regime across Killurin Landfill comprises two groundwater bodies (*i.e.* one within the waste body and a separate water body within the overburden/bedrock) that appear to be hydraulically connected. Leachate within the unlined waste migrates vertically downwards to the underlying aquifer with leachate percolating vertically at a rate proportional to the leachate head. Other times of the year, groundwater intersects the lower levels of the waste body which facilitates the migration of leachate generation and migration towards the River Slaney.
- Groundwater levels remained relatively consistent over time with only minor variations in groundwater levels. The leachate mound within the waste body impacts on the local groundwater flow pattern although the impact is significantly less prior to the completion of the capping. Leachate continues to appear to act as a raised mound radially emitting groundwater.
- Most recent groundwater levels confirm a groundwater flow towards the River Slaney with a maximum gradient of 0.035 recorded in 2017 (between BR01 and BR04) was utilised .
- Groundwater or leachate discharge at the southern and southwestern boundaries of the landfill appears to be occurring along preferential pathways that occupies a significant portion of the site. A major fracture zone within the bedrock was revealed by a geophysical survey which correlated with the site investigation data and the regional fault pattern. A deep zone of leachate between monitoring wells GW21 and GW22 was interpreted to be associated with leachate moving down a faulted or fractured zone.
- Groundwater is providing baseflow to the River Slaney via the overburden deposits. It is currently unclear if groundwater within the bedrock, in particular along the fault zone in the south/southwestern region of the site, is providing significant baseflow. The depth of the channel relative to the depth to bedrock is unclear. The shallow flux of baseflow to the river is likely to be affected by the presence of the reed beds; however, the effect is difficult to assess.

8.3 Receptors

- The only key potential environmental receptors that could be impacted by the presence of the contaminant source on the site is the River Slaney. The Slaney estuary is designated a candidate Special Area of Conservation (Slaney River Valley SAC [000781]) and supports several species listed in the European Habitats Directive (92/43/EEC). It is a Proposed Natural Heritage Area (Slaney River Valley pNHA [000781]) and Special Protected Area (Wexford Harbour and Slobs SPA [004076]).
- There are no source protection areas mapped in the vicinity of Killurin Landfill. A number of private groundwater wells are present in the vicinity of the site (see Figure D); however, these wells are not considered to be downgradient of the landfill site.
- No obvious impact has been recorded to date on the River Slaney by the presence of the landfill. Given the proximity of the landfill to the river, groundwater is not considered to be a receptor of concern.

8.4 Updated S-P-R – Risk Screening

The impact assessment is guided by the source-pathway-receptor (S-P-R) model. The S-P-R model is used to identify the sources of water and potential contaminants, the environmental assets affected by such, and the pathways by which water and contaminants reach those receptors. Table 8.1 summarises the SPR linkage for the landfill.

Sources	Pathways	Receptors	Risk
Leachate	Horizontal Migration of Groundwater	River Slaney	Low/Moderate
	Leachate vertical migration to groundwater		Low/Moderate
		Groundwater	Low
	Leachate horizontal migration to surface water	River Slaney	Low

Table 8.1 Updated S-P-R

8.5 Assessment of Current Groundwater Impacts & Extent of Plumes

The most recent set of groundwater data results in 2019 records Ammoniacal Nitrogen levels along the southern boundary of the landfill (GW24) greater than 130 times the GTV for ammoniacal nitrogen (0.175 mg/l). Levels typically range between 9 and 70 mg/l in 2019 in the southwestern region of the site which represents levels between 50 and 400 times the GTV of 0.175 mg/l.

In accordance with the WFD, these levels may potentially affect the status of the Castlebridge North GWB and potentially pose a risk to the objectives of the Water Framework Directive. The prevention of hazardous substances entering the groundwater system is not being met as per Water Framework Directive requirements. Limiting the ingress of non-hazardous substances is being met by the mitigation measures that have been installed to date at the site.

The following points are noted:

- No groundwater users are located downgradient of the landfill.
- The area of impact is considered to be minor relative to the groundwater body catchment area of the Castletown North GWB *i.e.* < 0.1%

- A plume has been identified along the southwestern and southern region of the site between the River Slaney and the site. The proximity of the plume to the river indicates that the impact on the groundwater body is very limited in extent and is not likely to extend under the river. The groundwater body is not therefore considered to be a receptor.
- Trends assessments broadly indicates that the strength of leachate within the landfill body is generally reducing over time and is expected to reduce even further since completion of all capping works in 2014.
- The plume indicator parameter trends in groundwater are generally stable and reducing over time and expected to reduce further over time.
 - Hydrochemistry data of groundwater in the northern region of the site indicates that shallow groundwater within the glacial deposits has a stable Ammoniacal Nitrogen trend between 7 and 12 mg/l (GW1). Elevated spikes were recorded within the bedrock, levels in GBH1, GBH2 and BR01 range between 0.013 and 35.7 mg/l, but levels are generally low or below detection level.
- Hydrochemistry data in the southern region of the site (in particular the region between BR03 and BR05) indicates a notable impact from leachate within groundwater. The impact appears to be represented by a plume of leachate flowing from the waste body in a south to south-westerly direction towards the River Slaney. The overburden impact is similar to the mechanism in the northern region of the site. However, the bedrock hydraulic conductivity in this area is significantly higher due to a local fracture network which appears to be facilitating the migration of leachate along this pathway and off-site.
- On-site surface water drains discharging from Killurín landfill site appear to have been impacted by the waste body. Ammonia levels in SW2 are increasing over time whereas SW1 and SW4 are stable and low but consistently above the surface water 2009 EQS standard.
- Within the River Slaney, the downstream ammonia levels within S3 are frequently greater than the upstream sample locations (i.e. S1 & S2) and could potentially indicate a possible impact by the landfill in addition to surrounding agricultural run-off. The most recent levels of Ammonia recorded downstream at S3 were elevated at 0.41 mg/l above the threshold for EQS, DWR and 'Good' WFD status thresholds as per 2009 Surface Water Regulations. The trend of Ammoniacal Nitrogen at S3 is broadly increasing over time.
- The dilution capacity of the River Slaney is substantial with a dilution effect of approximately 2,150 times the estimated groundwater flux from the landfill site. This equates to a conservatively calculated effect of 0.09 mg/l within the River Slaney which is notably lower than the levels recorded. Therefore, it appears that the conservatively calculated contaminant flux to the river from the landfill body would have a negligible effect on the quality of the River Slaney. It is also noted that the dilution effects ignore the further reducing effects of the reed beds between the landfill site and the river.
- It has been demonstrated that the river is of moderate status and is currently at risk. Groundwater trends are generally reducing or static in a GWB which has Poor status and is at risk of not improving. The objectives of the WFD and the status of the groundwater body are considered to be maintained. Also, no impact to the mudflat habitat has been identified to-date.

9 COMPLIANCE MONITORING

Discharge activities subject to Tier 2/3 assessments must undertake compliance monitoring to verify predicted impact and check compliance with terms of the authorisation. Compliance monitoring dictates that receptor-based water quality standards (or threshold values) should not be exceeded at receptor locations. For this reason, sampling is conducted to monitor water quality at receptors, as appropriate.

9.1 Compliance Points & Values

A compliance point is the point (location, depth) at which a compliance value should be met. Generally, it is represented by a borehole or monitoring well from which representative groundwater samples can be obtained. In the case of Killurin Landfill, the aim is to monitor baseflow before it enters local surface water bodies, *i.e.* groundwater downgradient of the landfill. Surface waters are also an equally reliable medium for measuring compliance given the proximity to the waste body. Sampling should continue to take place at the existing groundwater monitoring boreholes and surface water monitoring points. However, a number of amendments to the existing network are recommended in Section 11.

A compliance value is the concentration of a substance and associated compliance regime that, when not exceeded at the compliance point will prevent pollution and/or achieve water quality objectives at the receptor. In this case, the aim is to protect surface water quality in the River Slaney and its associated habitats.

The general chemical assessment test identifies groundwater bodies where widespread deterioration in quality has, or will, compromise strategic use of groundwater for existing or planned, human consumption and/or other potential purposes. Schedule 5 of the Groundwater Regulations (SI 9 of 2010) lists Threshold Values as shown in Table 9.2. Where significant and sustained upward trends are identified, corrective action must be taken.

The compliance values applied to each individual sampling point will depend on the location of such, distance from source, and distance to nearest identified receptor.

As most of these wells have already been impacted by landfill leachate, utilising the 2010 GTVs for indicator parameters such as Ammoniacal Nitrogen, Chloride and EC are not considered appropriate in this case for compliance. As discussed in Section 7.5, the dilution capacity of the river is significant and the compliance value should therefore be based on this receptor.

As discussed in Section 7.5, an Ammonia level of 4,000 mg/l in all downgradient monitoring wells would result in a 25% increase of the available headspace or 75% GTV in ammonia levels in the River Slaney. This level far exceeds the groundwater concentrations recorded to date at Killurin landfill.

Therefore, a series of compliance values for individual monitoring wells were developed for the site to act as indicators highlighting that leachate concentrations discharging from the site need to be reassessed. The values (see Table 9.1) were determined using the mean and 3 standard deviations (mean + 3sd) in accordance with the '*UK Environment Agency General Principals of Control and Trigger Levels for leachate contaminated sites, 2003*'. The levels of Chloride developed for a number of wells were considered unnecessarily low and the 2010 GTV value was selected instead.

Well ID	Ammoniacal Nitrogen	Chloride
	Trigger Level	
	mg/l	mg/l
GW1	12	187.5
GW9	26	187.5
GW10	11	235
GW11	0.09	187.5
GW21	75	220
GW22	76	187.5
GW23	53	189
GW24	120	799
GW25	70	993
BR01	42	187.5
BR02	28	187.5
BR03	94	188
BR04	60	187.5
BR05	85	187.5
BR06	14	238
BR07	0.38	242
EPA IGV	0.15	30
2010 GTV	0.175	187.5

Table 9.1 Proposed Groundwater Trigger Levels

Existing GTV, EQS and IGV are proposed for the remaining parameters *i.e.* Dissolved Inorganic Nitrogen (surface waters only), Orthophosphate as P, Nitrite (as NO₂), Nitrate (as NO₃), Sulphate (as SO₄), Sodium, Iron, Boron and Manganese.

Parameter	Units	Groundwater Regulations (SI 9 of 2010) ³	IGV	EQS for Surface Waters
Dissolved Inorganic Nitrogen	mg/l	-	-	2.49
Nitrite (as NO ₂)	mg/l	0.375	0.15	0.2
Nitrate (as NO ₃)	mg/l	37.5	25	50
Sulphate (as SO ₄)	mg/l	187.5	200	200
Sodium	mg/l	150	150	-
Iron	mg/l	-	0.2	-
Boron	µg/l	750	-	-
Manganese	mg/l	-	0.05	0.3

Table 9.2 Guideline Values

VOC and sVOC monitoring should also be undertaken on all groundwater monitoring wells, surface water discharge locations and leachate wells on an annual basis. In addition to the above-mentioned compliance and guideline levels, any **sustained upward trends** in contaminant flux from the site should also be utilised as an indicator of possible non-compliance and assessed. Trend analysis should be undertaken on an annual basis to identify upward trends.

³Schedule 5 of SI 9 of 2010. Assessment of the general quality of groundwater in the body in terms of whether it's ability to support human uses has been significantly impaired by pollution.

10 RECOMMENDATIONS / REMEDIAL STRATEGY

Based on the assessment undertaken as part of this report and the risk identified to the River Slaney and its associated habitats, the following further actions are recommended to support the existing data set for the site.

1. Continue with the current groundwater and surface water monitoring programme utilising the derived compliance trigger levels as detailed in Table 9.1 and Table 9.2. An annual groundwater monitoring report with trend with associated trend analysis should also be undertaken.
2. Sampling of groundwater and surface water on site should coincide with sampling within the River Slaney, if possible. All groundwater sampling and groundwater level monitoring should be undertaken on the same day.
3. Monitoring wells GW17, GW28, and GW19 are no longer operational and should be replaced with 1-2 shallow monitoring wells in the northern region of the site. Bedrock monitoring wells GBH1 and GBH2 should remain in the monitoring programme.
4. Wells GW17, GW18 and GW19 are no longer in use and should be appropriately decommissioned in accordance with EPA best practice.
5. An updated habitat condition survey is recommended to assess any impact to the habitat since the 2007 condition survey.

11 CONCLUSIONS & RECOMMENDATIONS

- A hydrogeological risk assessment of Killurin Landfill Site was undertaken by BREL based on previous investigation reports and monitoring data between 2015 and 2019.
- The landfill facility is located in a former sand and gravel quarry which was periodically used as a landfill during the 1970s and 1980s before it was purchased by Wexford County Council (WCC) in 1985. The council used the site as a landfill until 7th June 2008 and capping works were largely completed in 2011 with access road capping completed in 2014.
- A Conceptual Site Model (CSM) was developed based on available information and monitoring data and identified a number of SPR linkages ranging from Low to Moderate risk to identified sensitive receptors.
- The SPR linkages of concern relate to:
 - ✓ The vertical migration of leachate from the unlined waste cells to the underlying aquifer; and,
 - ✓ The horizontal migration of contaminant plume off-site to the River Slaney and the mudflats.
- The site is partially compliant with the “prevent” or “limit” objective of the WFD and GWD. The prevention of hazardous substances entering the groundwater system is not being met as per Water Framework Directive requirements monitoring event in 2010. However, it is noted that this determination is based on one round of monitoring only and further detailed monitoring is recommended to ascertain the persistency of these parameters. Limiting the ingress of non-hazardous substances is being met by the mitigation measures that have been installed to date at the site *i.e.* leachate abstraction, landfill capping and the lining of surface water drains.
- The most recent set of groundwater data results in 2019 records ammoniacal nitrogen levels along the southern boundary of the landfill greater than 100 times the GTV for Ammoniacal Nitrogen (0.175 mg/l). Levels typically range between 9 and 70 mg/l in 2019 in the southwestern region of the site which represents levels between 50 and 400 times the GTV of 0.175 mg/l. In accordance with the Water Framework Directive (WFD), these levels may potentially affect the status of the Castletown A-A groundwater body and potentially pose a risk to the objectives of the Water Framework Directive.
- It is noted that:
 - The area of impact is considered to be minor relative to the groundwater body catchment area of the Castletown North GWB *i.e.* < 0.1%
 - A plume has been identified along the southwestern and southern region of the site between the River Slaney and the site. The proximity of the plume to the river indicates that the impact on the groundwater body is very limited in extent and is not likely to extend under the river. The groundwater body is not therefore considered to be a receptor.
 - Trends assessments broadly indicates that the strength of leachate within the landfill body is generally reducing over time and is expected to reduce even further since completion of all capping works in 2014.
 - The plume indicator parameter trends in groundwater are generally stable and reducing over time and expected to reduce further over time.
- Hydrochemistry data in the southern region of the site (in particular the region between BR03 and BR05) indicates a notable impact from leachate within groundwater. The impact appears to be represented by a plume of leachate flowing from the waste body in a south to south-westerly direction towards the River Slaney. The overburden impact is similar to the mechanism in the northern region of the site. However, the bedrock hydraulic conductivity in this area is

significantly higher due to a local fracture network which appears to be facilitating the migration of leachate along this pathway and off-site.

- On-site surface water drains discharging from Killurin landfill site appear to have been impacted by the waste body. Ammonia levels in SW2 are increasing over time whereas SW1 and SW4 are stable and low but consistently above the surface water 2009 EQS standard.
- No clear impact on the River Slaney by the landfill is evident from the surface water data reviewed to-date. The variations recorded within the River Slaney between upgradient and downgradient locations of Killurin Landfill are considered to be consistent with natural variations within a water body of this scale, potential low-level impacts by the landfill and potential impacts effects from surrounding agricultural runoff.
- The dilution capacity of the River Slaney is substantial with a dilution effect of approximately 2,150 times the estimated groundwater flux from the landfill site. This equates to a conservatively calculated effect of 0.09 mg/l within the River Slaney which is notably lower than the levels recorded. Therefore, it appears that the conservatively calculated contaminant flux to the river from the landfill body would have a negligible effect on the quality of the River Slaney. It is also noted that the dilution effects ignore the further reducing effects of the reed beds between the landfill site and the river.
- It has been demonstrated that the river is of moderate status and is currently at risk. Groundwater trends are generally reducing or static in a GWB which has Poor status and is at risk of not improving. The objectives of the WFD and the status of the groundwater body are considered to be maintained. Also, no impact to the mudflat habitat has been identified to-date.
- The corrective actions undertaken to-date at the site include:
 - ✓ Landfill capping across the entire waste body;
 - ✓ Leachate collection from leachate abstraction wells and toe drains and disposal off-site to a WWTP;
 - ✓ Lining all surface waters across the site and sealing historical leachate breakout locations; and,
 - ✓ On-going groundwater and surface water monitoring as per the licence requirements.
- A series of proposed mitigation measures have been proposed to address the data gaps at the site, to facilitate a more detailed understanding of the hydrogeological regime and to assess the risk posed to downgradient receptors.
- The existing groundwater and surface water monitoring network is considered to be predominantly suitable to meet the requirements of the Groundwater Regulations. A number of additional investigation and monitoring locations and suite of testing have been recommended.
- The current landfill site appears to be having a low level of impact on the River Slaney and the mitigation measures completed to date in conjunction with the proposed additional monitoring and investigation locations will be sufficient for the site to be compliant with the Groundwater Regulations over time.

ooOOoo

Respectfully submitted by

Niall Mitchell

Hydrogeologist / Chartered Engineer

On behalf of Wexford County Council (Waste Licence No. W016-1)

FIGURES

Legend



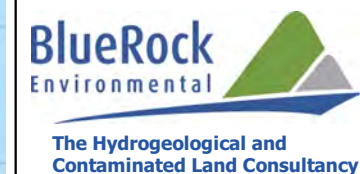
Project

**Killurin Landfill
Hydrogeological Risk
Assessment**

Client **Wexford
County Council**

Drawing **Figure 1**

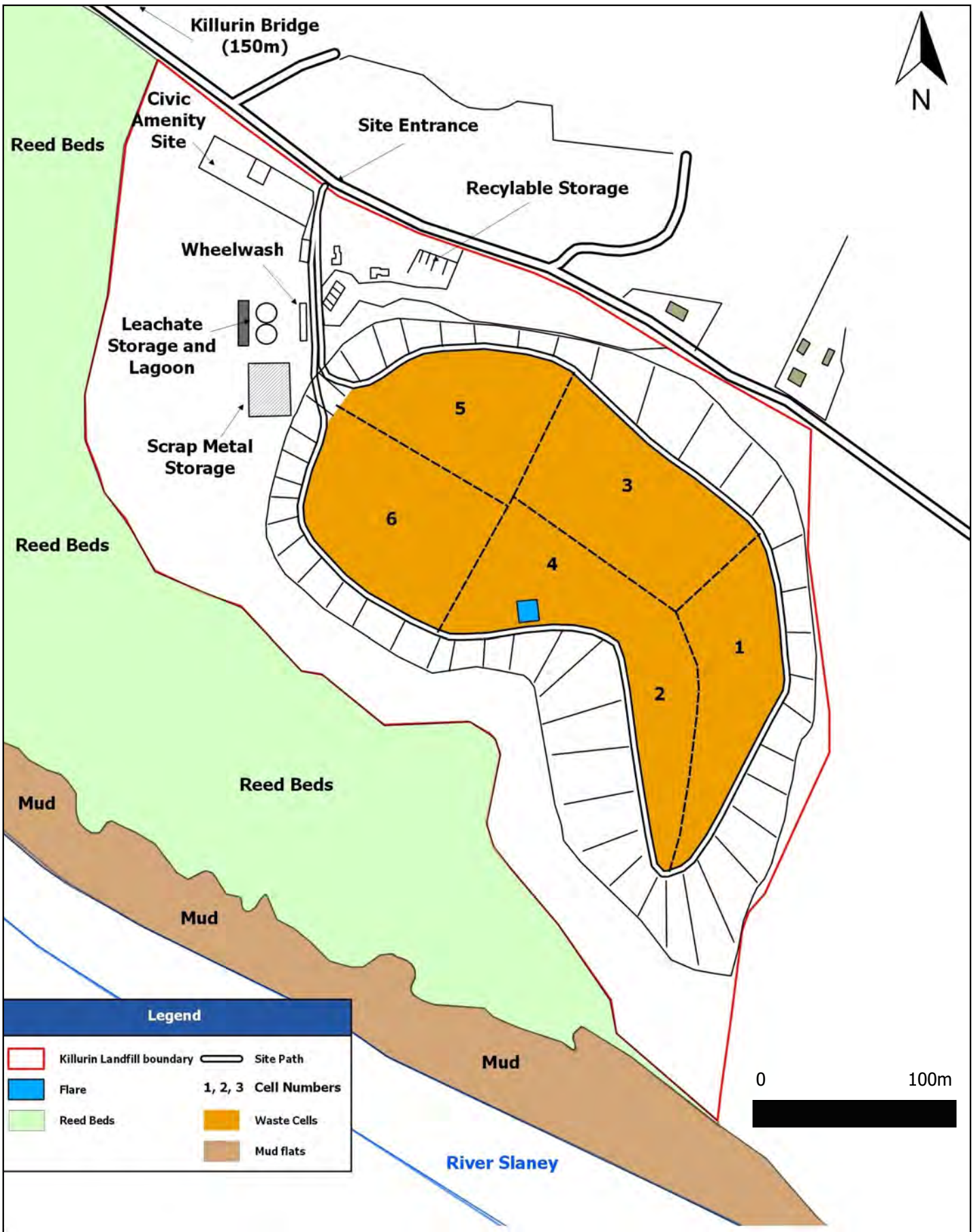
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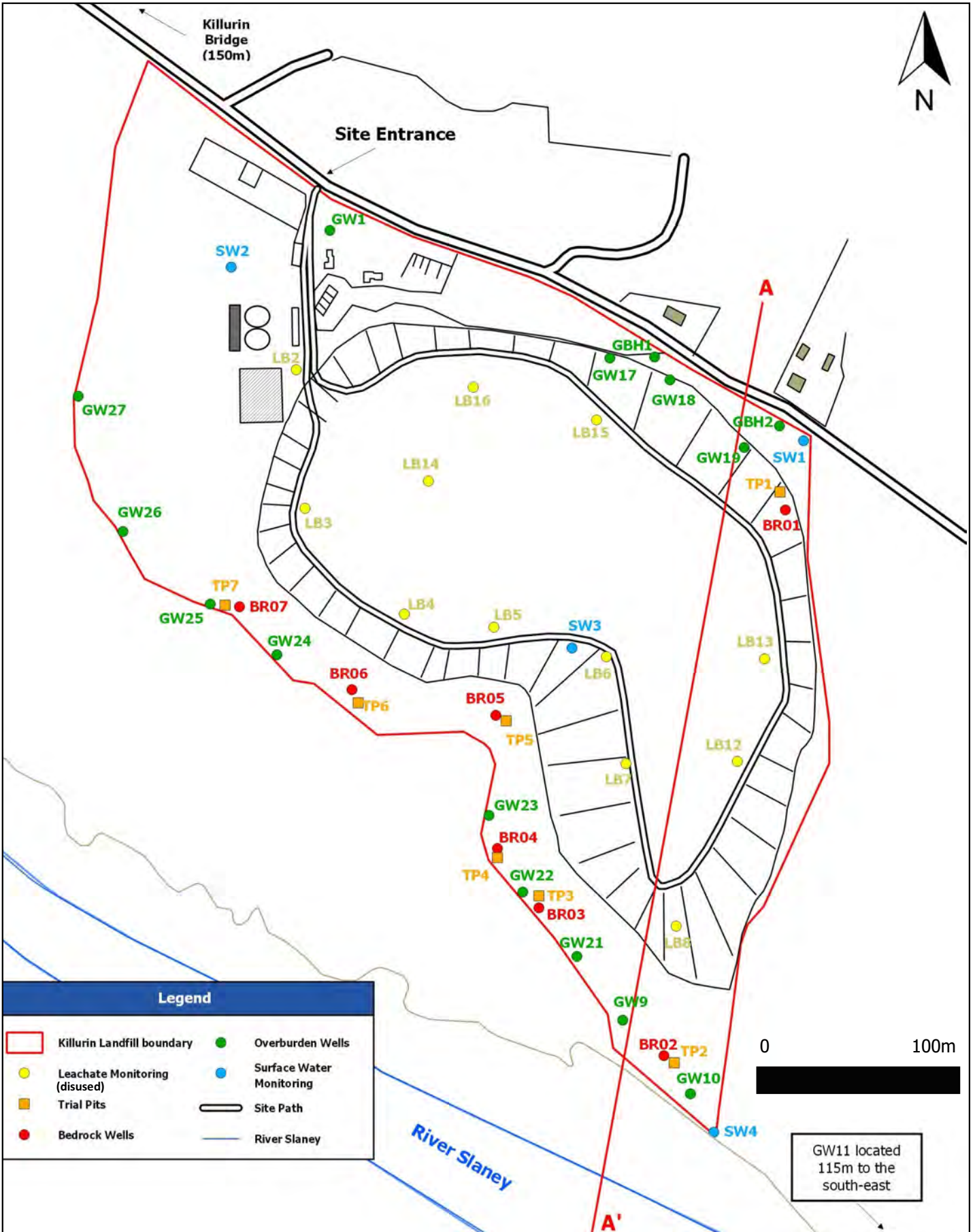
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File Ref : BRE14016
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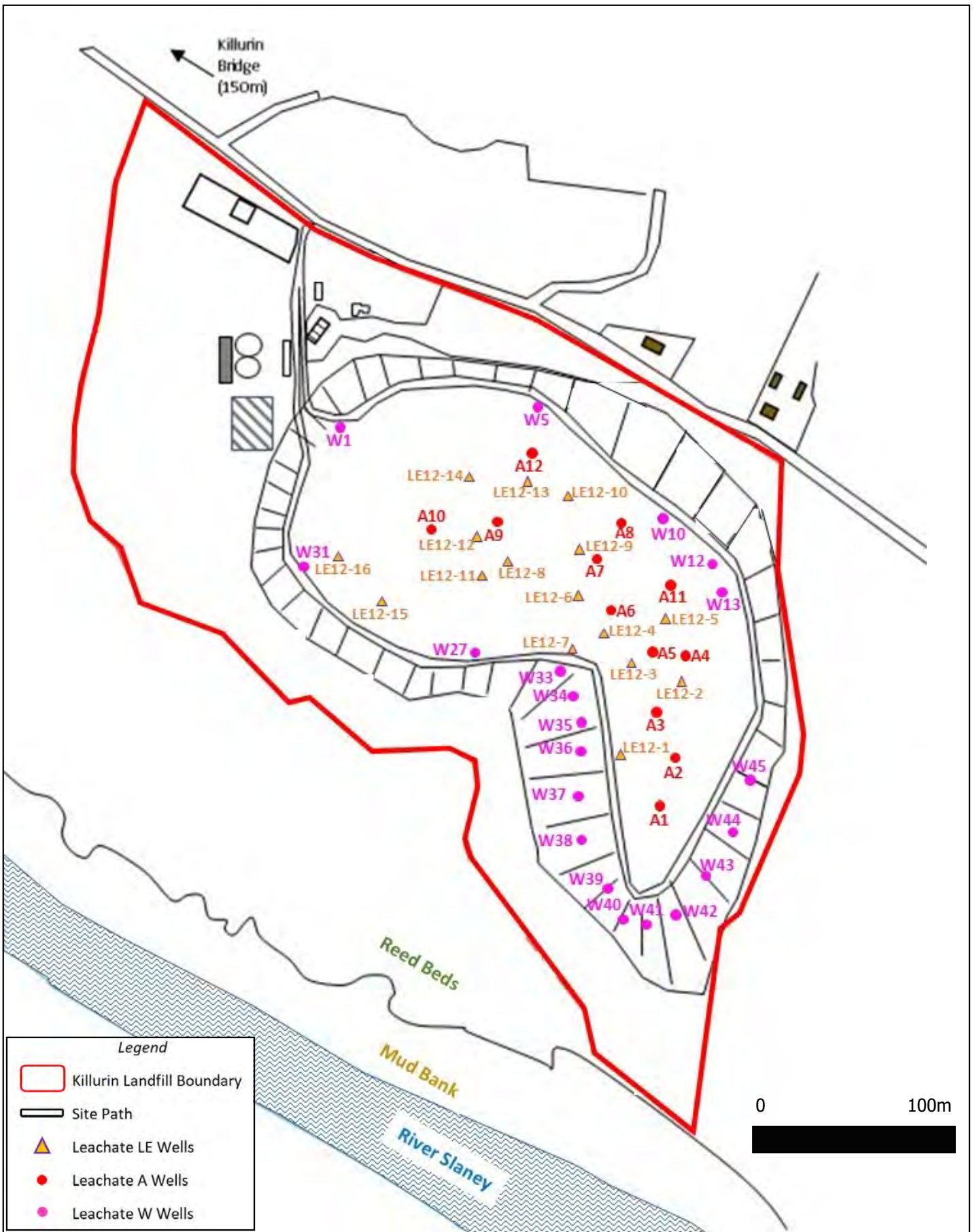



<i>Project</i>		Title		File Ref: BRE14008 Drawing Ref: BRE19003DG02 Revision: D01 Date: 07/07/2020 Drawn by: PK Copyright: N/A	 The Hydrogeological and Contaminated Land Consultancy T 00353 863856884 E admin@bluerockenv.ie W www.bluerockenvironmental.ie
Killurin Landfill Hydrogeological Risk Assessment		Site Layout			
Client		Drawing			
Wexford County Council		Figure 2			

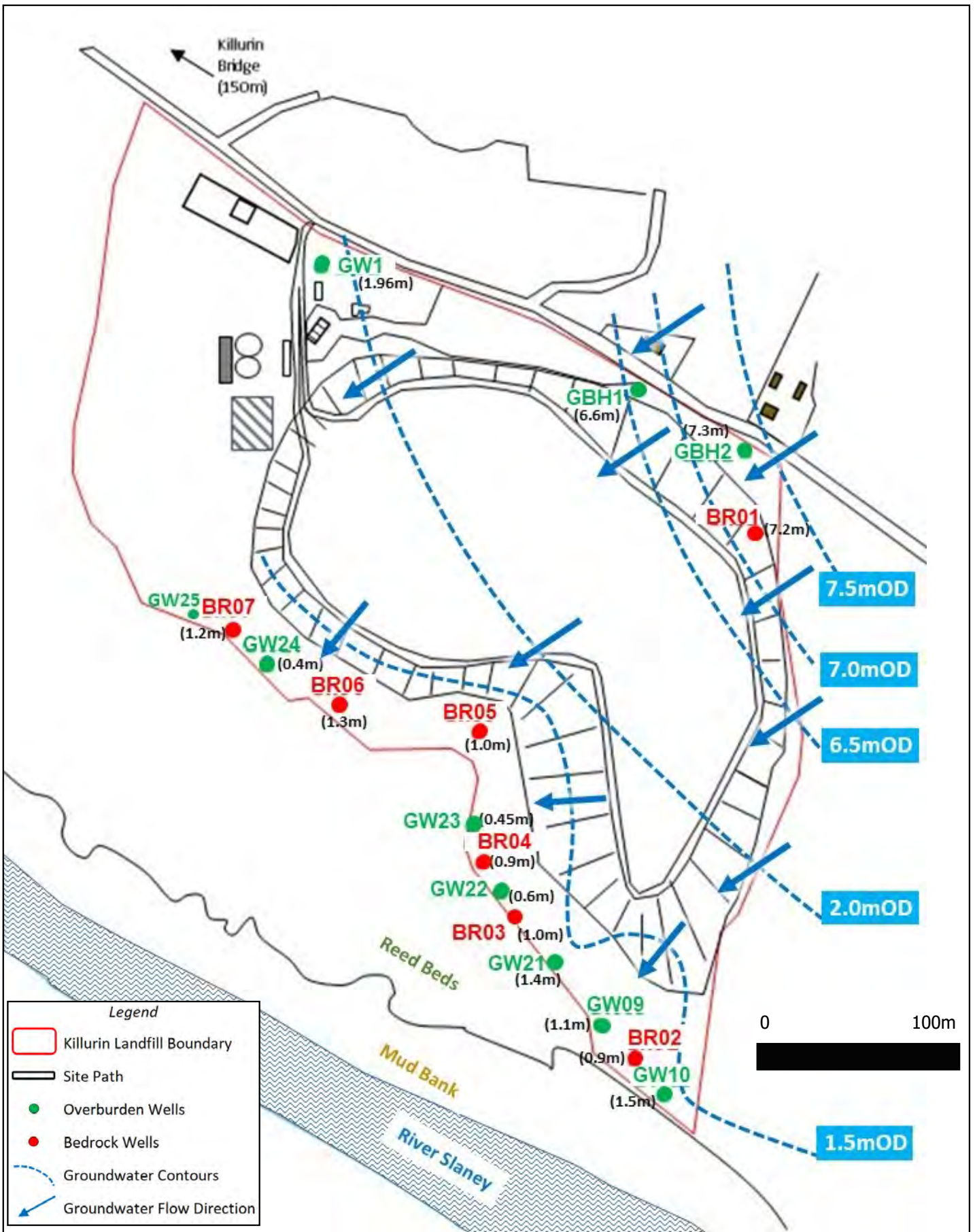



Legend	
	Killurin Landfill boundary
	Leachate Monitoring (disused)
	Trial Pits
	Bedrock Wells
	Overburden Wells
	Surface Water Monitoring
	Site Path
	River Slaney

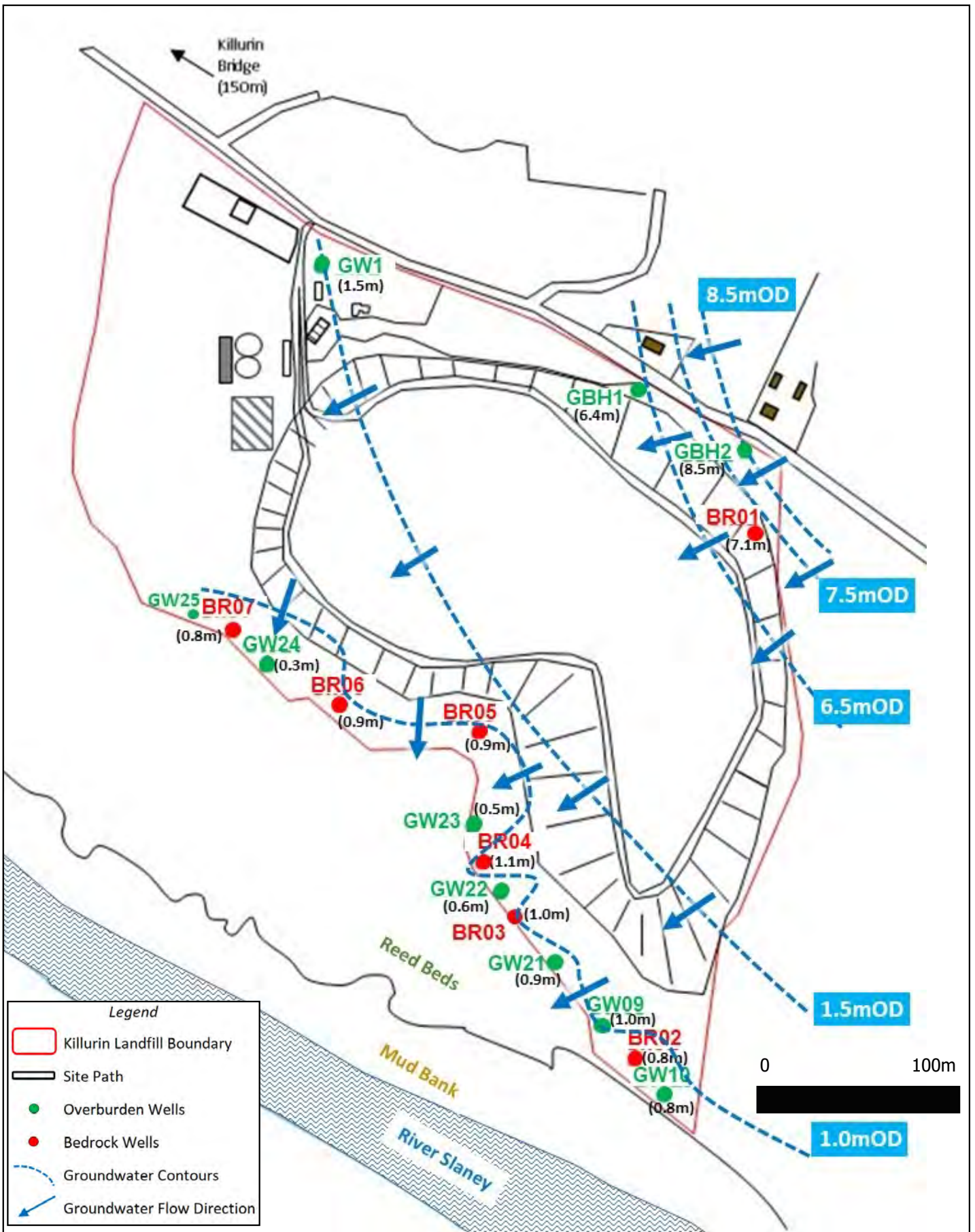
<i>Project</i>		Title		File Ref: BRE14008 Drawing Ref: BRE19003DG03 Revision: D01 Date: 07/07/2020 Drawn by: PK Copyright: N/A	 The Hydrogeological and Contaminated Land Consultancy T 00353 863856884 E admin@bluerockenv.ie W www.bluerockenvironmental.ie
Killurin Landfill Hydrogeological Risk Assessment		Monitoring Locations			
Client		Drawing			
Wexford County Council		Figure 3			




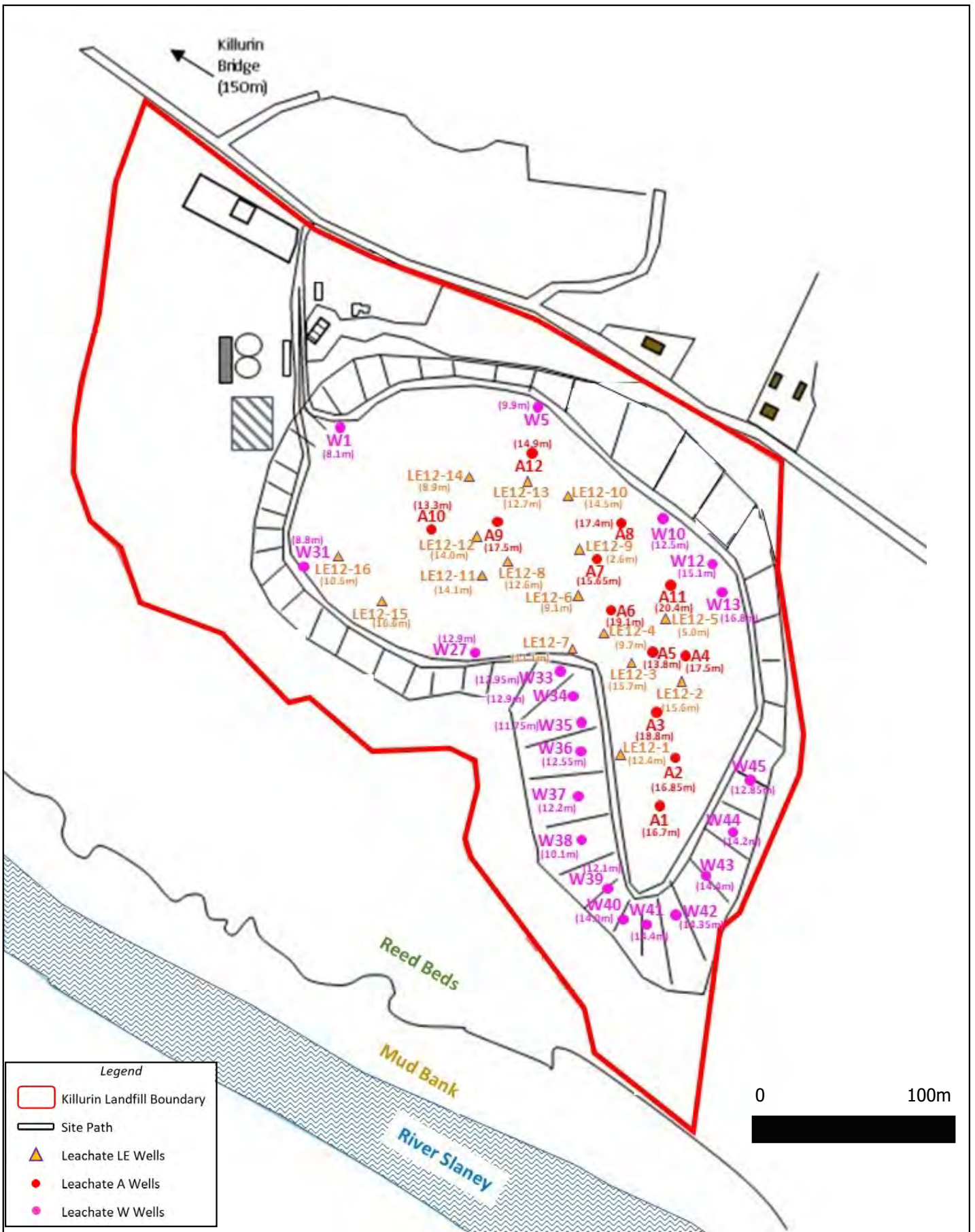
Project		Title	File Ref: BRE14008 Drawing Ref: BRE19003DG03a Revision: D01 Date: 07/07/2020 Drawn by: PK Copyright: N/A	 The Hydrogeological and Contaminated Land Consultancy
Killurin Landfill Hydrogeological Risk Assessment				
Client		Drawing	T 00353 863856884 E admin@bluerockenv.ie W www.bluerockenvironmental.ie	
Wexford County Council		Figure 3a		




Project		Title		File Ref: BRE14016 Drawing Ref: BRE14016DG04 Revision: D01 Date: 07/07/2020 Drawn by: PK Copyright: N/A	 The Hydrogeological and Contaminated Land Consultancy T 00353 863856884 E admin@bluerockenv.ie W www.bluerockenvironmental.ie
Killurin Landfill Hydrogeological Risk Assessment		Groundwater Contours August 2018			
Client		Drawing			
Wexford County Council		Figure 4			



Project		Title	File Ref: BRE14016 Drawing Ref: BRE14016DG05 Revision: V01 Date: 07/07/2020 Scale: PK Drawn by: N/A Copyright:	 The Hydrogeological and Contaminated Land Consultancy T 00353 863856884 E admin@bluerockenv.ie W www.bluerockenvironmental.ie
Killurin Landfill Hydrogeological Risk Assessment		Groundwater Contours December 2019		
Client	Wexford County Council	Drawing	Figure 5	



Project		Title	File Ref: BRE14016 Drawing Ref: BRE14016DG06 Revision: V01 Date: 07/07/2020 Drawn by: PK Copyright: N/A	 The Hydrogeological and Contaminated Land Consultancy T 00353 863856884 E admin@bluerockenv.ie W www.bluerockenvironmental.ie
Killurin Landfill Hydrogeological Risk Assessment		Leachate Levels September 2019		
Client	Drawing			
Wexford County Council	Figure 6			

