Hydrogeological Assessment

Erskine Park Landfill, Quarry Road, Erskine Park, NSW

Prepared for:
Cleanaway Solid Waste Pty Ltd
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Distribution

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List of Acronyms

Acronym	Definition
AHD	Australian Height Datum
BH	Borehole
CoPC	Contaminant of potential concern
CSM	Conceptual site model
DO	Dissolved oxygen
EC	Electrical conductivity
GME	Groundwater monitoring event
LFG	Landfill gas
m	Metre
m^3	Cubic metres
m AHD	Metres Australian Height Datum
m bgl	Metres below ground level
mg/L	Milligrams per litre
MW	Monitoring well
QA	Quality assurance
QC	Quality control
RWL	Reduced Water Level
TDS	Total dissolved solids
TKN	Total kjeldahl nitrogen
TOC	Total organic carbon
UK EA	United Kingdom Environment Agency
µg/kg	Micrograms per kilogram
µg/L	Micrograms per litre

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1.0 Introduction and Objectives

Senversa Pty Ltd (Senversa) was engaged by Cleanaway Solid Waste (Cleanaway) to complete a hydrogeological assessment (HA) for the Erskine Park Landfill (Landfill), located at Quarry Road, Erskine Park, Sydney, NSW (the site). The key objectives of the HA were to:

- Review the current leachate compliance level (30 metres (m) Australian Height Datum (AHD)), as derived in the 2005 Environmental Impact Statement (EIS), in the context of current groundwater conditions and site risk profile.
- Assess the requirement for maintaining leachate below the current 30 m AHD compliance level going forward.
- Assess the provenance of ammonia in groundwater in monitoring bores surrounding the landfill (conducted a separate work task but reported here); and
- Investigate the need of additional groundwater monitoring wells (both shallow and deep) to meet post closure monitoring requirements in the EIS.

1.1 Background

The site started life as a quarry in the 1920s and subsequently became a landfill site in 1994, originally under joint ownership between CSR and Cleanaway – a joint venture known as Enviroguard Pty Ltd. Cleanaway (formerly known as Transpacific Industries) commenced ownership of the landfill operations in 2007 when Transpacific acquired both CSR and Cleanaway, and has since begun a process of continual improvement to ensure the site meets the standards that Cleanaway expects of their facilities and to meet the conditions of the site's Environment Protection Licence (EPL) (No. 4865, dated 20 March 2019).

The landfill is scheduled to close in 2022, based on the revised March 2019 final landfill contours. Cleanaway will commence rehabilitation works on the site in accordance with its approved conditions stated in EPL 4865.

Cleanaway aims to maintain the compliance of the site against the EPL, as well as identifying preparation works required as the site enters its post closure phase. This HA report specifically focuses on assessment of the Landfill's impact on the surrounding groundwater system.

1.2 Summary of Previous and Relevant Investigations and Documentation

The following site-specific documentation was reviewed:

- AGC-Woodward Clyde (1997): Report on the Upgrade of the Groundwater Monitoring Network at the Erskine Park Landfill. January 1997. Doc ref: Project No. A8600128/0004 Document EPDR I - A. DOC.
- Arcadis (2016, 2017, 2018, 2019) Annual Environmental Monitoring Reports.
- Arcadis September 2019 Quarterly Groundwater Monitoring Event.
- Arcadis December 2019 Quarterly Groundwater Monitoring Event.
- CMPS&F Environmental (1994) EIS. October 1994. Doc ref: 1:\EF\5321\REPORT\R001-01.
- Consulting Earth Scientists (CES) (2009): Report on the Installation of Gas and Groundwater Monitoring Wells at Erskine Park Landfill, Erskine Park, NSW. Prepared for Trans-Pacific Industries Group Ltd, Report ID: CES000102-EGD-222-F.
- Douglas Partners (2005): Report on Geological and Groundwater Assessment, Enviroguard Waste Centre, Erskine Park Road, Erskine Park. Project 43311. October 2005.
- Enviroguard (2005) Environmental Impact Statement (EIS) (Volumes 1 and 4) (referred to here as the 2005 EIS).

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Excerpts and data from the above reports are reproduced in the relevant sections below.

1.3 Important information About This Report

This revision of the report updates Revision 0 issued previously on 25 October 2019. It has incorporated further historical groundwater monitoring data than previously available, more accurate leachate elevations recorded within the landfill in December 2019 and January 2020, and includes a more detailed conceptual site model attached in **Appendix A**, which highlights and links the findings of this report with the findings of other reports recently completed by Senversa.

This report should be read in conjunction with Senversa's Landfill Gas Risk Assessment (LFG RA) Report (S17375_RPT_004_Rev0_LFGRA) and Assessment of Stormwater Management (ASM) Report (S17375_005_RPT_Rev0_ASW), both prepared for the Erskine Park Landfill in parallel with the preparation of this document.

The LFG RA describes the impact that reducing leachate levels within the landfill will potentially have on landfill gas monitoring and management at the site, while the ASM describes current management of surface water runoff at the site and how it may be impacting some of the groundwater bores at the site.

As a separate task, Senversa has also prepared an improved conceptual site model (CSM) for the landfill, which can be found in **Appendix A**. As our understanding of the site over the last few months has grown as further information became available, Senversa identified that the site setting around the landfill perimeter and the landfill construction itself differs significantly along sections of the perimeter, and so it was decided that one typical perimeter cross-section would not be sufficient to represent the landfill's CSM. Twenty cross-sections have been prepared, in order to best capture the various site features and sensitive receptors surrounding the landfill, including the clay side liner wall, various leachate drainage blankets, the first quarry bench, recent test pit information collected in late 2019, the average leachate elevation across the landfill, the surrounding groundwater elevations in the nearest monitoring bores, the buried Austral Bricks gas feed pipeline and the surface profile of the surrounding land, both on and off site, between the edge of waste and the closest on and off site buildings.

Within **Appendix A**, a covering memorandum outlines the information used to prepare the cross-sections, how it was used, and lists the findings. The location of the cross-sections is shown in the attached Figure 1, while the twenty cross-sections are attached as Figures 2 to 21, inclusive.