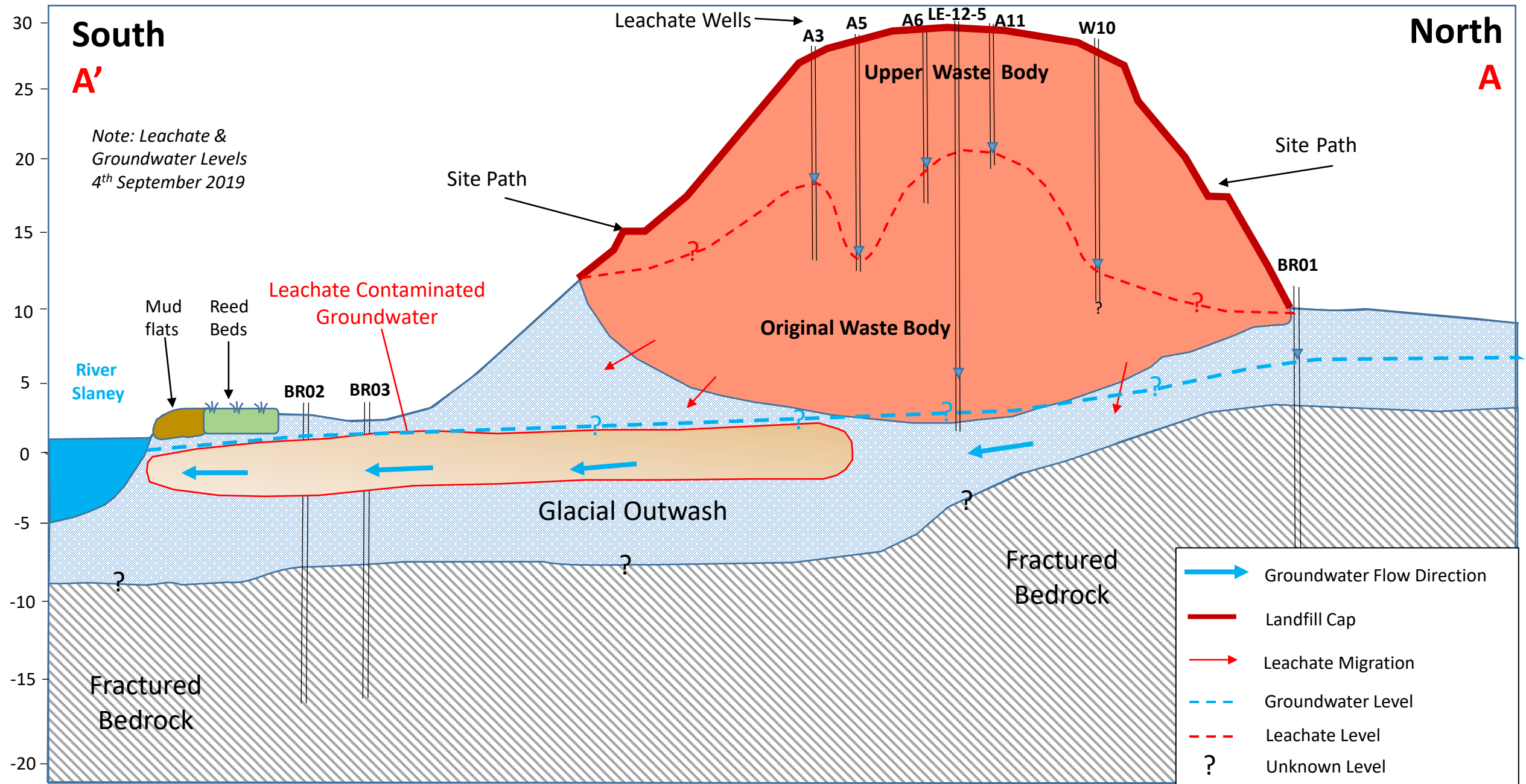
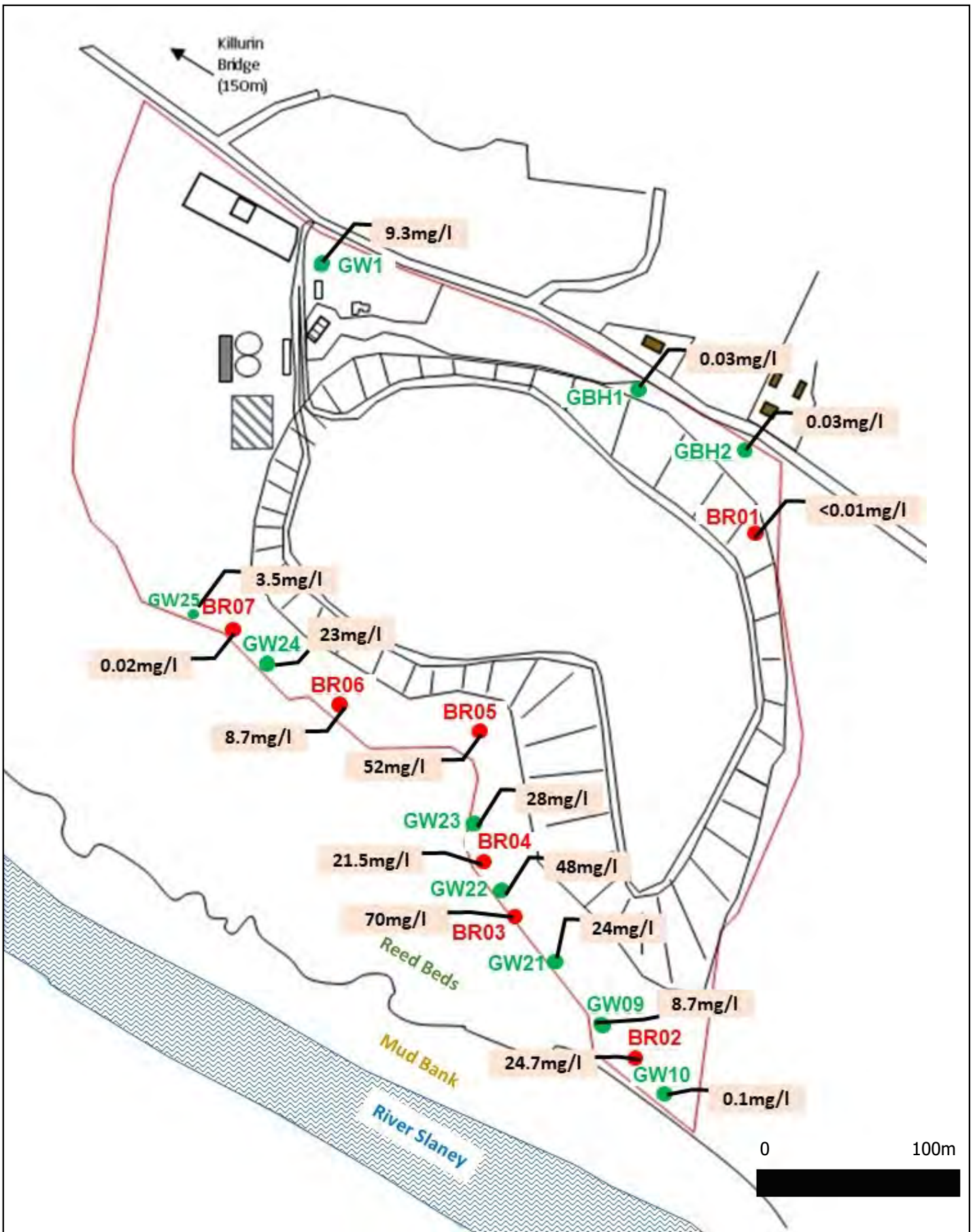



Figure 7 - Killurin Landfill Cross-Section A – A'

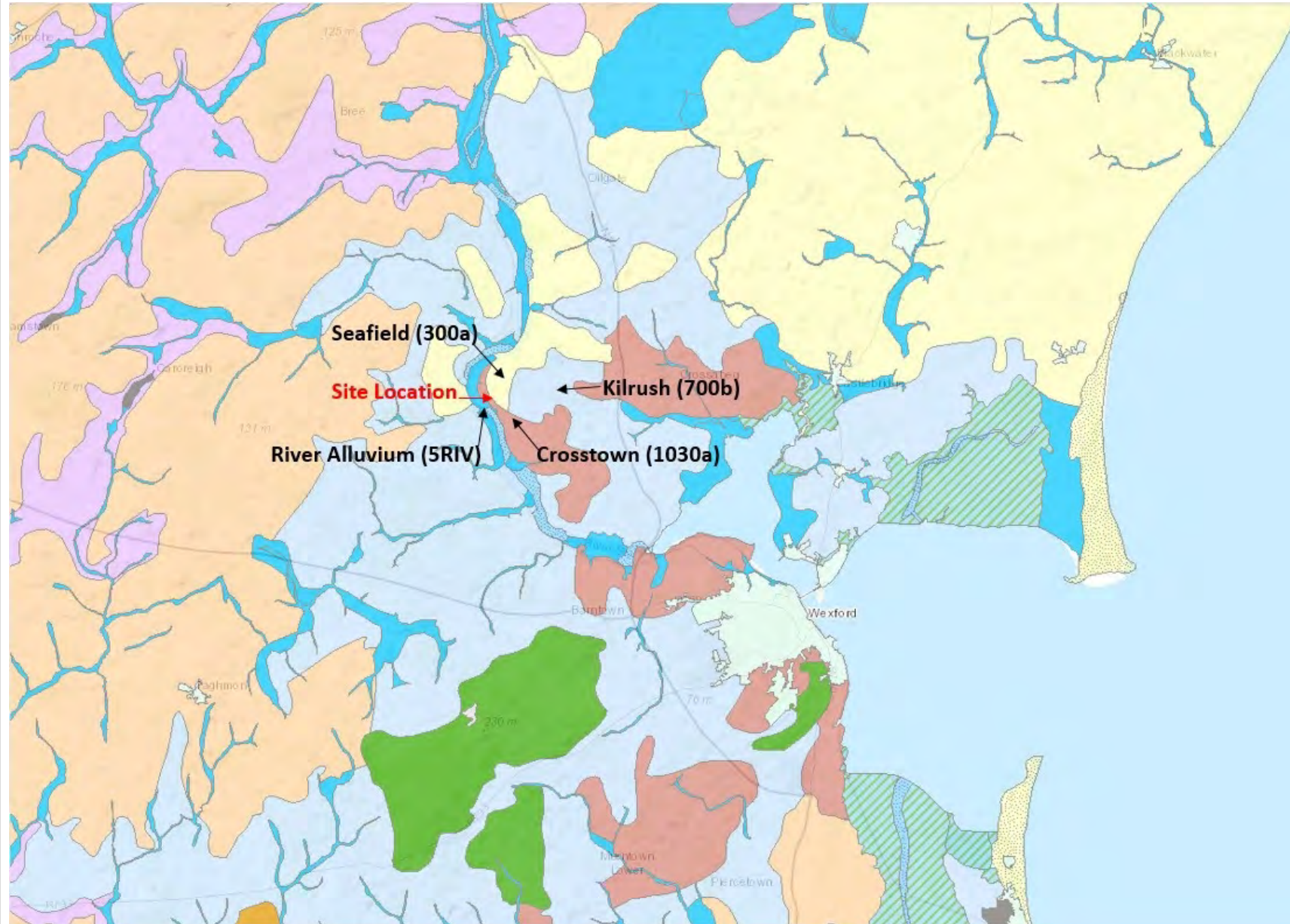
Note: Horizontal NTS



Project		Title		File Ref: BRE14016 Drawing Ref: BRE14016DG08 Revision: D01 Date: 07/07/2020 Drawn by: PK Copyright: N/A	 The Hydrogeological and Contaminated Land Consultancy T 00353 863856884 E admin@bluerockenv.ie W www.bluerockenvironmental.ie
Killurin Landfill Hydrogeological Risk Assessment		Ammoniacal Nitrogen Levels Oct-2019			
Client	Drawing	Figure 8			
Wexford County Council					

APPENDIX A

GSI Mapping



Legend

Project

**Killurin Landfill
Hydrogeological Risk
Assessment**

Client **Wexford
County Council**

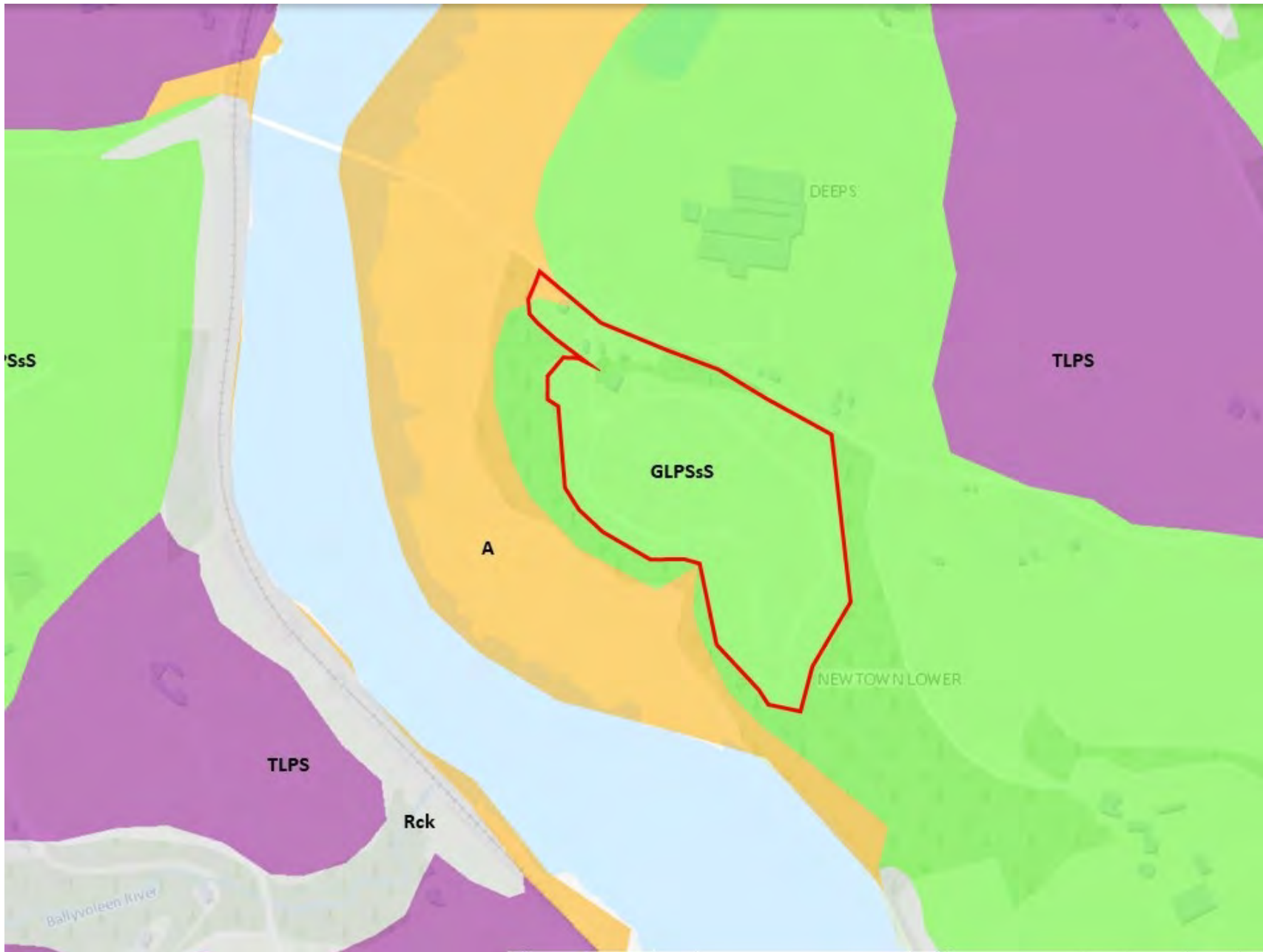
Drawing **Figure A1**

Title **Teagasc Soil Classification**



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W www.bluerockenvironmental.ie

File Ref : BRE14016
Drawing Ref : BRE14016DGA1
Revision : D01
Date : 07/07/2020
Drawn by : PK
Copyright : Teagasc/Cranfield



Legend

- GLPSsS** Gravels derived from Lower Palaeozoic sandstones and shales
- A** Alluvium
- Rck** Bedrock
- TLPS** Till derived from Lower Palaeozoic shales

Project

**Killurin Landfill
Hydrogeological Risk
Assessment**

Client **Wexford
County Council**

Drawing **Figure A2**

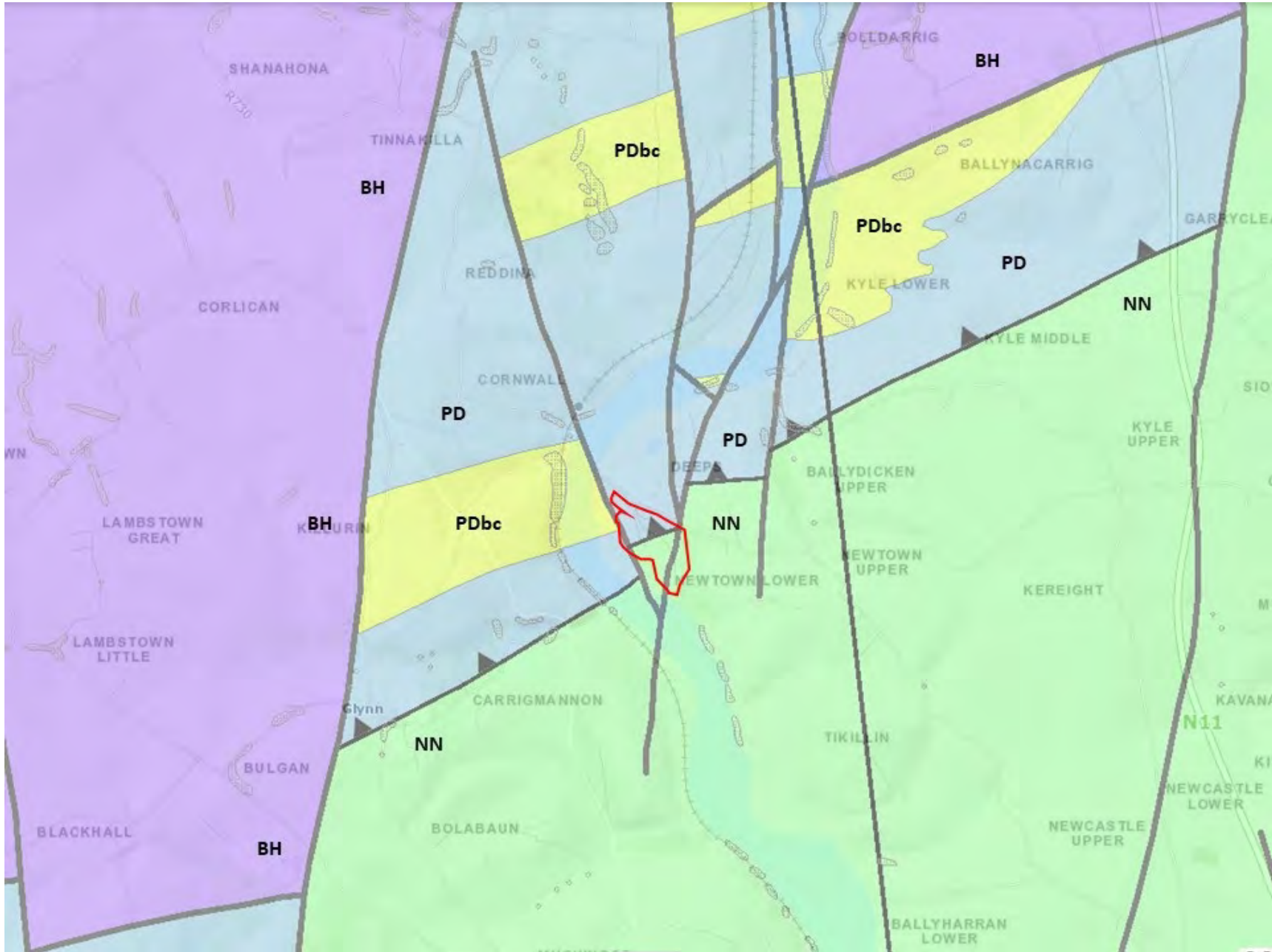
Title **Subsoil Classification**



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File Ref : BRE14016
Drawing Ref : BRE14016DGA2
Revision : D01
Date : 07/07/2020
Drawn by : PK

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Legend

- PD - Polldarrig Formation
- NN - Newtown Formation
- PDbc - Ballynacarrig Member
- BH - Ballyhoge Formation
- Thrust, barbs on hanging-wall side

Project

**Killurin Landfill
Hydrogeological Risk
Assessment**

Client **Wexford
County Council**

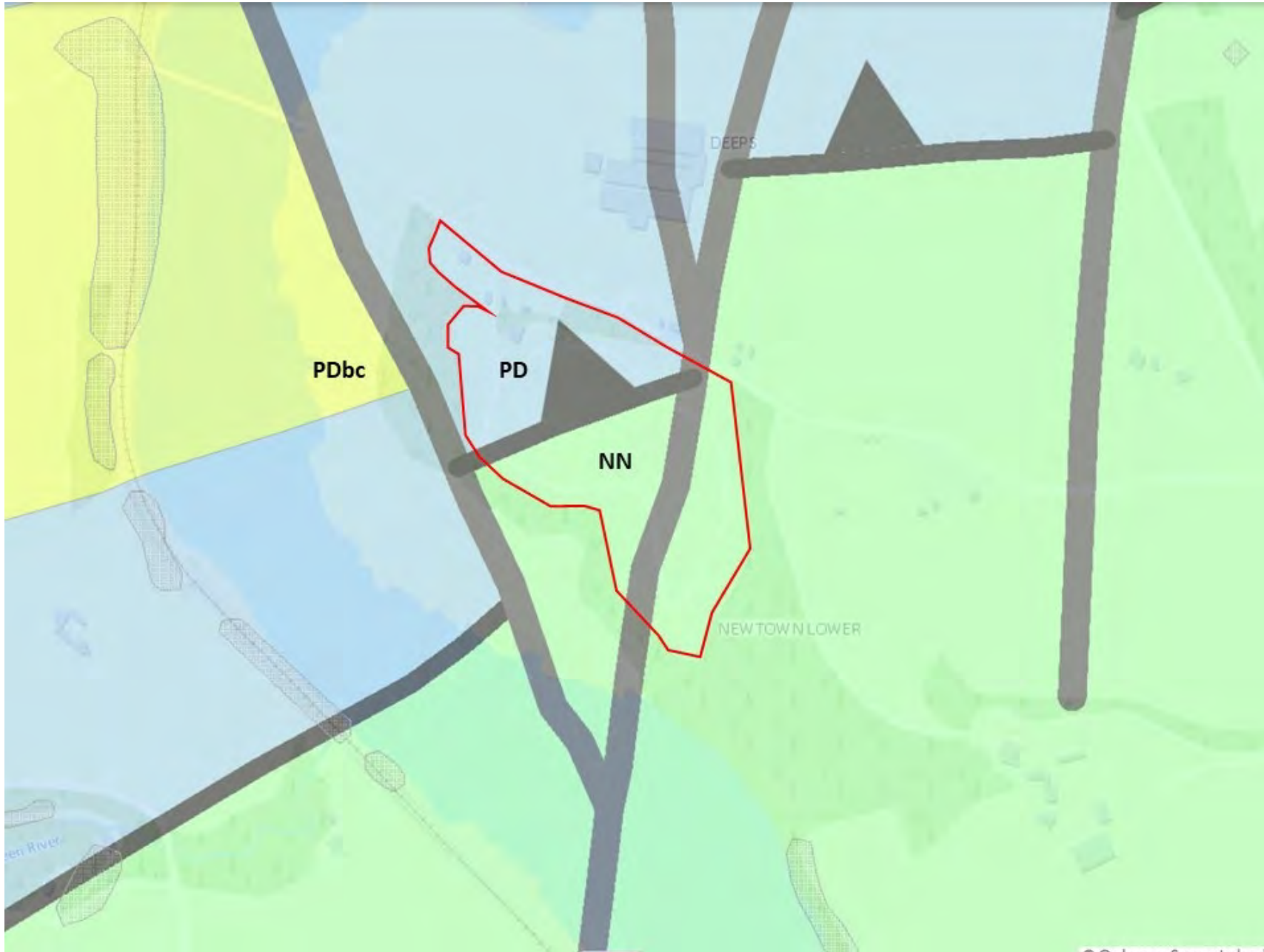
Drawing **Figure B1**

Title **Bedrock Classification**



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File Ref : BRE14016
Drawing Ref : BRE14016DGB2
Revision : D01
Date : 07/07/2020
Drawn by : PK
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Legend

- PD - Polldarrig Formation
- NN - Newtown Formation
- PDbc - Ballynacarrig Member
- BH - Ballyhoge Formation
- Thrust, barbs on hanging-wall side

Project

**Killurin Landfill
Hydrogeological Risk
Assessment**

Client **Wexford
County Council**

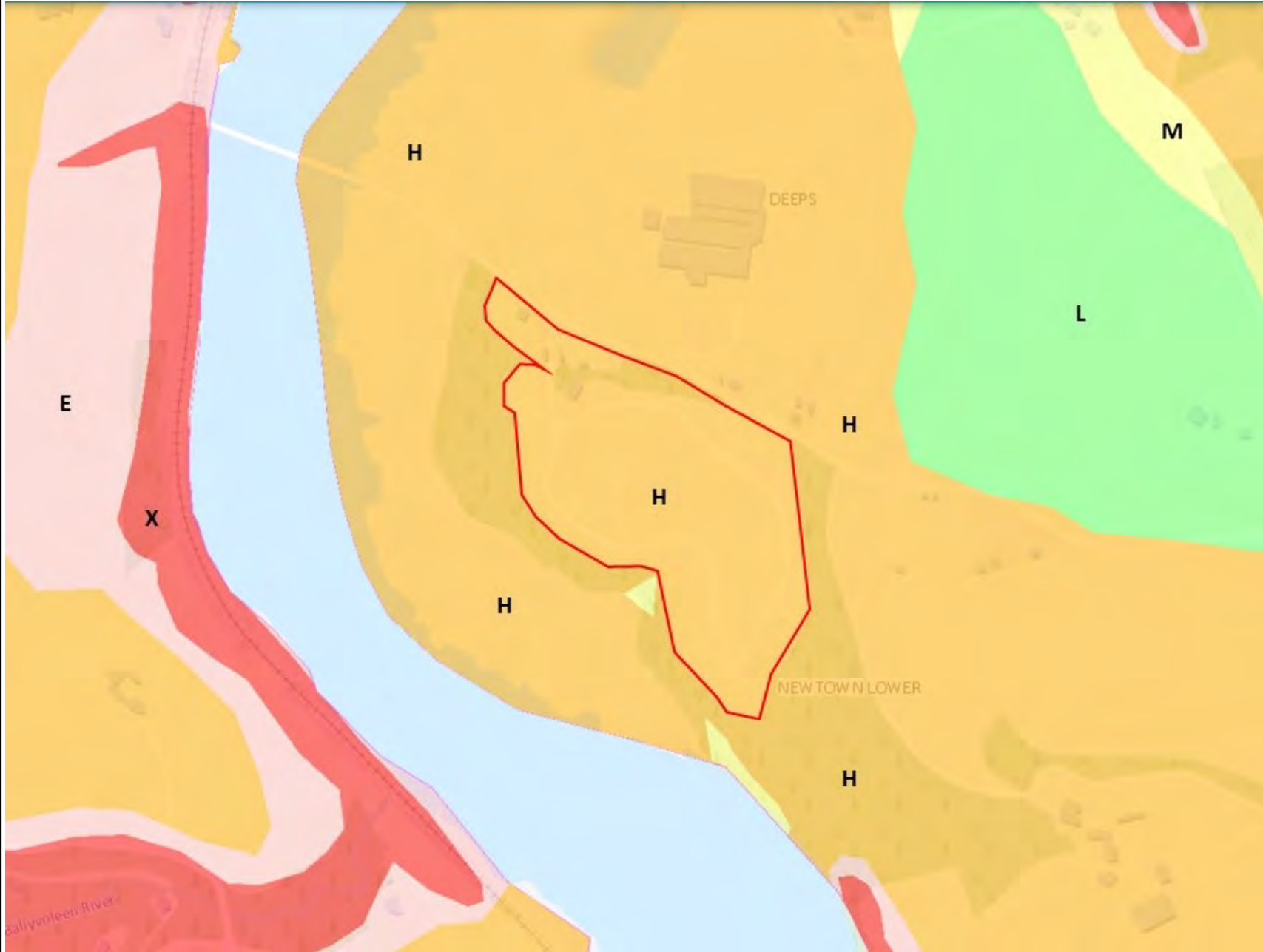
Drawing **Figure B (2)**

Title **Bedrock Classification**



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File Ref : BRE14016
Drawing Ref : BRE14016DGB2
Revision : D01
Date : 07/07/2020
Drawn by : PK
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Legend

- Groundwater Vulnerability**
 National Groundwater Vulnerability Ireland
- Rock at or near Surface or Karst
 - Extreme
 - High
 - Moderate
 - Low

Project

**Killurin Landfill
 Hydrogeological Risk
 Assessment**

Client **Wexford
 County Council**

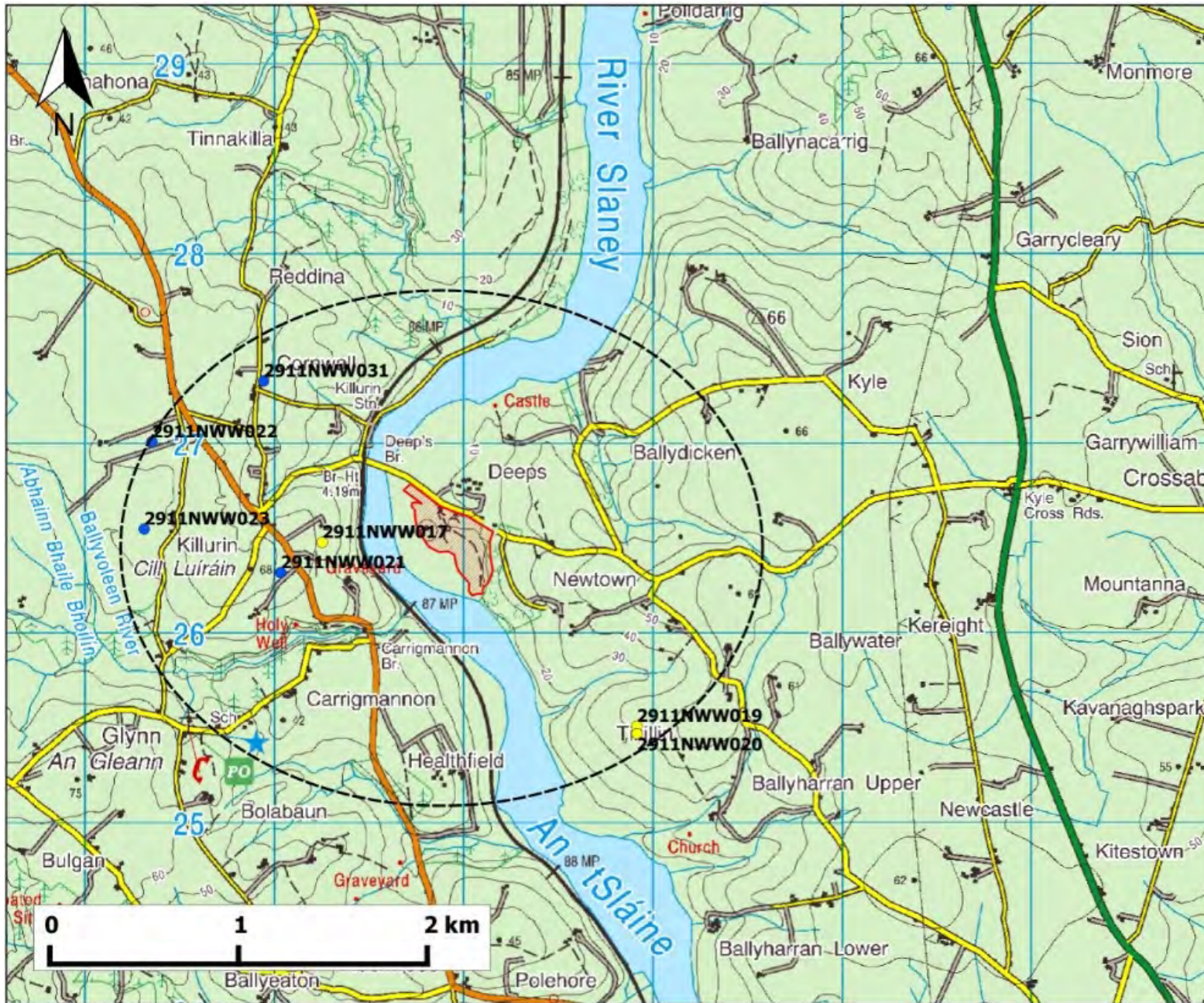
Drawing **Figure C**

Title **Aquifer Vulnerability**



T 00353 863856884
 E admin@bluerockenv.ie
 W www.bluerockenvironmental.ie

File Ref : BRE14016
 Drawing Ref : BRE14016DGC
 Revision : D01
 Date : 07/07/2020
 Drawn by : PK



Legend

- Killurin Landfill
- 2km Boundary
- Wells (500m accuracy)
- Wells (10m to 50m accuracy)

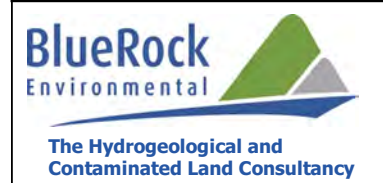
Project

**Killurin Landfill
Hydrogeological Risk
Assessment**

Client **Wexford
County Council**

Drawing **Figure D**

Title **Groundwater Wells**



T 00353 863856884
E admin@bluerockenv.ie
W www.bluerockenvironmental.ie

File Ref : BRE14016
Drawing Ref : BRE14016DGD
Revision : D01
Date : 07/07/2020
Drawn by : PK

APPENDIX B

Trial Pit Logs

REPORT NO. 10965

TRIAL PIT RECORD

IGSL

CONTRACT:	Kilurin Landfill	Trial Pit No.:	TP1
		Sheet:	Sheet 1 of 2
CLIENT:	Wexford County Council	Excavation Method:	JCB
ENGINEER:	Fehily Timoney and Company	Date Started:	14/07/2005
CO-ORDINATES:	E 298160.00 N 126518.00	Date Completed:	15/07/2005
		Ground Level (mOD):	10.69

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples			Vane Test (KPa)	Hand Penetrometer (KPa)
						Ref. No.	Type	Depth (m)		
0.0	MADE GROUND Road base		0.10	10.59						
	Soft to firm brown sandy gravelly CLAY with occasional cobbles and some fill material		0.50	10.19		Q7409	B	0.50		
	Soft to firm grey/brown mottled sandy gravelly CLAY with occasional cobbles, some boulders and constituents of fill/waste		1.00	9.69		Q7410	B	1.00		
1.0	Compact grey brown gravelly SAND with occasional cobbles		1.30	9.39		Q7411	B	1.30		
	Compact grey gravelly SAND with occasional cobbles and some boulders		1.70	8.99		Q7412	B	1.60		
2.0	Firm and stiff grey/brown mottled sandy gravelly CLAY with occasional cobbles and some boulders					Q7413	B	2.00		
						Q7414	B	3.50		
4.0	Continued next sheet									

Groundwater Conditions: No Groundwater observed

Stability: No instability observed

Remarks:

REPORT NO. 10965

TRIAL PIT RECORD

IGSL

CONTRACT:	Kilurin Landfill	Trial Pit No.:	TP1
		Sheet:	Sheet 2 of 2
CLIENT:	Wexford County Council	Excavation Method:	JCB
ENGINEER:	Fehily Timoney and Company	Date Started:	14/07/2005
CO-ORDINATES:	E 298160.00	Date Completed:	15/07/2005
	N 126518.00	Ground Level (mOD):	10.69

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples			Vane Test (KPa)	Hand Penetrometer (KPa)
						Ref. No.	Type	Depth (m)		
-4.0	Firm and stiff grey/brown mottled sandy gravelly CLAY with occasional cobbles and some boulders End of Trial Pit at 4.10 m		4.10	6.59						
-5.0										
-6.0										
-7.0										
-8.0										

Groundwater Conditions: No Groundwater observed

Stability: No instability observed

Remarks:

REPORT NO. 10965**TRIAL PIT RECORD****IGSL**

CONTRACT: Kilurin Landfill

Trial Pit No.: TP2

Sheet: Sheet 1 of 1

CLIENT: Wexford County Council

Excavation Method: JCB




ENGINEER: Fehily Timoney and Company

Date Started: 14/07/2005

Date Completed: 15/07/2005

CO-ORDINATES: E 298078.00
N 126193.00

Ground Level (mOD): 1.84

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples			Vane Test (KPa)	Hand Penetrometer (KPa)
						Ref. No.	Type	Depth (m)		
0.0	Brown TOPSOIL		0.15	1.69						
	Compact brown clayey gravelly SAND		0.40	1.44						
	Compact grey/brown gravelly SAND				▽					
1.0						Q7401	B	1.20		
	End of Trial Pit at 1.50 m		1.50	0.34						
2.0										
3.0										
4.0										

Groundwater Conditions: Slow groundwater ingress at 0.8m

Stability: Trial Pit terminated at 1.5m due to ingress of water which caused instability of the trial pit

Remarks:

REPORT NO. 10965

TRIAL PIT RECORD

IGSL

CONTRACT:	Kilurin Landfill	Trial Pit No.:	TP3
		Sheet:	Sheet 1 of 1
CLIENT:	Wexford County Council	Excavation Method:	JCB
ENGINEER:	Fehily Timoney and Company	Date Started:	14/07/2005
CO-ORDINATES:	E 298034.00 N 126254.00	Date Completed:	15/07/2005
		Ground Level (mOD):	2.06

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples			Vane Test (KPa)	Hand Penetrometer (KPa)
						Ref. No.	Type	Depth (m)		
0.0	Brown sandy TOPSOIL									
	Firm light brown gravelly sandy CLAY with occasional cobbles, some boulders and shale fragments		0.50	1.56						
1.0	Firm grey brown mottled sandy slightly gravelly CLAY with lens of silt		0.90	1.16		Q7402	B	0.90		
						Q7403	B	1.30		
	Firm grey/brown slightly gravelly CLAY with horizons of firm/stiff silt		1.60	0.46						
2.0	Soft to firm brown sandy SILT		2.10	-0.04	▽	Q7406	B	2.00		
	End of Trial Pit at 2.50 m		2.50	-0.44		Q7405	B	2.50		

Groundwater Conditions: Groundwater seepage observed at 2.2m

Stability: Trial Pit terminated at 2.5m due to ingress of water which caused instability of the trial pit

Remarks:

REPORT NO. 10965**TRIAL PIT RECORD****IGSL**

CONTRACT: Kilurin Landfill

Trial Pit No.: TP4

Sheet: Sheet 1 of 1

CLIENT: Wexford County Council

Excavation Method: JCB



ENGINEER: Fehily Timoney and Company

Date Started: 14/07/2005

Date Completed: 15/07/2005

CO-ORDINATES: E 298020.00
N 126299.00

Ground Level (mOD): 2.94

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples			Vane Test (KPa)	Hand Penetrometer (KPa)
						Ref. No.	Type	Depth (m)		
0.0	Brown TOPSOIL									
0.50	Compact orange/grey/brown mottled silty gravelly SAND		0.50	2.44						
1.0					▽	Q7407	B	1.00		
2.0										
2.50	End of Trial Pit at 2.50 m		2.50	0.44		Q7408	B	2.40		
3.0										
4.0										

Groundwater Conditions: Slow groundwater ingress at 1.0m

Stability: Trial Pit terminated at 2.5m due to ingress of water which caused instability of the trial pit

Remarks:

REPORT NO. 10965

TRIAL PIT RECORD

IGSL

CONTRACT:	Kilurin Landfill	Trial Pit No.:	TP5
		Sheet:	Sheet 1 of 1
CLIENT:	Wexford County Council	Excavation Method:	13t hytachi
ENGINEER:	Fehily Timoney and Company	Date Started:	19/07/2005
CO-ORDINATES:	E 298009.00 N 126380.00	Date Completed:	19/07/2005
		Ground Level (mOD):	1.63

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples			Vane Test (KPa)	Hand Penetrometer (KPa)
						Ref. No.	Type	Depth (m)		
0.0	Grey/black sandy TOPSOIL		0.15	1.48						
	Soft grey sandy slightly gravelly CLAY									
1.0	Soft brown sandy slightly gravelly CLAY		0.90	0.73		Q7422	B	0.80		
						Q7423	B	1.40		
	Compact light grey clayey very sandy GRAVEL with shale fragments		1.60	0.03		Q7424	B	1.70		
	Compact dense grey/orange mottled clayey very sandy GRAVEL		1.80	-0.17	▽	Q7426	B	1.90		
2.0	Firm grey/brown/ orange mottled sandy gravelly SILT/CLAY		2.00	-0.37						
			2.00	-0.37		Q7425	B	2.30		
	Possible obstruction or boulder		2.50	-0.87						
	End of Trial Pit at 2.50 m									
3.0										
4.0										

Groundwater Conditions: Slow groundwater ingress at 1.8m

Stability: Trial Pit unstable below 1.8m

Remarks:

REPORT NO. 10965

TRIAL PIT RECORD

IGSL

CONTRACT:	Kilurin Landfill	Trial Pit No.:	TP6
		Sheet:	Sheet 1 of 1
CLIENT:	Wexford County Council	Excavation Method:	13t hytachi
ENGINEER:	Fehily Timoney and Company	Date Started:	19/07/2005
CO-ORDINATES:	E 297913.00 N 126392.00	Date Completed:	19/07/2005
		Ground Level (mOD):	1.22

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples			Vane Test (KPa)	Hand Penetrometer (KPa)
						Ref. No.	Type	Depth (m)		
0.0	Brown/black sandy TOPSOIL		0.15	1.07						
	Soft brown sandy CLAY		0.30	0.92						
	Soft grey slightly very sandy gravelly CLAY		0.80	0.42						
1.0	Loose grey/blue silty slightly gravelly SAND		1.40	-0.18		Q7420	B	0.90		
	Loose grey clayey gravelly SAND with some limestone cobbles		2.10	-0.88	▽	Q7418	B	1.30		
2.0	Stiff grey/orange mottled silt(possible marl)		2.10	-0.88		Q7419	B	2.00		
	End of Trial Pit at 2.80 m		2.80	-1.58		Q7421	B	2.70		
3.0										
4.0										

Groundwater Conditions: Slow groundwater ingress at 2m

Stability: Trial Pit terminated at 2.8m due to ingress of water which caused instability of the trial pit.