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2.0 Scope of Work

The HA is based on a risk assessment approach to evaluate whether the current leachate compliance level of 30 m AHD is appropriate from a groundwater quality risk perspective. Senversa's approach was limited to a focus on key leachate indicators (including ammonia) based on leachate quality and the EPL conditions (e.g. ammonia criterion). As such, the scope of work consisted of the following tasks:

- Site characterisation, including:
  - Compilation and summary review of site setting, historical data and previous investigations relevant to the preparation of the HA report in documents made available to Senversa.
  - Review of EPL conditions specific to groundwater.
  - Assessment of background groundwater quality and potential sensitive receptors.
  - Consideration of other sources of potential groundwater impact/contamination other than the landfill, such as the on site stormwater and leachate dams.
  - Development of a conceptual site model (CSM), which brings together the above information in the context of source-pathway-receptor linkages.
- Analytical fate and transport modelling to assess the effect of different leachate levels (or heads) within the landfill on the potential for leachate plume migration (if any).
- Based on the above, completed a qualitative assessment of risk posed by current leachate levels on:
  - The potential for leachate (i.e. ammonia) migration from the landfill into surrounding groundwater and discharge to surface water drainage lines.
  - Effects on groundwater quality; and
  - Effects on identified sensitive receptors.
- A further assessment of the current leachate compliance level in the above context and development of alternative risk-based leachate control levels.
- An assessment of the adequacy of the existing groundwater monitoring well network (i.e. well condition, locations relative to groundwater flow and expected leachate plume centreline).
- Assessment of the provenance of ammonia observed historically in groundwater monitoring wells around the Landfill based on the following tasks:
  - Sampling of the groundwater and leachate monitoring network.
  - Analysis for major cations and anions together with ^{13}C and ^{15}N isotopes; and
  - Interpretation of the hydrochemical and isotopic data.

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3.0 Site Characterisation

3.1 Site Setting

3.1.1 Site Location and Surrounding Land Usage

Erskine Park landfill is located at Erskine Park in the Penrith Local Government Area (LGA) approximately 40 km west of the Sydney Central Business District (CBD). The EPA licence area includes Part Lot 4 DP 1094504, Part Lot 1 DP 1140063 and Part Lot 103 DP 1143935 and occupies an area of 39.11 Ha. The landfill area covers Part Lot 4 DP 1094504, and has an area of approximately 22 Ha.

Erskine Park and Mamre Roads form the northern and western boundaries of the property, respectively. The site and surrounding land is zoned 4(e) Employment under the Penrith Local Environment Plan (LEP) 1994. Until recently, the site was mostly surrounded by low density rural residential land zoned Rural 1A, however, in recent years several commercial/industrial estates have been constructed around the site.

Figure 1 shows the site and surrounding land usage.

3.1.2 Site Operations

Erskine Park Landfill formerly known as Enviroguard Landfill is located at 85-87 Quarry Road, Erskine Park and holds EPA licence number 4865. The access to the landfill is via the recently established waste transfer station facility located to the west of the property and the transfer station holds a seperate licence to the landfill. The inbound and outbound weighbridges are shared between the two facilities.

Both the facilities accept only pre-authorised commercial waste vehicles, operate in isolation to each other and are not open to the public. Heavy vehicles transporting waste are vetted at the inbound weighbridge upon arrival against the pre-authorisation booking details and then directed to the relevant disposal location. The waste haulage vehicle destined for landfill goes east of the transfer station facility via a designated haul road to the tipping face. Once waste is tipped, the waste haulage vehicle heads west and exits via the outbound weighbridge before leaving site.

The site is accessed through Quarry Road which adjoins Mamre Road to the west of the Site. The site office/weighbridge building is located adjacent to the entrance of the site.

There is a vehicle wheel wash facility. Other office and amenities buildings are located on the site.

There are currently two sedimentation dams on site including a dam on the south east corner of the landfill (SD002) and a dam on the northwest corner of the Site (SD003). These two sedimentation dams currently receive surface water runoff from the Site.

The leachate recovered from the landfill is treated at the on site leachate treatment plant located in the northwest corner of the landfill.

Landfill gas is managed on and off site by extracting gas from the landfill and transferring it to the nearby Austral Bricks facility. A landfill gas flare is also in use to maintain gas extraction volumes.

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Figure 1: Site Location and Surrounding Land Usage (Source: Near Map image 20 July 2019)

3.1.3 Topography

The site surrounds had an overall topographic gradient of approximately 67 m AHD to the west to approximately 35 m AHD at Mamre Road. The landforms are gently undulating slopes rising in an easterly direction.

The original hill in the Erskine Park Landfill site was approximately 500 m long and between 200 to 300 m in width rising to about 50 m above the nearby creek line with steep southern and western slopes and gentle northern and eastern slopes. This landform was subsequently quarried, to a depth of about 100 m deep below the quarry rim in 1983 (the base of the quarry had recorded elevations of -40 m AHD). This topography has changed over subsequent years as the quarry filled up with landfill materials.

The gradient of the surrounding area is generally level, with some gentle slopes. The landfill currently has a maximum elevation in the order of 90 m AHD, with a planned, final elevation of 92 m AHD (i.e. same as the original landform).

3.1.4 Local Hydrology

The two major drainage channels in the surrounding area are Ropes Creek and South Creek. The Landfill site drains to South Creek in a westerly direction via two drainage lines which enter South Creek approximately 2.5 km downstream of the site. Ropes Creek, which is approximately 800 m east of the site, flows in a north-west direction and joins South Creek to the north of St Marys. South Creek flows in a north direction to the west of Mamre Road and joins the Hawkesbury River at Windsor (EIS, 2005).

Creek channels containing intermittent streams occur in the area around the landfill site flowing from the eastern end towards the south-west. Another intermittent creek occurs in the riparian corridor to the south of Lenore Lane. The area has a low flooding potential due to the site topography and the ephemeral nature of the flow regime in the on site creeks.

3.1.5 Climate

The general climate of the site location is warm-subtropical with a summer-autumn rainfall peak. The region experiences a dry winter and spring with rainfall becoming unreliable in late winter / early spring. The average annual rainfall total is less than 800mm[1]

Figure 2 is a histogram showing the monthly rainfall totals over the entire groundwater monitoring period (2009-2019).

[1] Based on rainfall records at Bureau of Meteorology for Penrith weather station 67113

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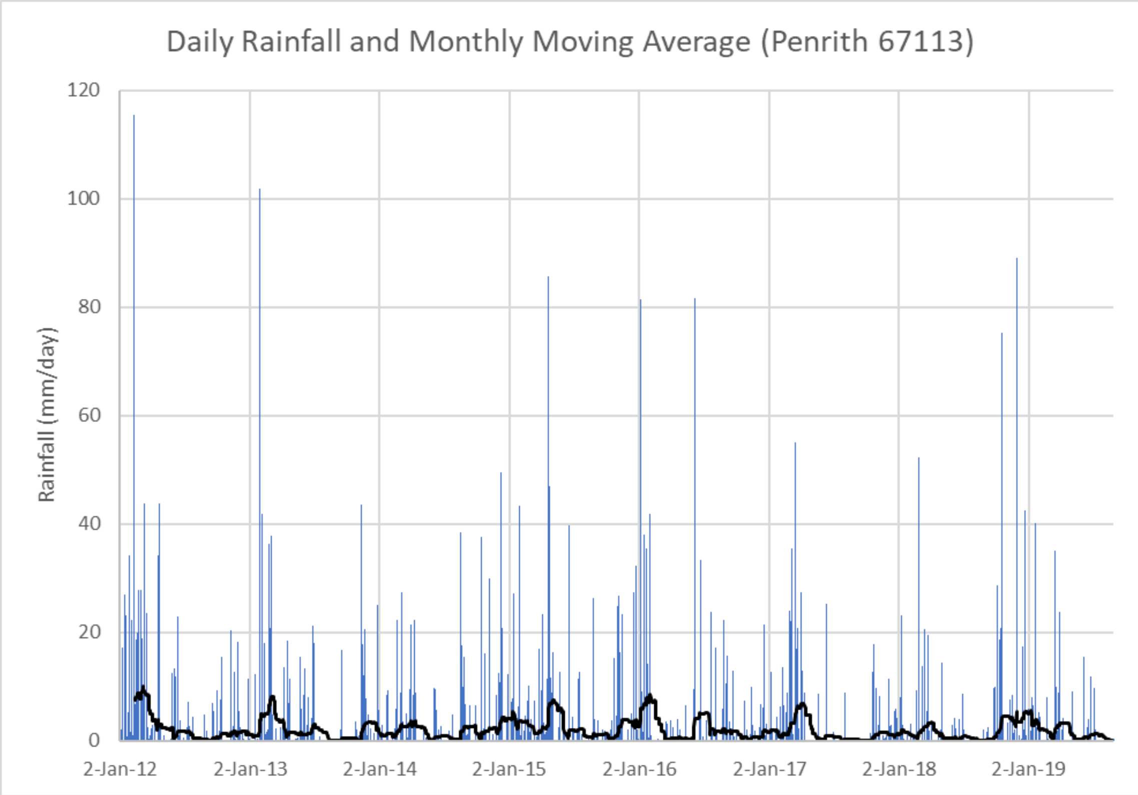

Figure 2: Daily Rainfall Trends (Penrith 67113))

3.1.6 Regional Geology

Regional geology surrounding the former Erskine Park diatreme comprise the Wianamatta Group, consisting of (from youngest to oldest) the Bringelly Shale, the Minchinbury Sandstone and the Ashfield Shale members, which were deposited in a broad, low lying coastal plain consisting of swamplands cut by meandering estuarine and alluvial channels, and grades upwards from a lagoonal coastal marsh sequence at the base to increasingly terrestrial, alluvial plain sediments towards the top of the formation. The rim of the landfill is located at an elevation of approximately 55 m AHD.

Table 1 summarises the site stratigraphy (after AGC, 1997).

Table 1: Site Stratigraphy (after AGC, 1997)

Unit	Description	Thickness (m)	Reduced Level (mAHD)
Bringelly Shale	Massive, dark silty shales with minor graywacke type sandstone lenses	50 to 60	+55 to -7
Minchinbury Sandstone	Massive calcareous Graywacke type sandstone	3	-7 to -10
Ashfield Shale	Humic black shale with small coal lenses and sideritic mudstone bands containing pyrite etc	50	-10 to -60

3.1.7 Regional Groundwater Quality

Groundwater associated with the Wianamatta Shale is characterised by high salinity and high (up to 10 mg/L) ammonia concentrations (Old, 1942). Douglas Partners (2005) reported on groundwater testing before and during the landfill operation, which indicated groundwater is highly saline, typical of groundwater within the Wianamatta Group. The analyses indicate a large variability in the total dissolved solids (TDS) values, ranging from 3,000 mg/L to 17,000 mg/L TDS, with background ammonia levels of 2 mg/L to 11 mg/L.

They also reported that numerous investigations in the western parts of Sydney underlain by Bringelly Shale and Ashfield Shale have found degraded groundwater quality due to naturally occurring factors relating to the marine environment which prevailed during much of the Triassic period. Salt deposited in the interstitial pore spaces of the shale beds during formation has not been fully leached owing to the low permeability of these materials and the fact that the major cations are bonded to the clay mineral structure by electrostatic forces. The saline depositional conditions have caused the high salinity measured in groundwater over the entire western area of Sydney.

The presence of naturally occurring ammonia may be explained by the nature of the Bringelly and Ashfield Shales, which are both dark in appearance, with impure coal bands and lenses and iron oxide concretions being recorded in both shales. Petrological analysis of both shales indicated a relatively high organic content, observed occasionally as immature coal beds, resulting from deposition in swampy, low energy environments (Lovering, 1954). During installation of site monitoring wells, AGC (1997) reported the presence of “shale oil" (crushed carbonaceous shale) in the drilling water circulation tanks, which supports the dominance of carbonaceous shale bedrock around the landfill.

Subsurface conditions characterised by abundant organic matter in a highly reduced state would potentially lead to formation and persistence of naturally occurring ammonia in groundwater.

3.2 Site History

3.2.1 Landfilling History

The site is located on the former CSR quarry that mined breccia from the Erskine Park diatreme, which formed a prominent hill at an approximate elevation of 87 m AHD. Quarrying began in 1925 on this hill and continued until 1994, extracting volcanic breccia as well as some clays and shales.

Landfilling was contained within the void created by former quarry operations. The void was constructed with terraced sides for stability. Volcanic breccia was extracted from an original hill to a level of about -40 m AHD at the base of the void prior to landfilling. Overburden was stockpiled mainly around the rim of the void upon establishment of the quarry. Overburden stockpiles are currently stabilised with grass and mature trees. The landfill was developed using ramp-area techniques. The floor of the void was progressively raised by the placement of successive tabular lifts of waste with an average thickness of 4.5 m (EIS, 2005).

Leachate management infrastructure consisted originally of a central riser (LP001) constructed of 1,200 mm diameter concrete pipes. A layer of coarse material to facilitate leachate drainage was placed around the base of the riser, which penetrates to the base of the fill. This coarse material was covered with a clay cap to prevent clogging by deposited waste. As the waste height increased, LP001 was subsequently replaced by a 400 mm diameter steel riser placed within the original concrete pipe, and this was supplemented by a second 400 m diameter PVC riser designated LP002. These risers were augmented by LP003 (referred to as the Auxiliary Riser) in late 2016, and located on the western slope. Leachate extraction currently occurs from LP003, at an average rate of 60 m^3/day, which is transferred to the treatment plant.