Remarks:

REPORT NO. 10965

TRIAL PIT RECORD

IGSL

CONTRACT:	Kilurin Landfill	Trial Pit No.:	TP7
		Sheet:	Sheet 1 of 1
CLIENT:	Wexford County Council	Excavation Method:	13t hytachi
ENGINEER:	Fehily Timoney and Company	Date Started:	19/07/2005
CO-ORDINATES:	E 297855.00 N 126433.00	Date Completed:	19/07/2005
		Ground Level (mOD):	1.09

Depth (m)	Geotechnical Description	Legend	Depth (m)	Elevation (mOD)	Water Strike (m)	Samples			Vane Test (KPa)	Hand Penetrometer (KPa)
						Ref. No.	Type	Depth (m)		
0.0	Brown sandy TOPSOIL									
	Soft brown sandy PEAT (Von Post H5/H6)		0.40	0.69						
1.0	Loose grey/orange clayey gravelly SAND with occasional cobbles		0.80	0.29	▽	Q7417	B	0.90		
	Loose grey/orange slightly clayey very gravelly SAND		1.50	-0.41						
2.0	Compact grey slightly clayey very gravelly SAND		1.90	-0.81		Q7416	B	1.90		
						Q7415	B	2.20		
	End of Trial Pit at 2.50 m		2.50	-1.41						
3.0										
4.0										

Groundwater Conditions: Slow groundwater ingress at 1.2m

Stability: Trial Pit terminated at 2.5m due to ingress of water which caused instability of the trial pit

Remarks:

APPENDIX C

Borehole Logs

CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-01 SHEET: Sheet 1 of 2
----------------------------	---

CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): 86 GROUND LEVEL (mOD): 10.69	DATE STARTED: 22/08/2005 DATE COMPLETED: 22/08/2005
--	---	--

CO-ORDINATES: 298159.76 126518.00	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
--------------------------------------	--	-------------------------------------

DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
1								[Symbolic Log Pattern]					SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of clayey sandy gravel
2								[Symbolic Log Pattern]					
3								[Symbolic Log Pattern]	7.69	3.00			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of silty clay
4								[Symbolic Log Pattern]					
5								[Symbolic Log Pattern]					
6								[Symbolic Log Pattern]	4.39	6.30			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of angular gravel
7								[Symbolic Log Pattern]	3.79	6.90			SYMETREX OPEN HOLE DRILLING: Observed by driller as clayey sandy angular gravel size returns of greywacke (probable greywacke bedrock)
7.40								[Symbolic Log Pattern]	3.29	7.40			
8	7.40	100	0	0				[Symbolic Log Pattern]					Moderately strong, thinly bedded, medium grained GREYWACKE, moderately weathered with disseminated quartz veining throughout, intersected by rough, undulose to irregular, open, iron Continued next sheet
8.40								[Symbolic Log Pattern]					

REMARKS: Groundwater encountered at 7.0m at start of drilling; Headworks: concrete & cap	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 8.40 Depth to Response Zone bottom (m) : 13.40 Comments : Pea Gravel Pack: 8.4m-13.4m; Seal: 0.0m-8.4m
---	--

CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-01 SHEET: Sheet 2 of 2
----------------------------	---

CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): 86 GROUND LEVEL (mOD): 10.69	DATE STARTED: 22/08/2005 DATE COMPLETED: 22/08/2005
--	---	--

CO-ORDINATES: 298159.76 126518.00	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
--------------------------------------	--	-------------------------------------

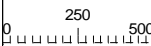
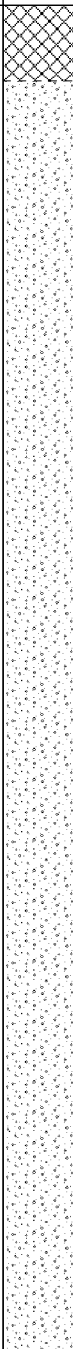
DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
9	9.40	100	30	30									oxide stained fractures of sub-45° & irregular dip
10	10.40	100	11	11									
11	11.40	100	52	52					-0.11	10.80			Strong to locally moderately strong, medium to thinly bedded, medium grained GREYWACKE, slightly to locally moderately weathered with disseminated quartz veining throughout, intersected by rough, undulose, open to locally tight, iron oxide stained fractures of sub-45° & irregular dip
12	12.10	100	94	94									
13	13.40	100	6	0					-2.71	13.40			End of Borehole at 13.40 m
14													
15													
16													

REMARKS: Groundwater encountered at 7.0m at start of drilling; Headworks: concrete & cap	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 8.40 Depth to Response Zone bottom (m) : 13.40 Comments : Pea Gravel Pack: 8.4m-13.4m; Seal: 0.0m-8.4m
---	--

CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-02 SHEET: Sheet 1 of 2
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): 74 GROUND LEVEL (mOD): 1.84	DATE STARTED: 23/08/2005 DATE COMPLETED: 23/08/2005
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CO-ORDINATES: 298077.92 126193.46	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
1 2 3 4 5 6 7 8									1.34	0.50			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of hardcore</p> <hr style="border-top: 1px dashed black;"/> <p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sandy gravel</p>
Continued next sheet													

REMARKS: Groundwater encountered at 7.0m at start of drilling; Headworks: concrete & cap; Packer test from 11.7m- 13.7m	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 11.70 Depth to Response Zone bottom (m) : 17.70 Comments : Pea Gravel Pack: 11.7m-17.7m; Seal: 0.0m-11.7m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-02
	SHEET: Sheet 2 of 2

CLIENT: Wexford County Council	CORE DIAMETER (mm): 74	DATE STARTED: 23/08/2005
ENGINEER: Fehily Timoney and Company	GROUND LEVEL (mOD): 1.84	DATE COMPLETED: 23/08/2005

CO-ORDINATES: 298077.92 126193.46	INCLINATION (Degrees): 90	DRILLED BY: IGSL
	FLUSH: Air/Mist	LOGGED BY: IGSL

DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
9													<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sandy gravel</p>
10									-7.86	9.70			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as clayey sandy angular gravel size returns of greywacke (probable greywacke bedrock)</p>
11	10.50	100	34	0					-8.66	10.50			<p>Moderately strong, thinly bedded, fine to medium grained GREYWACKE, moderately to slightly weathered, intersected by rough to smooth, planar to undulose to irregular, open to locally tight, heavily iron oxide stained, commonly clay smeared fractures of sub-45° & irregular dip (Symetrex open hole drilling continued to 17.7m)</p>
12	11.40												
13	12.70	100	18	0									
14	13.50	87	61	50									
15	13.70	100	0	0					-11.86	13.70			<p>SYMETREX OPEN HOLE DRILLING: No recovery recorded by driller</p>
16													
17	17.70								-15.86	17.70			<p>End of Borehole at 17.70 m</p>

REMARKS: Groundwater encountered at 7.0m at start of drilling; Headworks: concrete & cap; Packer test from 11.7m- 13.7m	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 11.70 Depth to Response Zone bottom (m) : 17.70 Comments : Pea Gravel Pack: 11.7m-17.7m; Seal: 0.0m-11.7m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-03 SHEET: Sheet 1 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 2.06	DATE STARTED: 25/08/2005 DATE COMPLETED: 25/08/2005
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CO-ORDINATES: 298034.20 126254.12	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
1									1.56	0.50			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of hardcore
2									0.36	1.70			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of clayey sandy gravel
3													SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sand
4													
5													
6									-4.04	6.10			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sandy gravel
7													
8													

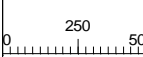
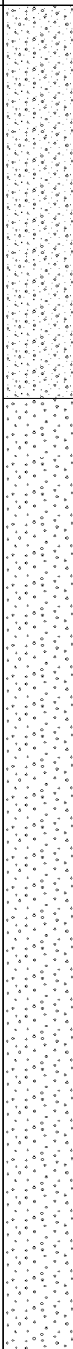
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REMARKS: Borehole dry at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 12.80 Depth to Response Zone bottom (m) : 18.80 Comments : Pea Gravel Pack: 12.8m-18.8m; Seal: 0.0m-12.8m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-03 SHEET: Sheet 2 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 2.06	DATE STARTED: 25/08/2005 DATE COMPLETED: 25/08/2005
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CO-ORDINATES: 298034.20 126254.12	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
9 10 11 12 13 14 15 16									-9.44	11.50			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sandy gravel</p> <hr/> <p>SYMETREX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone</p>
Continued next sheet													

REMARKS: Borehole dry at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 12.80 Depth to Response Zone bottom (m) : 18.80 Comments : Pea Gravel Pack: 12.8m-18.8m; Seal: 0.0m-12.8m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-03 SHEET: Sheet 3 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 2.06	DATE STARTED: 25/08/2005 DATE COMPLETED: 25/08/2005
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CO-ORDINATES: 298034.20 126254.12	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
18									-16.74	18.80			SYMETREX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone <hr style="border-top: 1px dashed black;"/> End of Borehole at 18.80 m
19													
20													
21													
22													
23													
24													
25													

REMARKS: Borehole dry at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 12.80 Depth to Response Zone bottom (m) : 18.80 Comments : Pea Gravel Pack: 12.8m-18.8m; Seal: 0.0m-12.8m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-04 SHEET: Sheet 1 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 2.94	DATE STARTED: 25/08/2005 DATE COMPLETED: 25/08/2005
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CO-ORDINATES: 298019.81 126299.00	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
					0 250 500			[Symbolic Log Pattern]	2.64	0.30			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of hardcore
								[Symbolic Log Pattern]	2.34	0.60			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of peat
1								[Symbolic Log Pattern]	1.94	1.00			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of brown clayey sandy gravel
2								[Symbolic Log Pattern]					SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sand
3								[Symbolic Log Pattern]					
4								[Symbolic Log Pattern]					
5								[Symbolic Log Pattern]					
6								[Symbolic Log Pattern]					
7								[Symbolic Log Pattern]	-3.86	6.80			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sandy gravel
8								[Symbolic Log Pattern]					

Continued next sheet

REMARKS: Borehole dry at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 14.00 Depth to Response Zone bottom (m) : 20.00 Comments : Pea Gravel Pack: 14.0m-20.0m; Seal: 0.0m-14.0m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-04 SHEET: Sheet 2 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 2.94	DATE STARTED: 25/08/2005 DATE COMPLETED: 25/08/2005
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CO-ORDINATES: 298019.81 126299.00	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
9									-6.36	9.30			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sandy gravel</p> <p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of brown sandy gravelly clay</p>
10													
11													
12									-8.76	11.70			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone</p>
13													
14													
15													
16													

Continued next sheet

REMARKS: Borehole dry at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 14.00 Depth to Response Zone bottom (m) : 20.00 Comments : Pea Gravel Pack: 14.0m-20.0m; Seal: 0.0m-14.0m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-04 SHEET: Sheet 3 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 2.94	DATE STARTED: 25/08/2005 DATE COMPLETED: 25/08/2005
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CO-ORDINATES: 298019.81 126299.00	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
18					0 250 500 ----- ----- ----- -----								SYMETREX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone ----- End of Borehole at 20.00 m
19								-17.06	20.00				
20													
21													
22													
23													
24													
25													

REMARKS: Borehole dry at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 14.00 Depth to Response Zone bottom (m) : 20.00 Comments : Pea Gravel Pack: 14.0m-20.0m; Seal: 0.0m-14.0m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-05 SHEET: Sheet 1 of 2
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): 74 GROUND LEVEL (mOD): 1.63	DATE STARTED: 26/08/2005 DATE COMPLETED: 26/08/2005
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CO-ORDINATES: 298008.80 126380.50	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
1					0 250 500				1.23	0.40			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of hardcore
2									0.63	1.00			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of brown clayey sandy gravel
3													SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of silty gravel
4									-2.47	4.10			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of sandy gravel
5													
6													
7													
8									-6.37	8.00			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of silty clay
									-6.87	8.50			SYMETREX OPEN HOLE DRILLING: Continued next sheet

REMARKS: Groundwater encountered at 1.0m at start of drilling; Headworks: concrete & cap; Packer test from 10.0m-12.0m	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 10.00 Depth to Response Zone bottom (m) : 16.00 Comments : Pea Gravel Pack: 10.0m-16.0m; Seal: 0.0m-10.0m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-05
	SHEET: Sheet 2 of 2

CLIENT: Wexford County Council	CORE DIAMETER (mm): 74	DATE STARTED: 26/08/2005
ENGINEER: Fehily Timoney and Company	GROUND LEVEL (mOD): 1.63	DATE COMPLETED: 26/08/2005

CO-ORDINATES: 298008.80	INCLINATION (Degrees): 90	DRILLED BY: IGSL
126380.50	FLUSH: Air/Mist	LOGGED BY: IGSL

DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
9	9.00	100	0	0					-7.37	9.00			Observed by driller as clayey sandy angular gravel size returns of greywacke (probable greywacke bedrock)
10	9.80	100	0	0									Moderately weak to locally moderately strong, thinly bedded, fine to medium grained GREYWACKE, moderately to locally slightly weathered, intersected by rough, irregular, open, iron oxide stained, clay/gravel infilled (at 15.7m-16.0m) fractures of irregular dip (predominantly gravel and cobble size returns)
11	11.20	100	0	0									
12	12.00	100	22	14									
13	13.00	100	0	0									
	13.50	100	24	24									
14	14.00	100	22	16									
15	15.00	100	25	25									
16	16.00								-14.37	16.00			End of Borehole at 16.00 m

REMARKS: Groundwater encountered at 1.0m at start of drilling; Headworks: concrete & cap; Packer test from 10.0m-12.0m	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 10.00 Depth to Response Zone bottom (m) : 16.00 Comments : Pea Gravel Pack: 10.0m-16.0m; Seal: 0.0m-10.0m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-06 SHEET: Sheet 1 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 1.22	DATE STARTED: 26/08/2005 DATE COMPLETED: 26/08/2005
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CO-ORDINATES: 297913.28 126392.46	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
0					0 250 500				0.92	0.30			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of hardcore</p> <p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of silty gravel</p>
1													
2									-0.78	2.00			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of silty clay</p>
3													
4													
5													
6													
7													
8									-7.28	8.50			<p>SYMETREX OPEN HOLE DRILLING: Continued next sheet</p>

REMARKS: Groundwater encountered at 9.2m at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 13.20 Depth to Response Zone bottom (m) : 19.20 Comments : Pea Gravel Pack: 13.2m-19.2m; Seal: 0.0m-13.2m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-06 SHEET: Sheet 2 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 1.22	DATE STARTED: 26/08/2005 DATE COMPLETED: 26/08/2005
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CO-ORDINATES: 297913.28 126392.46	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
9													Observed by driller as returns of clayey sandy gravel
10									-8.78	10.00			SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of clayey sandy gravel
11													
12									-10.98	12.20			SYMETREX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone
13													
14													
15													
16													

Continued next sheet

REMARKS: Groundwater encountered at 9.2m at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 13.20 Depth to Response Zone bottom (m) : 19.20 Comments : Pea Gravel Pack: 13.2m-19.2m; Seal: 0.0m-13.2m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-06 SHEET: Sheet 3 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 1.22	DATE STARTED: 26/08/2005 DATE COMPLETED: 26/08/2005
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CO-ORDINATES: 297913.28 126392.46	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
18									-17.98	19.20			SYMETREX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone ----- End of Borehole at 19.20 m
19													
20													
21													
22													
23													
24													
25													

REMARKS: Groundwater encountered at 9.2m at start of drilling; Headworks: concrete & cap;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 13.20 Depth to Response Zone bottom (m) : 19.20 Comments : Pea Gravel Pack: 13.2m-19.2m; Seal: 0.0m-13.2m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-07 SHEET: Sheet 1 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 1.09	DATE STARTED: 27/08/2005 DATE COMPLETED: 27/08/2005
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CO-ORDINATES: 297855.28 126432.89	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
0					0 250 500			[Symbolic Log Pattern]	0.79	0.30			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of hardcore</p> <p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of clayey sandy gravel</p>
1								[Symbolic Log Pattern]					
2								[Symbolic Log Pattern]	-0.91	2.00			<p>SYMETREX OPEN HOLE DRILLING: Observed by driller as returns of silty clay</p>
3								[Symbolic Log Pattern]					
4								[Symbolic Log Pattern]					
5								[Symbolic Log Pattern]					
6								[Symbolic Log Pattern]					
7								[Symbolic Log Pattern]					
8								[Symbolic Log Pattern]					

Continued next sheet

REMARKS: Borehole dry at start of drilling;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 14.50 Depth to Response Zone bottom (m) : 20.50 Comments : Pea Gravel Pack: 14.5m-20.5m; Seal: 0.0m-14.5m
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CONTRACT: Kilurin Landfill	DRILLHOLE NO : BR-07 SHEET: Sheet 3 of 3
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CLIENT: Wexford County Council ENGINEER: Fehily Timoney and Company	CORE DIAMETER (mm): GROUND LEVEL (mOD): 1.09	DATE STARTED: 27/08/2005 DATE COMPLETED: 27/08/2005
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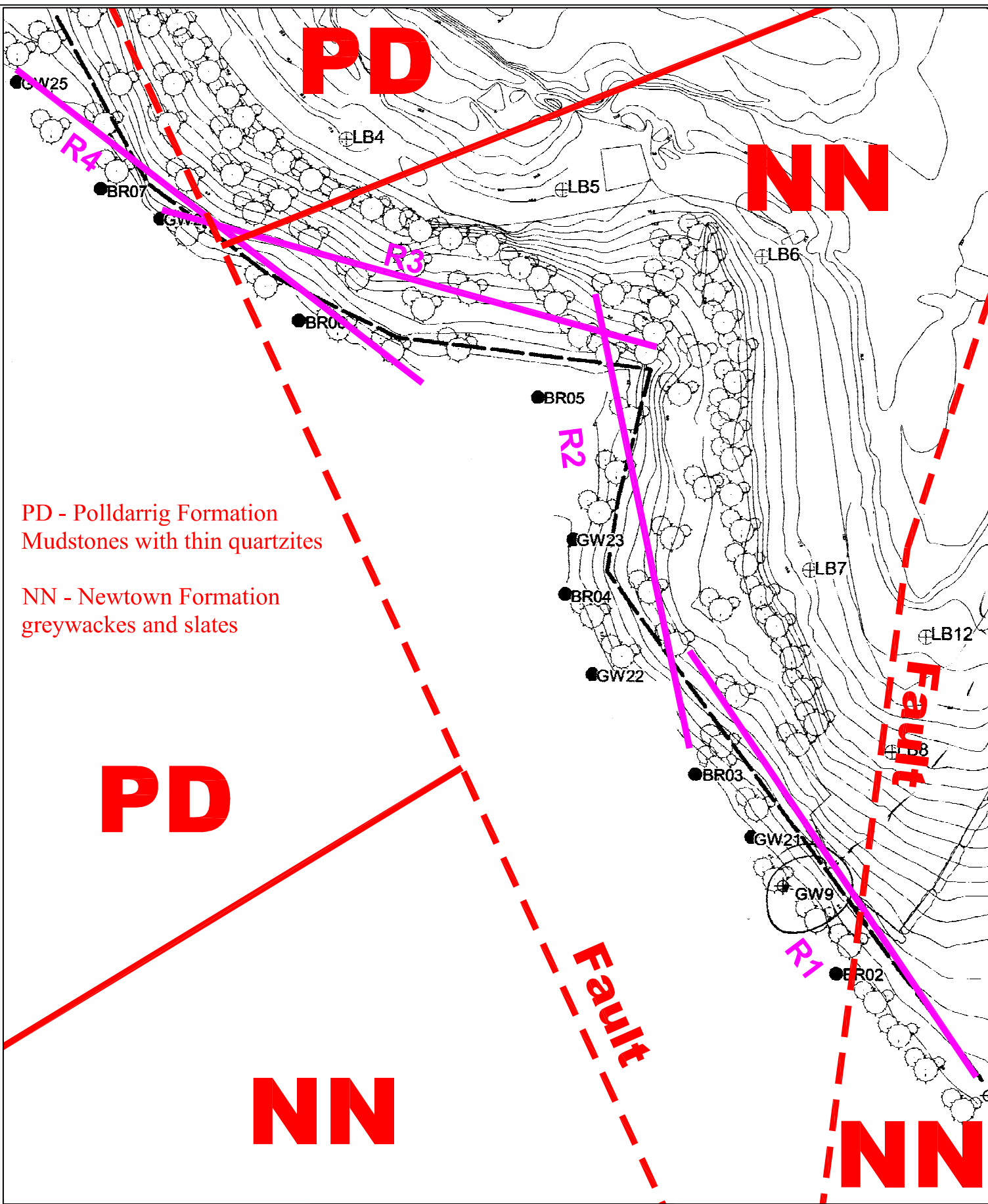
CO-ORDINATES: 297855.28 126432.89	INCLINATION (Degrees): 90 FLUSH: Air/Mist	DRILLED BY: IGSL LOGGED BY: IGSL
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DOWNHOLE DEPTH (m)	CORE RUN DEPTH (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing (mm)	UCS (MPa)	POINT LOAD Is(50) MPa	SYMBOLIC LOG	ELEVATION (mOD)	DEPTH (m)	SPT (N value)	STANDPIPE DETAILS	GEOTECHNICAL DESCRIPTION
18													SYMETREX OPEN HOLE DRILLING: Observed by driller as angular gravel size returns of siltstone ----- End of Borehole at 20.50 m
19								-19.41	20.50				
20													
21													
22													
23													
24													
25													

REMARKS: Borehole dry at start of drilling;	INSTALLATION DETAILS Installation Type : SP Depth to Response Zone top (m) : 14.50 Depth to Response Zone bottom (m) : 20.50 Comments : Pea Gravel Pack: 14.5m-20.5m; Seal: 0.0m-14.5m
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APPENDIX D

Geophysical Survey




PD - Polldarrig Formation
Mudstones with thin quartzites

NN - Newtown Formation
greywackes and slates

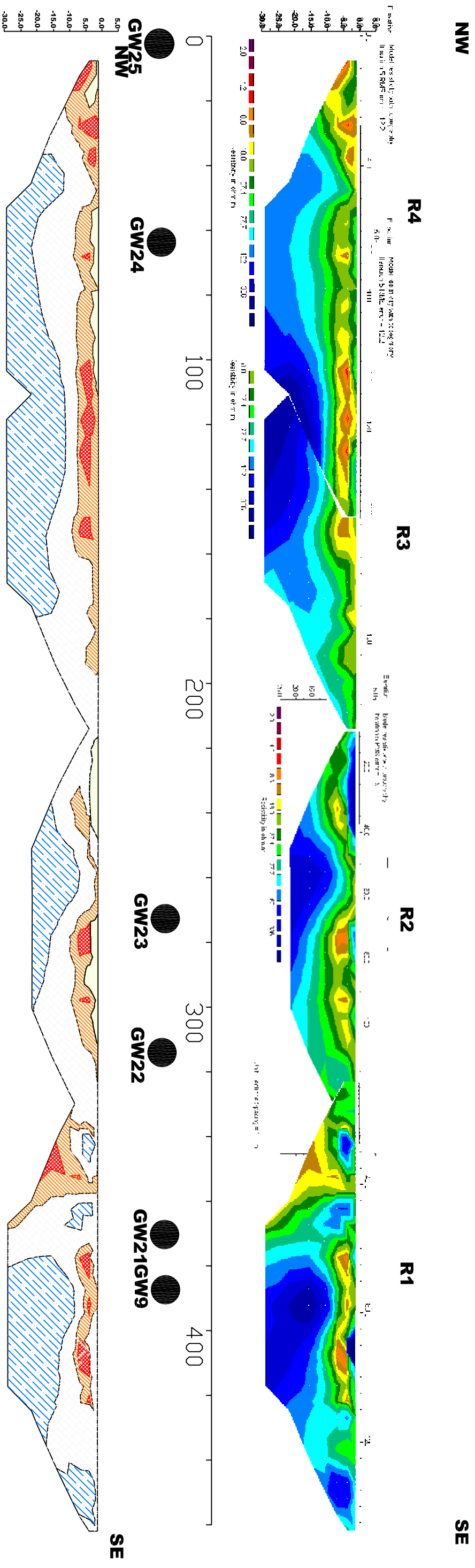


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2D Resistivity Profile

PROJECT:	Killuran Landfill, Co. Wexford
DRAWING TITLE:	Map 1- Geophysical Survey Locations
DATE:	November 2005
CLIENT:	IGSL
SCALE:	1:1500



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	Dry Sandy Clay		Fresh Rock
	Saturated Sandy Clay		
	Leachate		
	Weathered Rock		

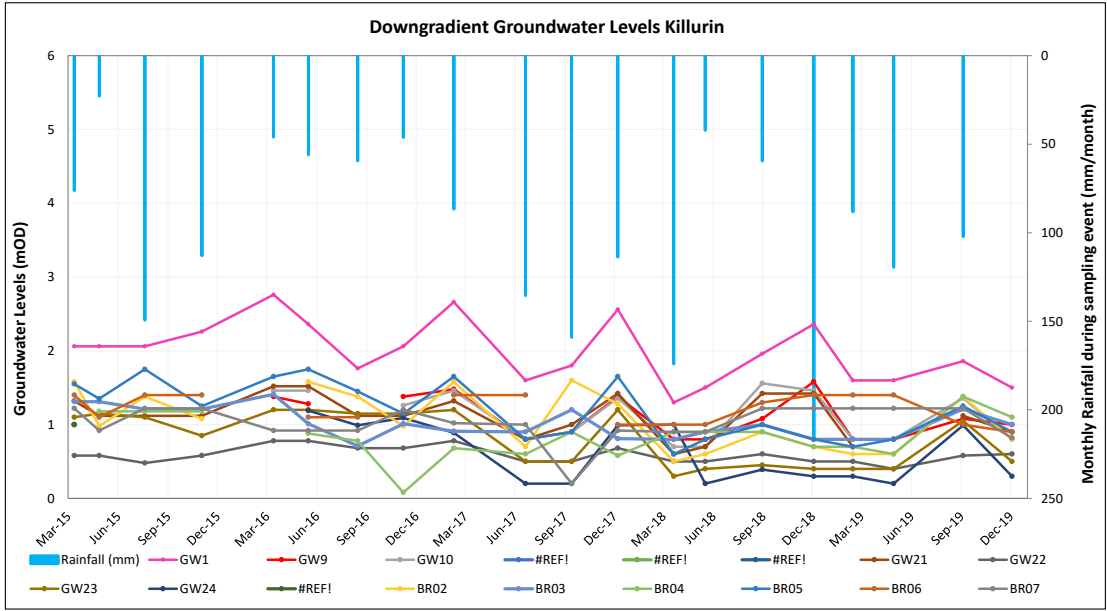
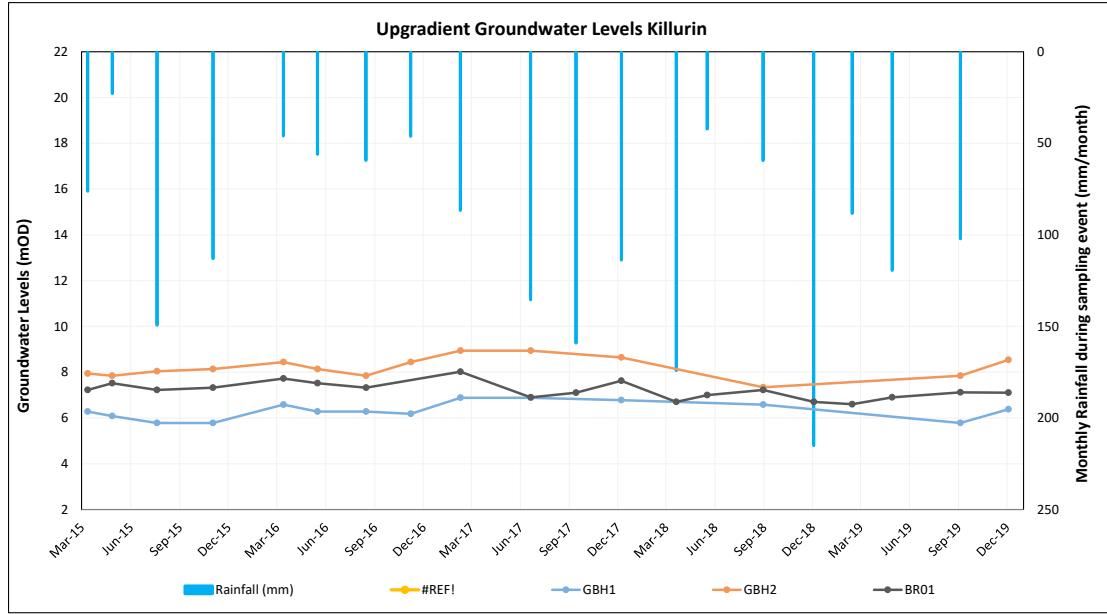
PROJECT:	Killuran Landfill, Co. Wexford
DRAWING TITLE:	Section 1
DATE:	November 2005
CLIENT:	IGSL
SCALE:	HZ 1:1250 VV 1:1250

APPENDIX E

Groundwater & Leachate Levels

DATE	GW1	GW9	GW10	GW21	GW22	GW23	GW24	GBH1	GBH2	BR01	BR02	BR03	BR04	BR05	BR06	BR07	Rainfall (mm)
12/03/2015	2.06			1.32	0.58	1.10		6.28	7.94	7.22	1.58	1.31		1.55	1.40	1.22	76.20
27/04/2015	2.06			1.12	0.58	1.15		6.08	7.84	7.52	0.98	1.31	1.18	1.35	1.10	0.92	22.90
20/07/2015	2.06			1.12	0.48	1.10		5.78	8.04	7.22	1.38	1.21	1.18	1.75	1.40	1.22	149.40
02/11/2015	2.26			1.12	0.58	0.85		5.78	8.14	7.32	1.08	1.21	1.18	1.25	1.40	1.22	113.00
13/03/2016	2.76	1.38	1.46	1.52	0.78	1.20		6.58	8.44	7.72		1.41		1.65		0.92	46.00
16/05/2016	2.36	1.28	1.46	1.52	0.78	1.20	1.19	6.28	8.14	7.52	1.58	1.01	0.88	1.75	1.10	0.92	56.00
15/08/2016	1.76			1.12	0.68	1.15	0.99	6.28	7.84	7.32	1.38	0.71	0.78	1.45	1.10	0.92	59.40
07/11/2016	2.06	1.38	1.26	1.12	0.68	1.15	1.09	6.18	8.44		0.98	1.01	0.08	1.15		1.20	46.20
08/02/2017	2.66	1.48	1.46	1.32	0.78	1.2	0.89	6.88	8.94	8.02	1.58	0.91	0.68	1.65	1.4	1.02	86.7
20/06/2017	1.60	0.8	0.80	0.80	0.50	0.50	0.20	6.88	8.94	6.90	0.70	0.90	0.60	0.80	1.40	1.00	135.50
13/09/2017	1.80	0.90	0.90	1.00	0.50	0.50	0.20			7.10	1.60	1.20	0.90	0.90		0.20	159.10
07/12/2017	2.56	1.38	1.36	1.42	0.68	1.2	0.99	6.78	8.64	7.62	1.28	0.81	0.58	1.65	1	0.92	113.8
20/03/2018	1.30	0.80	0.70	0.60	0.50	0.30	1.00			6.70	0.50	0.80	0.90	0.60	1.00	0.90	174.10
17/05/2018	1.50	0.80	0.70	0.70	0.50	0.40	0.20			7.00	0.60	0.90	0.90	0.80	1.00	0.90	42.20
30/08/2018	1.96	1.08	1.56	1.42	0.6	0.45	0.39	6.58	7.34	7.22	0.90	1.00	0.90	1.00	1.30	1.22	59.5
03/12/2018	2.36	1.58	1.46	1.42	0.50	0.40	0.30			6.70	0.70	0.80	0.70	0.80	1.40	1.22	215.10
13/02/2019	1.60	0.80	0.80	0.70	0.50	0.40	0.30			6.60	0.60	0.80	0.70	0.70	1.40	1.22	88.30
29/04/2019	1.60	0.80	0.80		0.40	0.40	0.20			6.90	0.60	0.80	0.60	0.80	1.40	1.22	119.50
04/09/2019	1.86	1.08	1.36	1.12	0.58	1.05	0.99	5.78	7.84	7.12	1.38	1.21	1.38	1.25	1	1.22	102.2
03/12/2019	1.5	1	0.8	0.9	0.6	0.5	0.3	6.38	8.54	7.1	0.8	1	1.1	0.9	0.9	0.82	-

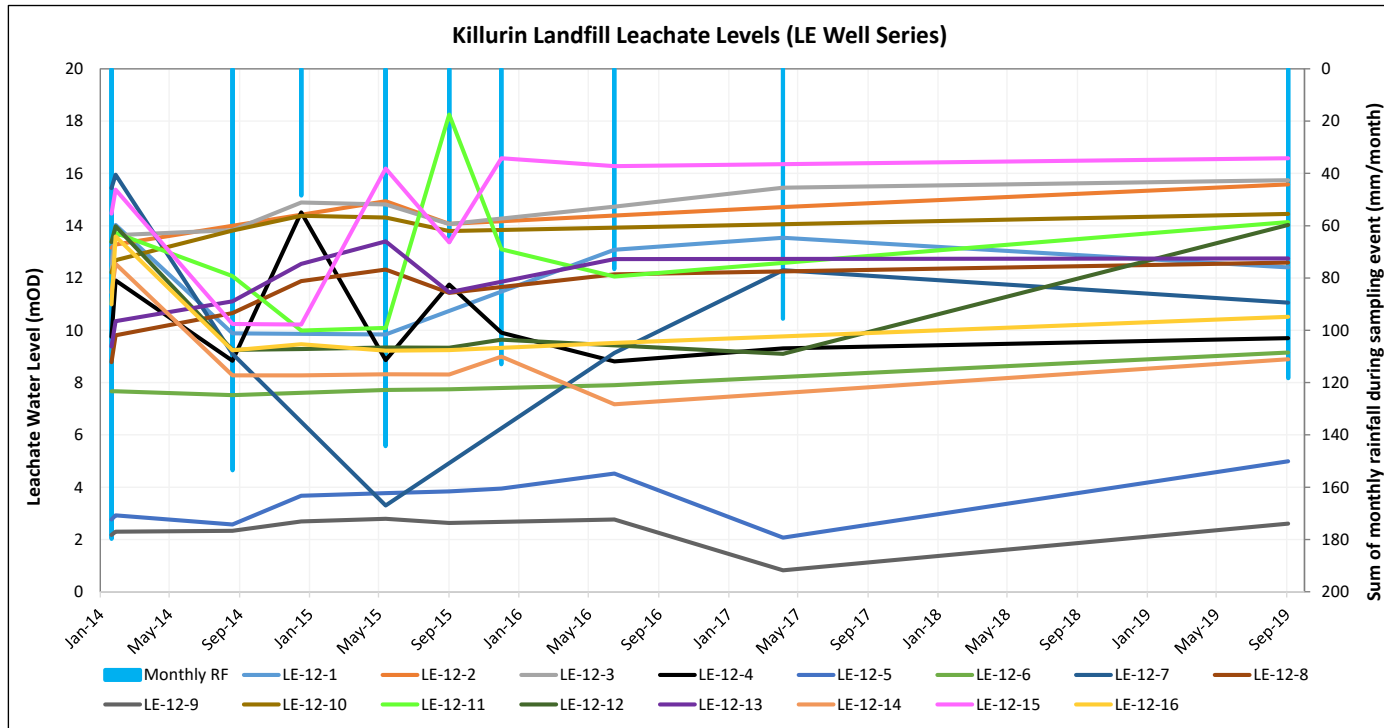
	GW1	GW9	GW10	GW21	GW22	GW23	GW24	GBH1	GBH2	BR01	BR02	BR03	BR04	BR05	BR06	BR07
Min	1.30	0.80	0.70	0.60	0.40	0.30	0.20	5.78	7.34	6.60	0.50	0.71	0.08	0.60	0.90	0.20
Max	2.76	1.58	1.56	1.52	0.78	1.20	1.19	6.88	8.94	8.02	1.60	1.41	1.38	1.75	1.40	1.22
Variance	1.46	0.78	0.86	0.92	0.38	0.90	0.99	1.10	1.60	1.42	1.10	0.70	1.30	1.15	0.50	1.02



Leachate Levels (mOD) - Killurin Landfill

Date	LE-12-1	LE-12-2	LE-12-3	LE-12-4	LE-12-5	LE-12-6	LE-12-7	LE-12-8	LE-12-9	LE-12-10	LE-12-11	LE-12-12	LE-12-13	LE-12-14	LE-12-15	LE-12-16	Monthly RF (mm)
20/01/2014	12.62	13.16	12.29	9.75	2.76	7.67	15.44	8.78	2.17	12.21	13.40	13.37	9.38	11.44	14.46	10.99	179.8
27/01/2014	14.03	13.28	13.64	11.91	2.92	7.67	15.95	9.81	2.30	12.68	13.72	13.98	10.35	12.54	15.38	13.59	179.8
19/08/2014	9.88		13.83	8.83	2.57	7.52	9.1	10.66	2.33	13.81	12.07	9.25	11.11	8.28	10.24	9.23	153.5
17/12/2014			14.89	14.51	3.67			11.88	2.69	14.38	9.99	9.28	12.54	8.28	10.22	9.47	48.5
13/05/2015	9.84	14.94	14.81	8.86	3.77	7.72	3.30	12.32	2.79	14.31	10.09	9.34	13.40	8.32	16.19	9.22	144.3
01/09/2015		14.07	14.06	11.75	3.84	7.74		11.43	2.63	13.80	18.25	9.33	11.46	8.31	13.36	9.24	66.1
01/12/2015				9.91	3.95						13.1	9.64		8.99	16.58		113
15/06/2016	13.08		14.73	8.81	4.52	7.9	9.13	12.14	2.76		12.06		12.72	7.17	16.28	9.52	76.6
05/04/2017	13.54	14.71	15.45	9.31	2.07		12.3		0.82			9.1					95.6
03/09/2019	12.41	15.58	15.74	9.7	4.99	9.15	11.06	12.59	2.61	14.45	14.14	14.03	12.75	8.89	16.58	10.52	118.3

Min	9.84	13.16	12.29	8.81	2.07	7.52	3.30	8.78	0.82	12.21	9.99	9.10	9.38	7.17	10.22	9.22	
Max	14.03	15.58	15.74	14.51	4.99	9.15	15.95	12.59	2.79	14.45	18.25	14.03	13.40	12.54	16.58	13.59	
Variance	4.19	2.42	3.45	5.70	2.92	1.63	12.65	3.81	1.97	2.24	8.26	4.93	4.02	5.37	6.36	4.37	



APPENDIX F

Groundwater & Leachate Hydrochemistry

Ammoniacal Nitrogen (mg/l)

Date	GW1	GW9	GW10	GW11	GW21	GW22	GW23	GW24	GW25	GBH1	GBH2	BR01	BR02	BR03	BR04	BR05	BR06	BR07	IGV	GTV	
12-Mar-15	8			0.021	58	67	36			0.029	0.041	0.12	23	86	47	72	4.6	0.19	0.15	0.175	
27-Apr-15	8				63	66	41			0.42	<0.02	0.02	23	84	44	72	9	0.025	0.15	0.175	
20-Jul-15	8.1			0.052	44	56	24			0.047	<0.02	<0.02	20	84	48	74	7.1	<0.02	0.15	0.175	
02-Nov-15	8.4			0.02	39	64	34			0.04	0.02	0.029	21	83	52	71	5.2	0.028	0.15	0.175	
13-Mar-16	8.74	20.7	<0.2	<0.2	36.5	61.6	46.6	47.3	1.29	<0.2	<0.2	<0.2	19.4	79.7	30.1	67.4	8	<0.2	0.15	0.175	
16-May-16	8.7	18.9	<0.2		40.5	62.5	40.2	50.2	79.3	<0.2	3.12	<0.2	19	79.4	32.6	67	4.51	<0.2	0.15	0.175	
15-Aug-16	8.61	14.7	<0.2		40.5	48.5	37.7	52.1	3.12	<0.2	<0.2	<0.2	19	78.8	29.7	64	2.72	<0.2	0.15	0.175	
07-Nov-16	8.5	9.48	<0.2		30.9	53.5	33.2	35.9	10.9	<0.2	<0.2	<0.2	19.6	75.8	23.8	61.9	2.71	<0.2	0.15	0.175	
08-Feb-17	8.44	17.4	<0.2		22.6	57.6	27.4	55.5	2.43	<0.2	<0.2	<0.2	23.7	71.5	23.6	61.4	6.53	<0.2	0.15	0.175	
20-Jun-17	7.85	13.8	1.09		19.8	57.9	22.4	77.8	2.72	<0.2	<0.2	<0.2	19.7	75	26.5	61.6	6.53	<0.2	0.15	0.175	
13-Sep-17																				0.15	0.175
07-Sep-17																				0.15	0.175
21-Mar-18	7.18	14.2	<0.2		12.8	56.5	37.7	94	1.65	<0.2	<0.2	<0.2	18.9	72.4	23.6	56.5	9.57	<0.2	0.15	0.175	
17-May-18	7.05	6.44	<0.2		15.8	54.8	36.6	63.7	1.19	0.262	<0.2	<0.2	18.9	71.4	24.7	56.8	10.8	<0.2	0.15	0.175	
30-Aug-18	12.4	17.3	8.78		36.1	48.8	32.4	47.5	6	12.8	4.39	0.208	20.2	70.1	24.9	54.4	6.95	0.306	0.15	0.175	
03-Dec-18	7.79	10.6	0.1		22.9	54.3	35.3	76.5	2.34	0.0444	0.065	35.7	20.3	67.2	24.2	53.3	6.98	0.0401	0.15	0.175	
13-Feb-19	8.15	11.6	0.124		17.6	55.1	40.9	87.3	1.71	23.9	0.039	0.0188	24.2	70.6	24.6	53.4	8.96	0.0319	0.15	0.175	
29-Apr-19	8.11	13	0.0769		16.5	53	37.5	59.1	3.52	0.0433	0.021	0.0128	25		25.4	53.1	10.2	0.0289	0.15	0.175	
04-Sep-19	8.84	9.15	0.138		26.9	42.4	29.6	23.1	3.47	0.0251	0.03	0.0132	24.4	69.4	24.8	51.9	8.89	0.0318	0.15	0.175	
16-Oct-19	9.33	8.72	0.0953		24.1	47.7	28.1		3.5	0.0308	0.034	<0.01	24.7	70	21.5	52.1	8.71	0.0234	0.15	0.175	
Max	12.4	20.7	8.78	0.052	63	67	46.6	94	79.3	23.9	4.39	35.7	25	86	52	74	10.8	0.306	GTV/IGV exceed		
Min	7.05	6.44	0.0769	0.02	12.8	42.4	22.4	23.1	1.19	0.0251	0.02	0.0128	18.9	67.2	21.5	51.9	2.71	0.0234			
Average	8.46	13.29	1.49	0.03	31.53	55.96	34.48	59.23	8.80	3.42	0.86	4.52	21.33	75.78	30.61	61.32	7.11	0.08			

Chloride (mg/l)

Date	GW1	GW9	GW10	GW11	GW21	GW22	GW23	GW24	GW25	GBH1	GBH2	BR01	BR02	BR03	BR04	BR05	BR06	BR07	IGV	GTV
12-Mar-15	81			17	205	178	110	dry	dry	22	29	34	74	176	86	85	125	231	30	187.5
27-Apr-15	74			dry	184	168	119	dry	dry	24	27	32	65	169	84	78	127	216	30	187.5
20-Jul-15	82			17	180	162	103	dry	dry	18	26	33	56	170	84	78	114	225	30	187.5
02-Nov-15	80			14	177	161	80	dry	dry	17	39	32	71	162	91	78	149	217	30	187.5
13-Mar-16	68.4	60.8	145	26.8	162	148	103	92.1	100	20.4	26.8	31.2	54.4	174	73.2	71.7	191	200	30	187.5
16-May-16	74.1	58.3	161		164	152	91.9	184	395	19.1	26.6	31.6	49.2	165	64.6	65	105	198	30	187.5
15-Aug-16	73.2	59.2	133		155	148	93	180	151	15.4	22.9	32.8	54.4	159	63	63.2	98.4	200	30	187.5
07-Nov-16	65	84.6	71.5		154	149	75.5	167	366	18.5	29.4	32.8	65.1	152	62.1	66.7	119	206	30	187.5
08-Feb-17	68	84.4	69.4		149	151	78.7	172	237	20.8	23.8	31	97.2	154	57.7	63.9	171	187	30	187.5
20-Jun-17	54.6	79	60.1		141	143	140	152	177	20.8	23.8	28.4	58.5	160	62.2	65.5	171	187	30	187.5
13-Sep-17	53.3	70.3	35.2		176	162	110	173	183	17.2	28	31.5	65.3	164	70.8	66.8	173	206	30	187.5
07-Sep-17	54.9	85.7	47.2		150	149	93.6	169	189	19.7	23.3	30.4	80.8	157	52.8	63.4	164	199	30	187.5
21-Mar-18	44	82.3	128		126	140	117	199	152	20.4	27.1	29.1	59.6	156	60.7	63	182	193	30	187.5
17-May-18	41	79.7	143		130	135	111	191	107	19.4	25.6	30	49.3	152	63	57.6	175	183	30	187.5
30-Aug-18	46.7	79.8	91.2		176	147	103	192	189	17	28.8	32.7	57.5	154	58.2	61.7	151	199	30	187.5
03-Dec-18	55.5	138	46.3		159	138	78.9	909	916	23.4	28.2	30.4	69.9	142	71.1	58.3	166	188	30	187.5
13-Feb-19	67	97.4	132		143	142	191	209	315	17.6	26.9	28.4	96.1	151	62.4	61	168	189	30	187.5
29-Apr-19	69.6	98.8	147		136	140	144	199	177	16	23.1	30	66.6		64.4	59	178	188	30	187.5
04-Sep-19	88.9	84.7	119		150	135	105	169	598	15.5	22.4	30.9	71.4	150	67.9	58.6	169	187	30	187.5
16-Oct-19	134	95.6	24.3		129	133	90.4		635	23	19.9	30.4	69.1	140	51	52.7	171	176	30	187.5
Max	134	138	161	26.8	205	178	191	909	916	24	39	34	97.2	176	91	85	191	231	GTV/IGV exceed	
Min	41	58.3	24.3	14	126	133	75.5	92.1	100	15.4	19.9	28.4	49.2	140	51	52.7	98.4	176		
Average	68.8	83.7	97.1	18.7	157.3	149.1	106.9	223.8	305.4	19.3	26.4	31.1	66.5	158.3	67.5	65.9	153.4	198.8		

Electrical Conductivity (uS/cm)

Date	GW1	GW9	GW10	GW11	GW21	GW22	GW23	GW24	GW25	GBH1	GBH2	BR01	BR02	BR03	BR04	BR05	BR06	BR07	IGV	GTV
12-Mar-15	786			183	2180	1868	1300			315	320	619	1121	1902	1196	1422	951	1529	1000	1875
27-Apr-15	760				2130	1806	1233			303	332	608	996	1964	1091	1380	963	1496	1000	1875
20-Jul-15	757			141	1991	1660	924			257	315	596	957	1798	1168	1382	906	1518	1000	1875
02-Nov-15	789			148	1967	1736	1121			239	419	602	1049	1766	1220	1375	1121	1511	1000	1875
13-Mar-16	781	683	737	171	1911	1782	1244	1243	628	297	300	599	980	1857	967	1358	1416	1448	1000	1875
16-May-16	755	631	755		1815	1693	1107	1667	2175	269	311	561	892	1737	897	1277	909	1415	1000	1875
15-Aug-16	748	643	723		1916	1606	1084	1801	1086	236	364	612	959	1767	883	1289	837	1554	1000	1875
07-Nov-16	800	728	492		1836	1666	983	1448	1870	260	345	606	1030	1716	853	1289	913	1554	1000	1875
08-Feb-17	828	782	489		1679	1691	969	1818	1321	323	397	604	1241	1699	813	1282	1309	1507	1000	1875
20-Jun-17	779	702	525		1558	1610	1192	1774	1093	323	397	596	1030	1749	899	1265	1309	1507	1000	1875
13-Sep-17	711	571	342		1850	1454	1122	1843	1128	269	347	583	1038	1719	866	1248	1185	1532	1000	1875
07-Sep-17	734	705	406		1485	1599	1092	1529	1074	281	451	604	1143	1691	845	1236	1212	1492	1000	1875
21-Mar-18	671	713	701		1403	1630	1213	2100	861	350	367	593	999	1702	835	1212	1508	1462	1000	1875
17-May-18	nr	298	749		1498	1615	1141	1774	689	298	444	592	945	1702	835	1204	1463	1439	1000	1875
30-Aug-18	46.7	79.8	91.2		176	147	103	192	189	17	28.8	32.7	57.5	154	58.2	61.7	151	199	1000	1875
03-Dec-18	712	963	389		1686	1581	1042	3950	3340	377	351	596	1066	1621	914	1188	1288	1460	1000	1875
13-Feb-19	753	774	733		1572	1576	1362	2130	1486	320	343	591	1242	1671	874	1165	1277	1428	1000	1875
29-Apr-19	765	814	741		1545	1556	1248	1763	996	292	373	585	1104		882	1152	1417	14658	1000	1875
04-Sep-19	899	726	630		1686	1399	1102	1218	2500	246	365	588	1122	1651	897	1141	1309	1496	1000	1875
16-Oct-19	964	803	187		1601	1455	1039		2700	299	376	579	1143	1625	821	1139	1361	1444	1000	1875
																			1000	1875
																			1000	1875

Max	964	963	755	183	2180	1868	1362	3950	3340	377	451	619	1242	1964	1220	1422	1508	14658	GTV/IGV exceed	
Min	46.7	79.8	91.2	141	176	147	103	192	189	17	28.8	32.7	57.5	154	58.2	61.7	151	199		
Average	739	663	543	161	1674	1557	1081	1750	1446	279	347	567	1006	1657	891	1203	1140	2082		