As the site is elevated compared to the surrounding topography, runoff drains from the landfill batters into a perimeter drainage system where it is conveyed to two on site sediment basins in the north west (SD003) and south east (SD002) of the site. SD003 discharges to the South Creek tributary via an open channel located adjacent to Erskine Park Road. SD002 discharges to the South Creek tributary via an open channel to the south of the site.

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CSW reports both dams rarely overflow off site into the South Creek tributary.

During test pitting works around the landfill perimeter in November 2019, Senversa observed some stormwater runoff divert from the southern perimeter swale in the southwest corner of the landfill and drain into the wheel wash water source/pond located on the western boundary of the landfill perimeter. Nearmap images and aerial photos provided by Cleanaway suggest this pond has been in use and in the same location for many years, at least since 2007. As there is no evidence to suggest this pond is lined, Senversa recommends it is decommissioned and replaced with an above ground storage tank or the wheel wash water source be replaced with mains water and the runoff diverted to the southeast dam.

3.2.2 Landfill Design

According to the 2005 EIS, "*the landfill was designed as a 'saturating entombment landfill', where groundwater flows into the landfill from the surrounding rocks until the level of water in the Landfill reaches the level of the surrounding groundwater and...* "*as a general principle the level of the leachate in the landfill is maintained below the water levels in the surrounding rock so that there is a positive flow direction into the landfill*", and that "*engineered landfills have been developed and approved in Australia without lining the walls due to sufficient thickness and low permeability of surrounding soil/rock material, and an inward hydraulic gradient (where the leachate level within the landfill is maintained below the surrounding groundwater level)*".

The landfill design is therefore effectively based on a 'bathtub', or sub-water table landfill, but where the natural ground acts as the landfill barrier between waste and surrounding groundwater.

3.2.3 Pre-Landfilling Groundwater Flow Conditions

AGC (1997) found that "*the hydraulic gradients (during quarry operations) were very steep, due to the quarry acting as a groundwater 'sink', maintaining an inward movement of groundwater. The quarry records revealed that groundwater inflows are very small in volume and probably derived largely from quarry catchment runoff infiltration on fractured benches of the diameter material…salt balance calculations…estimated that the average groundwater flow into the quarry was approximately 18 m^3/day*". The majority of this inflow was observed to occur in a fractured zone in the northwest part of the quarry face.

They further found that "*overall, apparent regional groundwater gradients are towards the west but the extreme variability in salinity from well to well…indicated that regional groundwater flow under natural gradients is likely to be insignificant, and at depth below the local watercourses and on this basis, it is not considered possible for leachate to escape before the water levels within and external to the landfill equilibrate*", and that "*by the time that the landfill saturates, it is likely that the leachate may be stabilised and be of superior "quality" to that found in the regional groundwater aquifer*".

Douglas Partners (2005) reported that "t*he natural groundwater table is located at a level approximately 60 m above the base of the quarry void, which is 10 to 12 m below the natural ground level. The influence of the quarry void on the groundwater table appears to extend some 200 to 300 metres outwards from the edge of the hole. Within this 200 - 300 metre region the hydraulic gradients towards the quarry void are very high, however, quarry records reveal that groundwater inflows were very small", and that "the water levels in these bores had recovered substantially by 1996. There has been no other significant change in water levels in the bores surrounding the landfill".*

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3.2.4 Pre-Landfilling Groundwater Quality

CMPS&F (1994) describe groundwater sampling activities conducted by CSR Readymix in 1981, consisting of five groundwater samples taken from groundwater monitoring wells and analysed for various leachate and quality indicators. In 1993, prior to commencement of landfilling, further groundwater sampling and analysis was undertaken.

Figure 3 shows the approximate locations of the monitoring wells sampled in 1981 (green circles) and 1993 (red circles), as well as water table drawdown contours around the quarry, which indicate the large cone of depression developed around the landfill due to dewatering.

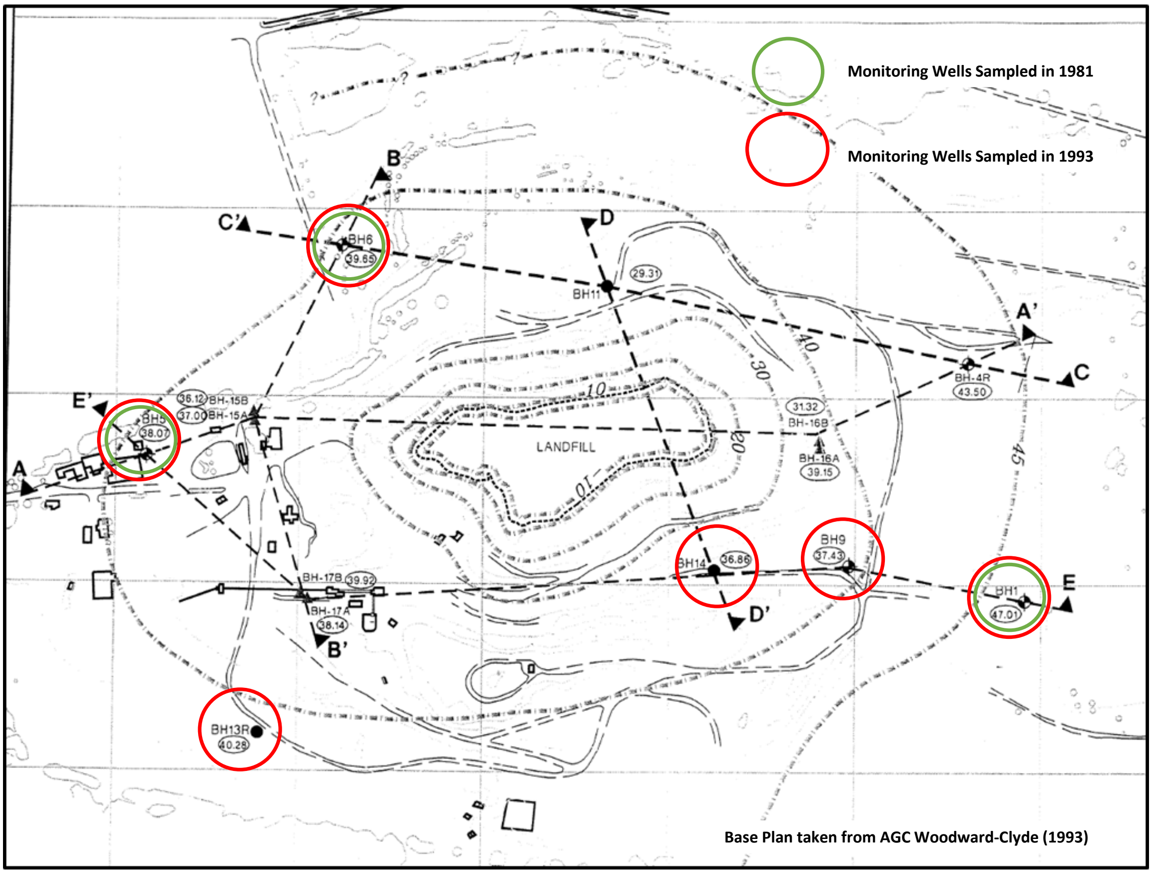

Figure 3: Locations of Former Groundwater Monitoring Wells Sampled in 1981 and 1993

Tables 2 and **3** summarise the groundwater gauging and analytical results for the 1981 and 1993 monitoring rounds, respectively. The ammonia results have been shaded.

Table 2: Summary of Groundwater Analytical Results (1981)

Parameter [1]	BH1	BH2	BH3	BH5	BH6
Groundwater Surface (metres)	49.9	51.4	44.4	43.6	45.7
Water Level (metres)	46.00	46.01	42.66	39.21	39.24
Sample Level (metres)	35.5	37.0	35.0	37.0	31.5
Temperature (°C)	17.0	17.0	17.0	18.0	17.0
pH (pH units)	7.2	7.3	7.7	6.8	7.3

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Parameter [1]	BH1	BH2	BH3	BH5	BH6
Electrical Conductivity (µS/cm)	12800	12400	22200	18800	11000
Biochemical Oxygen Demand (5 day)	180	74	-	-	85
Calcium	540	400	-	-	360
Magnesium	1800	750	-	-	1000
Sodium	8750	7500	-	-	4000
Total Iron	1.6	2.5	-	-	0.5
Total Zinc	0.4	0.1	-	-	0.4
Chloride	-	-	-	6260	3500
Nitrogen-ammonia (NH_3 as N)	4.5	3.9	-	-	4.8
Nitrogen-nitrate (NO_3 as N)	0.10	0.10	-	-	<0.05
Faecal coliform (organisms/100 mL)	nil	20	-	-	Nil

Notes 1. All units are mg/L except where shown otherwise.

Table 3: Summary of Groundwater Analytical Results (1993)

Parameter [1]	POND	BH1	BH5	BH6	BH9	BH13	BH14
Field							
Temperature (°C)	-	21.2	19.8	22.8	22.7	22.5	22.5
pH (pH units)	-	6.30	6.04	6.60	6.33	6.83	7.53
Electrical Conductivity (µSiem)	-	23600	14500	18460	20800	11700	11700
Dissolved Oxygen	-	3	2.8	2.6	3.1	3.3	2.9
Dissolved Oxygen(%)	-	33	29	28	36	36	34
Redox Potential (mV)	-	-1.2	-3.3	26	11.4	11	-19
Laboratory							
Total Dissolved Solids	760	15000	8910	8570	12240	4750	4400
Sodium	223	4400	2430	2680	3100	1260	1270
Calcium	8.7	260	200	280	325	205	200
Magnesium	11.8	720	540	220	850	260	150
Potassium	2.2	42	26	61	54	43	35

Parameter [1]	POND	BH1	BH5	BH6	BH9	BH13	BH14
Nitrogen-ammonia (NH_3 as N)	0.06	1.4	0.9	7.1	3.9	4.5	5.6
Chloride	77	8160	4950	4900	6850	2650	2450
Sulphate	115	760	290	<5	410	<5	6
Bicarbonate	320	1290	990	860	1300	660	570
Nitrogen-nitrate (NO_3 as N)	0.20	<0.1	<0.1	0.82	0.87	<0.1	<0.1
Lead	<0.001	0.03	0.06	.05	0.02	<0.01	<0.01
Zinc	<0.01	0.5	0.08	0.08	0.08	<0.01	<0.01
Cadmium	<0.001	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium	0.001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	<0.001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	<0.1	0.62	1.2	0.87	0.56	0.11	0.02
Arsenic	0.003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Organic Carbon	-	1	12	1	1	1	1
TPH[2]	ND	ND	ND	ND	ND	ND	ND
BTEX[2]	ND	ND	ND	ND	ND	ND	ND

Notes 1. All units are mg/L except where shown otherwise. 2. ND - Not Detected

The groundwater analytical results clearly show the presence of ammonia and highly saline groundwater prior to landfilling and during a period when the landfill was acting as a groundwater sink. This is considered reasonable evidence that ammonia is naturally occurring in groundwater surrounding the landfill, however, this is further assessed by a lines of evidence approach (refer to **Section 5**).

3.2.5 Licence Conditions Specific to Groundwater

The following conditions specific to groundwater are contained in EPL 4865:

- Operating Conditions (O5.6): The Licensee must ensure that the leachate level in the landfill (measured at point 2) does not exceed 30 metres AHD.

  Senversa notes that 'point 2' was defined by the former leachate extraction point (LP001), which is now buried, and that leachate extraction now occurs at Point 33 (LP003, also referred to as the 'Auxiliary Riser'). We also note that there is no justification provided for the 30 m AHD leachate compliance elevation, but that this elevation is marginally lower than the surrounding groundwater elevations. Based on the site history, we interpret this to mean that the key objective of the 30 m AHD level is to create an inward hydraulic gradient to the landfill.

- Section 8 - Pollution Studies and Reduction Programs (Ongoing groundwater management) Condition U1.1: The licensee must prepare and submit a report to the EPA within two months of any groundwater monitoring at the premises that detects ammonia at a concentration above 15 mg/L in any groundwater monitoring bore on this licence. The report must propose actions which the licensee will implement (including timeframes) to prevent contaminated groundwater migrating from the premises.

  Senversa has used the above ammonia criterion as a basis for comparison against measured ammonia in groundwater.

4.0 Site Hydrogeology

4.1 Groundwater and Leachate Monitoring Network

4.1.1 Leachate Extraction and Monitoring Network

There has been some confusion in previous reporting regarding leachate extraction and monitoring points, and recent information has provided a better understanding. Leachate extraction and monitoring has occurred at three different points over time:

- LP001, the initial main leachate riser, was constructed progressively with waste lifts as a series of 1,200 mm concrete pipe sections, which ultimately extended from the landfill base to approximately 65 m AHD in 2005 (Douglas Partners, 2005). This report mentions that LP001 was damaged in 2005, but that '*it remained open for the full depth*', and subsequently two 400 mm diameter HDPE pipes were installed inside the concrete pipe to assist with leachate extraction and monitoring. One of these pipes, currently present as a steel riser, has retained the LP001 designation.
- The other 400 mm pipe (currently present as a PVC riser) was tagged as LP002. Previous reporting suggested that LP002 was a sampling point at the Leachate Treatment Plant, for leachate extracted from LP001, however, this is not the case. After mid-2014, LP001 apparently became too damaged, and extraction and monitoring switched to LP002 for the period late 2014-late 2016.
- After late 2016, leachate monitoring and extraction then switched to LP003 (also referred to as the Auxiliary Riser). There are no logs or well construction details available for LP003, however, a down hole camera survey conducted in late 2019 indicated that LP003 is approximately 45 m deep (sump base elevation sitting at approx. RL 34.1 m AHD). LP003 has been extracting leachate at an average rate of approximately 60 m^3/day.