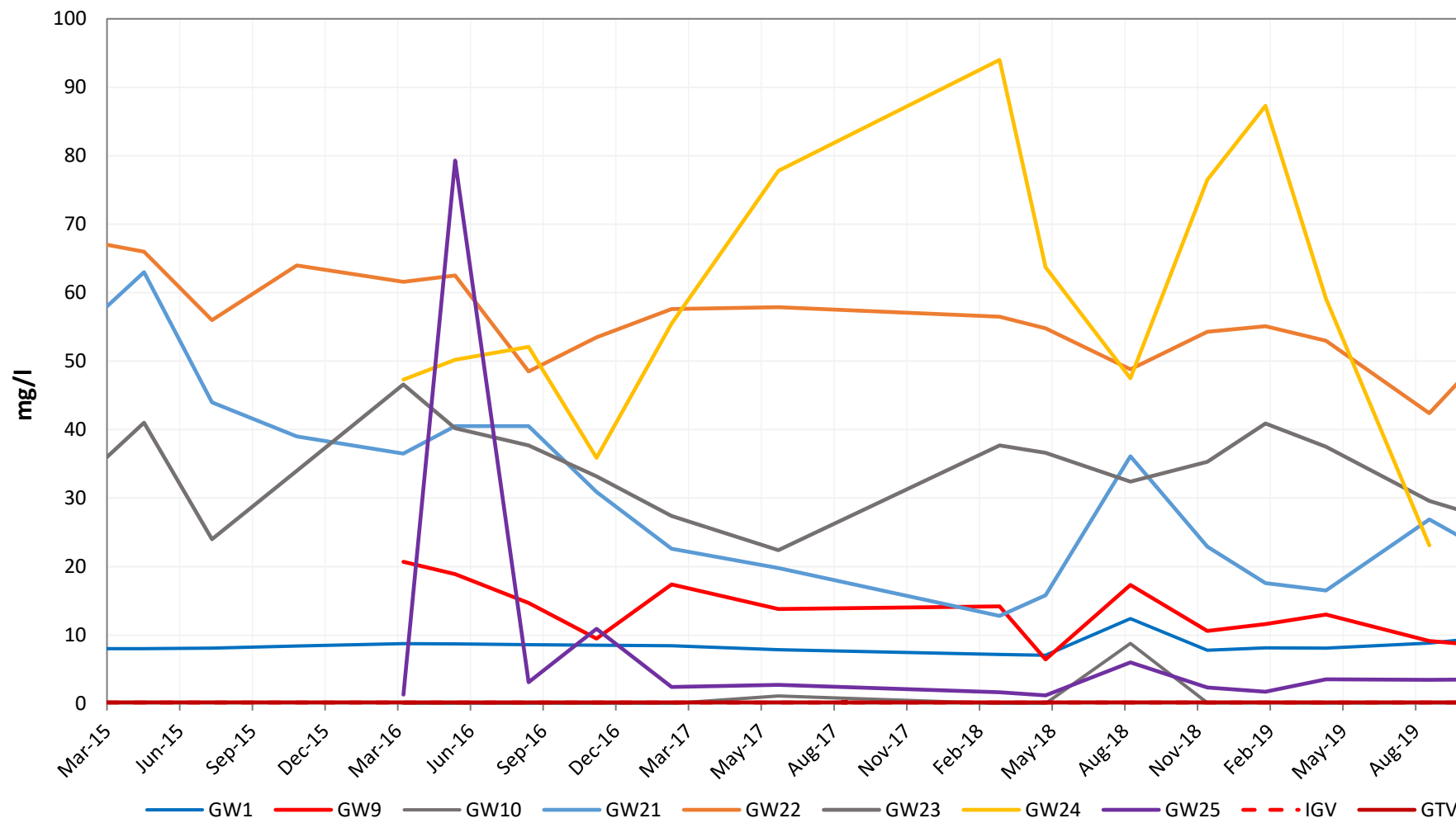
pH

Date	GW1	GW9	GW10	GW11	GW21	GW22	GW23	GW24	GW25	GBH1	GBH2	BR01	BR02	BR03	BR04	BR05	BR06	BR07	IGV (lower)	IGV (upper)
12-Mar-15	6.8			7	6.8	6.7	6.6	dry	dry	6.7	6.8	6.8	6.7	6.8	7.2	6.9	6.8	6.8	6.5	9.5
27-Apr-15	6.3				6.8	7	6.7	dry	dry	6.3	6.5	6.4	6.7	7	7	6.9	6.9	6.7	6.5	9.5
20-Jul-15	6.5			6.5	6.6	6.8	6.8	dry	dry	6.7	7	6.8	6.9	6.9	7.2	6.9	7.2	6.8	6.5	9.5
02-Nov-15	6.4			6.8	6.8	6.8	6.5	dry	dry	7.5	6.9	7.1	7.1	6.7	6.8	6.9	7	6.8	6.5	9.5
13-Mar-16	6.7	6.9	6.6	5.9	6.8	6.9	6.7	6.8	6.8	6.6	6.9	6.9	7	7	7.1	7.1	7.1	6.9	6.5	9.5
16-May-16	6.5	7	7		6.9	7	6.8	7.1	6.9	6.4	6.8	7.3	7.1	7.1	7.2	7.1	7.4	7	6.5	9.5
15-Aug-16	6.7	7	6.5		6.8	7.2	6.7	6.6	6.7	6.7	7.3	7.2	7	7	7.1	6.9	7.4	6.8	6.5	9.5
07-Nov-16	6.7	6.7	6.9		6.9	7.3	6.8	7.1	7	6.9	6.8	7.1	7	7	7.4	7.1	7.3	6.1	6.5	9.5
08-Feb-17	6.6	6.8	6.5		6.7	7	6.4	6.9	6.9	6.5	6.9	7	7	7	7.2	6.9	7.1	6.9	6.5	9.5
20-Jun-17	6.6	6.8	6.4		6.8	7	6.6	7	6.9	6.5	6.9	7.1	7	7	7.1	7	7.1	6.9	6.5	9.5
13-Sep-17	6.6	6.7	6.4		6.9	7.6	6.7	6.8	6.9	6.3	6.9	6.9	7	7	7.1	6.9	7.2	6.9	6.5	9.5
07-Sep-17	6.7	6.9	6.9		6.9	6.9	6.7	7.5	7.1	6.7	7.2	7.2	7	7	7.2	7	7.2	6.9	6.5	9.5
21-Mar-18	6.5	6.9	7.2		7	7	6.6	7	7.1	6.9	6.9	7	7.1	7	7.1	7.1	7.1	6.9	6.5	9.5
17-May-18	nr	6.7	6.6		7	6.9	6.9	7.5	7.6	6.7	7.1	7	7	7.1	7.1	7	7	6.9	6.5	9.5
30-Aug-18	6.81	7.01	6.81		7.16	7.51	7.07	7.5	7.2	7.1	7.33	7.4	7.19	7.3	7.39	7.35	7.36	7.07	6.5	9.5
03-Dec-18	7.07	8.17	6.88		7.25	7.42	7.08	7.18	8.03	7.32	8.07	8.28	7.86	8.11	8.37	8.64	8.32	8.12	6.5	9.5
13-Feb-19	6.8	7.1	6.8		7.1	7.1	6.9	7.1	7.1	6.6	7.1	7.3	7.1	7.1	7.2	7.2	7.2	7	6.5	9.5
29-Apr-19	6.8	7	6.7		7.1	7	6.9	6.8	6.9	6.5	7.2	7.2	7.2		7.2	7.1	7.1	7	6.5	9.5
04-Sep-19	6.3	6.5	6.7		6.4	6.7	6.3	6.6	6.6	6.3	6.6	6.9	6.5	6.6	6.7	7.1	6.7	6.6	6.5	9.5
16-Oct-19	6.6	6.9	6.2		6.9	6.8	6.5		6.2	6.5	7.3	7.3	6.7	7	6.9	6.8	6.7	6.6	6.5	9.5

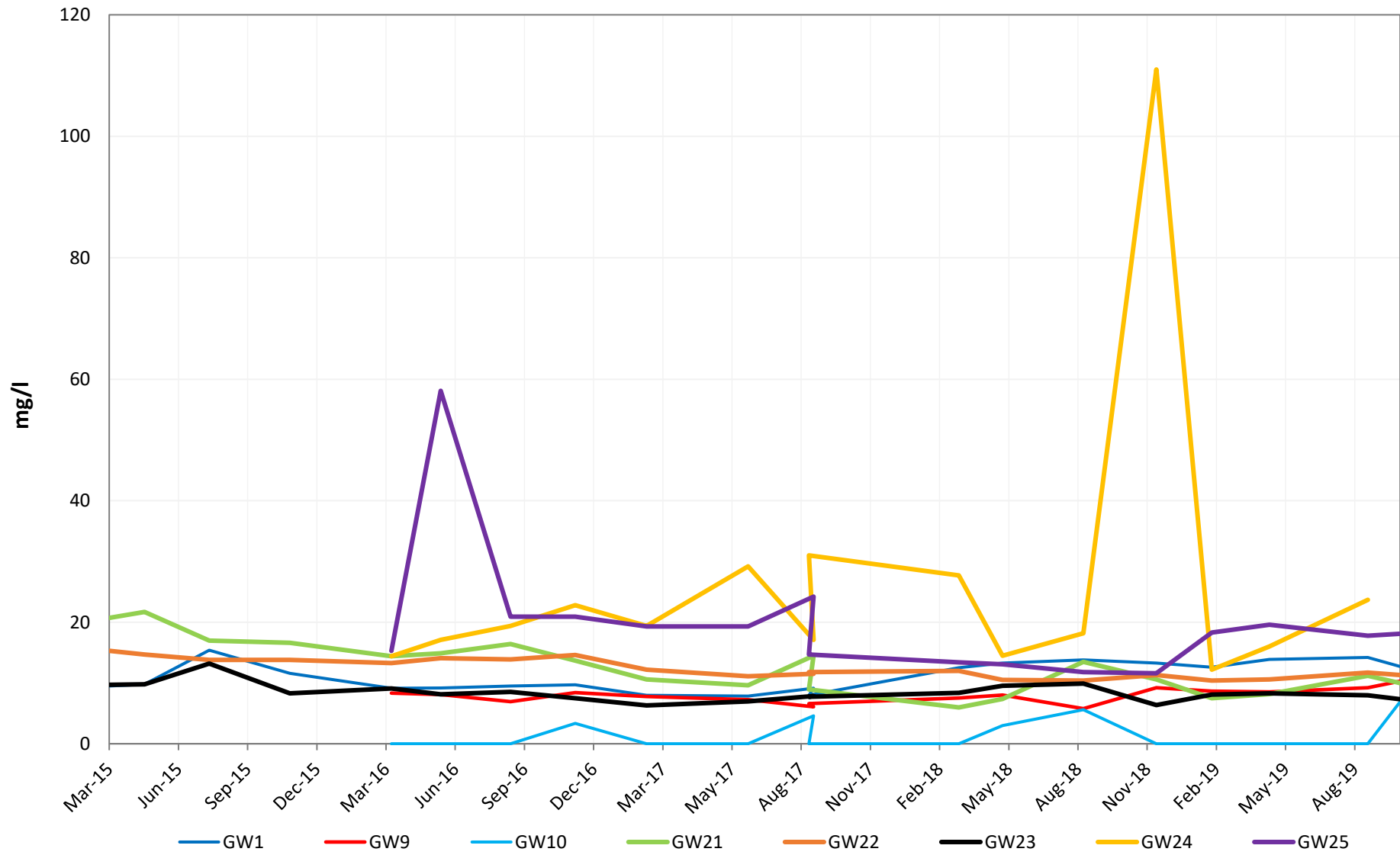
Max	7.07	8.17	7.2	7	7.25	7.6	7.08	7.5	8.03	7.5	8.07	8.28	7.86	8.11	8.37	8.64	8.32	8.12	IGV exceed	
Min	6.3	6.5	6.2	5.9	6.4	6.7	6.3	6.6	6.2	6.3	6.5	6.4	6.5	6.6	6.7	6.8	6.7	6.1		
Average	6.6	6.9	6.7	6.6	6.9	7.0	6.7	7.0	7.0	6.7	7.0	7.1	7.0	7.0	7.2	7.1	7.2	6.9		

TOC																		
Date	GW1	GW9	GW10	GW11	GW21	GW22	GW23	GW24	GW25	GBH1	GBH2	BR01	BR02	BR03	BR04	BR05	BR06	BR07
12-Mar-15	9.5			1.5	20.7	15.3	9.7		20.9	1.2	2.3	1.2	13	19.9	7.2	6.8	3.6	3.4
27-Apr-15	9.8				21.7	14.7	9.8			<1.0	1.7	<1.0	10.1	20.8	6.3	6	3.6	2.6
20-Jul-15	15.4			2.2	17	13.8	13.2			1	2.6	<1.0	8.7	18.7	7	5.8	3.2	3.2
02-Nov-15	11.6			1.8	16.6	13.8	8.3			1.2	2.6	<1.0	11.3	17.4	6.9	6.1	4	2.9
13-Mar-16	9.13	8.34	<3	<3	14.4	13.3	9.1	14.4	15.3	<3	<3	<3	9.02	19.8	5.25	7.29	5.18	3.65
16-May-16	9.19	8.1	<3		14.9	14.1	8.13	17.1	58.1	<3	<3	<3	7.9	21.3	4.7	6.15	<3	<6
15-Aug-16	9.52	6.94	<3		16.4	13.9	8.53	19.4	20.9	<3	<3	<3	9.37	27	4.59	7.1	<3	<6
07-Nov-16	9.71	8.43	3.34		13.7	14.6	7.5	22.8	20.9	<3	<3	<3	11.5	18.8	4.09	6.88	<3	<6
08-Feb-17	7.99	7.79	<3		10.6	12.2	6.31	19.4	19.3	<3	<3	<3	15.2	18.6	<3	<6	3.75	<3
20-Jun-17	7.85	7.24	<3		9.63	11.1	6.96	29.2	19.3	<3	<3	<3	9.36	18.9	3.22	<6	3.75	<3
13-Sep-17	9.14	6.07	4.61		14.5	11.5	7.84	17.1	24.2	<3	<3	<3	10.6	21.6	3.22	<6	3.8	<6
07-Sep-17	7.96	6.62	<3		8.96	11.8	7.74	31	14.7	<3	<3	<3	13.2	18	3.03	4.8	3.07	3.38
21-Mar-18	12.5	7.52	<3		5.98	12	8.38	27.7	13.4	6.58	<3	<3	8.75	17.5	3.29	3.42	4.5	<3
17-May-18	13.3	8.01	3		7.38	10.5	9.56	14.5	13.1	4.45	<3	<3	7.72	17.7	3.71	4.38	4.61	3.8
30-Aug-18	13.8	5.78	5.6		13.5	10.4	9.9	18.2	11.8	<3	<3	<3	8.59	17	<3	3.69	<3	<3
03-Dec-18	13.3	9.21	<3		10.6	11.3	6.36	111	11.6	4.02	4.39	<3	10.6	15.8	<3	3.36	3.67	<3
13-Feb-19	12.6	8.64	<3		7.51	10.4	8.1	12.2	18.3	<3	<3	<3	15.2	15.9	3.36	3.25	<3	<3
29-Apr-19	13.9	8.53	<3		8.18	10.6	8.29	16	19.6	8.09	<3	<3	10.5		6.54	<3	5.86	<3
04-Sep-19	14.2	9.22	<3		11.2	11.7	7.97	23.7	17.8	<3	<3	<3	12.3	17.1	<3	3.37	<3	<3
16-Oct-19	12.7	10.3	6.91		10	11.3	7.35		18.1	3.43	<3	<3	13	16.8	<3	3.87	3.53	<3
Max	15.4	10.3	6.91	2.2	21.7	15.3	13.2	111	58.1	8.09	4.39	1.2	15.2	27	7.2	7.29	5.86	3.8
Min	7.85	5.78	3	1.5	5.98	10.4	6.31	12.2	11.6	1	1.7	1.2	7.72	15.8	3.03	3.25	3.07	2.6
Average	11.15	7.92	4.69	1.83	12.67	12.42	8.45	26.25	19.78	3.75	2.72	1.20	10.80	18.87	4.83	5.14	4.01	3.28

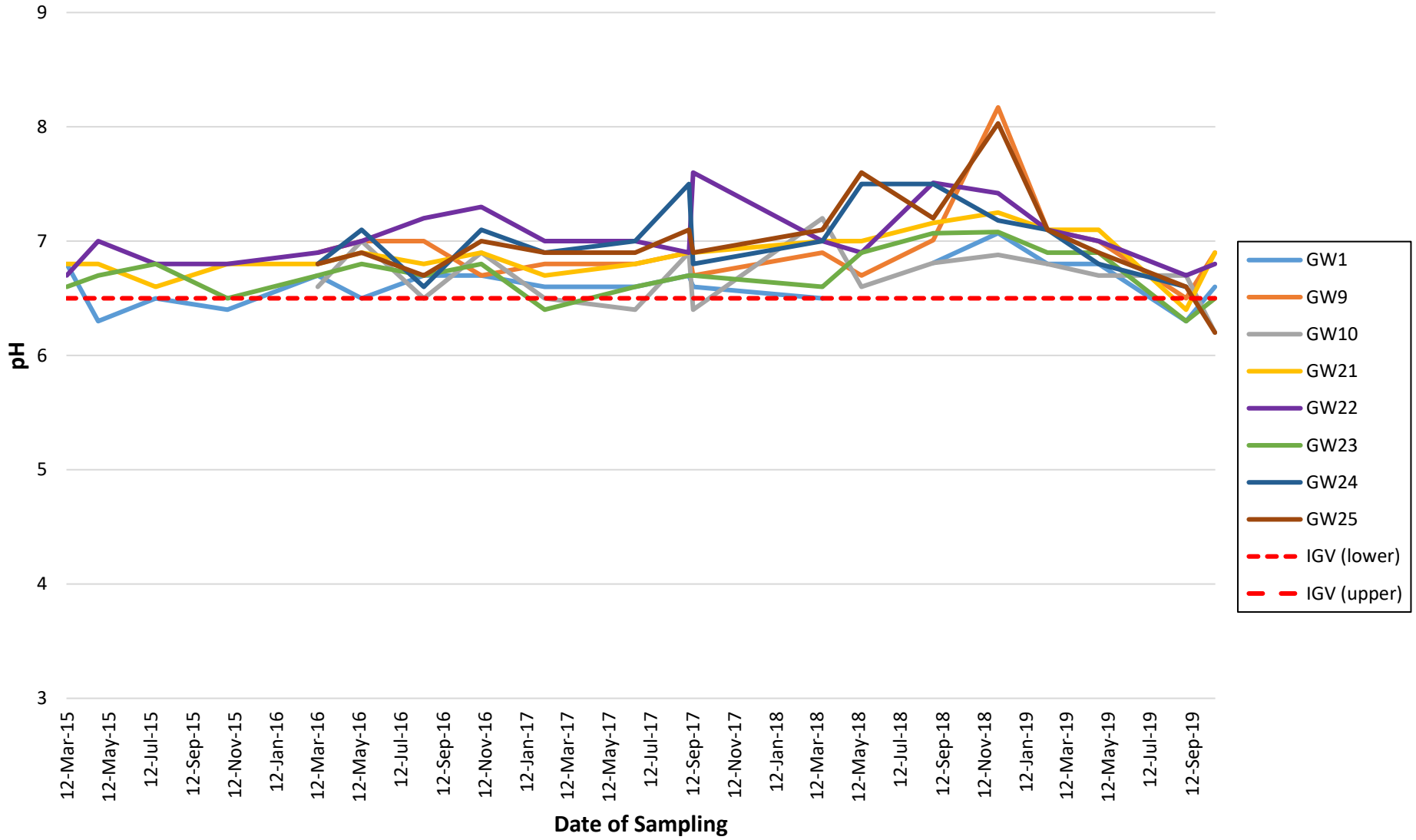
Ammonium (overburden downgradient)



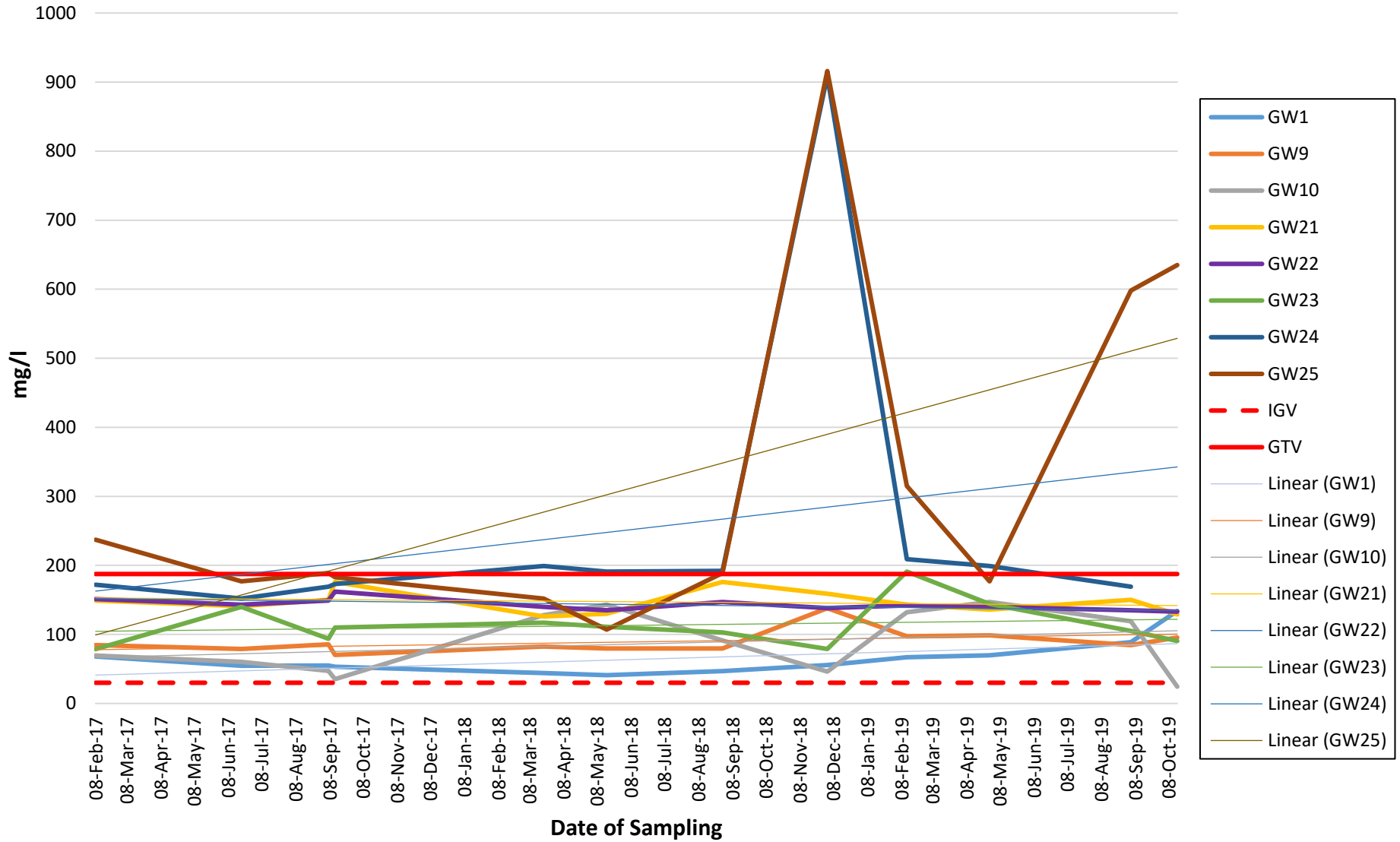
TOC (overburden downgradient)



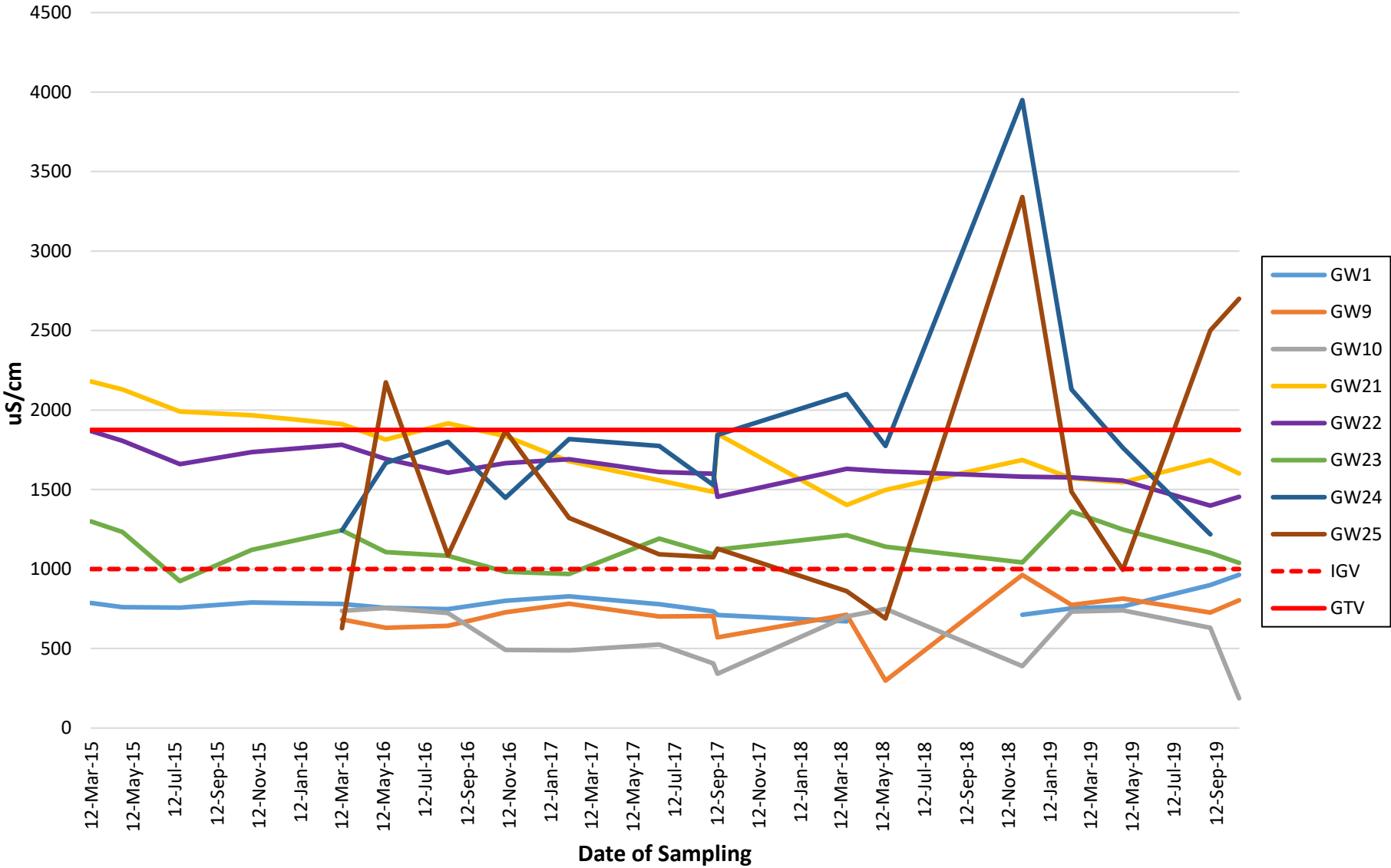
pH (overburden downgradient)



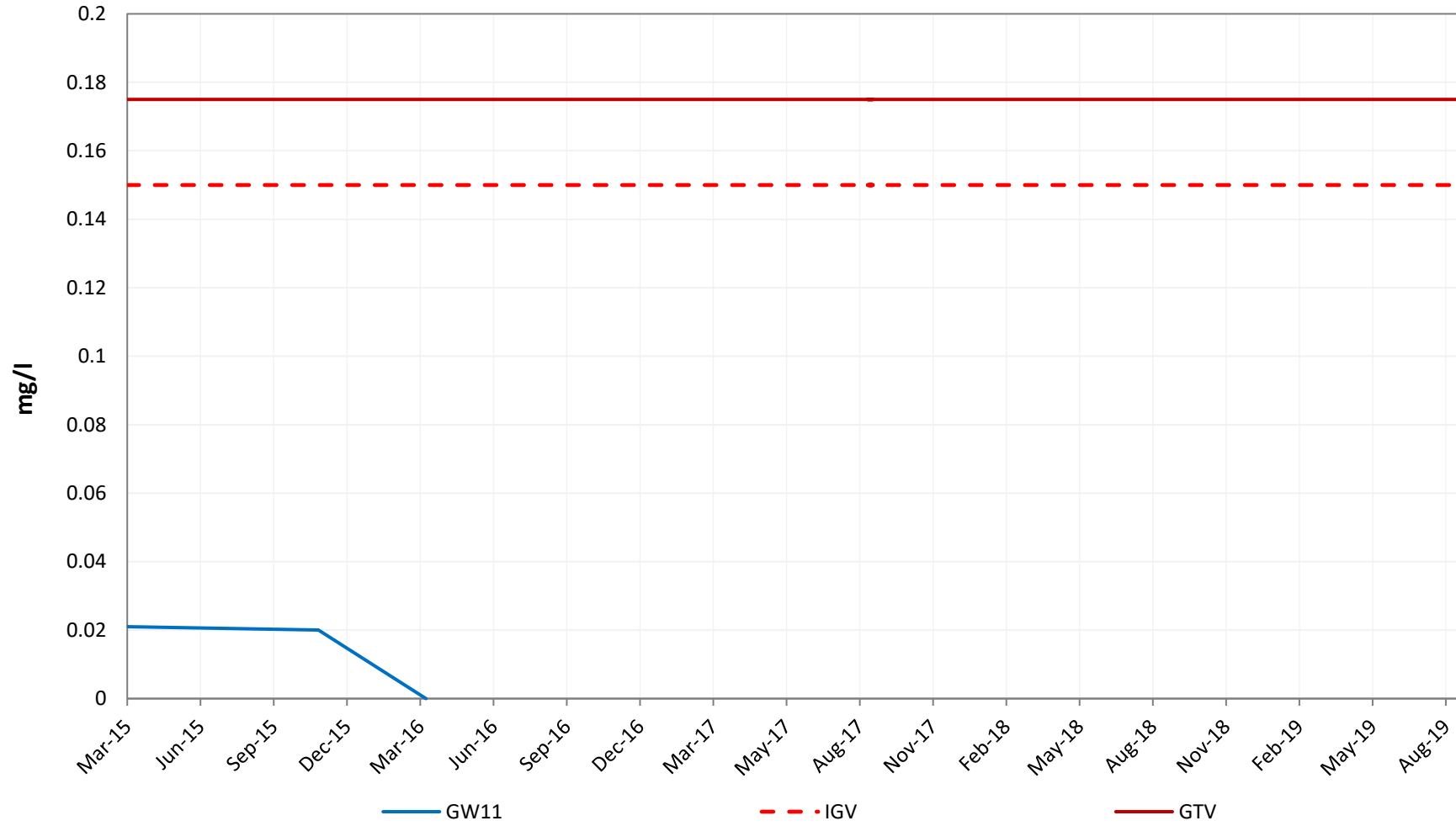
Chloride (overburden downgradient)



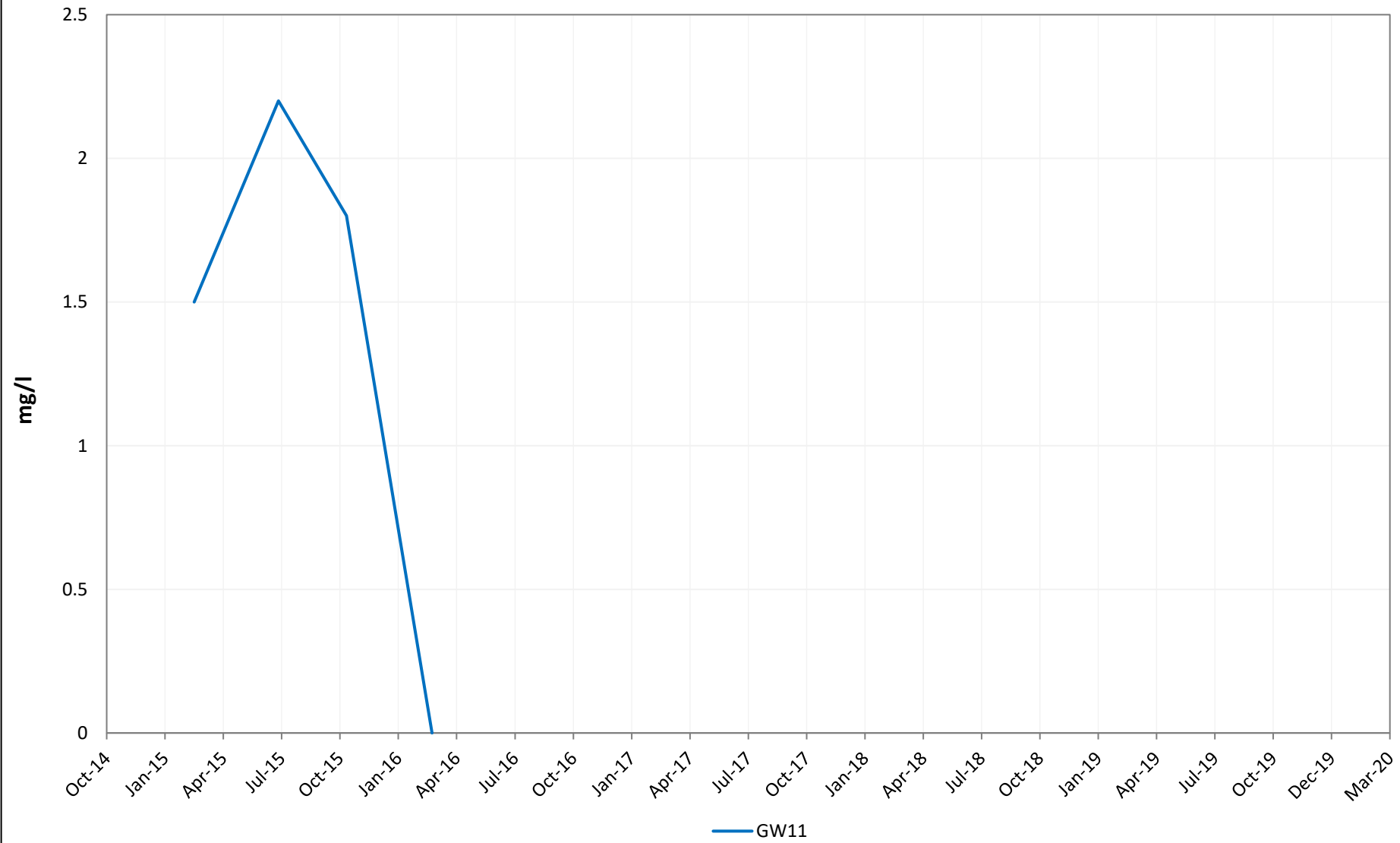
Conductivity (overburden downgradient)



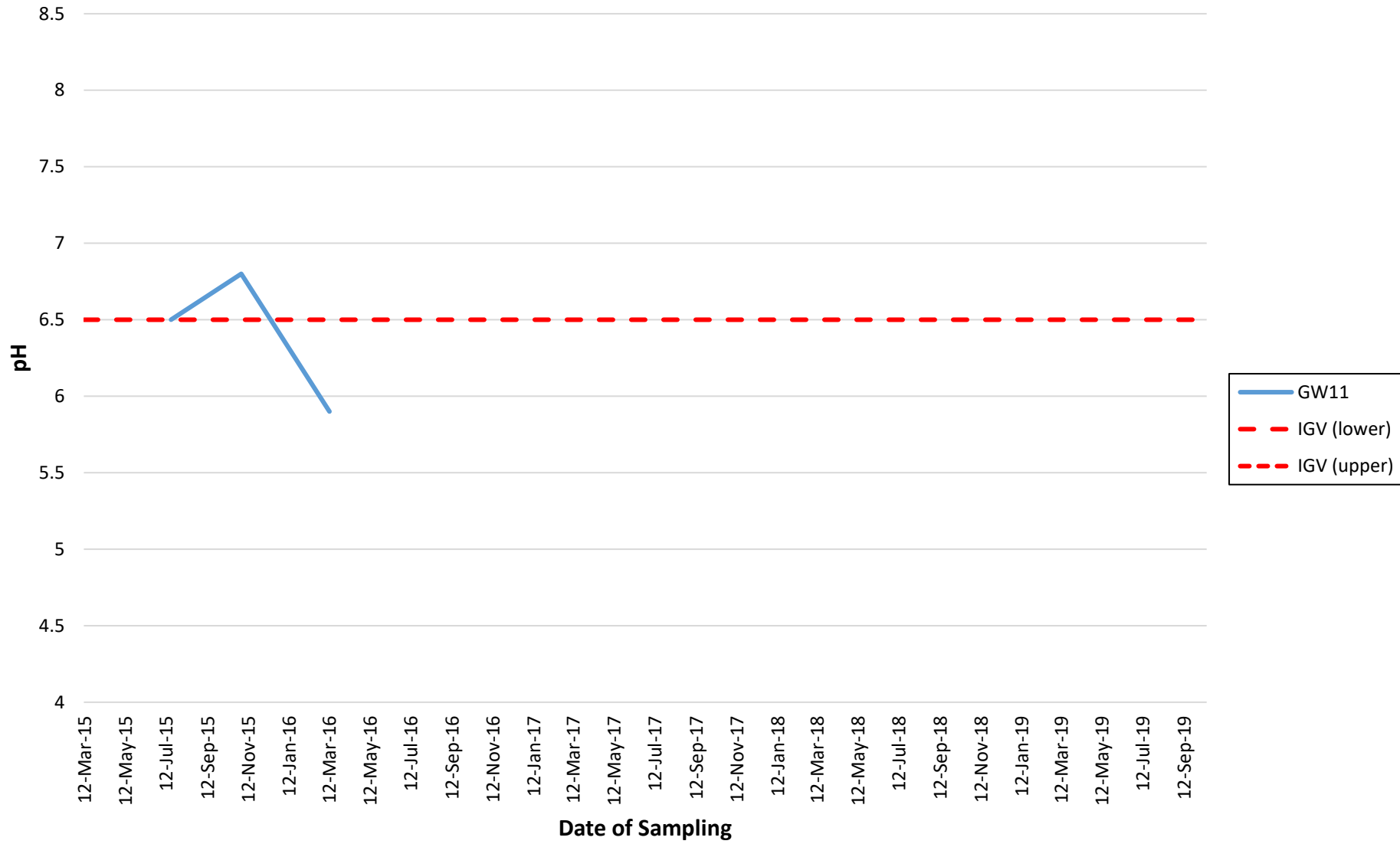
Ammonium (overburden upgradient)



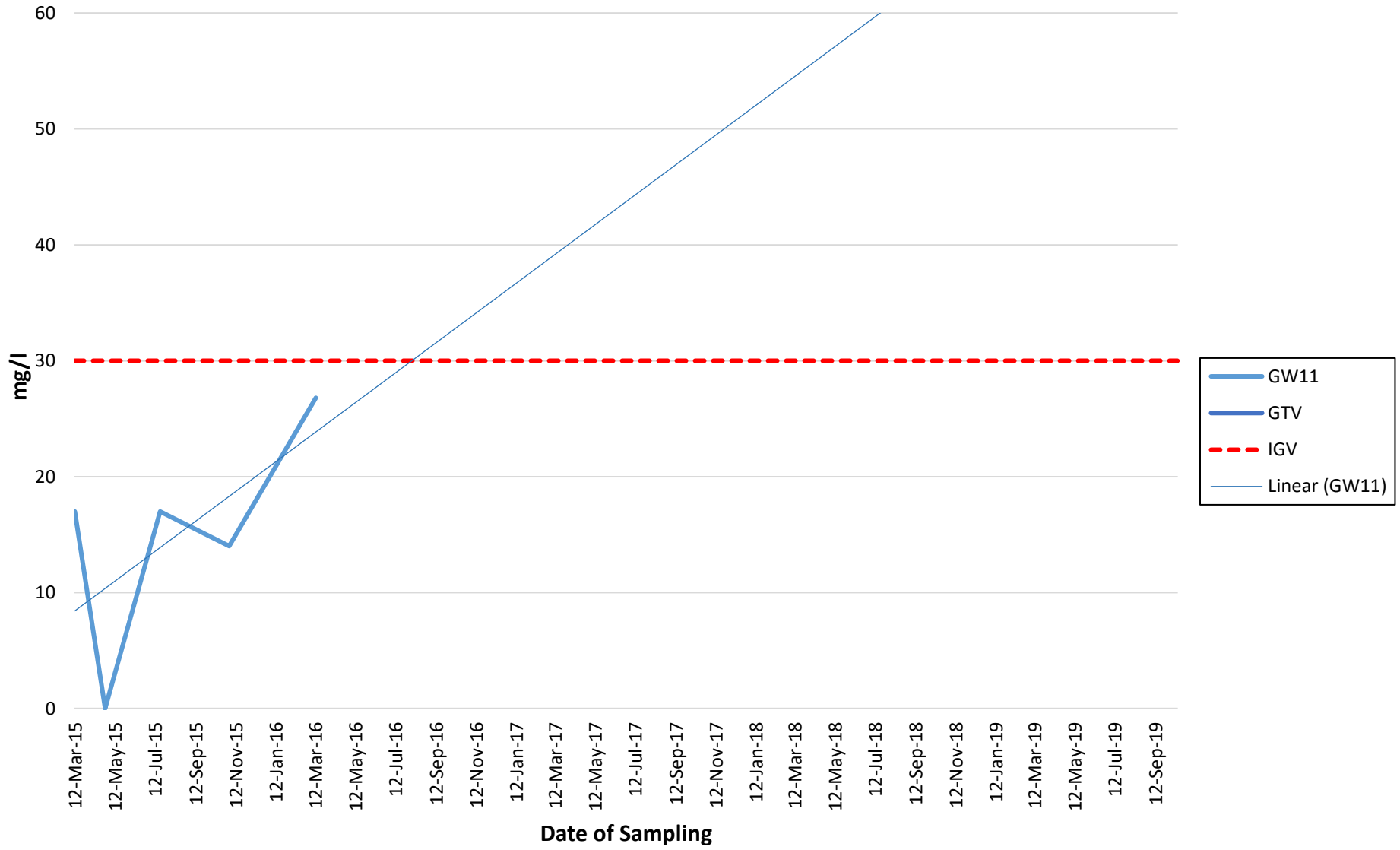
TOC (overburden upgradient)



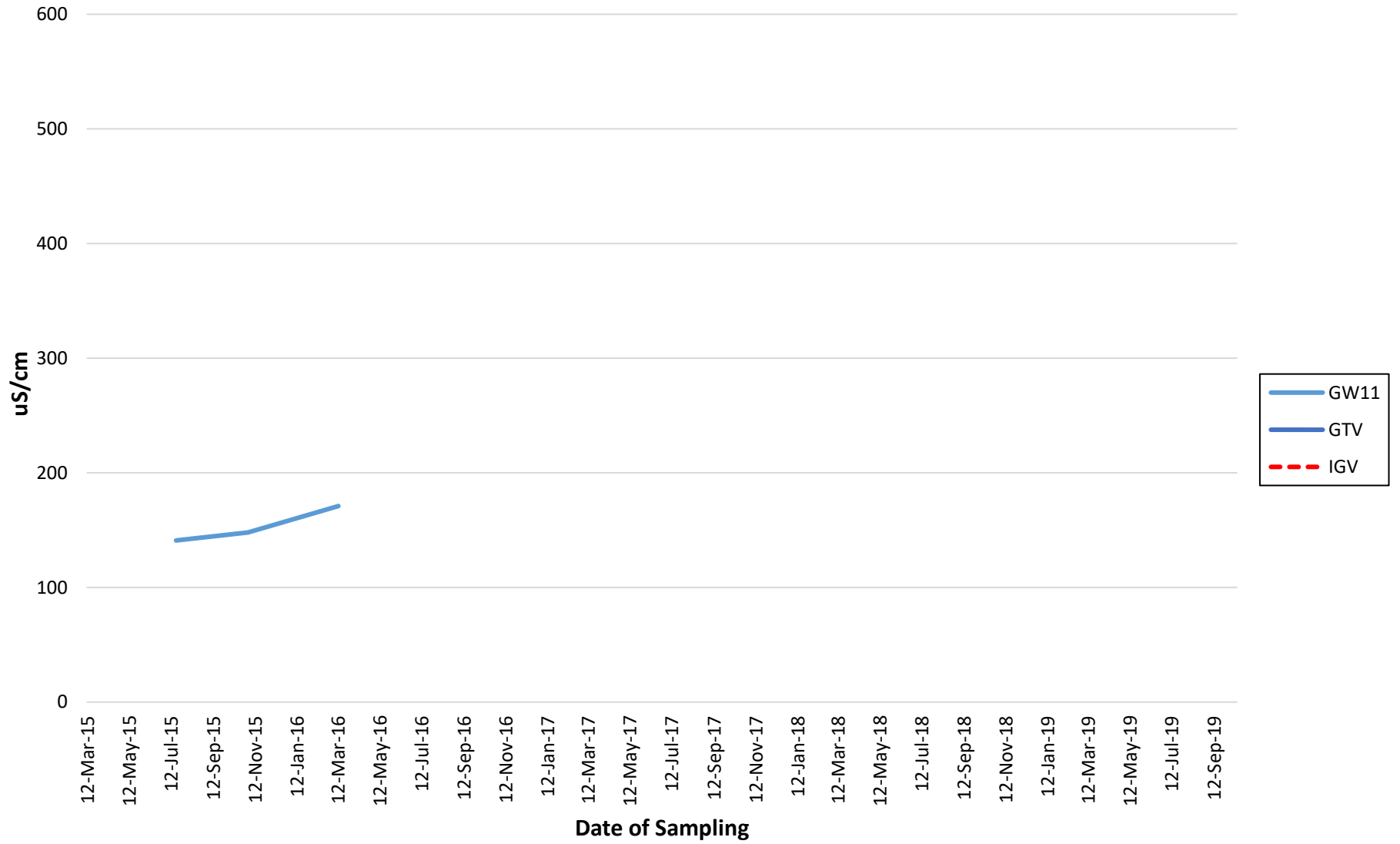
pH (overburden upgradient)



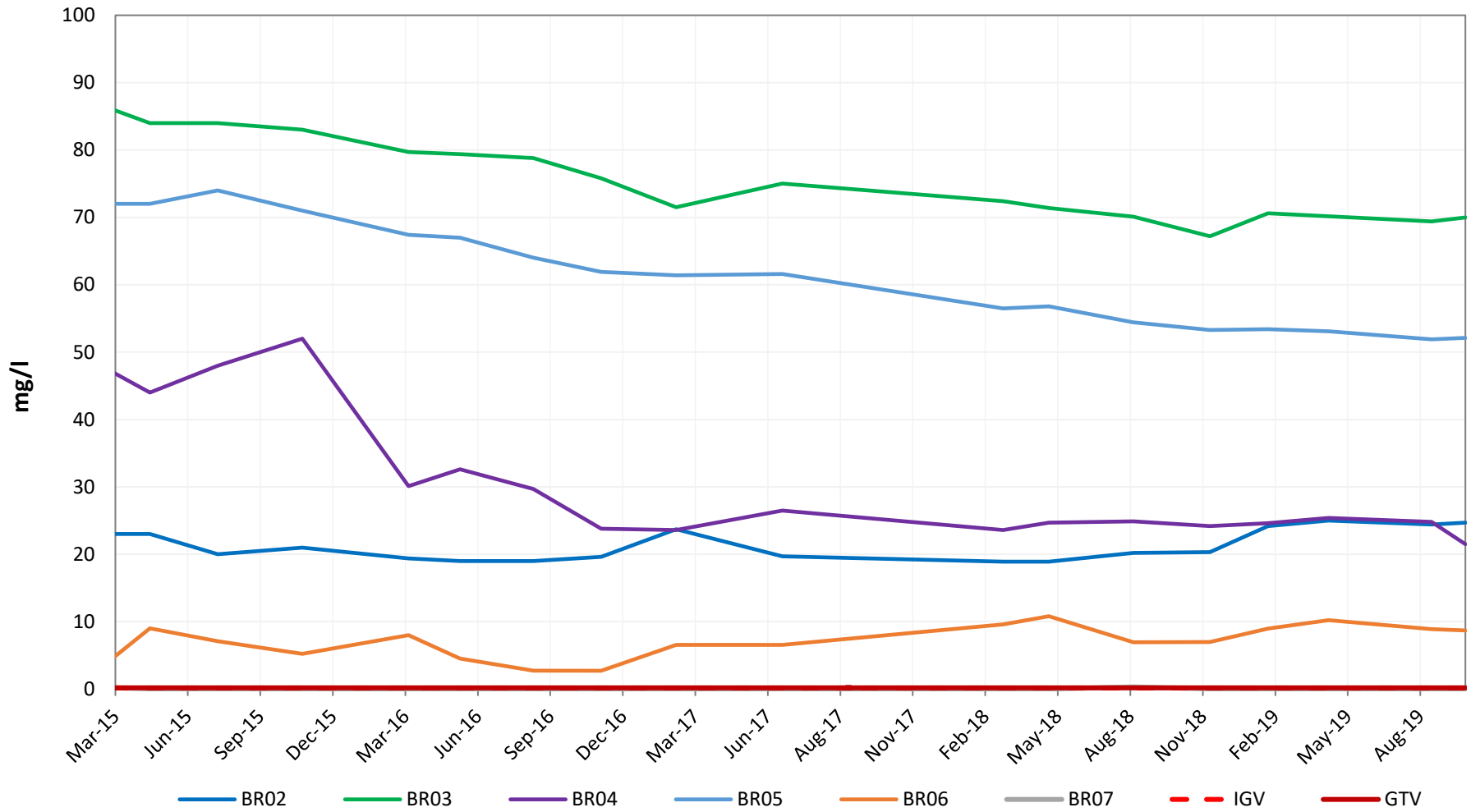
Chloride (overburden upgradient)



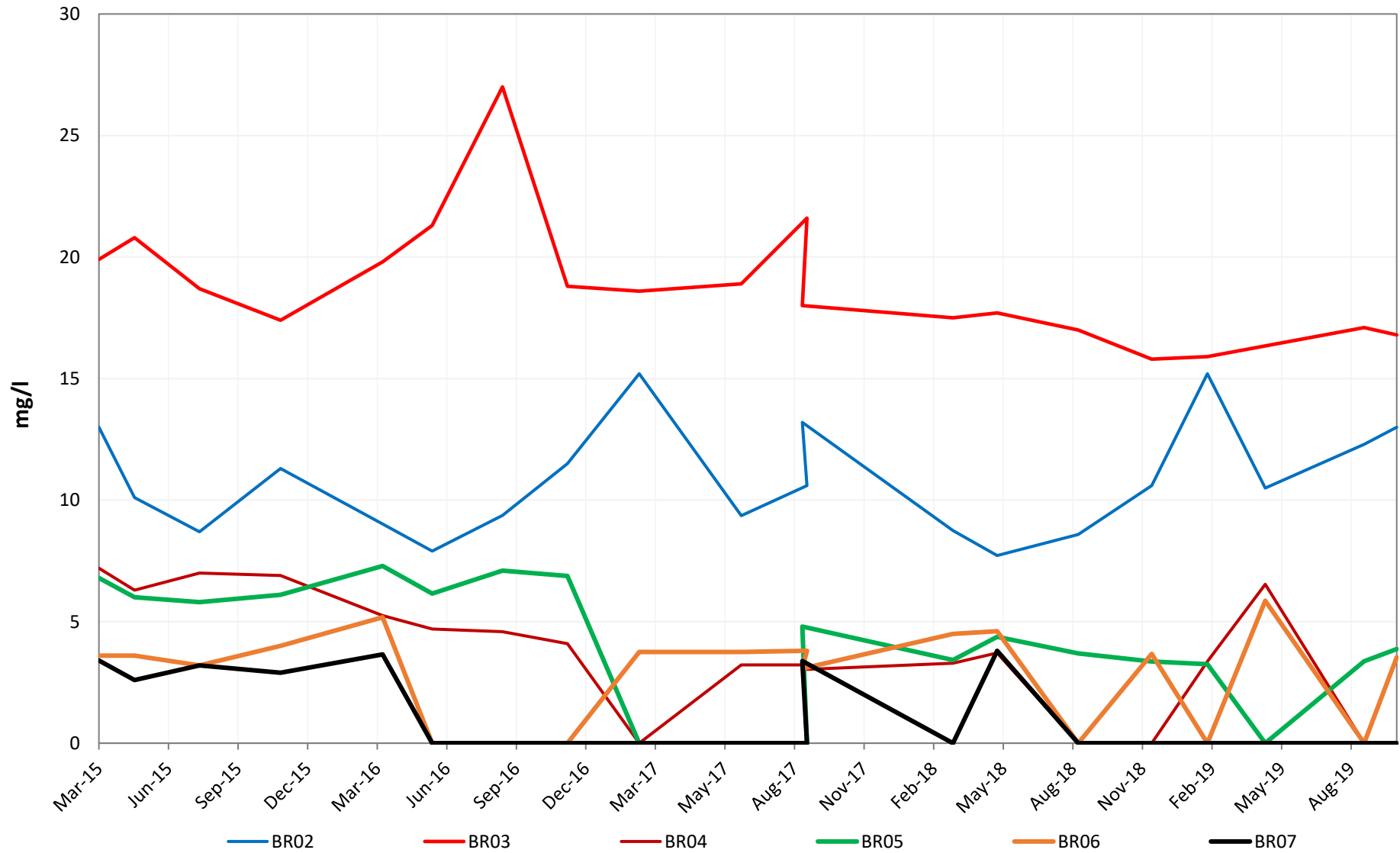
Conductivity (upgradient overburden)



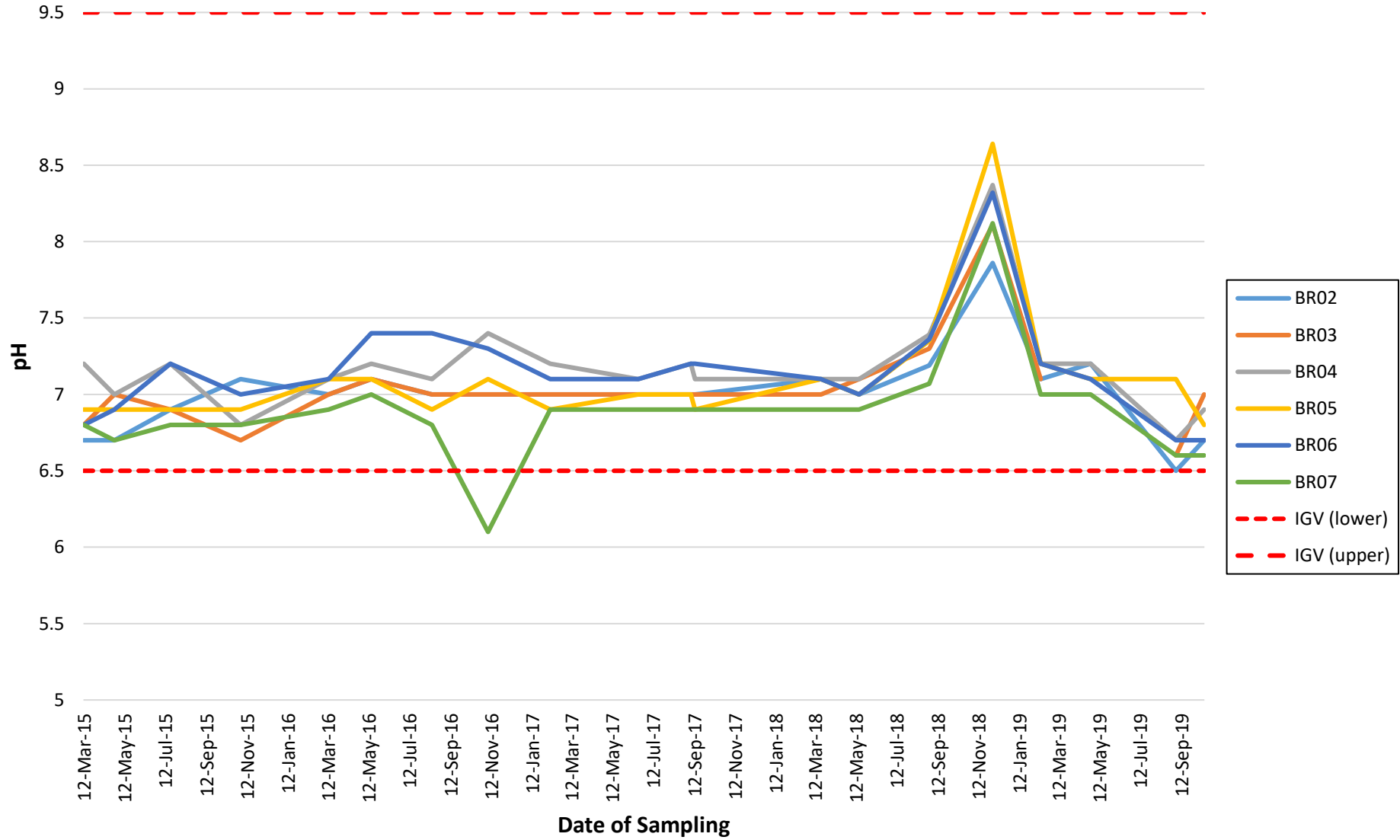
Ammonium (bedrock downgradient)



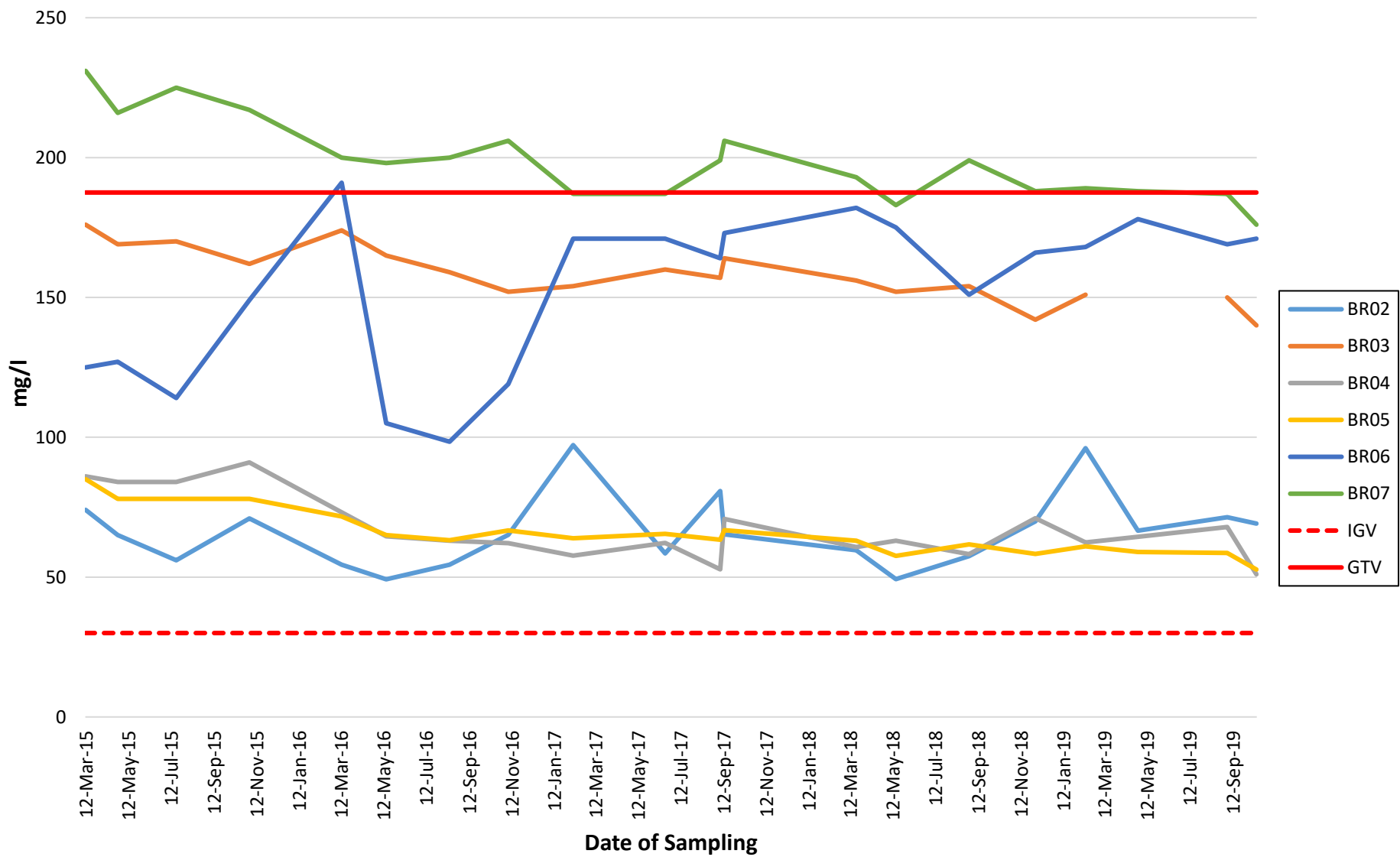
TOC (bedrock downgradient)



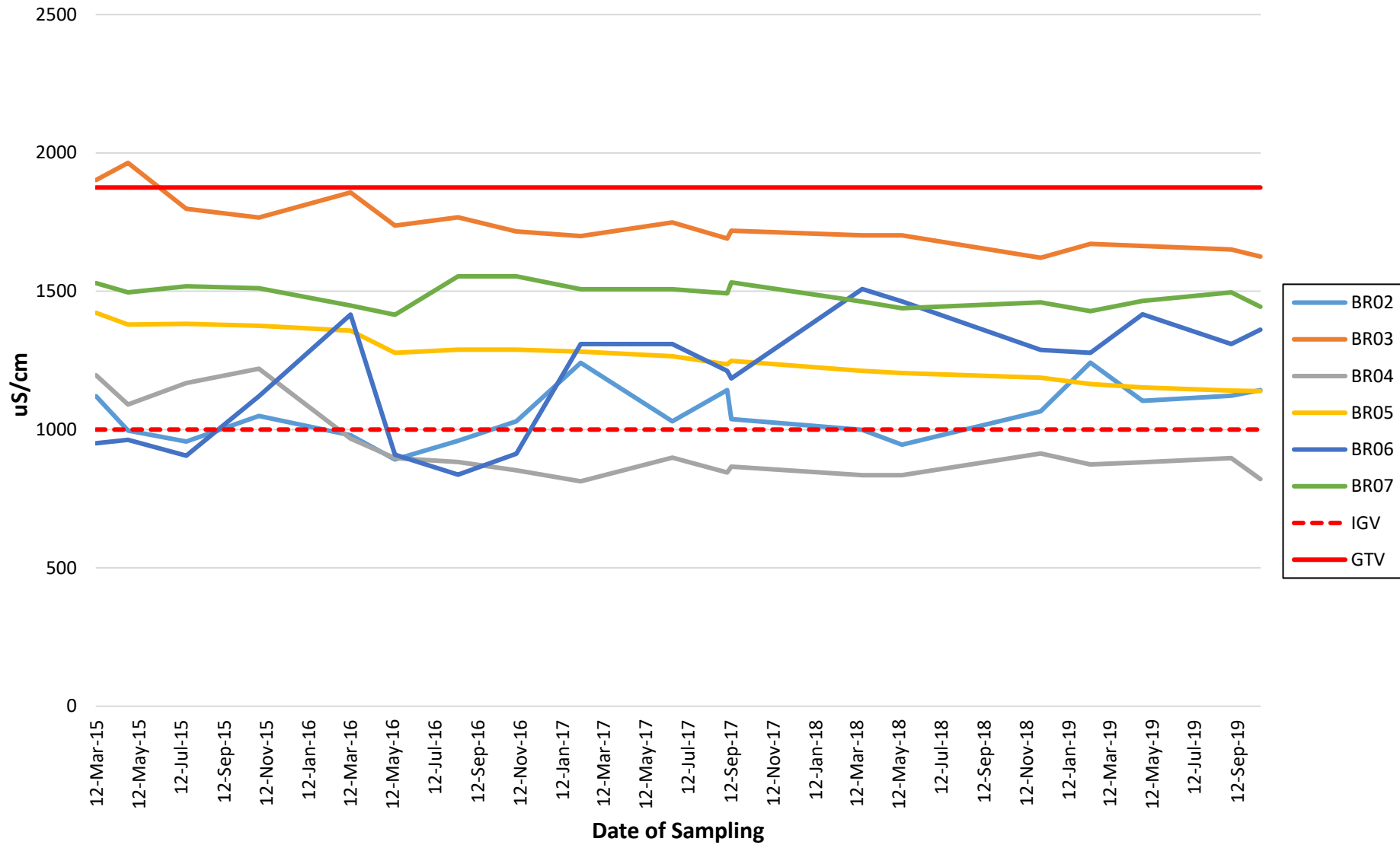
pH (bedrock downgradient)



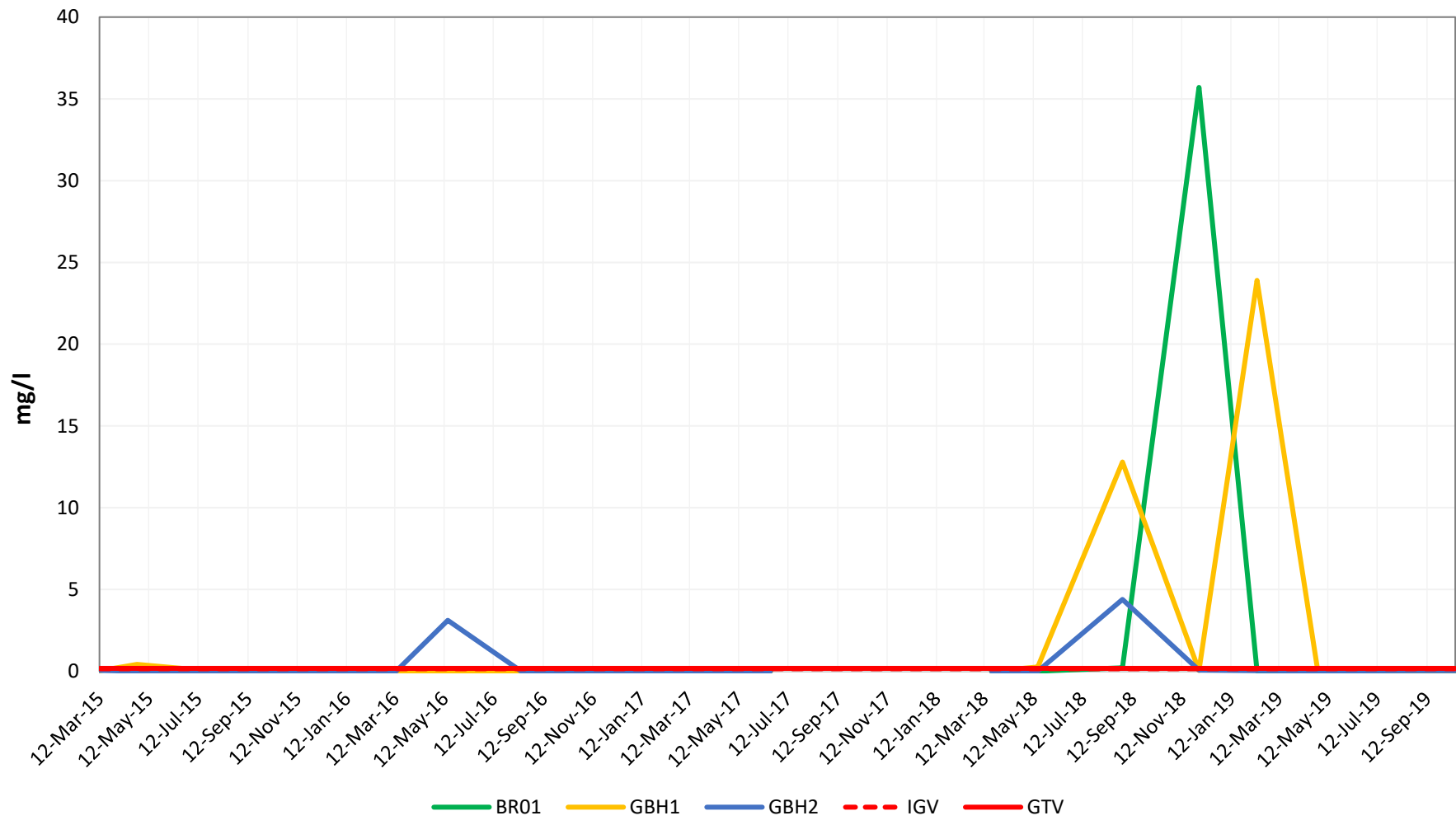
Chloride (bedrock downgradient)



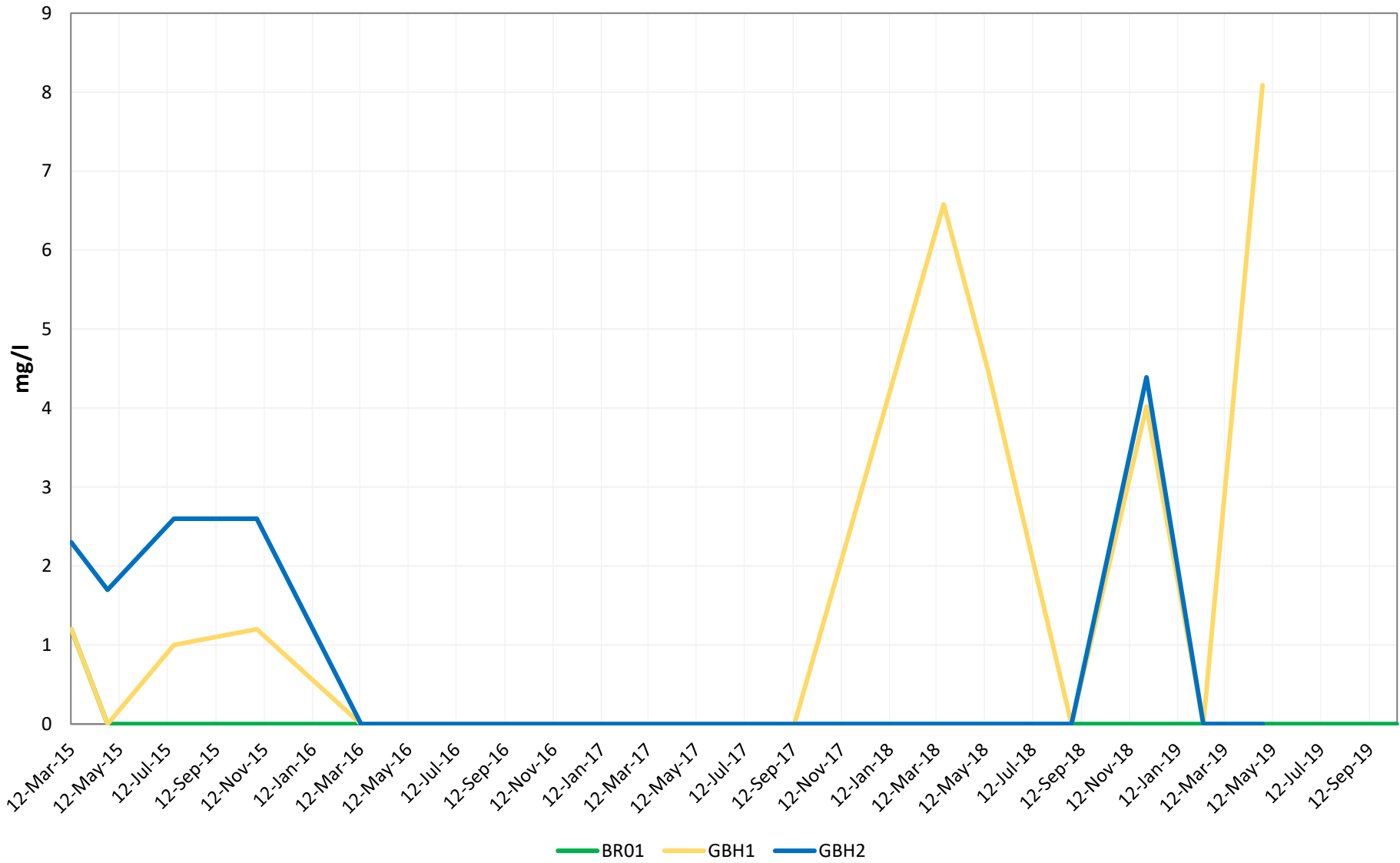
Conductivity (bedrock downgradient)



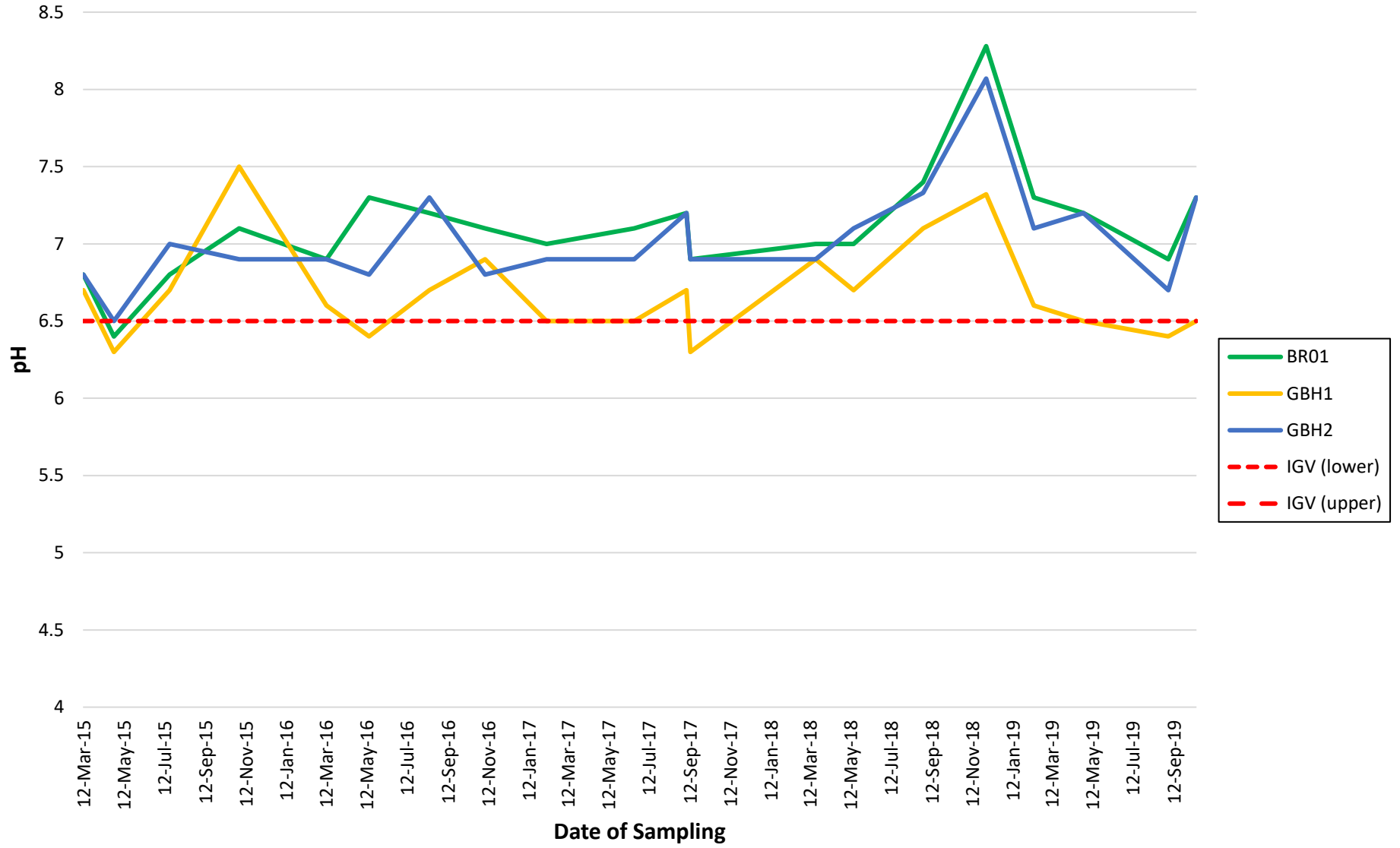
Ammonium (Bedrock upgradient)



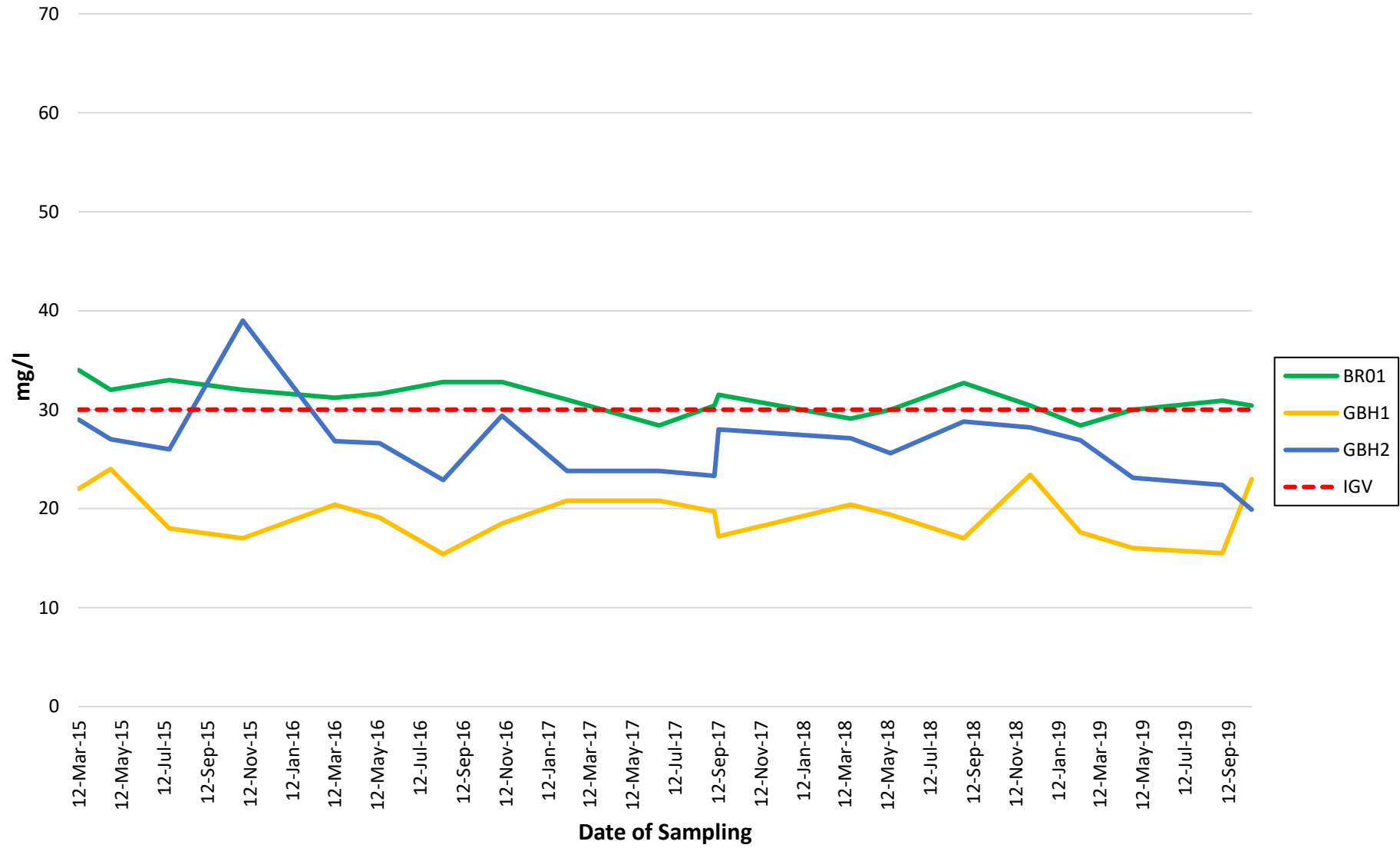
TOC (upgradient Bedrock)



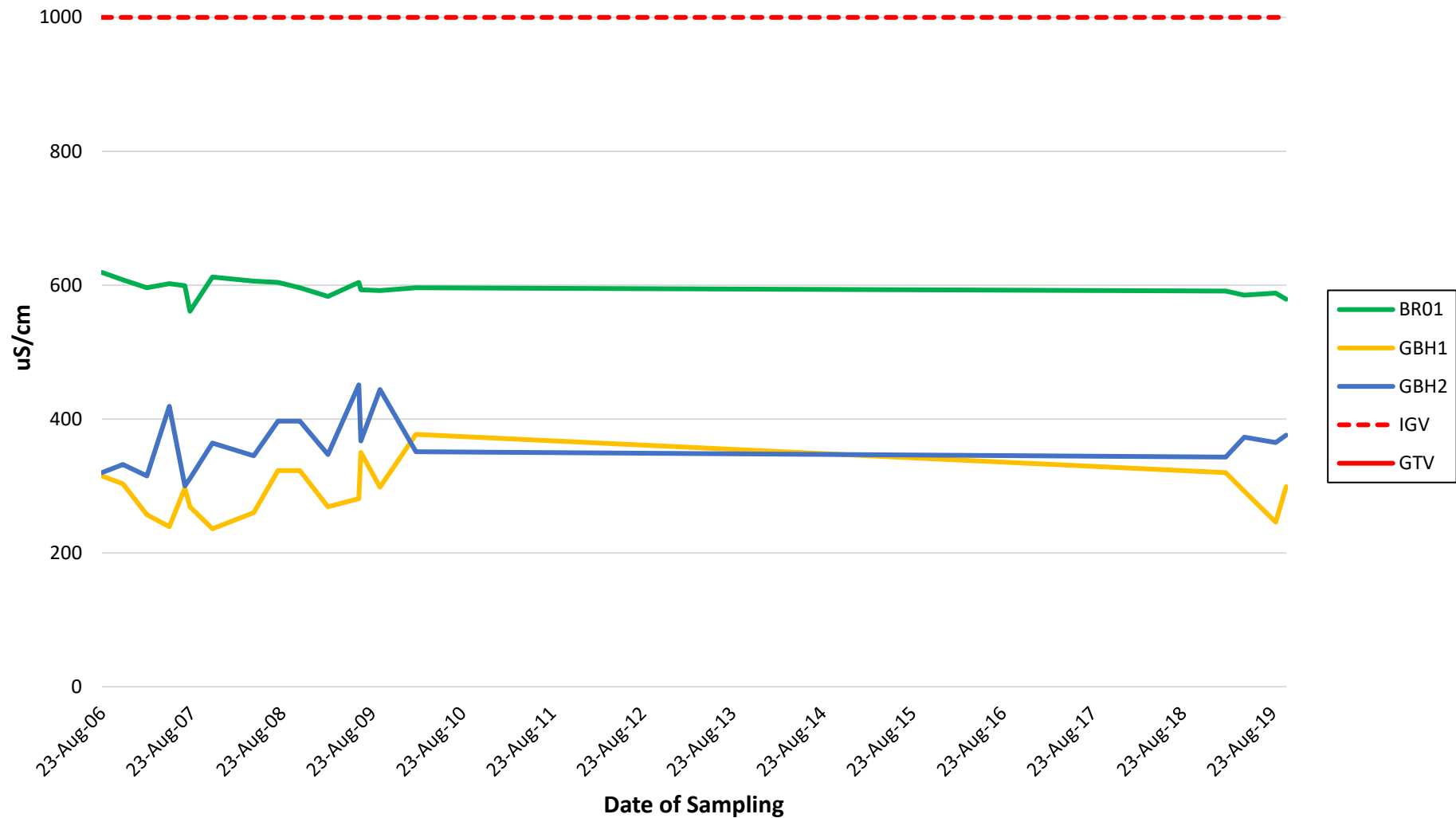
pH (bedrock upgradient)



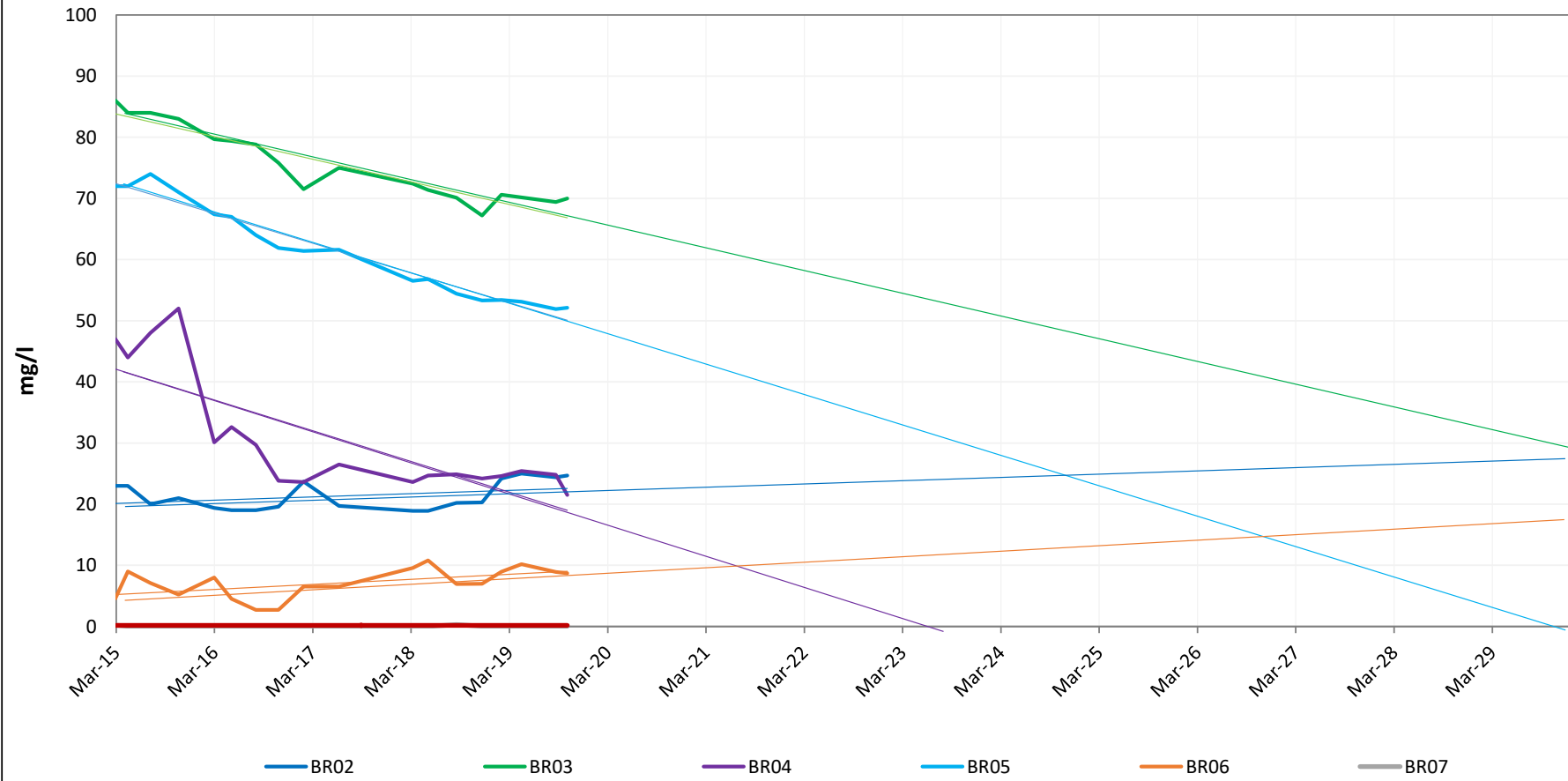
Chloride (bedrock upgradient)



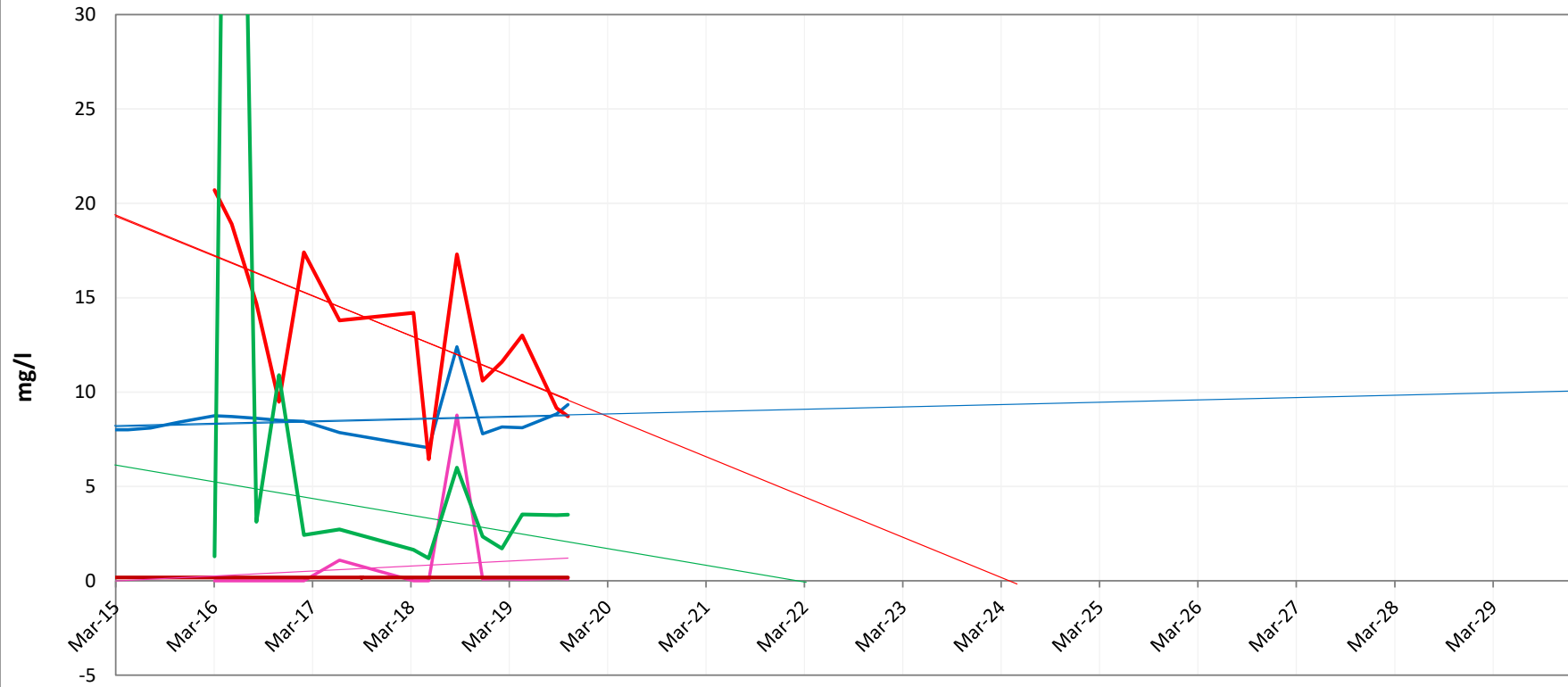
Conductivity (upgradient bedrock)



Ammonium (bedrock downgradient)