The following table summarises leachate extraction, sampling and gauging locations:

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Table 4a: Summary of Erskine Park Landfill Leachate Sump Network

ID	Easting	Northing	Notes	RL Top of Casing (TOC) (m AHD)[3]	Latest Depth to Leachate (m BTOC)[2]	Latest Leachate Elevation (m AHD)[2]	Sump Depth (m)	RL Base of Sump (m AHD)	Sample Frequency
LP001 (located in Jan 2020)	295277.748	6255817.191	Former leachate extraction location Gas extraction only	5/02/20 89.316	23/01/20 50.162	23/01/20 39.154	23/01/20 51.700	23/01/20 37.616	Ad hoc
LP002 (located in Jan 2020)	295284.884	6255803.267	Gas extraction only Sump riser likely to be bent as approx. 7 m difference in N coordinate	5/02/20 89.63	23/01/20 49.602	23/01/20 40.028	23/01/20 59.000	23/01/20 30.63	Ad hoc
LP002 (as per EPL coordinates)	295285.021	6255810.009							
LP003 Auxillary Riser Leachate Riser	295164.987	6255733.875	Leachate extraction Leachate level gauging location N & E coordinates in EPL likely to be erroneous.	21/06/19 79.214	2/12/19 35.5 (recovered leachate level) 9/12/19 38.539 (pump off for 4 days)	2/12/19 43.714 (recovered leachate level) 9/12/19 40.675 (pump off for 4 days)	2/12/19 45.02 (pump pulled out 19//02/20 and sump depth measured the same)	2/12/19 34.194 (similar elevation to first quarry bench)	Quarterly
LP003 (as per EPL coordinates)	295200.015	6255749.982							
LP003 (leachate sampling tap on inlet pipe at treatment plant)			Leachate sampling conducted at this point	na					Quarterly
					Average leachate elevation:	**40.893**			

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4.1.2 Groundwater Monitoring Network

The groundwater monitoring network has evolved over time as the landfill has developed. **Figure 4** below is a monitoring network plan supplied by Cleanaway, showing the locations of all current groundwater monitoring wells (red solid circles).

Table 4b summarises the construction and survey data for the current groundwater monitoring well network. The definition previously used for defining Shallow, Intermediate and Deep monitoring wells is as follows for the base of the wells:

- Shallow: >0 m AHD.
- Intermediate: 0 to > -15 m AHD.
- Deep: < -15 m AHD.

During groundwater sampling activities conducted by Senversa in July 2019, Senversa field staff encountered some difficulties with sampling including, for example:

- BH15A was found to contain a large amount of sediment which interfered with the dedicated sample pump.
- The pump in BH22 was unable to provide flow to surface.
- BH24 was found to be dry; and
- BH5 was unable to be located.

Senversa was on several occasions required to remove the dedicated sample pump, insert a hired pump and then re-install the dedicated sample pump after completion of sampling.

Based on our observations, the majority of the existing well network is fit for purpose, however, some wells should be subject to a specific condition assessment, with recommendations for relocating, redevelopment, rehabilitation and/or pump replacement.

As a separate task, Senversa has also prepared an improved conceptual site model (CSM) for the landfill, which can be found in **Appendix A**. A covering memorandum outlines the information used to prepare the cross-sections, how it was used, and lists the findings. The location of the cross-sections is shown in the attached Figure 1, while the twenty cross-sections are attached as Figures 2 to 21, inclusive.

During the preparation of the improved CSM, Senversa scrutinised the last two quarterly groundwater monitoring reports prepared by Arcadis for the September and December 2019 monitoring rounds. These two reports contained further detailed groundwater monitoring information than previously reported, including tabulated historical groundwater gauging and monitoring results and groundwater monitoring field sheets.

The memorandum in **Appendix A** outlines the groundwater monitoring bores that require attention. The groundwater sampling methodology may also be in need of review to ensure representative groundwater samples continue to be collected, as the following table highlights that most of the groundwater sample pumps within each groundwater monitoring bore, do not sit within the screened interval of the bore.

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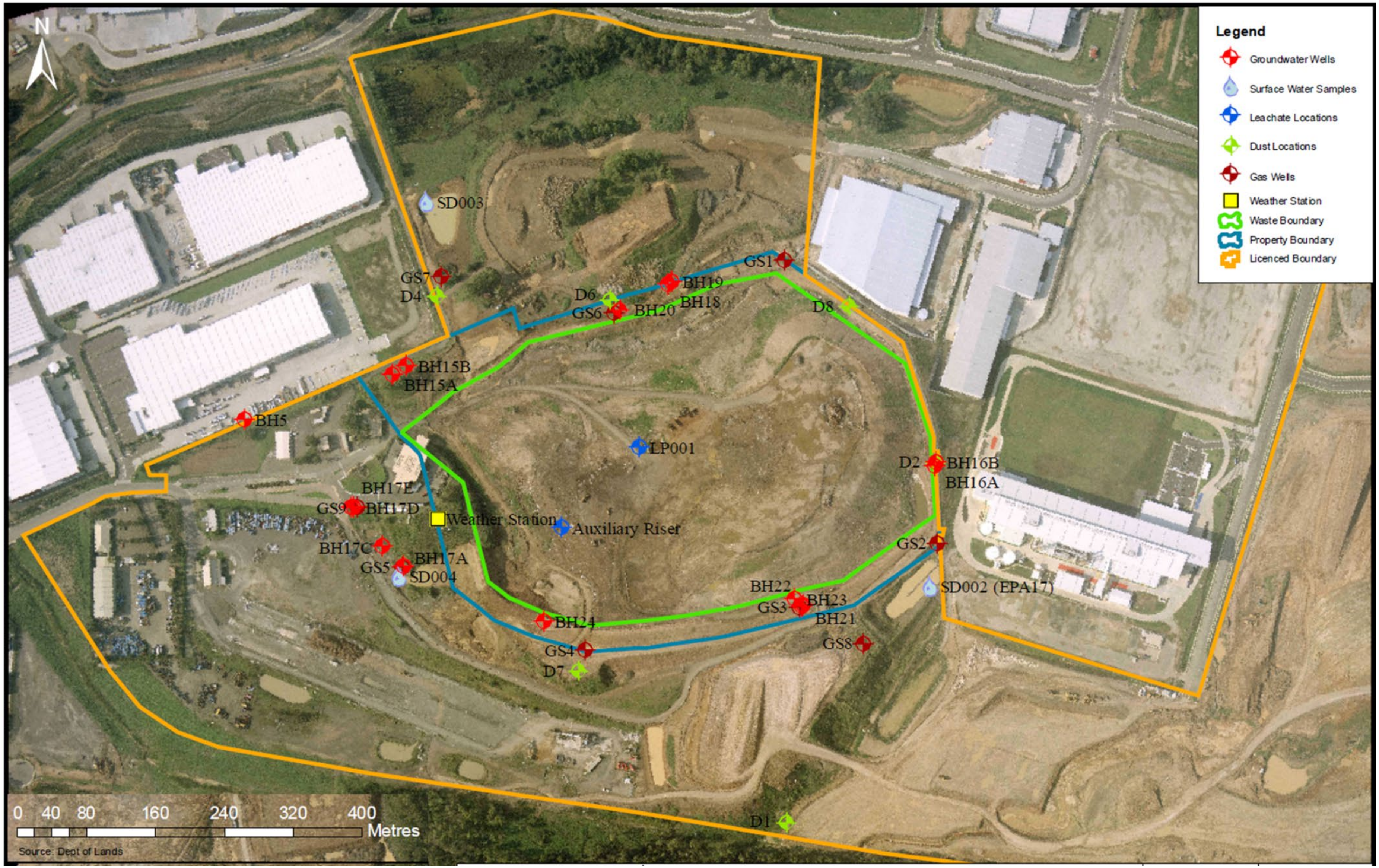