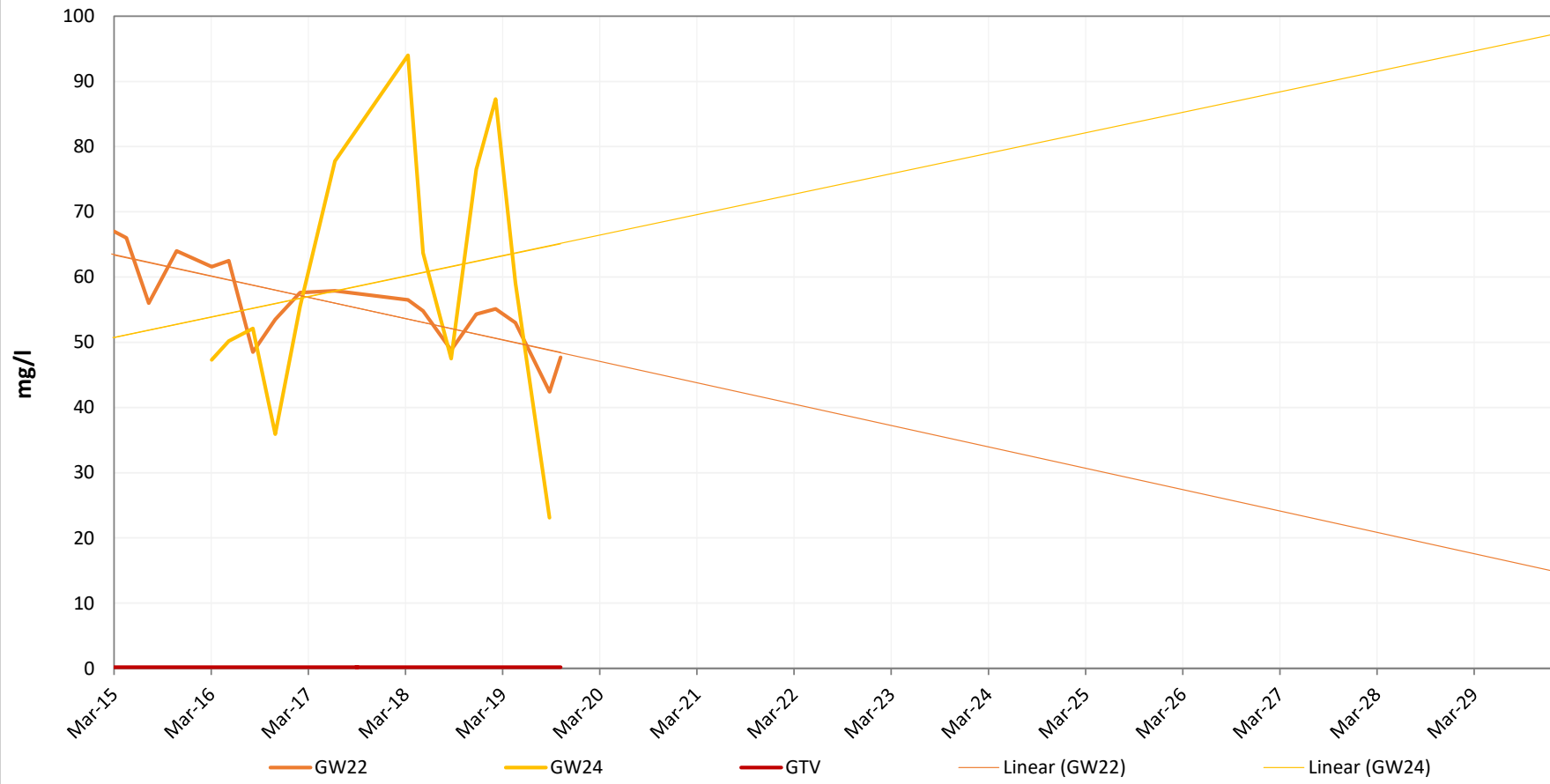


Ammonium (overburden downgradient)

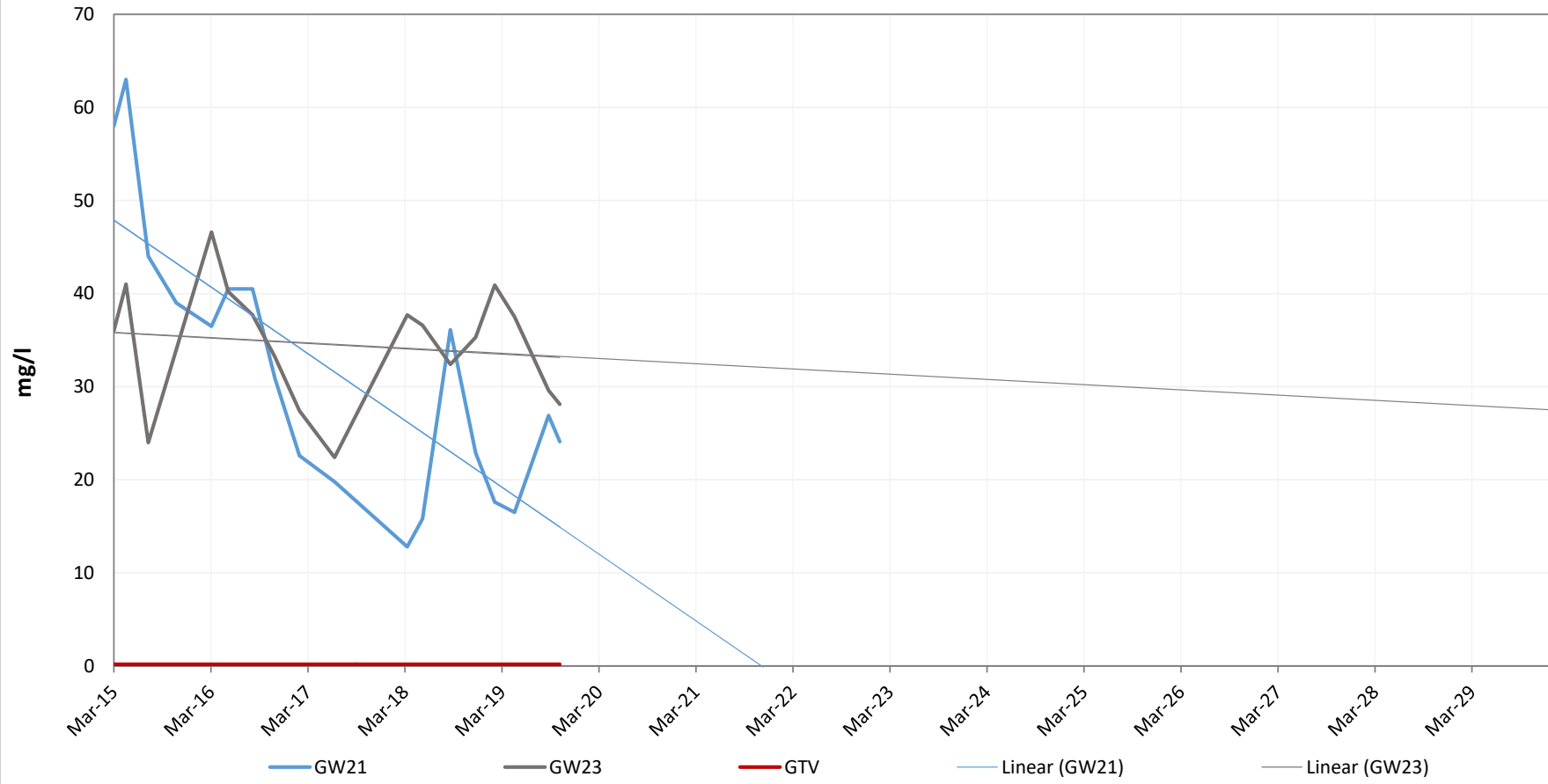


GW1 GW9 GW10 GW25 GTV Linear (GW1) Linear (GW9) Linear (GW10)

Ammonium (overburden downgradient)



Ammonium (overburden downgradient)



Leachate A Wells Quality

	Date	Temperature °C	Ammonia mg/l N	Chloride mg/l Cl	Electrical Conductivity µS/cm	pH pH
A1	21/10/2016		480	889	6960	7.4
A1	20/04/2017		629.5	1181	8890	7.4
A1	27/03/2018		302	561	4340	7.4
A1	13/12/2018		504.9	961	7090	7.3
A1	22/08/2019		333.5	607	5220	7.3
A2	13/05/2015	17.2	437	9611	8670	7.5
A2	01/09/2015		946	2476	14210	7.9
A2	17/12/2015		734	1054	7780	7.6
A2	09/06/2016		547	1035	7540	7.8
A2	21/10/2016		862	1045	7620	7.7
A3	13/05/2015					
A3	01/09/2015					
A3	21/10/2016					
A4	13/05/2015	22.7	1017	1611	12970	8.6
A4	01/08/2015					
A4	21/10/2016					
A4	13/12/2018		<0.02	1591	12880	7.8
A4	22/08/2019		<0.04	2374	15280	7.7
A5	01/09/2015	27.7	868	2227	13720	7.7
A5	17/12/2015		1014	2136	13390	7.9
A5	21/10/2016		1003	2196	3050	7.5
A5	27/03/2018		66	2189	12810	7.7
A5	13/12/2018		0.93	2268	11980	8
A5	22/08/2019		0.67	2544	12070	7.6
A6	13/05/2015	19.5	965	1867	14120	7.4
A6	01/09/2015		1127	2120	14460	7.5
A6	17/12/2015		1201	1927	14580	7.8
A6	21/10/2016					
A6	20/04/2017		454.7	2622	12270	7.5
A6	27/03/2018		8	1565	10720	7.6
A6	13/12/2018		512.9	1166	7730	7.4
A6	22/08/2019		<0.02	2130	12830	7.6
A7	13/05/2015	22.9	799	1907	13180	8.7
A7	01/09/2015	27	963	1905	13690	8.7
A7	17/12/2015		1259	2166	14740	8.8
A7	09/06/2016		1061	957	13530	9.1
A7	21/10/2016		1187	2179	13070	9
A7	27/03/2018		809.7	1695	12040	7.8
A7	13/12/2018		0.03	1923	13190	8.4
A8	13/05/2015	No pump				
A8	15/06/2015	17.1	1943	2683	22700	7.6
A8	01/09/2015		987	2783	22100	7.5
A8	17/12/2015		1932	2855	22700	7.9
A8	21/10/2016		1852	2859	22100	7.5
A9	09/06/2016		294	290	3700	7.2
A9	21/10/2016		304	352	4150	7.1
A9	20/04/2017		476.4	565	5600	7.3
A9	29/03/2018		315.7	455	4840	7
A9	13/12/2018		309.5	706	5750	7.2
A9	22/08/2019		218.2	280	3540	7.1
A10	13/05/2015	15.1	1263	2274	18800	7.6
A10	01/09/2015		1322	2940	19620	7.6
A10	17/12/2015		1982	2798	19450	7.9
A10	09/06/2016		521	2849	14510	7.9
A10	21/10/2016		1128	2835	15730	8.2
A10	20/04/2017		614.8	3180	15590	7.7
A10	29/03/2018		995.1	2865	17090	7.7
A10	13/12/2018		0.05	3131	15930	8
A11	13/05/2015					
A11	21/10/2016					
A12	13/05/2015	20.3	882	1546	12200	7.5
A12	01/09/2015		819	1430	12050	7.5
A12	17/12/2015		1072	1445	12350	8
A12	14/06/2016		1025	1320	11250	7.6
A12	21/10/2016		963	1348	11310	7.4
A12	20/04/2017		929.2	1384	11290	7.5
A12	29/03/2018		656.6	1055	9420	7.4
A12	13/12/2018		504.4	681	6690	7.4
A12	22/08/2019		341.4	612	5580	7.5

Leachate W wells Quality

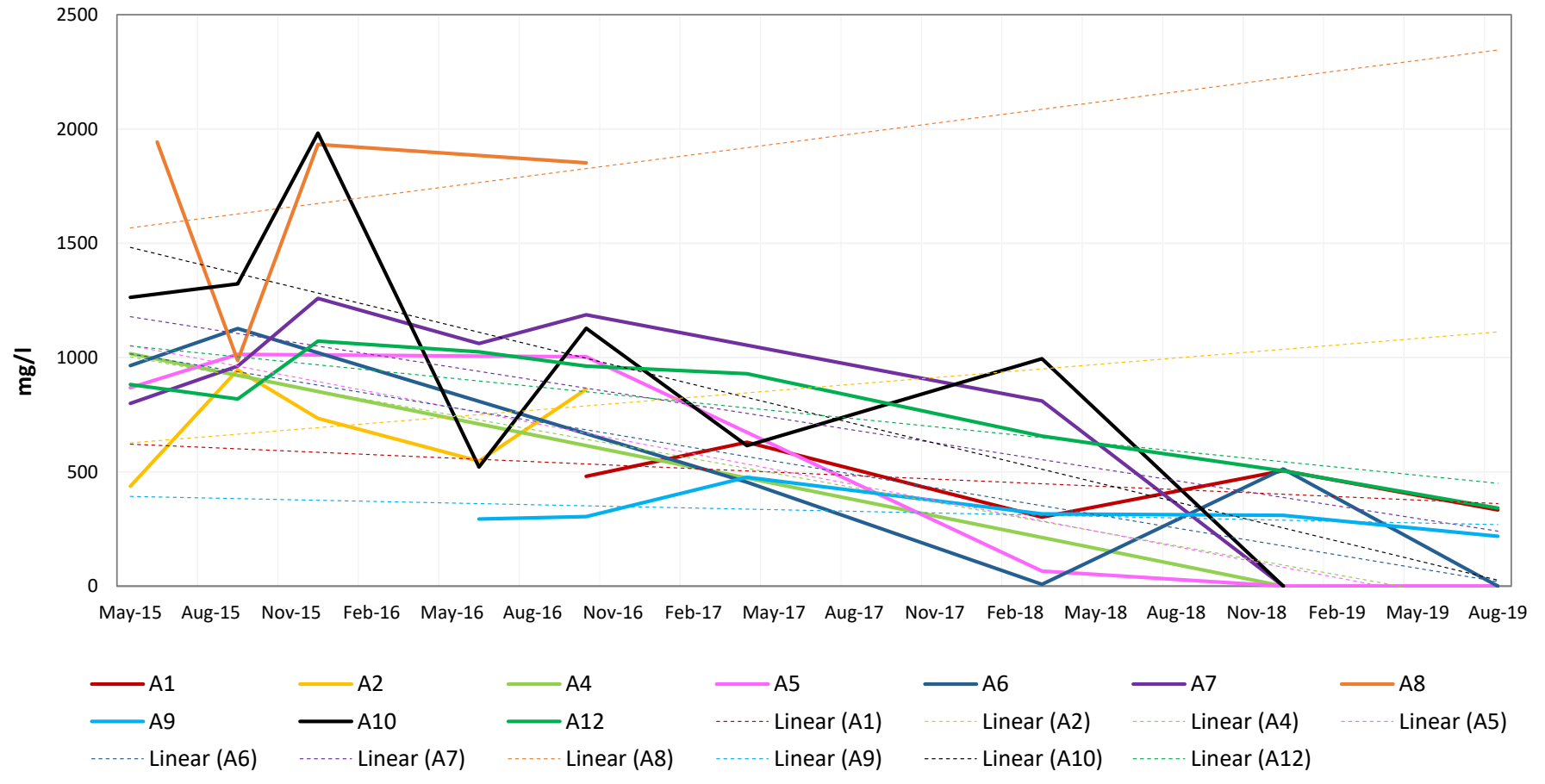
	Date	Temperature °C	Ammonia mg/l N	Chloride mg/l Cl	Electrical Conductivity µS/cm	pH pH
W1	18/05/2015	12	8.9	32.6	751	7.1
W1	01/09/2015	15.3	22.9	52.8	914	6.7
W1	01/12/2015	12.6	2.1	19.6	604	7.4
W1	10/06/2016		24.5	62.4	1190	6.8
W1	20/10/2016		7.8	27.6	707	8
W1	06/04/2017		11.1	32.2	766	7.3
W1	22/03/2018		20.6	39	967	7
W1	21/06/2018		65.7	204	2050	7.1
W1	13/12/2018		0.79	779	7640	7.2
W1	22/08/2019		21.4	49	929	7
W5	18/05/2015	13.4	0.06	936	9510	7.4
W5	01/09/2015	14.5	733	1302	11240	7.2
W5	01/12/2015	12.8	673	774	8110	7.3
W5	10/06/2016		643	859	8150	7.2
W5	20/10/2016		0.06	806	8030	7.3
W5	22/03/2018		512.8	773	7900	7.1
W5	21/06/2018		471.7	592	7200	7.4
W5	22/08/2019		<0.02	2854	19180	7.5
W10	18/05/2015	13.6	93	210	13560	7.4
W10	01/09/2015		875	1924	12990	7.6
W10	01/12/2015	17	1003	2336	14320	7.5
W10	10/06/2016		899	2255	13280	7.5
W10	20/10/2016					
W10	22/03/2018		590.5	1213	9240	7.3
W10	21/06/2018		641.3	1278	9650	7.2
W10	13/12/2018		0.77	1235	9090	7.3
W10	22/08/2019		0.36	1383	9500	7.3
W12	18/05/2015	18.6	108	239	16910	7.7
W12	01/09/2015		1279	2608	17060	7.7
W12	01/12/2015	12.9	1223	2571	16520	7.7
W12	10/06/2016		1008	2201	13920	7.8
W12	20/10/2016		<0.02	2288	14020	7.5
W12	06/04/2017		1128	2666	15420	7.6
W12	22/03/2018		419.3	814	6650	7.2
W12	21/06/2018		468	785	6860	7.4
W12	13/12/2018		417	741	6150	7.2
W12	22/08/2019		462.8	937	7200	7.4
W13	18/05/2015	19.3	71	141	10390	7.6
W13	01/09/2015		729	1343	10320	7.5
W13	01/12/2015	15.9	672	1322	10110	7.6
W13	10/06/2016		623	1292	9930	7.8
W13	20/10/2016		0.06	1334	10070	7.6
W13	06/04/2017		649.6	1211	9170	7.5
W13	22/03/2018		354.6	447	4790	7.5
W13	21/06/2018		628	807	8210	7.6
W27	15/06/2015	14.1	144	242	2610	6.8
W27	01/12/2015		103	167	1980	6.5
W27	10/06/2016		115	149	2540	6.7
W27	20/10/2016		40	58	1227	6.4
W27	20/04/2017		163.3	275	2930	6.7
W27	22/03/2018		157.6	137	2650	6.8
W27	22/08/2019		215.1	205	3150	6.9
W31	01/09/2015		209	198	3310	6.8
W31	01/12/2015	12.1	216	197	3220	6.7
W31	10/06/2016		258	187	3130	6.9
W31	20/10/2016		217	196	3270	6.7
W31	20/04/2017		205.8	174	3110	6.8
W31	13/12/2018		165.7	153	2790	6.8
W33	18/05/2015	23.3	14	27	2710	7
W33	14/06/2016		201	402	3530	8.1
W33	20/10/2016		14	126	807	6.7
W33	06/04/2017		556.9	933	7400	8
W33	22/03/2018		110.8	173	2070	7.1
W33	22/08/2019		13.8	32.7	781	6.9
W34	18/05/2015	17.8	75	115	2020	6.9
W34	01/09/2015		2.2	115	1205	7.6
W34	01/12/2015	13.8	51	85	1258	7.2
W34	14/06/2016		3.4	58.4	913	7.4
W34	20/10/2016		0.35	287	2470	6.7
W34	06/04/2017		333.3	502	4940	7.2
W34	22/03/2018		200.2	300	3260	7

W34	13/12/2018		338.2	535	5040	7.1
W34	22/08/2019		709.8	1131	8360	7.7
W35	18/05/2015	15	18	33	3510	6.9
W35	01/12/2015	13.8	194	248	3050	7.2
W35	14/06/2016		244	323	3660	7.1
W35	20/10/2016		237	327	3760	7.2
W35	06/04/1917		568.7	898	7320	7.5
W35	22/03/2018		206.8	345	3740	6.9
W35	21/06/2018		194.3	316	3540	8
W35	22/08/2019		608.4	1237	8360	7.7
W36	18/05/2015	13.3	96	150	2280	6.7
W36	01/09/2015		129	161	2510	6.7
W36	14/06/2016		91	167	1995	7.4
W36	05/04/2017		159.2	225	2900	6.8
W36	22/03/2018		192.8	347	3070	7
W36	21/06/2018		340.3	482	4880	7.6
W36	13/12/2018		317.1	519	4630	7.5
W36	22/08/2019		113.2	192	2340	7.1
W37	18/05/2015					
W37	15/06/2015	19.3	525	690	7410	7.4
W37	01/12/2015	13.4	324	440	4440	7.5
W37	14/06/2016		320	311	4340	7.5
W37	20/10/2016					
W37	22/03/2018		138.9	187	2460	6.9
W37	21/06/2018		142.1	245	2720	7.2
W37	22/08/2019		505.8	1004	7290	7.7
W38	18/05/2015	12.9	197	234	3490	7.6
W38	20/10/2016					
W38	22/03/2018		137	176	2370	7
W38	21/06/2018		191.5	208	3240	7.1
W38	13/12/2018		185.2	206	3240	7.1
W38	22/08/2019		227	250	3660	7.4
W39	18/05/2015	14	105	172	2120	6.7
W39	01/12/2015	13	41	52	1274	6.7
W39	20/10/2016		12	24	817	6.6
W39	05/04/2017		205.2	274	3440	7
W39	22/03/2018		24.2	22	1008	6.7
W39	21/06/2018		39.1	47.7	1573	6.7
W40	18/05/2015	13	73	70	1500	6.7
W40	01/12/2015	13.1	41	44	1082	7.1
W40	14/06/2016		75	86	1752	6.9
W40	21/10/2016		50	41	1131	6.7
W40	06/04/2018		38.1	48.1	1082	6.7
W40	22/03/2018		46.2	35	1118	6.8
W40	21/06/2018		80.2	102	2100	6.8
W40	13/12/2018		49.7	48.9	1174	6.8
W40	22/08/2019		74.9	96.8	1609	6.8
W41	18/05/2015	13	143	224	2910	7
W41	01/09/2015		135	191	3610	7
W41	01/12/2015	13.1	238	346	3910	7.3
W41	14/06/2016		100	136	2160	7.1
W41	21/10/2016		94	28	1849	7.9
W41	06/04/2017		80.2	160	2180	7
W41	13/12/2018		130.1	222	2610	7.2
W41	22/08/2019		168.2	255	3330	7.1
W42	18/05/2015					
W42	01/12/2015	15.2	254	314	3750	7
W42	14/06/2016		265	384	4370	7.1
W42	21/10/2016		170	207	2830	6.9
W42	05/04/2017		44.2	65.4	1266	6.7
W42	22/03/2018		130	208	2570	6.9
W42	21/06/2018		280.7	402	4340	7.1
W42	13/12/2018		129.9	207	2520	6.8
W43	18/05/2015					
W43	01/12/2015	15.8	21	271	2450	7
W43	14/06/2016		145	245	3260	7.1
W43	20/10/2016		160	257	3300	7.3
W43	06/04/2017		106.5	234	2930	7.3
W43	22/03/2018		248.8	337	4220	7.6
W43	21/06/2018		261.1	319	4170	7.3
W43	13/12/2018		214.6	234	3380	7.1
W43	23/08/2019		209.7	286	3830	7.3
W44	18/05/2015					
W44	01/09/2015		544	650	7050	7.1
W44	01/12/2015	12.6	446	548	6140	8
W44	14/06/2016		78	400	2780	8.2
W44	20/10/2016					
W44	06/04/2017		110.6	1001	8020	7.6
W44	22/03/2018		151.1	238	2690	8.2
W45	18/05/2015					
W45	01/09/2015		165	156	3020	6.9
W45	01/12/2015	12.1	163	126	2800	6.8
W45	14/06/2016		151	109	2470	6.9
W45	20/10/2016		131	94	2490	6.8
W45	06/04/2017		155.4	154	2960	6.9
W45	22/03/2018		229.4	280	4010	7
W45	21/06/2018		14.1	25.6	643	6.5
W45	13/12/2018		158.5	152	2910	6.9
W45	22/08/2019		0.55	14.8	231	7

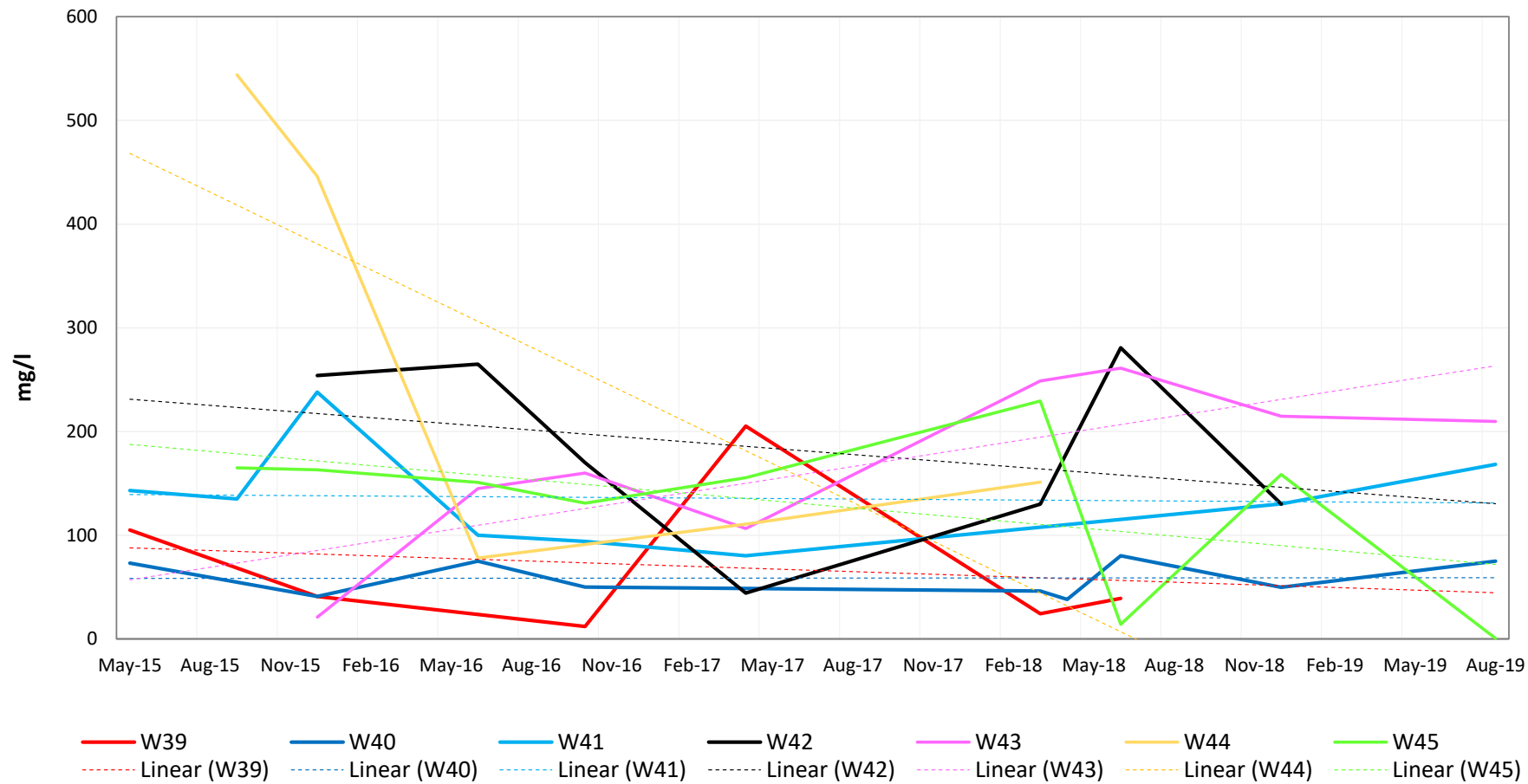
Leachate LE wells Quality

		Salinity	Ammonia	Chloride	Conductivity	pH
		-	mg/l N	mg/l Cl	µS/cm	pH
LE-12-1	13/05/2015		566	1079	7810	7.8
LE-12-1	01/12/2015		165	269	3040	7.3
LE-12-1	10/06/2016		929	1672	13230	7.8
LE-12-1	20/04/2017		42.7	80.4	1370	7.1
LE-12-1	22/03/2018		0.3	<5	622	7.6
LE-12-1	21/06/2018		123.1	229	2610	7.1
LE-12-1	13/12/2018		12.8	35.7	983	7
LE-12-1	22/08/2019		215.1	48.5	1251	6.8
LE-12-2	13/05/2015	9.9	1786	2280	15120	8
LE-12-3	13/05/2015					
LE-12-4	13/05/2015		280	428	4360	6.9
LE-12-4	01/09/2015		955	2267	14010	7.6
LE-12-4	17/12/2015		111	175	2300	7.1
LE-12-4	09/06/2016		1106	2217	15040	7.5
LE-12-4	21/10/2016		412	592	15250	7.3
LE-12-4	27/03/2018		259.1	309	3560	7.7
LE-12-4	13/12/2018		0.06	1345	10520	8.2
LE-12-4	22/08/2019		0.09	1407	9550	7.3
LE-12-5	13/05/2015					
LE-12-6	13/05/2015					
LE-12-7	13/05/2015		17.8	23	875	6.7
LE-12-7	01/12/2015		9.5	28.6	784	6.7
LE-12-7	10/06/2016		52.2	60.2	138.3	6.7
LE-12-7	20/10/2016		15	29	861	6.7
LE-12-7	22/03/2018		38.9	31	999	6.8
LE-12-7	13/12/2018		27	38.4	943	6.7
LE-12-7	22/08/2019		34.2	38	1085	6.9
LE-12-8	13/05/2015					
LE-12-9	13/05/2015					
LE-12-10	13/05/2015					
LE-12-11	13/05/2015		512	809	7340	7.2
LE-12-11	01/09/2015		617	1087	8010	7.4
LE-12-11	17/12/2015		470	695	5990	7.6
LE-12-11	09/06/2016		661	732	6600	7.3
LE-12-11	21/10/2016		759	997	8260	7.9
LE-12-12	13/05/2015		716	1527	10940	7.4
LE-12-12	01/09/2015		889	1769	11750	7.6
LE-12-12	17/12/2015		572	962	7850	7.6
LE-12-12	09/06/2016		884	1605	12310	7.6
LE-12-12	21/10/2016		653	1216	8470	7.3
LE-12-12	29/03/2019		649.5	1027	9080	7.4
LE-12-13	13/05/2015					
LE-12-14	13/05/2015		369	674	5910	7.2
LE-12-14	01/09/2015		687	1344	9510	7.5
LE-12-14	17/12/2015		186	285	3010	7.8
LE-12-14	14/06/2016		853	1999	12860	7.7
LE-12-14	21/10/2016		193	475	3570	7.2
LE-12-14	20/04/2017		808.4	1338	10260	7.5
LE-12-14	29/03/2018		649.5	1027	9080	7.4
LE-12-14	13/12/2018		104.6	253	2320	7.1
LE-12-14	22/08/2019		699.7	1120	8150	7.5
LE-12-15	13/05/2015		606	985	8480	7.2
LE-12-15	01/09/2015		725	985	7950	7.3
LE-12-15	17/12/2015		716	1197	9430	7.9
LE-12-15	14/06/2016		670	854	7250	7.7
LE-12-15	20/04/2017		391.5	588	5630	7.2
LE-12-16	13/05/2015		976	1751	14850	7.6
LE-12-16	01/09/2015		1172	2014	15520	7.8
LE-12-16	17/12/2015		485	773	7360	7.6
LE-12-16	14/06/2016		1340	1978	16250	7.7
LE-12-16	21/10/2016		994	1555	13390	7.7
LE-12-16	20/04/2017		1409.1	2055	16160	7.6
LE-12-16	29/03/2018		862	1271	11630	7.6
LE-12-16	13/12/2018		0.04	1097	10350	7.4
LE-12-16	22/08/2019		1082.9	1535	13470	8

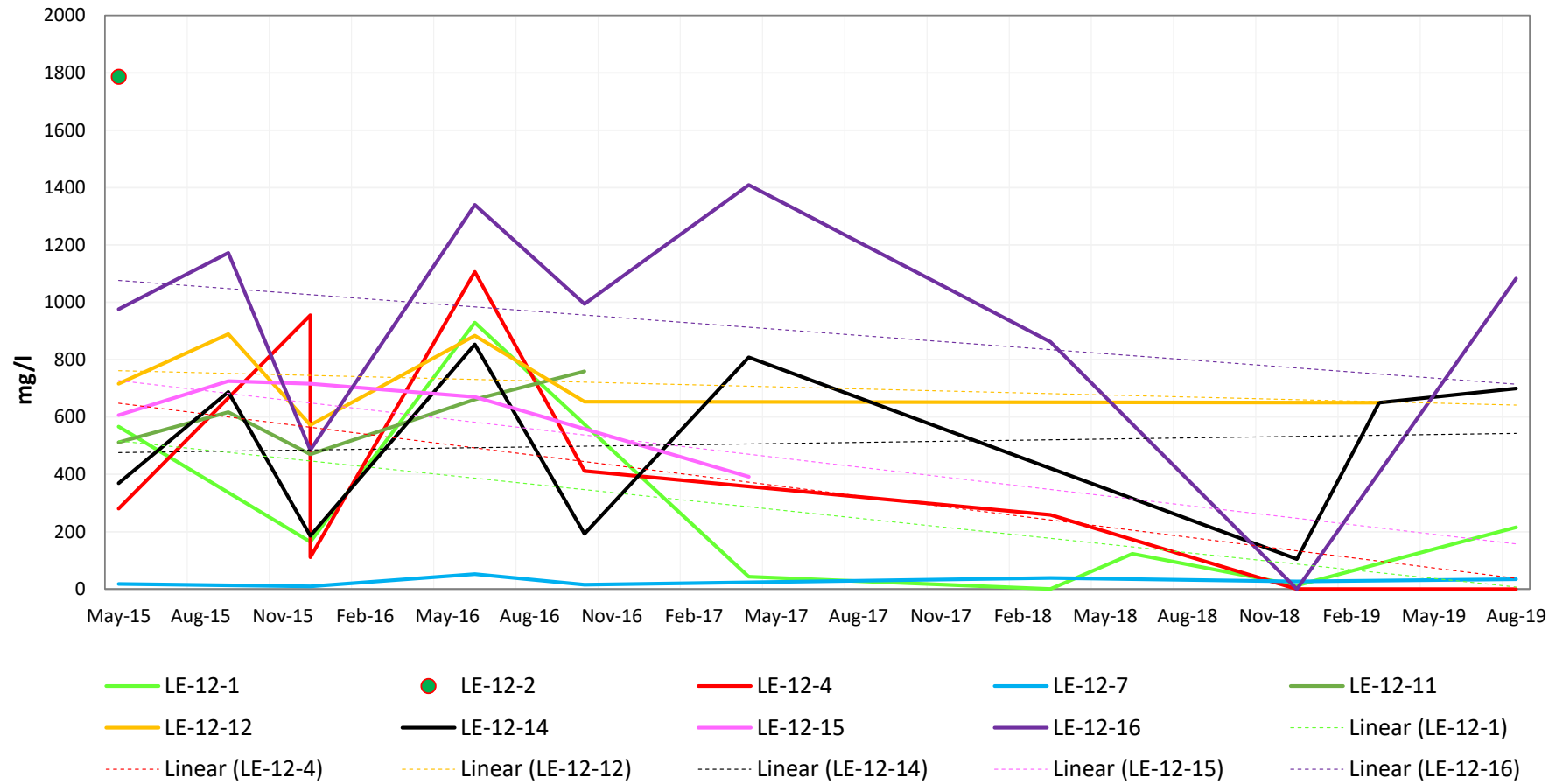
Ammoniacal Nitrogen (A-Wells)



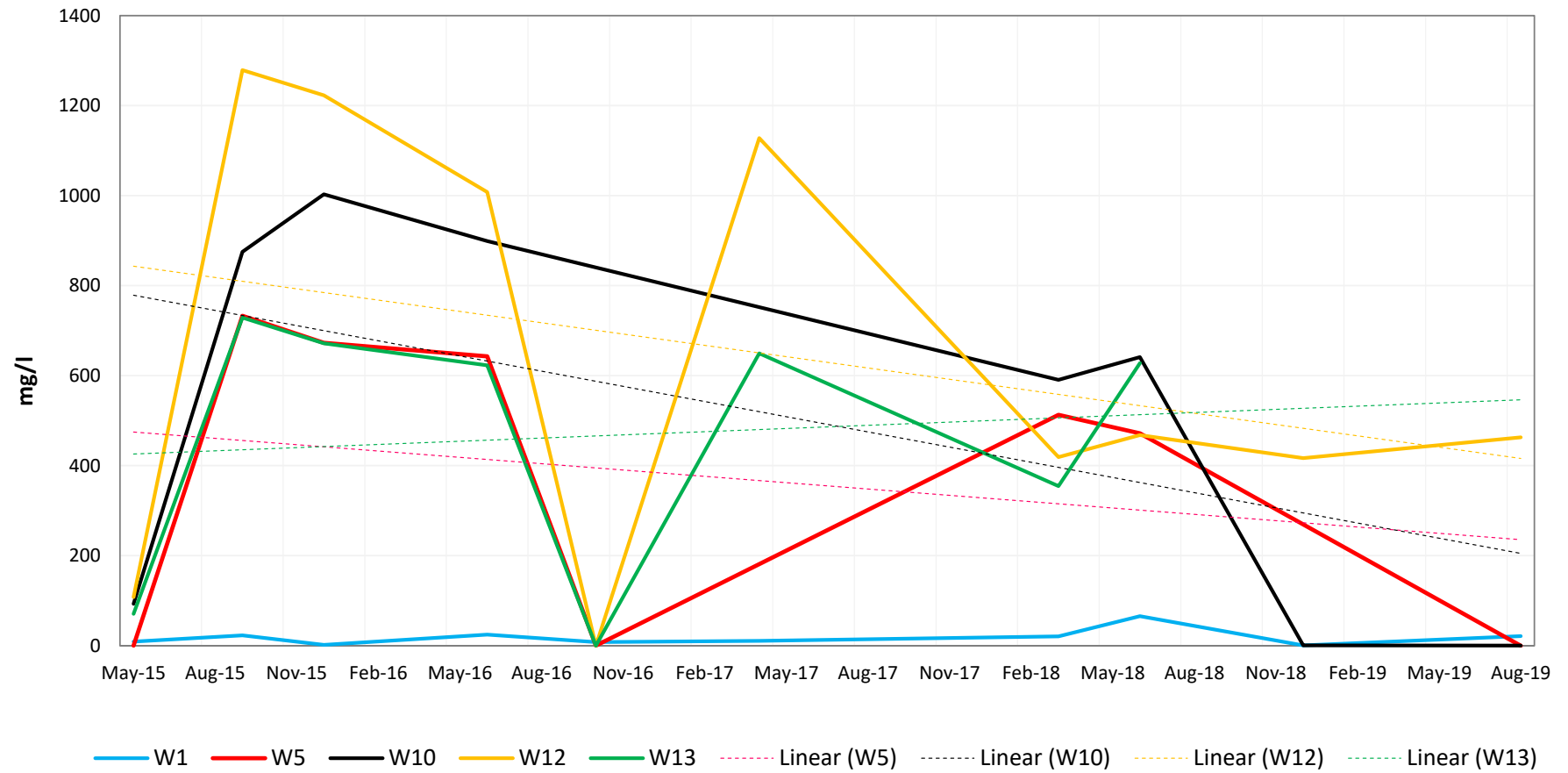
Ammoniacal Nitrogen (W-Wells southeast)



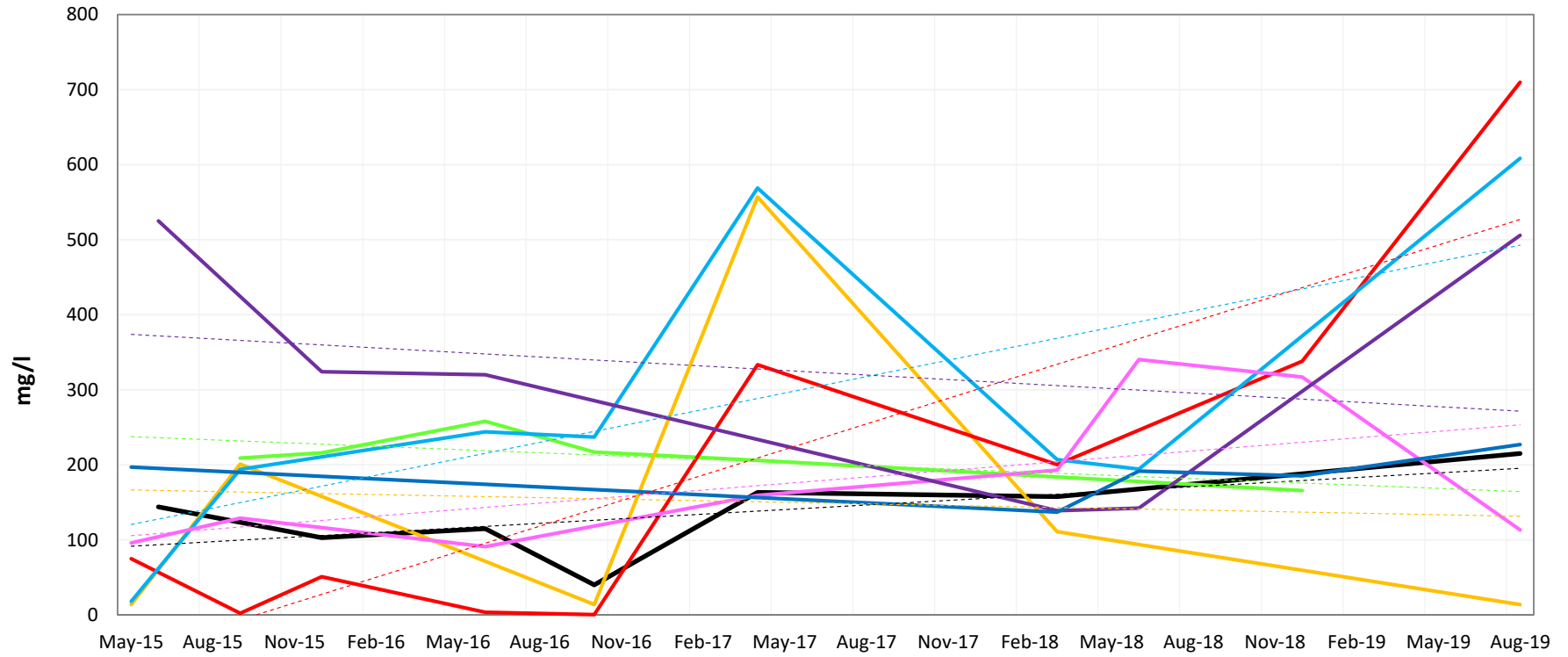
Ammoniacal Nitrogen (LE-Wells)



Ammoniacal Nitrogen (W-Wells northern)



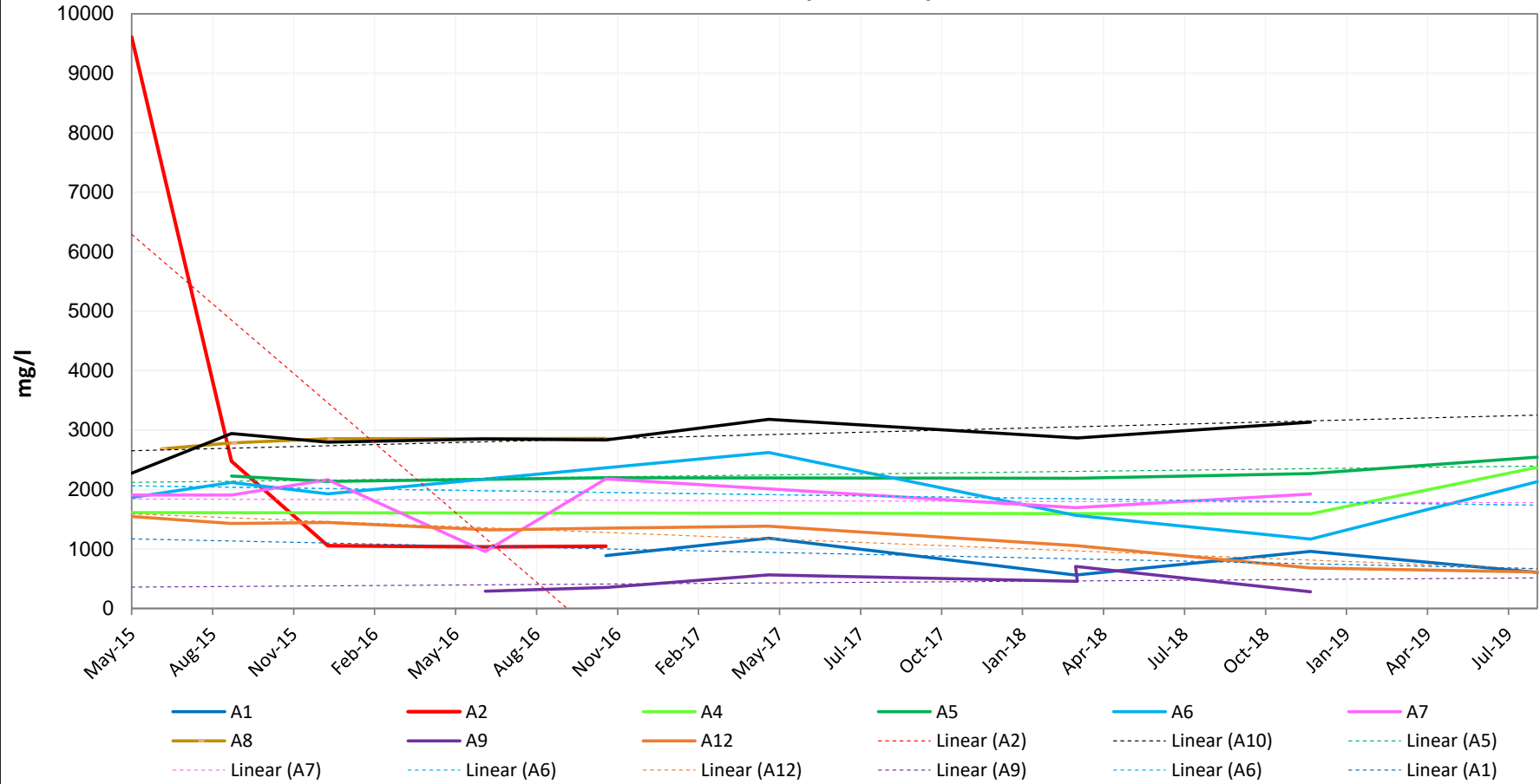
Ammoniacal Nitrogen (W-Wells south-central)



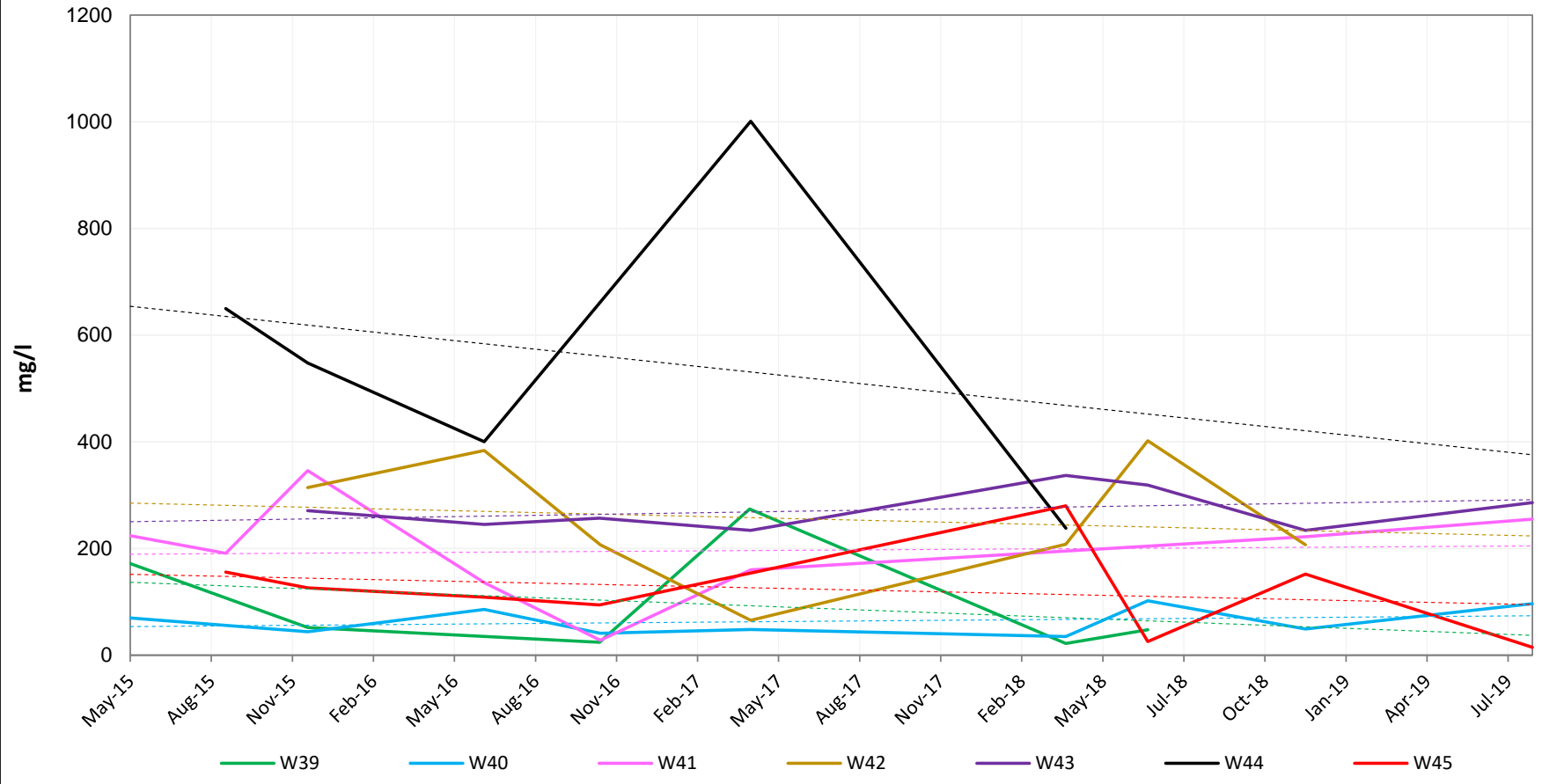
- W27
- W31
- W33
- W34
- W35
- W36
- W37
- W38
- Linear (W27)
- Linear (W31)
- Linear (W33)
- Linear (W34)
- Linear (W35)
- Linear (W36)
- Linear (W37)

WELL ID No.	Ammoniacal Nitrogen Trend (Increasing / Reducing / Stable)	No. of monitoring rounds (2015-2019)	Last monitoring round
A1	Reducing	5	Aug-19
A2	Stable / Increasing slightly / limited data	5	Oct-16
A4	Reducing	1	Aug-19
A5	Reducing	6	Aug-19
A6	Reducing	5	Aug-19
A7	Reducing	7	Aug-19
A8	Stable / Increasing slightly / limited data	4	Oct-16
A9	Reducing	6	Aug-19
A10	Reducing	8	Dec-18
A12	Reducing	9	Aug-19
W1	Stable	10	Aug-19
W5	Reducing	7	Aug-19
W10	Reducing	8	Aug-19
W12	Reducing	9	Aug-19
W13	Stable / Increasing slightly	8	Jun-18
W27	Increasing slightly	7	Aug-19
W31	Reducing slightly	6	Dec-18
W33	Stable	6	Aug-19
W34	Increasing	9	Aug-19
W35	Increasing	8	Aug-19
W36	Increasing	8	Aug-19
W37	Overall reducing, spike in Aug-19	6	Aug-19
W38	Stable	5	Aug-19
W39	Reducing slightly	6	Jun-18
W40	Stable	9	Aug-19
W41	Stable	8	Aug-19
W42	Reducing	7	Dec-18
W43	Reducing	8	Aug-19
W44	Reducing	5	Mar-18
W45	Reducing	9	Aug-19
LE12-1	Reducing	8	Aug-19
LE12-2	Not enough data (high)	1	May-15
LE12-4	Reducing	8	Aug-19
LE12-7	Stable (low)	7	Aug-19
LE12-11	Increasing (limited data)	5	Oct-16
LE12-12	Reducing slightly	6	Mar-19
LE12-14	Stable	9	Aug-19
LE12-15	Reducing	5	Apr-17
LE12-16	Reducing	9	Aug-19
	Count	39	
	Increasing	4	
	Stable	7	
	Reducing	23	
	Stable / slight increase	4	

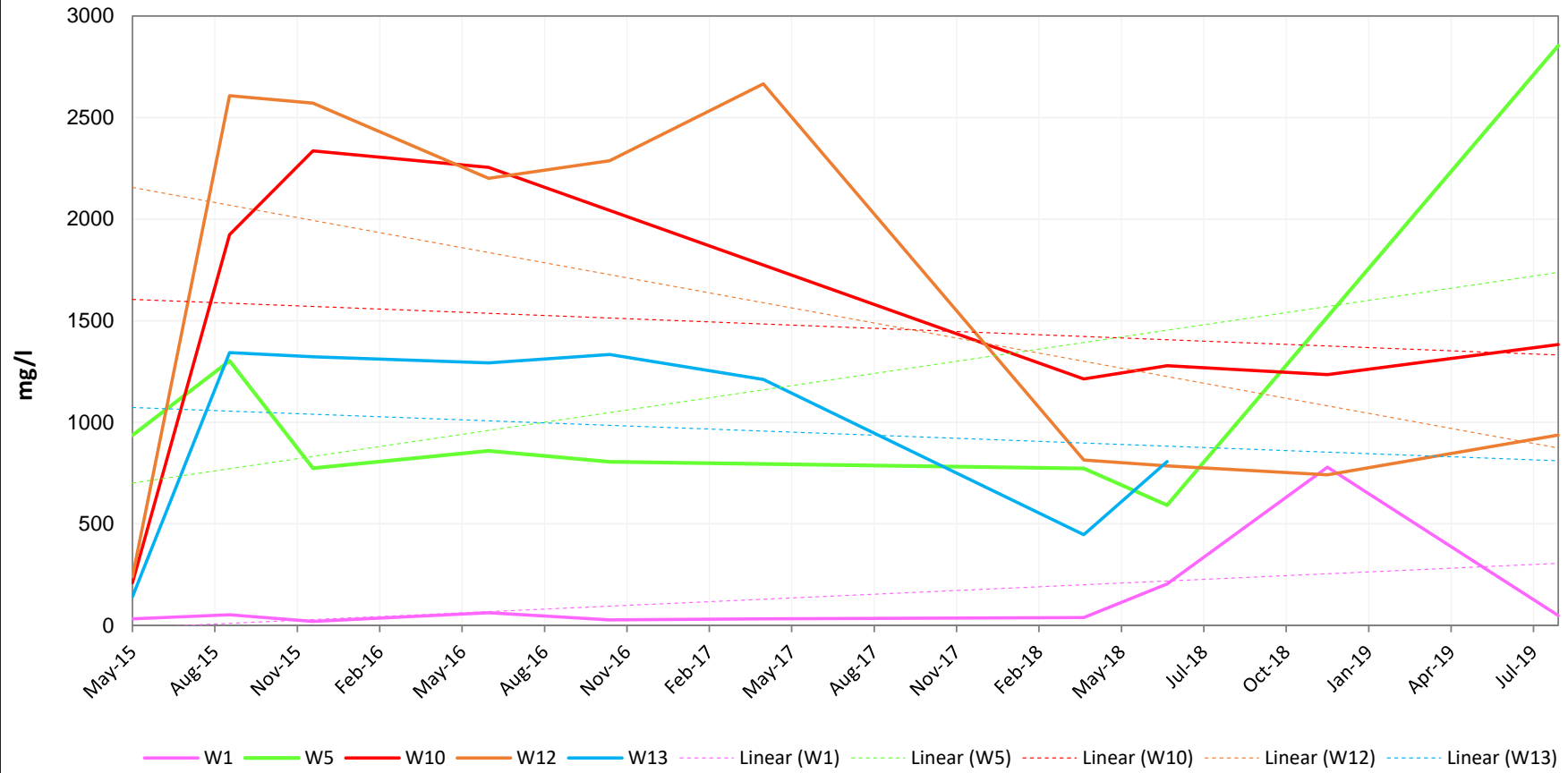
Chloride Trends (A- Wells)



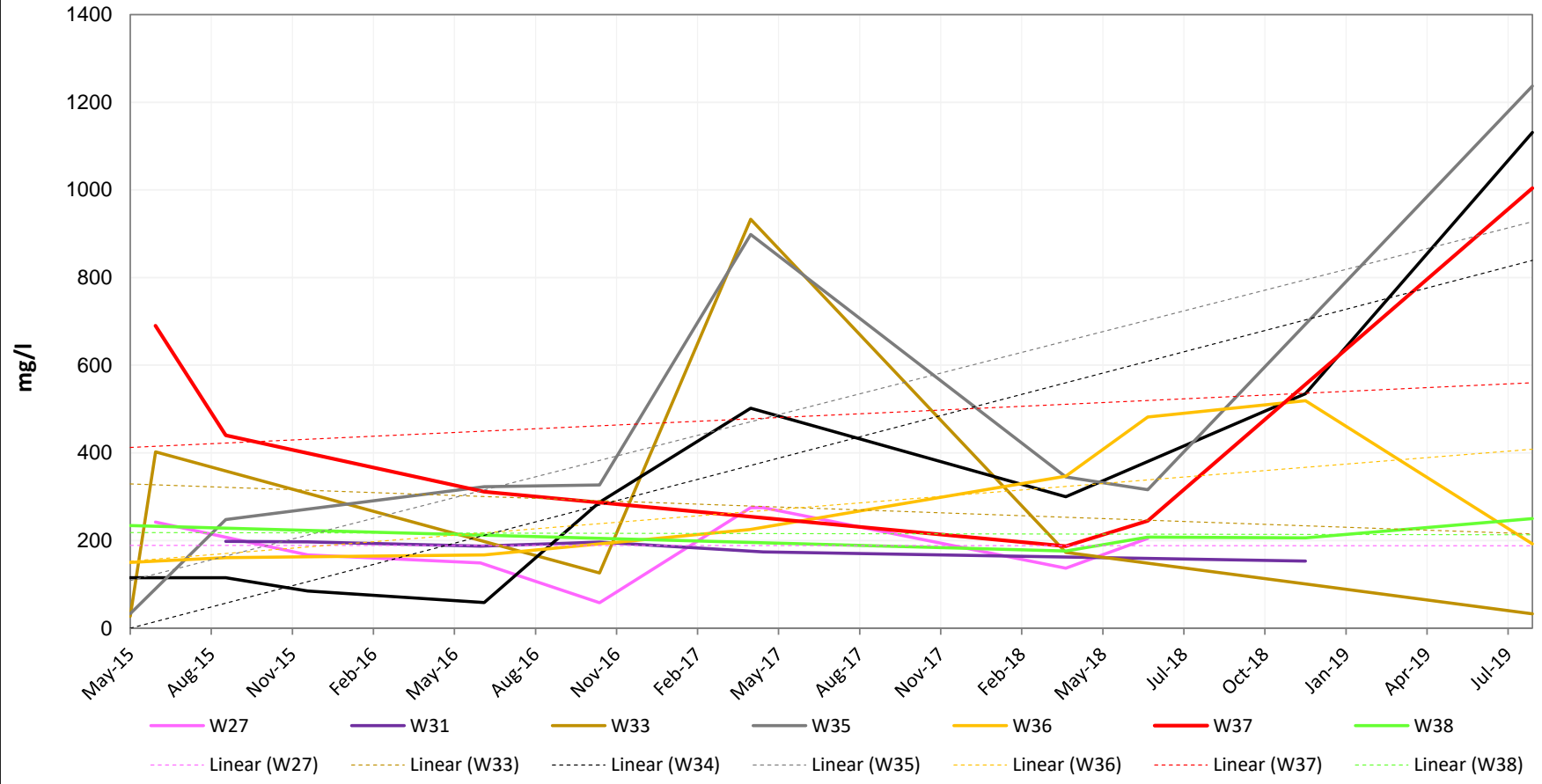
Chloride Trends (W- Wells southeast)



Chloride Trends (W- Wells northern)



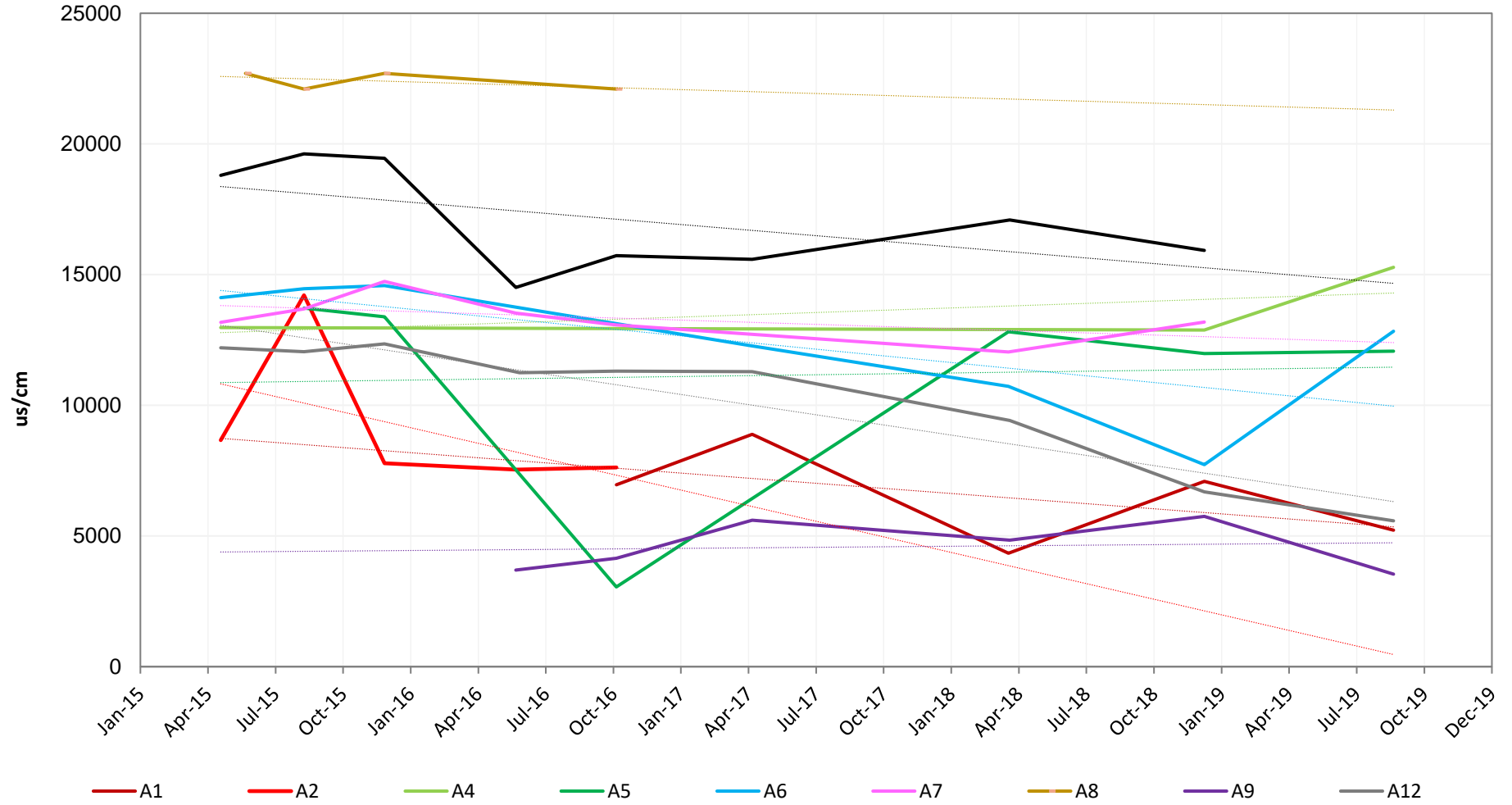
Chloride Trends (W- Wells south-central)



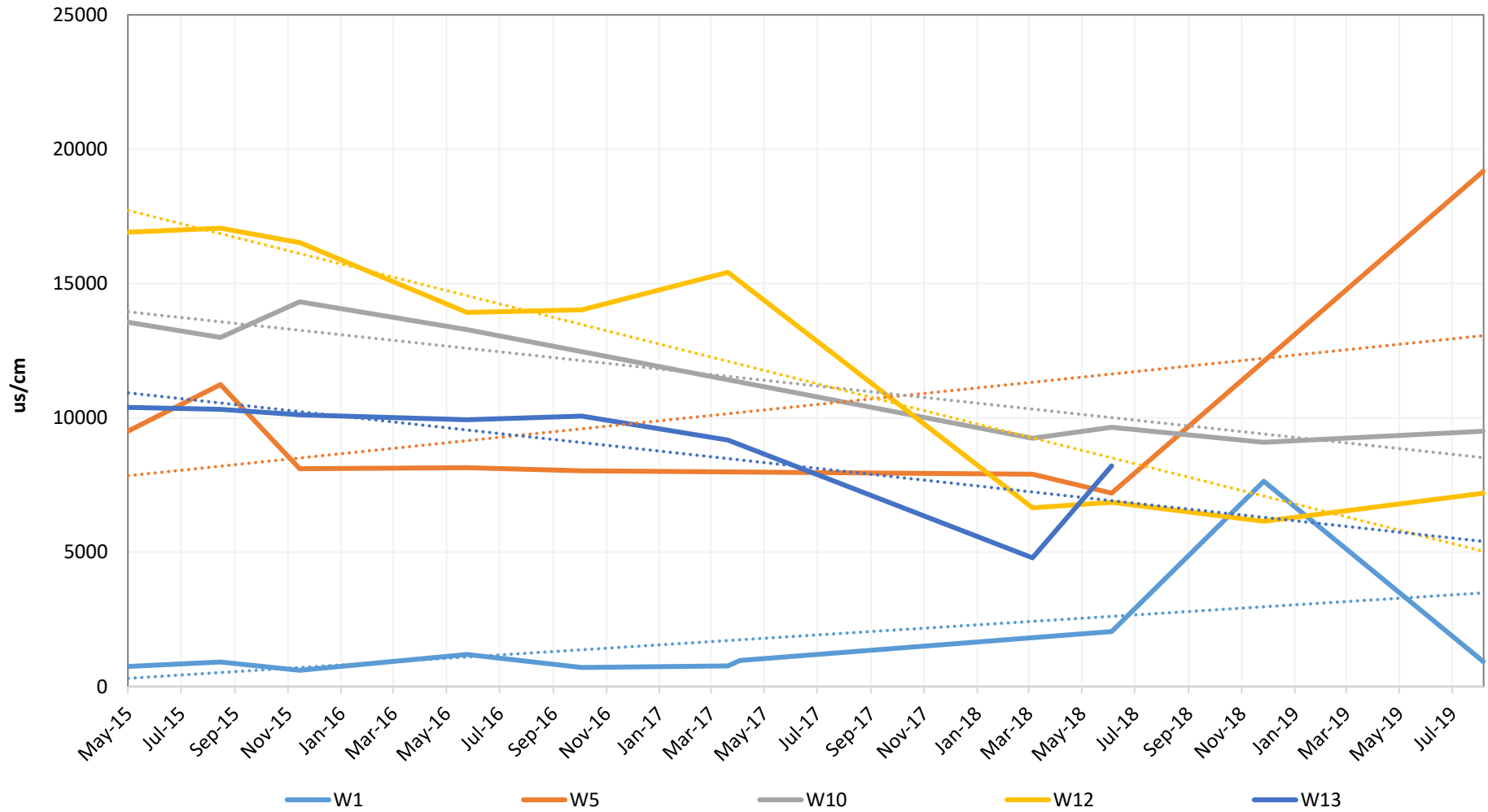
WELL ID No.	Chloride Trend (Increasing / Reducing / Stable)	No. of monitoring rounds (2015-2019)	Last monitoring round
A1	Reducing slightly	5	Aug-19
A2	Reducing	5	Oct-16
A4	Stable/increasing slightly	3	Aug-19
A5	Stable	6	Aug-19
A6	Reducing	7	Aug-19
A7	Stable	7	Dec-18
A8	Stable / increasing slightly	4	Oct-16
A9	Stable / increasing slightly	6	Dec-18
A10	Increasing slightly	8	Dec-18
A12	Reducing	9	Aug-19
W1	Stable/one-off spike Dec-18	10	Aug-19
W5	Stable / Increasing due to one-off spike Aug-19	8	Aug-19
W10	Reducing	8	Aug-19
W12	Reducing	10	Aug-19
W13	Stable	8	Jun-18
W27	Stable	8	Jun-18
W31	Stable	6	Dec-18
W33	Stable/Reducing	6	Aug-19
W34	Increasing+	9	Aug-19
W35	Increasing+	8	Aug-19
W36	Increasing	8	Aug-19
W37	Overall reducing, spike in Aug-19	6	Aug-19
W38	Stable	5	Aug-19
W39	Reducing	6	Jun-18
W40	Stable	9	Aug-19
W41	Stable	8	Aug-19
W42	Stable/Reducing	7	Dec-18
W43	Stable	8	Aug-19
W44	Reducing (spike Apr-17)	5	Mar-18
W45	Reducing	9	Aug-19
LE12-1	Reducing	7	Aug-19
LE12-2	No trend (high May-15)	1	May-15
LE12-4	Stable	8	Aug-19
LE12-7	Stable (low)	7	Aug-19
LE12-11	Stable	5	Oct-16
LE12-12	Reducing	6	Mar-19
LE12-14	Stable/Reducing	9	Aug-19
LE12-15	Reducing	5	Apr-17
LE12-16	Reducing	9	Aug-19
	Count	39	
	Increasing	3	
	Stable	14	
	Reducing	17	
	Stable / slight increase	5	

WELL ID No.	Conductivity Trend (Increasing / Reducing / Stable)	No. of monitoring rounds (2015-2019)	Last monitoring round
A1	Reducing	5	Aug-19
A2	Reducing	5	Oct-16
A4	Stable, increasing slightly, few data	3	Aug-19
A5	Stable, increasing slightly	6	Aug-19
A6	Stable, reducing slightly	7	Aug-19
A7	Stable, reducing slightly	7	Dec-18
A8	Reducing, no data since 2016	4	Oct-16
A9	Stable	6	Aug-19
A10	Reducing	8	Dec-18
A12	Reducing	9	Aug-19
W1	Stable, increasing trend due to 2018 spikes	10	Aug-19
W5	Stable/reducing, increasing trend due to 2019 spike	8	Aug-19
W10	Reducing	8	Aug-19
W12	Reducing	10	Aug-19
W13	Reducing	8	Jun-18
W27	Stable, increasing slightly	7	Aug-19
W31	Stable, reducing slightly	6	Dec-18
W33	Reducing	6	Aug-19
W34	Increasing	9	Aug-19
W35	Increasing	8	Aug-19
W36	Increasing	8	Aug-19
W37	Stable, reducing slightly, spike in 2019	6	Aug-19
W38	Stable	5	Aug-19
W39	Stable	6	Jun-18
W40	Stable	9	Aug-19
W41	Stable	8	Aug-19
W42	Stable, reducing slightly	7	Dec-18
W43	Increasing	8	Aug-19
W44	Reducing	5	Mar-18
W45	Reducing	9	Aug-19
LE12-1	Reducing	8	Aug-19
LE12-4	Increasing	8	Aug-19
LE12-7	Increasing (low levels)	6	Aug-19
LE12-11	Stable/increasing, no data since 2016	4	Aug-19
LE12-12	Reducing	6	Mar-19
LE12-14	Increasing slightly	7	Aug-19
LE12-15	Reducing	5	Apr-17
LE12-16	Reducing	8	Aug-19
	Count	38	
	Increasing	7	
	Stable	6	
	Reducing	20	
	Stable / slight increase or reduction	5	

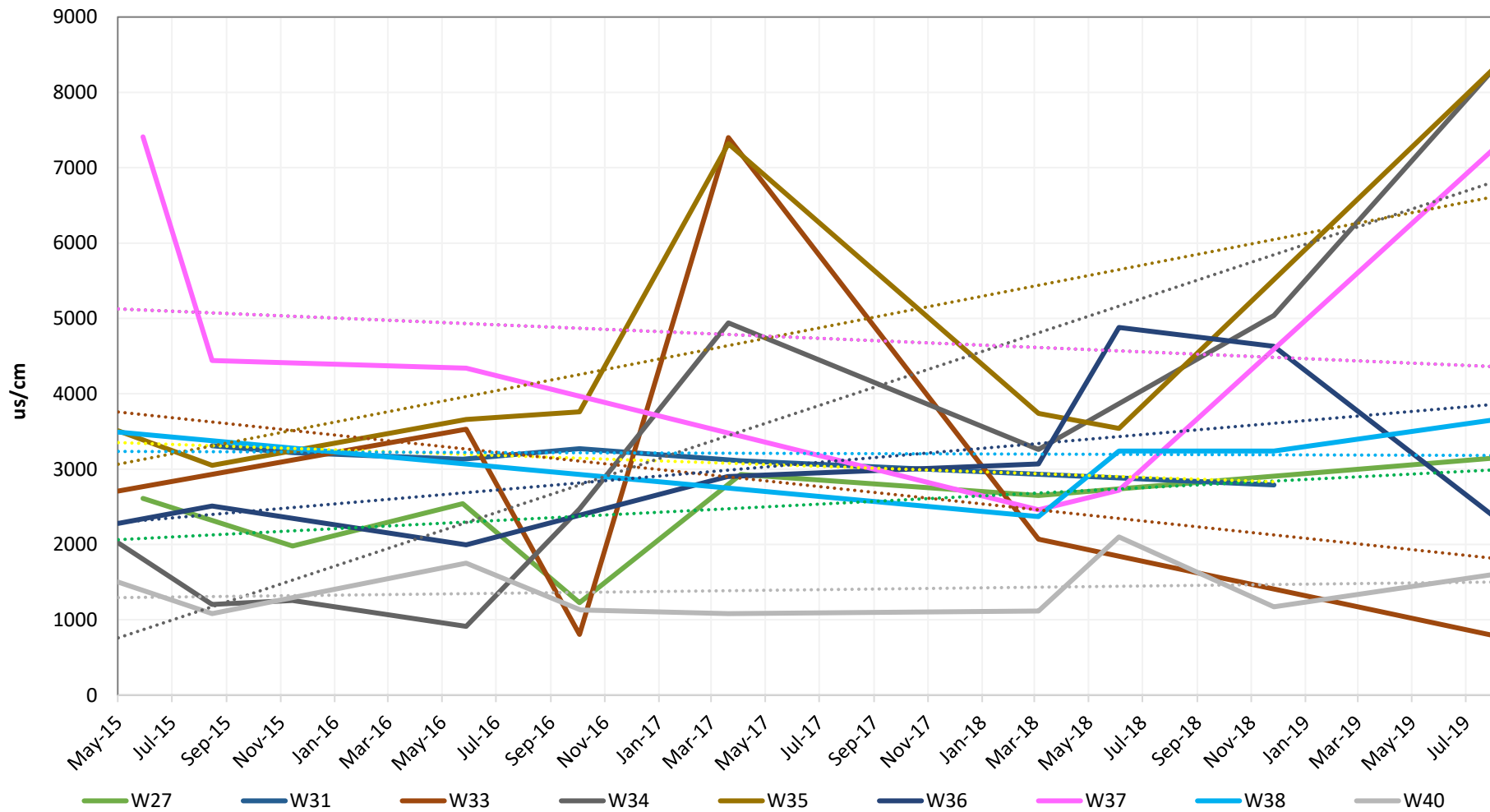
Conductivity Trends (A- Wells)



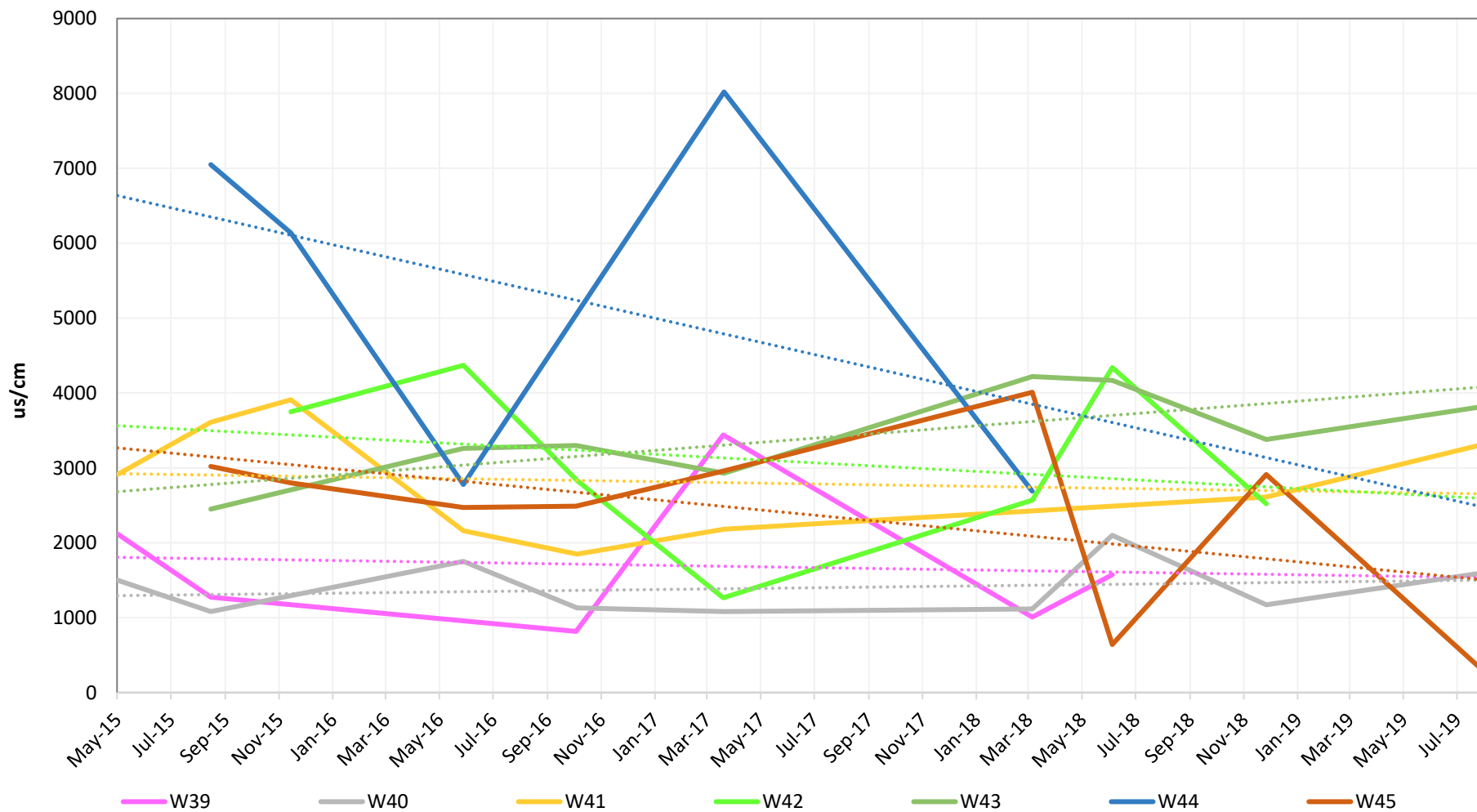
Conductivity (W Wells)



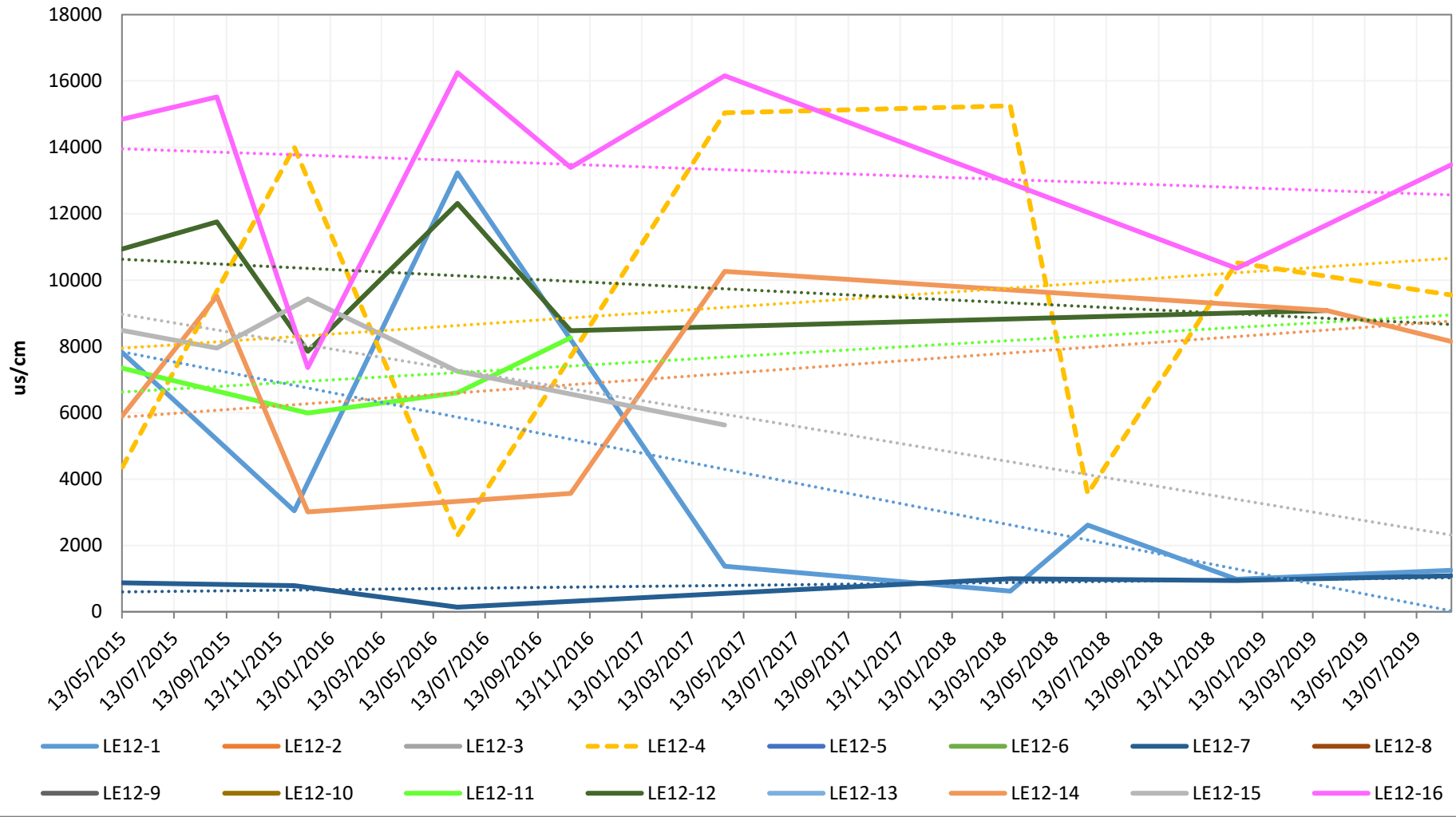
Conductivity (W Wells)



Conductivity (W Wells)



Conductivity (LE Wells)



Leachate Tank

Sampling Date		23/08/2006	15/08/2007	06/08/2008	30/06/2009	12/05/2010	30/03/2011	26/03/2012	15/04/2013	15/05/2014	27/04/2015	13/03/2016	13/09/2017	30/08/2018	04/09/2019	EPA IGV	EEC GTV	
Time		14.15	15.15	15.10	16.25	13.55	16.30	14.00	11.05	10.45	12.20	12.25	13.45	nr	17.10			
Laboratory Ref:		2604497	2703346	2803955	2093338	1001933	1101671	1201380	1301744	1421956	1521845	2028	3919	5072	6206			
Sampling point (visual)		Black Colour	Light Brown Colour	-	Black Colour	Black Colour	Clear	Brown	-	Dark	Dark	Amber Brown	Brown	Brown	Brown			
Parameters	Units																	
Temperature	°C	17	17	19	17.8	12.4	9.7	11.2	9.9	14.4	11.5	9.9	15.9	17.9	15.4	25	-	
Ammonia	mg/l N	930	110	230	740	390	470	330	340	610	340	190	157	250	249	-	0.175	
Biochemical Oxygen Demand	mg/l O2	50	19	32	800	42.5	42	12.2	35	54	<50	<10	26	34	-	-	-	
Chemical Oxygen Demand	mg/l O2	1338	80	319	1812	904	200	484	553	1170	828	nm	174	259	251	-	-	
Chloride	mg/l Cl	1449	174	404	1085	585	767	513	521	419	678	274	300	446	378	30	187.5	
Conductivity	µS/cm	12240	2030	4160	11900	6410	7320	5480	5750	9410	7510	3550	3150	4120	4140	1000	1875	
Cyanide (Total)	mg/l	16			<0.05		<0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.01	0.0375	
Flouride	mg/l F	0.18	0.74	4.4	2.1	<2.5	2.1	<2.5	<2.5	<1.6	<0.5	<0.5	nm	<0.5	1	-	-	
Mercury	µg/l	0.48	<0.5	<5	<5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.50	<0.01	<0.01	<0.01	<0.01	1	0.75	
Nitrite	mg/l N	nr	0.5	0.39	<0.02	1.96			nm	nm	0.421	nm	nm	nm	nm		0.375	
Ortho-Phosphate	mg/l P	3.5	0.088	0.33	5.5	1.8	1.3	1.4	0.58	3.2	1.1	0.251	0.112	0.0956	<0.02	0.03		
pH	pH	8.1	7.9	7.9	7.8	7.5	7.9	7.9	7.7	7.7	8.2	7.1	8	8.3	7.4	6.5 - 9.5	-	
Sulphate	mg/l SO4	24.4	54.4	92	30	100	31	<25	<25	<16	14.4	<10	39.4	5.8	200	187.5		
Total Oxidised Nitrogen	mg/l N	160	1	3.7	7	3.8	1.11	3.24	4.57	2.4	0.68	<0.1	12.9	7.3	5.46			
Aluminium	µg/l	198	623	<250	277	500	28	88	77	220	250	nm	nm	nm	nm	200	150	
Antimony	µg/l	7.51	<50	<10	12.7	7.1	2.9	4	2.6	7.4	3.8	nm	nm	nm	nm	-	-	
Arsenic	µg/l	101	53.8	<10	34.3	18	16	40	12	49	34	8.5	nm	nm	nm	10	7.5	
Barium	µg/l	91.4	384	<60	239	170	71	560	140	110	240	nm	nm	nm	nm	1000		
Beryllium	µg/l	<1	<50	<10	5.9	<0.5	1.4	<0.05	<0.5	<1.0	nm	nm	nm	nm	nm			
Boron	µg/l	3120	5180	1266	3050	1700	650		1700	2700	nm	735	681	1120	1130	1000	750	
Cadmium	µg/l	0.24	<50	<10	<5	<0.5	<0.5	<0.05	<0.5	0.18	<0.02	<0.1	<0.08	<0.08	<0.08	5	3.75	
Calcium	mg/l	93.5	754	131	92.1	96	47	56	86	100	120	109	85.4	99.2	124	200		
Chromium	µg/l	134	203	<10	108	60	15	110	33	94	72	13.3	13.5	10.6	8.59	30	37.5	
Cobalt	µg/l	24.5	<50	<10	27.1	7.7	5.9	8.3	7.6	15	15	nm	nm	nm	nm			
Copper	µg/l	34.5	117	<10	30	46	15	30	13	16	99	3.87	9.47	41.6	5.4	30	1500	
Iron	µg/l	7050	24000	2501	6610	20000	4500	5000	4600	4800	3800	1520	3060	4080	6010	200		
Lead	µg/l	22.5	<50	<10	35.1	52	2.8	3.3	1.1	2.8	<1.0	0.686	<0.2	<0.2	0.292	10	7.5	
Magnesium	mg/l	90.5	516	62.2	86.5	55	29	42	58	66	59	34.3	25.6	58	61.7	50	-	
Manganese	µg/l	507	2380	<500	1950	780	120	390	460	590	570	264	294	296	386	50	-	
Molybdenum	µg/l	<1	<50	<10	15	1.4	1	1.9	1.4	5.6	2	nm	nm	nm	nm	-	-	
Nickel	µg/l	147	133	18.3	106	32	24	44	36	77	74	nm	25.5	28.6	28.7	20	15	
Potassium	mg/l	625	721	208	549	270	180	170	210	470	320	126	125	187	187	5	-	
Selenium	µg/l	36	<50	<10	19.4	17	35	31	23	3	1.1	nm	nm	nm	nm	-	-	
Silver	µg/l	<50										nm	nm	nm	nm	-	-	
Sodium	mg/l	976	1380	387	890	420	430	390	440	800	580	212	245	286	269	150	150	
Thallium	µg/l	<1	<50	<10	<5	<0.5	1.7	<0.5	<0.5	<1.0	<1.0	nm	nm	nm	nm			
Thorium	µg/l	<1	<50									nm	nm	nm	nm			
Tin	µg/l	<50	<100	<10	66.7	14	6					nm	nm	nm	nm			
Uranium	µg/l	<1	<50	<10	<5	<0.5	0.5	0.6	<0.5	<1.0	<1.0	nm	nm	nm	nm	9		
Vanadium	µg/l	72.6	<50	<10	140	52	9.4	33	35	120	11	nm	nm	nm	nm			
Zinc	µg/l	278	631	200	168	110	44	470	75	120	250	20.3	9.77	nm	12.6	100	75	

APPENDIX G

Surface Water Hydrochemistry

Surface Water Quality Summary Results

AMMONIA	mg/l									
	SW1	SW2	SW3	SW4	S1	S2	S3	EQS	SWR (high)	SWR (good)
12-Feb-15	Dry	Dry	Dry	Dry				0.02	0.04	0.065
27-Apr-15	Dry	Dry	Dry	Dry				0.02	0.04	0.065
20-Jul-15	0.025	<0.02	Dry	0.021				0.02	0.04	0.065
02-Nov-15	0.038	0.35	Dry	0.024				0.02	0.04	0.065
23-Mar-15					0.02	0.02	0.35			
14-May-15					0.1	0.12	0.24			
01-Sep-15					0.03	0.02	0.10			
17-Dec-15					0.08	0.07	0.06			
13-Mar-16	<0.2	0.78	Dry	<0.2				0.02	0.04	0.065
17-May-16	<0.2	0.22	Dry	<0.2				0.02	0.04	0.065
15-Aug-16	Dry	Dry	Dry	Dry				0.02	0.04	0.065
07-Nov-16	Dry	Dry	Dry	Dry				0.02	0.04	0.065
08-Mar-16					0.03	0.03	0.04			
24-May-16					<0.02	<0.02	0.05			
20-Jul-16					<0.02	0.11	0.30			
11-Nov-16					0.09	0.09	0.65			
08-Feb-17	<0.2	<2	Dry	0.416				0.02	0.04	0.065
20-Jun-17	Dry	1.28	Dry	<0.2				0.02	0.04	0.065
15-Sep-17	nr	nr	Dry	nr				0.02	0.04	0.065
07-Dec-17	nr	nr	Dry	nr				0.02	0.04	0.065
14-Mar-17					0.04	0.04	0.05			
01-Jun-17					0.12	0.12	0.41			
05-Jul-17					<0.02	<0.02	0.48			
30-Nov-17					0.04	0.04	0.13			
21-Mar-18	0.0911	3.41	Dry	0.0413				0.02	0.04	0.065
17-May-18	Dry	Dry	Dry	0.0413				0.02	0.04	0.065
30-Aug-18	Dry	Dry	Dry	Dry				0.02	0.04	0.065
03-Dec-18	0.0356	0.206	Dry	0.0409				0.02	0.04	0.065
15-Mar-18					0.11	0.1	0.09			
01-Apr-18					nr	nr	nr			
21-Jun-18					<0.02	<0.02	0.48			
25-Nov-18					0.09	0.13	0.41			
13-Feb-19	0.0371	1.52	Dry	0.0393				0.02	0.04	0.065
29-Apr-19	0.0292	1.77	Dry					0.02	0.04	0.065
16-Oct-19	0.0275	0.738	Dry	0.0183				0.02	0.04	0.065
max	0.0911	3.41	0	0.416	0.12	0.13	0.65		SWR high	SWR good
min	0.025	0.206	0	0.0183	0.02	0.016	0.04			
average	0.04	1.31	-	0.10	0.07	0.07	0.26			