Figure 4: Current Groundwater Monitoring Well Network (after CES, 2009)

Table 4b: Summary of Erskine Park Landfill Groundwater Monitoring Network Construction and Survey Data

ID	Easting	Northing	EPA #	Targeted Groundwater Interval	RLNS (m AHD)[1]	RL Top of Casing (TOC) (m AHD)[3]	Depth to Groundwater as at Dec 2019 (m BTOC)[2]	Groundwater Elevation as at Dec 2019 (m AHD)[2]	Bore Depth (m)	RL Base of Well (m AHD)	Groundwater Sampling Pump Depth (m)[2]	Screen Interval (m bgl)	Screen Interval (m AHD)	Screen Length (m)	Sample Frequency
5	294830	6255836	N/A2	Shallow	43.6		Bore not found		12.5	31.1	Bore not found	6.0 to 12.6	37.6 to 31.1	6.5	Yearly
15A	295001	6255889	10	Intermediate	48.9	49.776	11.374	38.402	61	-12.1	37.870	40.4 to 58.2	8.5 to -9.3	17.8	Quarterly
15B	295018	6255899	11	Deep	49.2	49.805	12.578	37.227	91	-41.8	40.395	70.5 to 88.3	-21.3 to -39.1	17.8	Quarterly
16A	295629	6255782	12	Intermediate	59.1	59.788	17.301	42.487	70.5	-11.4	28.714	49.9 to 67.7	9.2 to -8.6	17.8	Quarterly
16B	295630	6255787	13	Deep	59.3	60.053	17.738	42.315	100.1	-40.8	29.541	79.5 to 97.3	-20.2 to -38.0	17.8	Quarterly
17D	294956	6255743	N/A6	Deep	51	49.797	17.329	32.468	95	-41	41.552	74.0 to 91.5	-23.0 to -40.5	17.5	Quarterly
17E	294953	6255744	N/A6	Shallow	51	49.327[4]	8.725	40.602	32	19	29.510	24.0 to 31.5	17.0 to 24.5	7.5	Quarterly
18	295320	6255994	9	Deep	55.79	56.539	24.392	32.147	94	-38.2	26.969	76.0 to 94.0	-20.2 to -38.2	18.0	Quarterly
19	295324	6255995	19	Intermediate	55.73	56.435	13.254	43.181	56.3	-0.6	40.474	36.3 to 56.3	19.4 to -0.6	20	Quarterly
20	295263	6255964	N/A2	Shallow	58	58.342	10.115	48.227	38.2	19.8	29.554	25.2 to 38.2	32.8 to 19.85	12	Quarterly
21	295478	6255621	20	Deep	59.67	60.409	17.939	42.470	103	-43.3	30.476	90.0 to 103.0	-30.3 to -43.3	13.0	Quarterly
22	295475	6255620	21	Intermediate	59.73	60.359	31.777	28.582	69	-9.3	Not recorded (total well depth reported as 56.357 m)	57.0 to 69.0	2.73 to -9.3	12.03	Quarterly
23	295467	6255629	22	Shallow	62.69	63.411	19.379	44.032	44	18.7	22.165	24.0 to 44.0	38.7 to 18.7	20	Quarterly

ID	Easting	Northing	EPA #	Targeted Groundwater Interval	RLNS (m AHD)[1]	RL Top of Casing (TOC) (m AHD)[3]	Depth to Groundwater as at Dec 2019 (m BTOC)[2]	Groundwater Elevation as at Dec 2019 (m AHD)[2]	Bore Depth (m)	RL Base of Well (m AHD)	Groundwater Sampling Pump Depth (m)[2]	Screen Interval (m bgl)	Screen Interval (m AHD)	Screen Length (m)	Sample Frequency
24	295176	6255602	28	Shallow	68.26	68.88	Unable to gauge in Dec 2019 ~26.36[5]	42.52	45	23.3	Not recorded	18.0 to 45.0	50.3 to 23.3	27	Quarterly

Notes to table: 1. As reported in Arcadis (2018); RLNS = reduced level of natural surface

2. As reported in Arcadis December 2019 Quarterly Groundwater Monitoring Event, the depth to the groundwater sampling pump in each bore is included in the field sheets in Appendix B.

3. As reported in previous Arcadis monitoring reports.

4. As surveyed by Keatley Surveyors on 24 June 2019.

5. As reported by Arcadis during 19 June 2019 monitoring round.

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4.2 Groundwater and Leachate Sampling and Analytical Program

Senversa conducted a groundwater and leachate monitoring event (GME) in July 2019. The sampling methodology was undertaken in general accordance with:

- The National Environmental Protection (Assessment of Site Contamination) Measure (NEPC, 2013).
- Senversa standard groundwater sampling procedures.