BOD	mg/l						
	SW1	SW2	SW3	SW4	S1	S2	S3
12-Feb-15	Dry	Dry	Dry	Dry			
27-Apr-15	Dry	Dry	Dry	Dry			
20-Jul-15	1.1	3.7	Dry	<1.0			
02-Nov-15	<1.0	1	Dry	<1.0			
23-Mar-15					<1	<1	2
14-May-15					<1	<1	<1
01-Sep-15					nr	nr	nr
17-Dec-15					<1	<1	<1
13-Mar-16	<2	<2	Dry	<2			
17-May-16	1	4	Dry	<2			
15-Aug-16	Dry	Dry	Dry	Dry			
07-Nov-16	Dry	Dry	Dry	Dry			
08-Mar-16					<1	<1	<1
24-May-16					2	2	2
20-Jul-16					8	10	4
11-Nov-16					2	2	4
08-Feb-17	<5	<5	Dry	17			
20-Jun-17	Dry	<2	Dry	Dry			
15-Sep-17	7	7	Dry	<5			
07-Dec-17	2	<5	Dry	<5			
14-Mar-17					<1	<1	<1
01-Jun-17					2	1	<1
05-Jul-17					3	3	2
30-Nov-17					<1	<1	<1
21-Mar-18	<2	<2	Dry	<2			
17-May-18	Dry	Dry	Dry	<2			
30-Aug-18	Dry	Dry	Dry	Dry			
03-Dec-18	3	3	Dry	2			
15-Mar-18					3	3	2
01-Apr-18					nr	nr	nr
21-Jun-18					7	8	23
25-Nov-18					2	2	3
13-Feb-19	<2	2		<2			
29-Apr-19	<2	5					
16-Oct-19	<2	3		2			
max	7	7	0	17	8	10	23
min	1	1	0	2	2	1	2
average	2.82	3.59	-	7.00	3.63	3.88	5.25

COD		mg/l					
	SW1	SW2	SW3	SW4	S1	S2	S3
12-Feb-15	Dry	Dry	Dry	Dry			
27-Apr-15	Dry	Dry	Dry	Dry			
20-Jul-15	30	30	Dry	<20			
02-Nov-15	20	36	Dry	<20			
23-Mar-15					9	6	56
14-May-15					11	14	<50
01-Sep-15					nr	nr	nr
17-Dec-15					29	32	27
13-Mar-16	nm	nm	Dry	nm			
17-May-16	24.7	61.8	Dry	16.7			
15-Aug-16	Dry	Dry	Dry	Dry			
07-Nov-16	Dry	Dry	Dry	Dry			
08-Mar-16					<5	10	18
24-May-16					13	5	<25
20-Jul-16					24.00	25.00	<50
11-Nov-16					30	<25	<100
08-Feb-17	31.5	30.3	Dry	23.4			
20-Jun-17	Dry	29.2	Dry	Dry			
15-Sep-17	47.6	62.6	Dry	22.5			
07-Dec-17	2.85	48.7	Dry	26.6			
14-Mar-17					7	13	23
01-Jun-17					6	<5	64
05-Jul-17					18	20	<50
30-Nov-17					10	<5	14
21-Mar-18	23.6	26.3	Dry	8.61			
17-May-18	Dry	Dry	Dry	Dry	21.1		
30-Aug-18	Dry	Dry	Dry	Dry			
03-Dec-18	23	50.3	Dry	18.2			
15-Mar-18					26	36	15
01-Apr-18					nr	nr	nr
21-Jun-18					32.00	33.00	72.00
25-Nov-18					114	44	184
13-Feb-19	<2	16.1	Dry	2.7			
29-Apr-19	50.5	38.9	Dry				
16-Oct-19	54.5	35.1	Dry	8.04			
max	47.6	62.6	-	26.6	114	44	184
min	2.85	26.3	-	8.61	6	5	14
average	25.41	41.69	-	19.59	25.31	21.64	52.56

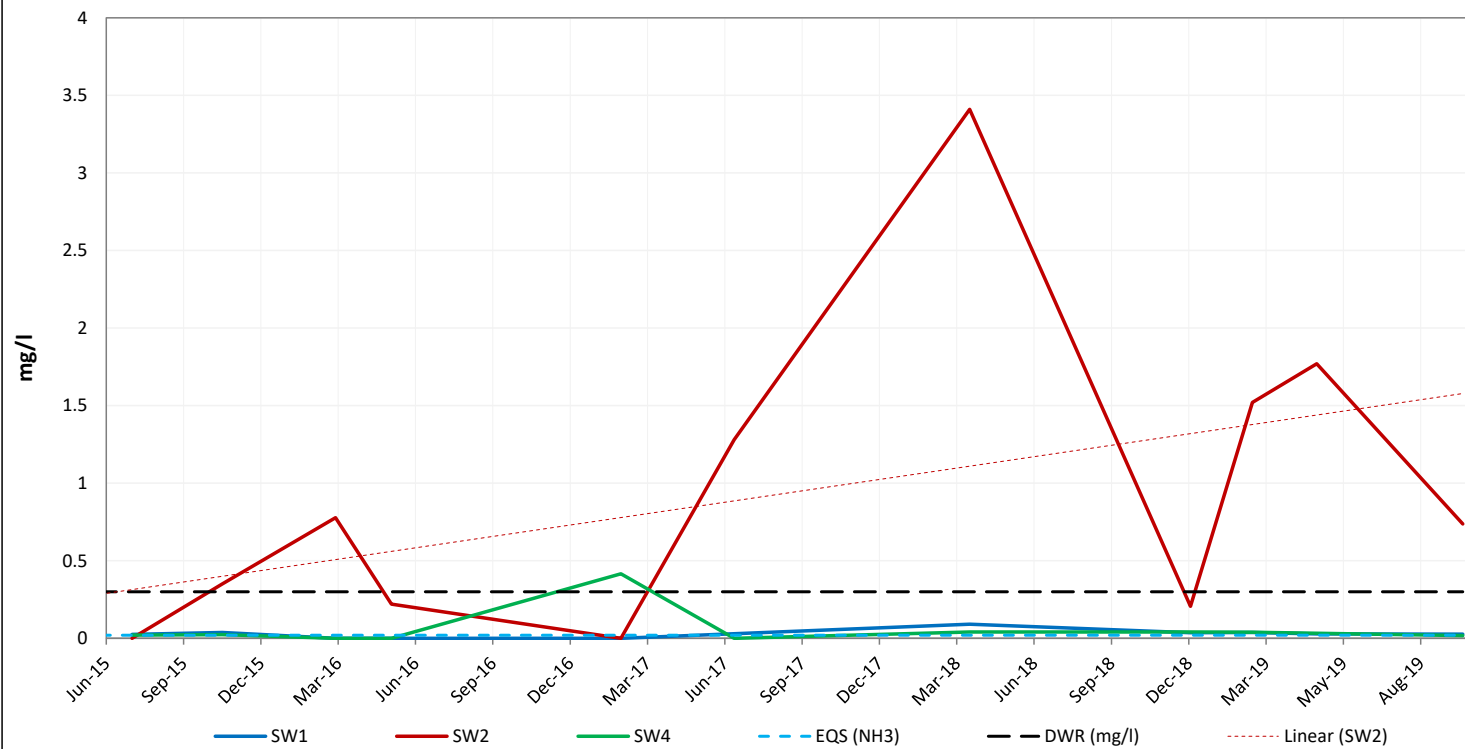
CHLORIDE		mg/l						EQS (mg/l)
	SW1	SW2	SW3	SW4	S1	S2	S3	
12-Feb-15	Dry	Dry	Dry	Dry				250
27-Apr-15	Dry	Dry	Dry	Dry				250
20-Jul-15	21	15	Dry	23				250
02-Nov-15	37	65	Dry	20				250
23-Mar-15					21.7	19.7	4634	250
14-May-15					209	208	24005	250
01-Sep-15					572	431	7485	250
17-Dec-15					21.8	17.6	26.8	250
13-Mar-16	31.8	50.5	Dry	29.8				250
17-May-16	31.9	75.8	Dry	38.2				250
15-Aug-16	Dry	Dry	Dry	Dry				250
07-Nov-16	Dry	Dry	Dry	Dry				250
08-Mar-16					21.3	19.6	366	250
24-May-16					39.2	40.7	1995	250
20-Jul-16					739	742	5829	250
11-Nov-16					2490	2953	7503	250
08-Feb-17	29.3	33.3	Dry	32.2				250
20-Jun-17	Dry	29	Dry	Dry				250
15-Sep-17	30.4	44.7	Dry	22.6				250
07-Dec-17	31.5	32.6	Dry	36.1				250
14-Mar-17					23	20	997	250
01-Jun-17					260	266	5599	250
05-Jul-17					1128	1228	7856	250
30-Nov-17					29	20	501	250
21-Mar-18	35.7	47.7	Dry	26.4				250
17-May-18	Dry	Dry	Dry	38.9				250
30-Aug-18	Dry	Dry	Dry	Dry				250
03-Dec-18	23	165	Dry	23.8				250
15-Mar-18					17.7	15.5	75.1	250
01-Apr-18					nr	nr	nr	250
21-Jun-18					912.00	838.00	6011.00	250
25-Nov-18					3002	2879	6884	250
13-Feb-19	29.9	67.4		28.4				250
29-Apr-19	31.3	40.5						250
16-Oct-19	17.2	22.6		17.3				250
max	37	165	-	38.9	3002	2953	24005	EQS
min	21	15	-	20	17.7	15.5	26.8	
average	30.2	55.9	-	29.1	632.4	646.5	5317.8	

CONDUCTIVITY	uS/cm									
	SW1	SW2	SW3	SW4	S1	S2	S3	DWR	EQS	
12-Feb-15	Dry	Dry	Dry	Dry				1500	1000	
27-Apr-15	Dry	Dry	Dry	Dry				1500	1000	
20-Jul-15	274	287	Dry	585				1500	1000	
02-Nov-15	379	535	Dry	630				1500	1000	
23-Mar-15					216	211	12190	1500	1000	
14-May-15					227	223	6850	1500	1000	
01-Sep-15					1905	1847	19850	1500	1000	
17-Dec-15					197	176	227	1500	1000	
13-Mar-16	403	637	Dry	415				1500	1000	
17-May-16	386	804	Dry	527				1500	1000	
15-Aug-16	Dry	Dry	Dry	Dry				1500	1000	
07-Nov-16	Dry	Dry	Dry	Dry				1500	1000	
08-Mar-16					229	228	1382	1500	1000	
24-May-16					305	311	5930	1500	1000	
20-Jul-16					2480	2450	14870	1500	1000	
11-Nov-16					6300	8700	19370	1500	1000	
08-Feb-17	345	386	Dry	327				1500	1000	
20-Jun-17	Dry	536	Dry	Dry				1500	1000	
15-Sep-17	323	576	Dry	603				1500	1000	
07-Dec-17	321	348	Dry	541				1500	1000	
14-Mar-17					242	225	3070	1500	1000	
01-Jun-17					1031	1062	13800	1500	1000	
05-Jul-17					3410	3890	19410	1500	1000	
30-Nov-17					256	227	1708	1500	1000	
21-Mar-18	394	652	Dry	354				1500	1000	
17-May-18	Dry	Dry	Dry	611				1500	1000	
30-Aug-18	Dry	Dry	Dry	Dry				1500	1000	
03-Dec-18	249	872	Dry	458				1500	1000	
15-Mar-18					156	146	380	1500	1000	
01-Apr-18					nr	nr	nr	1500	1000	
21-Jun-18					2980	2850	17990	1500	1000	
25-Nov-18					8870	8550	18650	1500	1000	
13-Feb-19	300	584	Dry	379				1500	1000	
29-Apr-19	347	613	Dry					1500	1000	
16-Oct-19	236	466	Dry	517				1500	1000	
								1500	1000	
max	403	872	-	630	8870	8700	19850			DWR
min	249	287	-	327	156	146	227			EQS
average	342	563	-	505	1920	2073	10378			

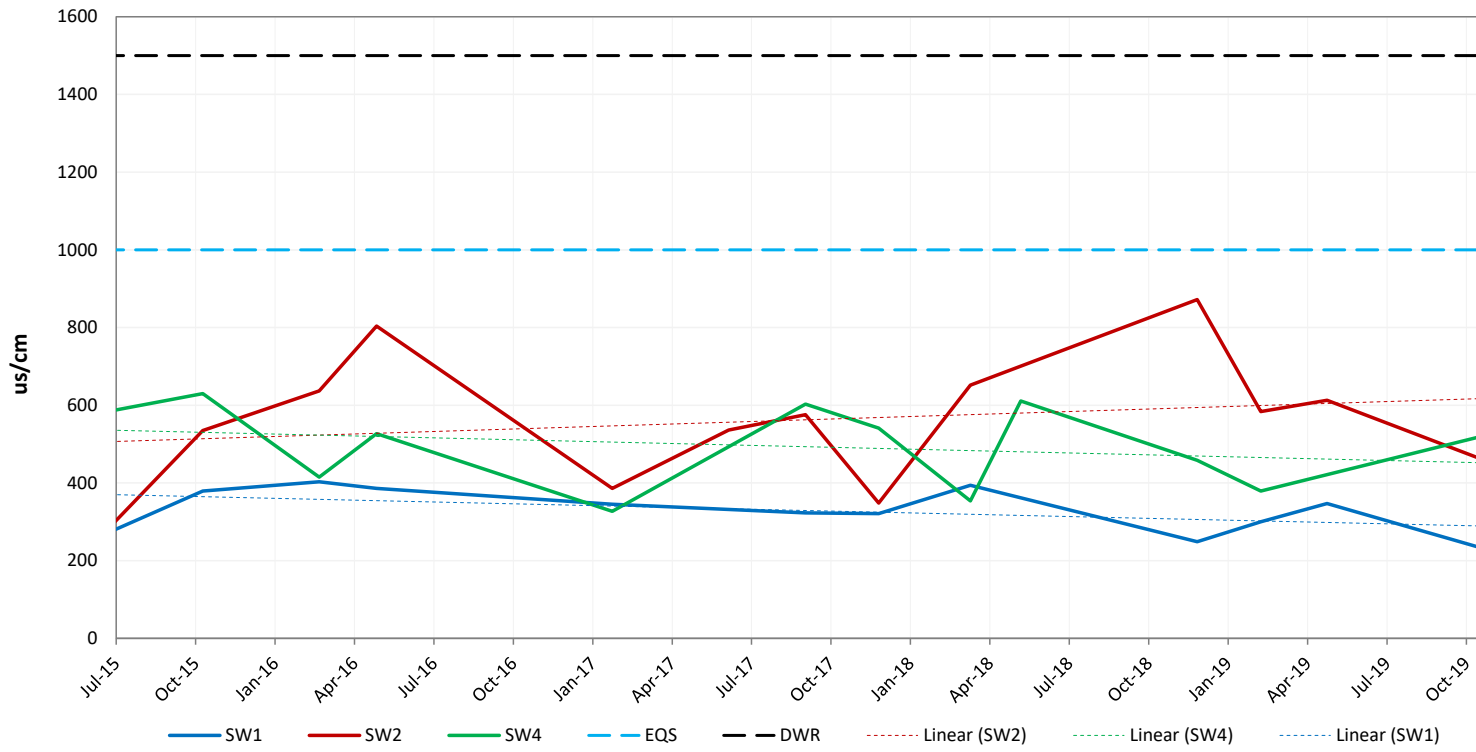
pH											
	SW1	SW2	SW3	SW4	S1	S2	S3	DWR	SWR (hard)	SWR (soft)	
12-Feb-15	Dry	Dry	Dry	Dry				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
27-Apr-15	Dry	Dry	Dry	Dry				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
20-Jul-15	7.1	6.9	Dry	7.6				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
02-Nov-15	7.3	6.3	Dry	7.6				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
23-Mar-15					7.8	7.8	8	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
14-May-15					7.9	8	8.2	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
01-Sep-15					8	8	9.7	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
17-Dec-15					7.8	7.7	7.8	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
13-Mar-16	8.3	6.7	Dry	8.2				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
17-May-16	7.3	6.6	Dry	8.2				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
15-Aug-16	Dry	Dry	Dry	Dry				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
07-Nov-16	Dry	Dry	Dry	Dry				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
08-Mar-16					7.5	7.9	7.9	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
24-May-16					8.2	8.4	8.2	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
20-Jul-16					8.6	8.8	8.6	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
11-Nov-16					8.0	8.0	8.2	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
08-Feb-17	7.7	7.1	Dry	7.6				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
20-Jun-17	Dry	6.5	Dry	Dry				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
15-Sep-17	7.2	6.7	Dry	7.9				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
07-Dec-17	7.5	7.1	Dry	8.2				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
14-Mar-17					7.9	7.9	7.9	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
01-Jun-17					7.8	7.8	8.0	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
05-Jul-17					8.4	8.3	8.7	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
30-Nov-17					7.6	7.7	8.3	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
21-Mar-18	7.4	6.4	Dry	7.6				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
17-May-18	Dry	Dry	Dry	7.5				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
30-Aug-18	Dry	Dry	Dry	Dry				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
03-Dec-18	7.92	8.21	Dry	8.37				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
15-Mar-18					7.4	7.4	7.6	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
01-Apr-18					nr	nr	nr	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
21-Jun-18					5	9.1	9	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
25-Nov-18					7.7	7.8	8.1	6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
13-Feb-19	7.9	6.5	Dry	8.3				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
29-Apr-19	7.5	6.7	Dry					6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
16-Oct-19	6.1	7.1	Dry	nm				6.5 - 9.5	4.5 - 9.5	6.0 - 9.0	
max	8.3	8.21	-	8.37	8.6	9.1	9.7				DWR
min	7.1	6.3	-	7.5	4.6	7.4	7.6				EQS
average	7.5	6.9	-	7.9	7.7	8.0	8.3				

TSS	mg/l							
	SW1	SW2	SW3	SW4	S1	S2	S3	DWR
12-Feb-15	Dry	Dry	Dry	Dry				1000
27-Apr-15	Dry	Dry	Dry	Dry				1000
20-Jul-15	4	12	Dry	<4				1000
02-Nov-15	5	7	Dry	<4				1000
23-Mar-15					3.6	7.2	38	1000
14-May-15					16	25	25	1000
01-Sep-15					nr	nr	nr	1000
17-Dec-15					24	36	19.5	1000
13-Mar-16	4.6	13.4	Dry	7.8				1000
17-May-16	6	35	Dry	1.4				1000
15-Aug-16	Dry	Dry	Dry	Dry				1000
07-Nov-16	Dry	Dry	Dry	Dry				1000
08-Mar-16					8	<5	33	1000
24-May-16					7	13	11	1000
20-Jul-16					145	15	53	1000
11-Nov-16					24	27.6	38	1000
08-Feb-17	32.9	44.3	Dry	<2				1000
20-Jun-17	Dry	5.5	Dry	Dry				1000
15-Sep-17	3	9.8	Dry	3.9				1000
07-Dec-17	70.4	33.1	Dry	3.45				1000
14-Mar-17					10.7	8.7	42.0	1000
01-Jun-17					41.5	30.5	50.5	1000
05-Jul-17					16.5	11.0	42.0	1000
30-Nov-17					44.0	<5	65.0	1000
21-Mar-18	3	22.2	Dry	<2				1000
17-May-18	Dry	Dry	Dry	<2				1000
30-Aug-18	Dry	Dry	Dry	Dry				1000
03-Dec-18	8.6	9.9	Dry	8.4				1000
15-Mar-18					47.3	84	26.8	1000
01-Apr-18					nr	nr	nr	1000
21-Jun-18					18	29	47	1000
25-Nov-18					12.8	12.4	11.9	1000
13-Feb-19	13.9	28.7		14.6				1000
29-Apr-19	4.15	7.95						1000
16-Oct-19	17.4	7.9		2.6				1000
max	70.4	44.3	-	8.4	145	84	65	
min	3	5.5	-	1.4	3.6	7.2	11	
average	15.3	19.22	-	5.0	29.9	24.9	35.9	

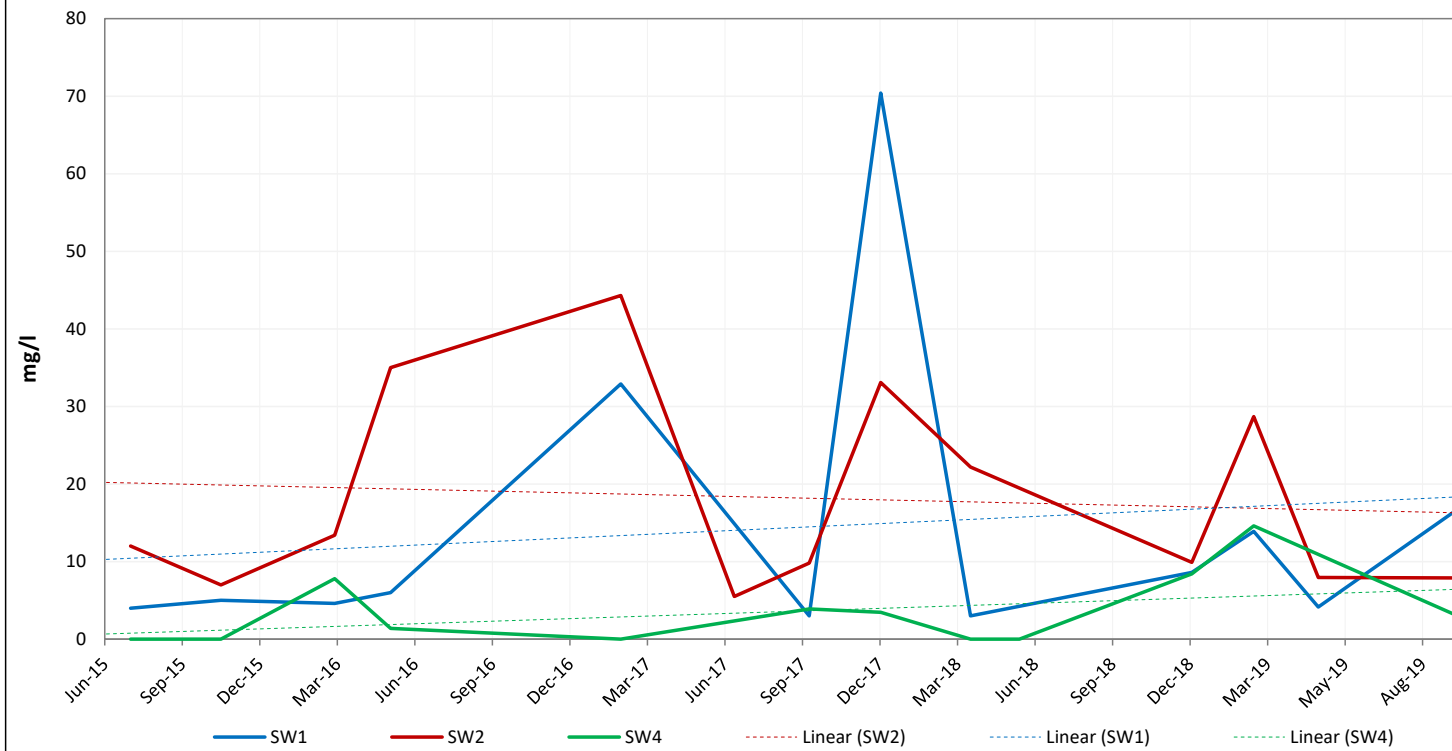
Ammonia (Landfill)

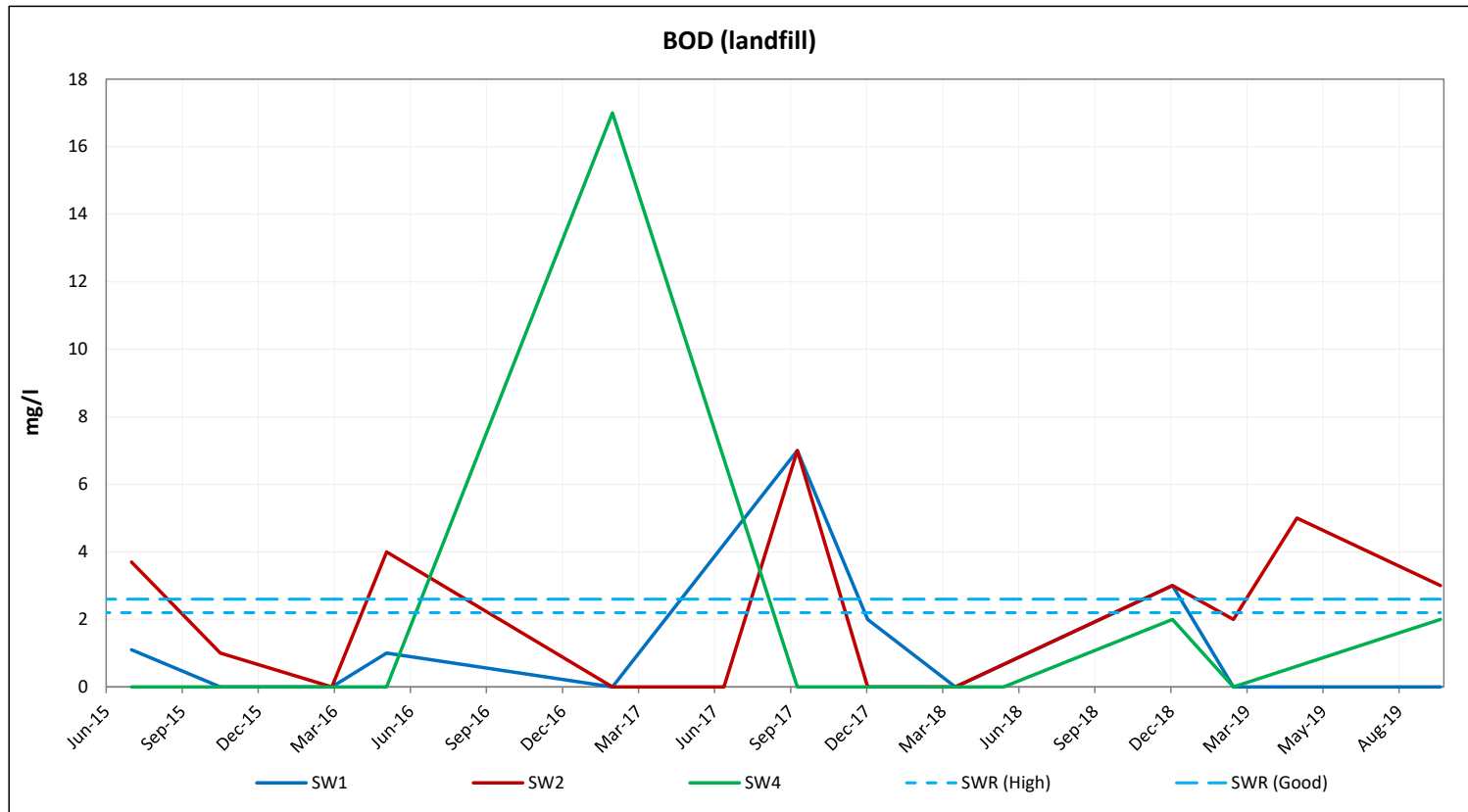


Conductivity (landfill)

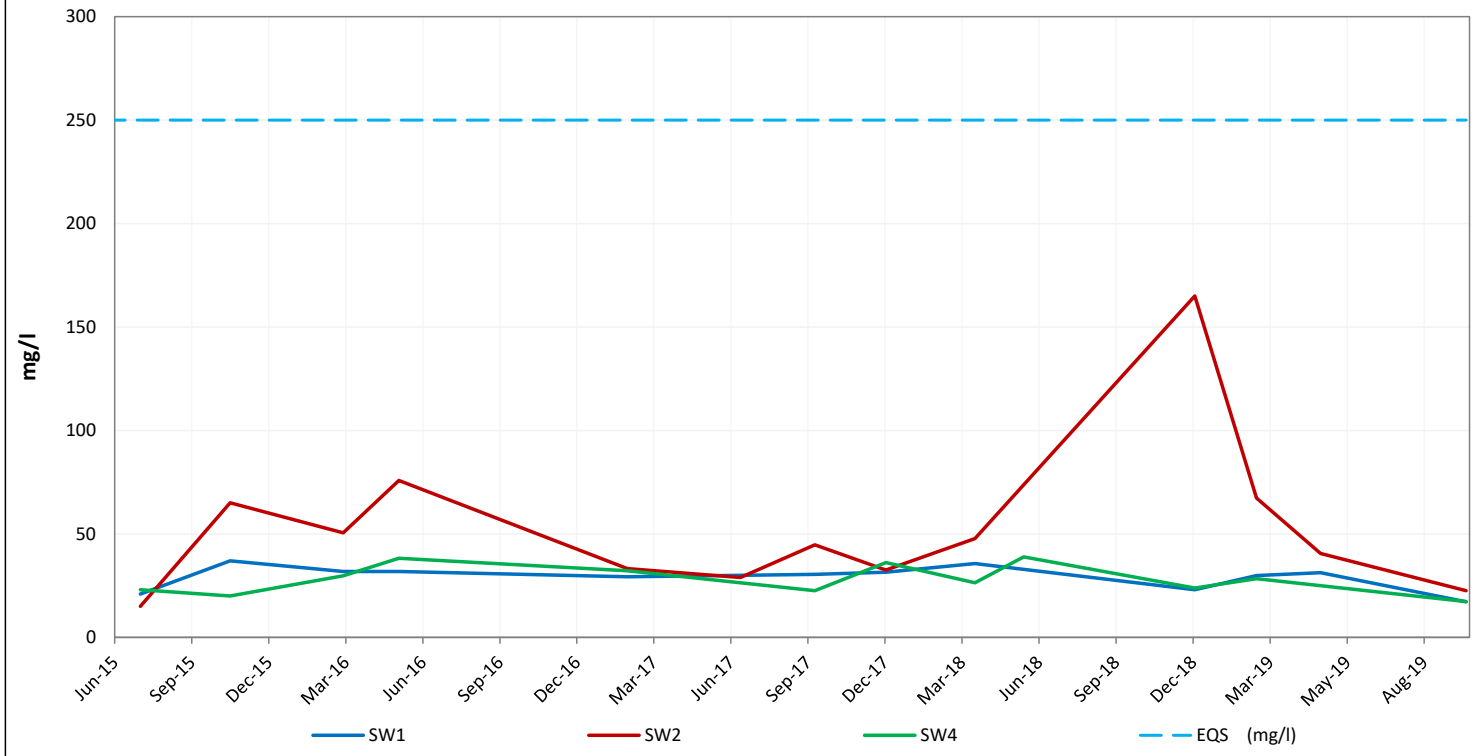


TSS (landfill)

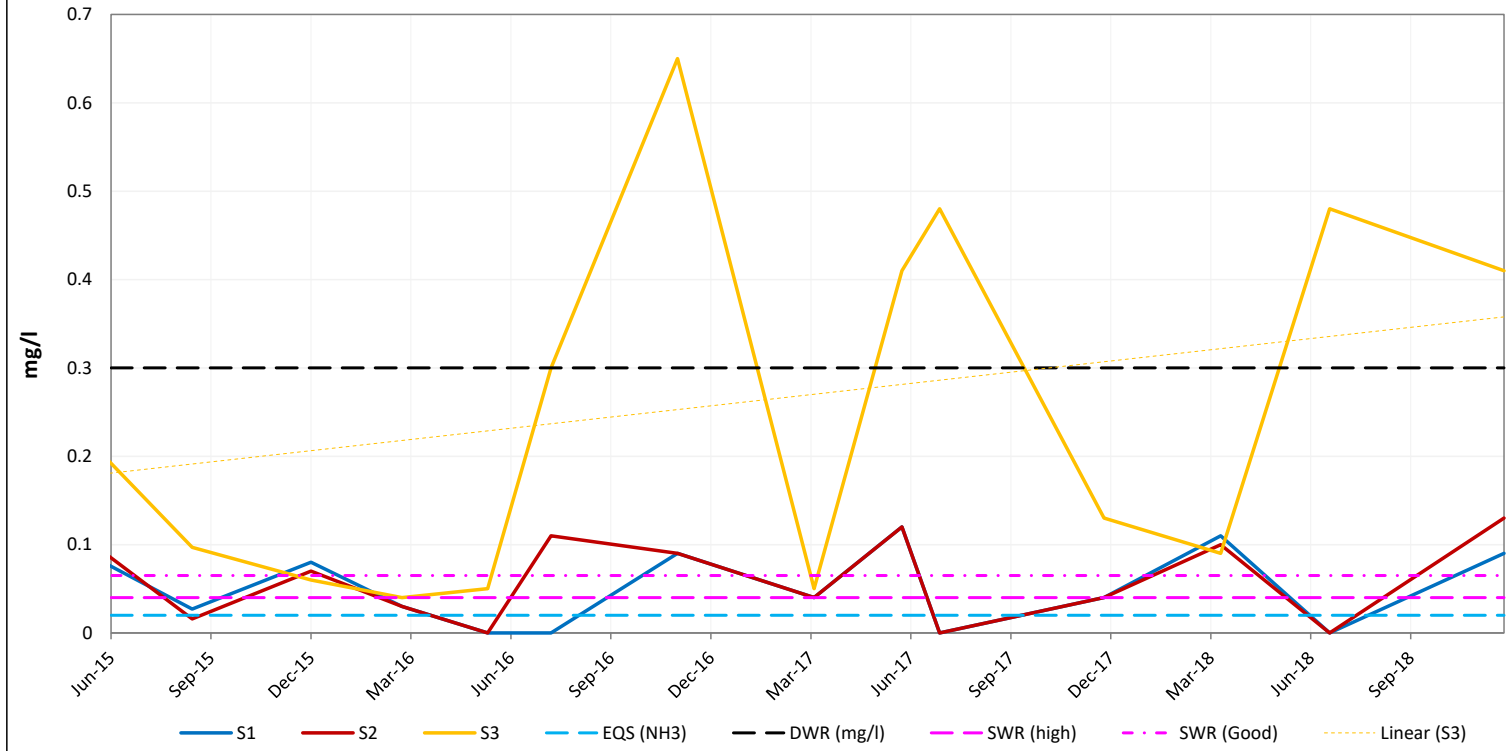




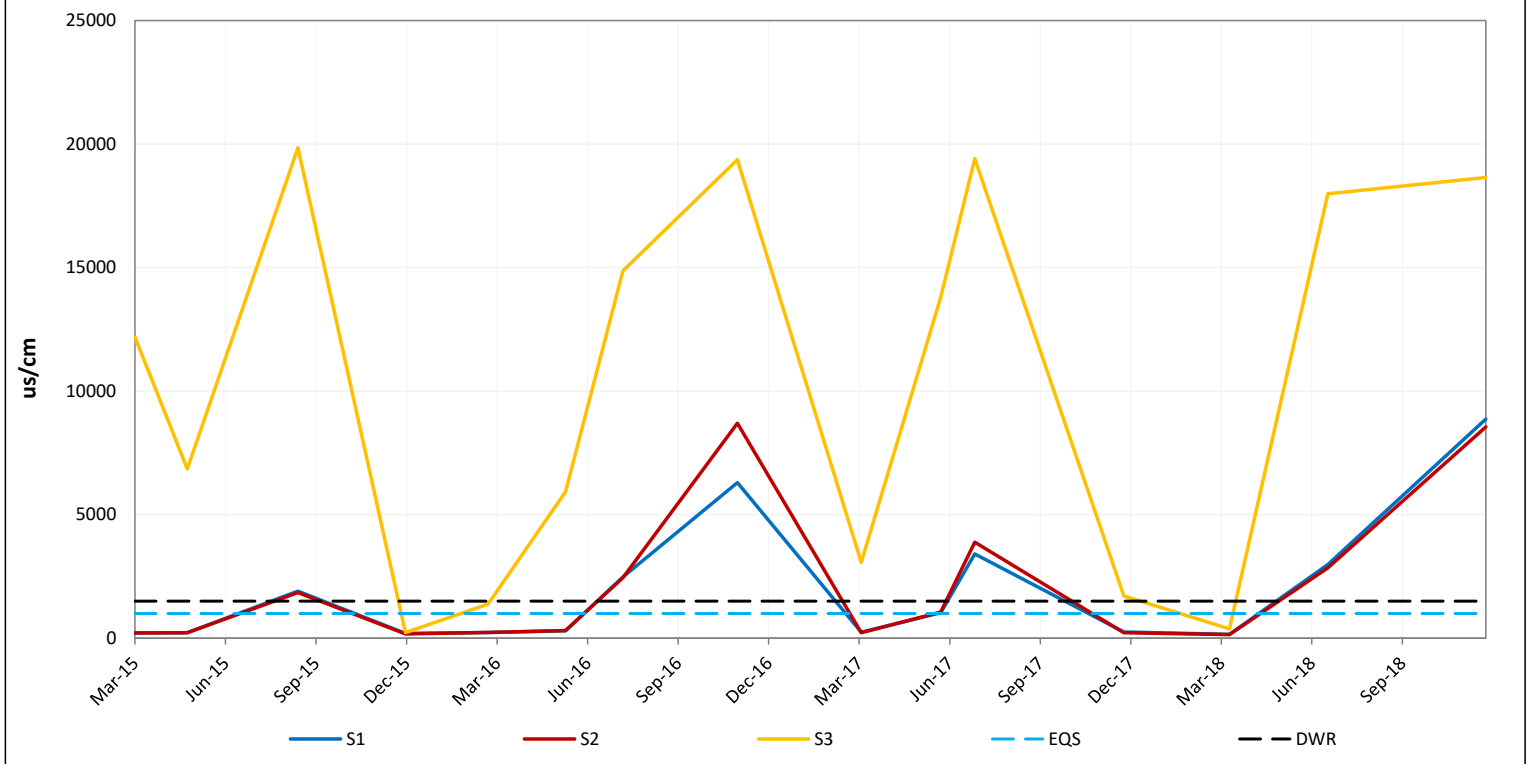
Chloride (landfill)



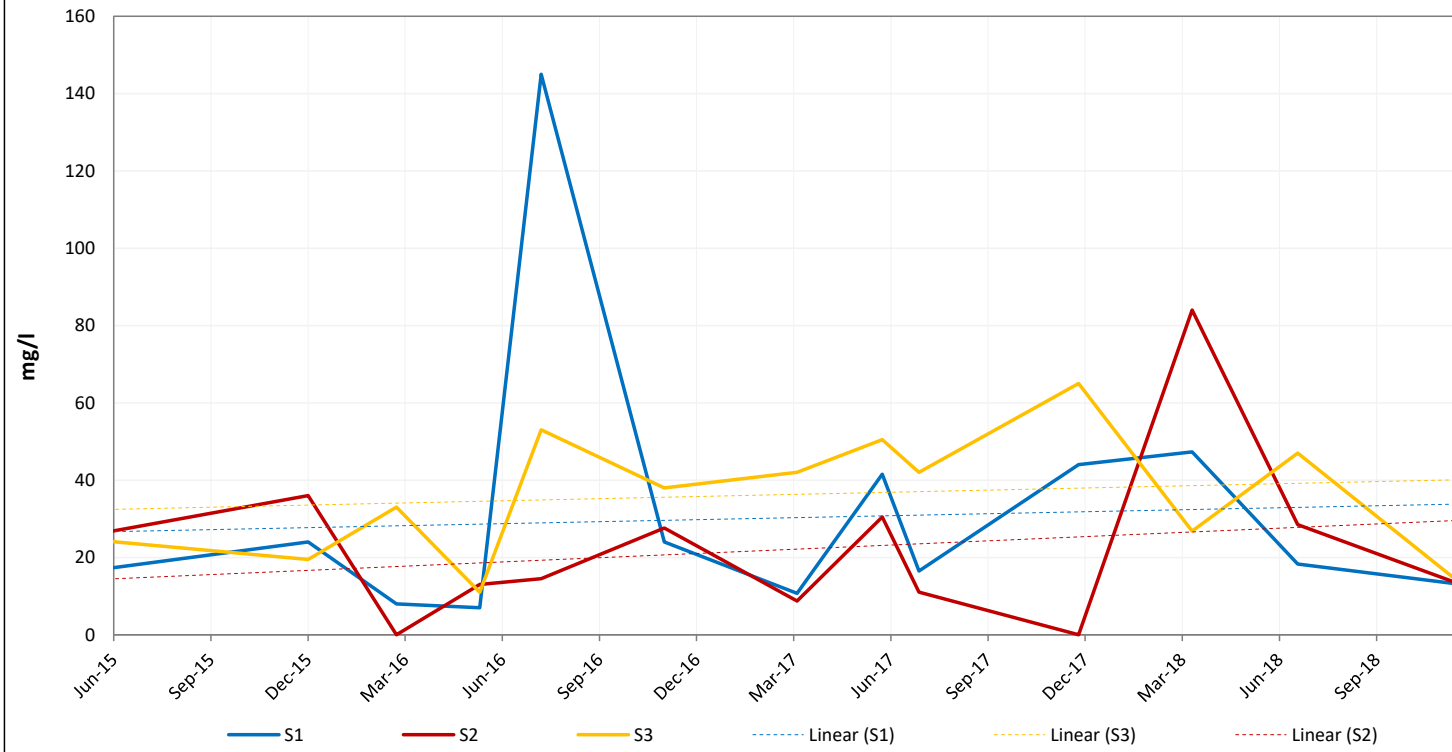
Ammonia (River Slaney)



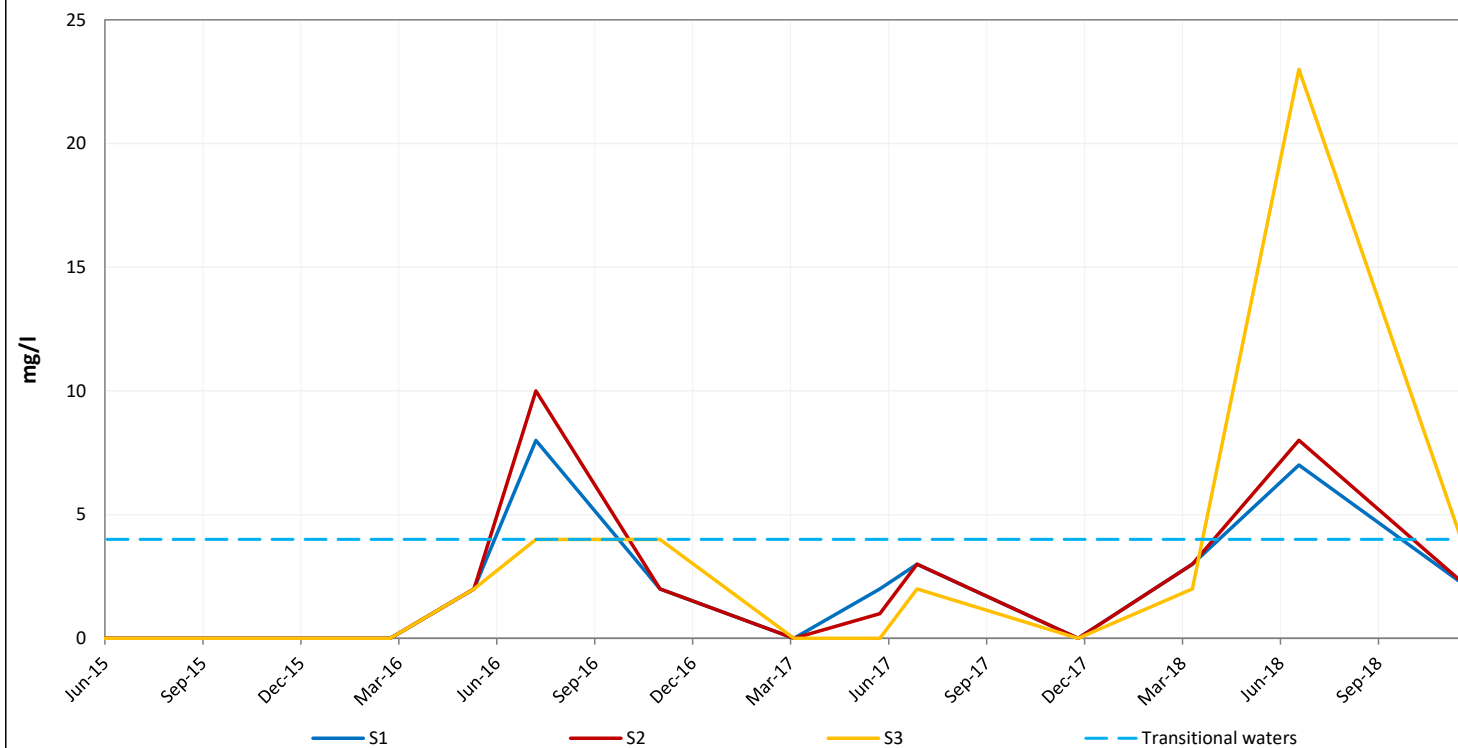
Conductivity (River Slaney)



TSS (River Slaney)



BOD (River Slaney)



Chloride (River Slaney)