The groundwater and leachate sampling and analytical program consisted of the following tasks:

- Gauging of the standing water level (SWL) and bore depth prior to sampling.
- Purging of the bore using the low-flow micro-purge method.
- Sampling of groundwater and leachate, after water quality parameters (temperature, oxidation-reduction potential (redox) dissolved oxygen (DO), pH and electrical conductivity (EC)) had stabilised.
- Water quality readings were collected using a calibrated water quality meter.
- Use of dedicated sample tubing and laboratory supplied sample containers to mitigate potential cross-contamination.
- Placement of collected samples into cooler boxes and transfer to the laboratory under chain of custody procedures.

4.3 Aquifer Hydraulics

4.3.1 Groundwater and Leachate Hydrographs

Figure 5 below summarises the available leachate and groundwater elevation data, as compiled from available documentation and recent data collected as part of this project. The leachate level was observed to be decreasing towards 30 m AHD during 2011 to 2013, after which a rapid increase occurs to approximately 50 m AHD by late-2015. As of December 2019, the leachate level in LP003 was measured at approximately 40.5 m AHD, as measured using a downhole camera. The average leachate RL was estimated at approximately 40.9 m AHD (refer **Table 4a** in **Section 4.1.1**).

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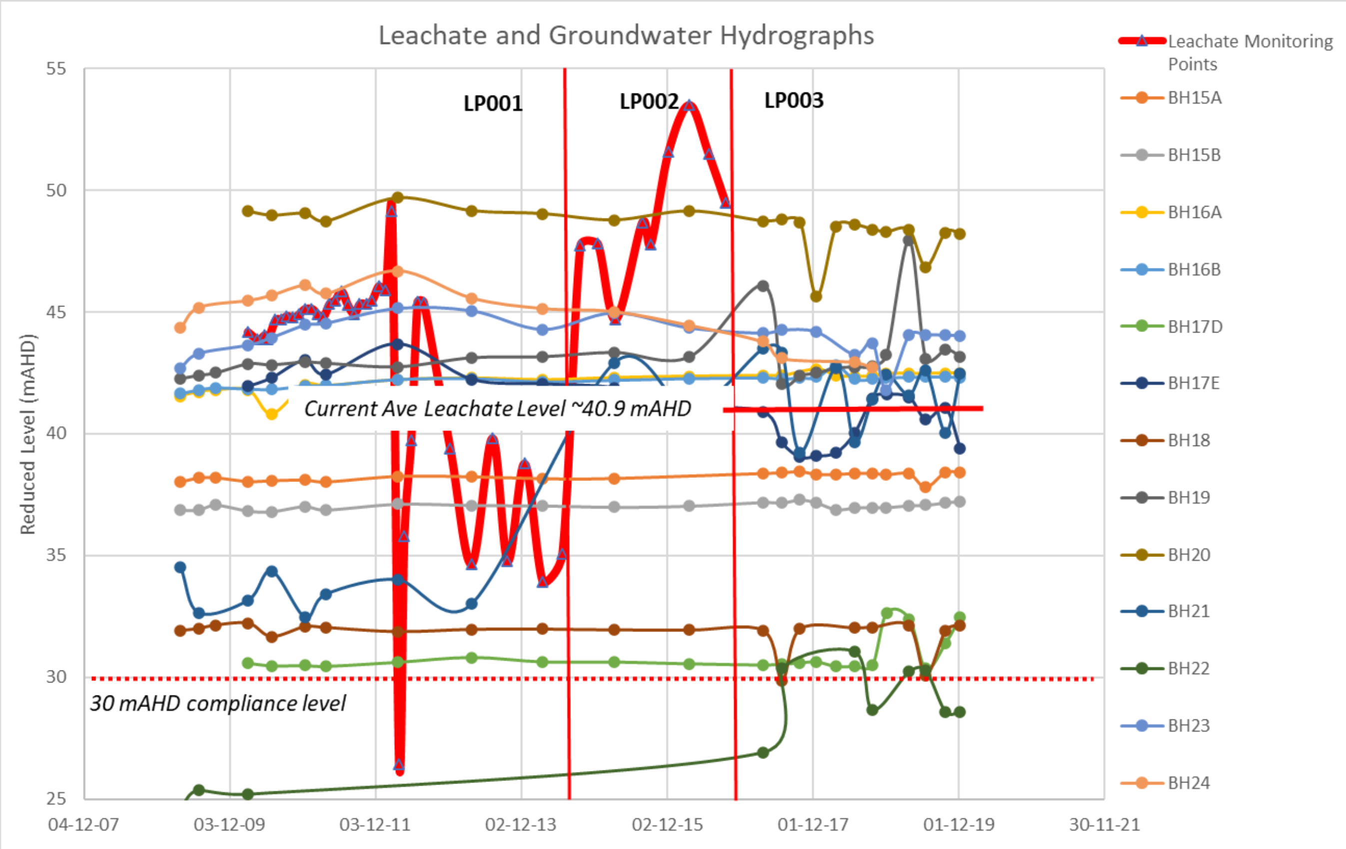

Figure 5: Leachate and Groundwater Hydrographs

4.3.2 Groundwater Elevations, Flow Directions and Hydraulic Gradients

Figures 6, 7 and 8 (below) show the inferred groundwater elevation contours for the Shallow, Intermediate and Deep monitoring wells (as defined in **Table 4b** above), respectively, based on July 2019 monitoring data. There was insufficient data for Shallow wells in the July 2019 GME (e.g. BH24 was dry, BH5 unable to be located) for contouring – the most recent complete gauging data was from the March 2017 GME by Arcadis, which was used for contouring Shallow well reduced water levels (RWLs) in **Figure 5** (above).

The groundwater elevation contours were sub-divided into these three categories based on review of groundwater hydrographs, which indicated significant differences in groundwater elevation between the three groups of wells. For example, for the nested triplet of wells BH21 (shallow), BH22 (intermediate) and BH23 (deep), the groundwater elevation in BH23 is higher than the intermediate well BH22. Overall there appears to be a downwards vertical hydraulic gradient, but this is not consistent, and is typical of the effects of strong heterogeneity in fractured rock aquifers.

The figures indicate the following:

- Shallow monitoring wells: a westerly flow direction, with an estimated hydraulic gradient of 0.02 metres per metre (m/m).
- Intermediate monitoring wells: a southerly flow direction, with an estimated hydraulic gradient of 0.04 m/m.
- Deep monitoring wells: a northerly flow direction with an estimated hydraulic gradient of 0.03 m/m.

It is important to note that these estimated hydraulic gradients are across the landfill, and do not represent gradients at distance from the landfill, which are likely to be much flatter. CMPS&F (1993) noted that "*to the east of the landfill the standing water levels are typically RL 45 m to RL 48m, while to the west and south of the landfill the standing water levels are typically RL 37 m to RL 39* m". Taking the average of these, and assuming this occurs over a distance of 1 km, this would provide a more regional hydraulic gradient estimate of approximately 0.01 m/m.

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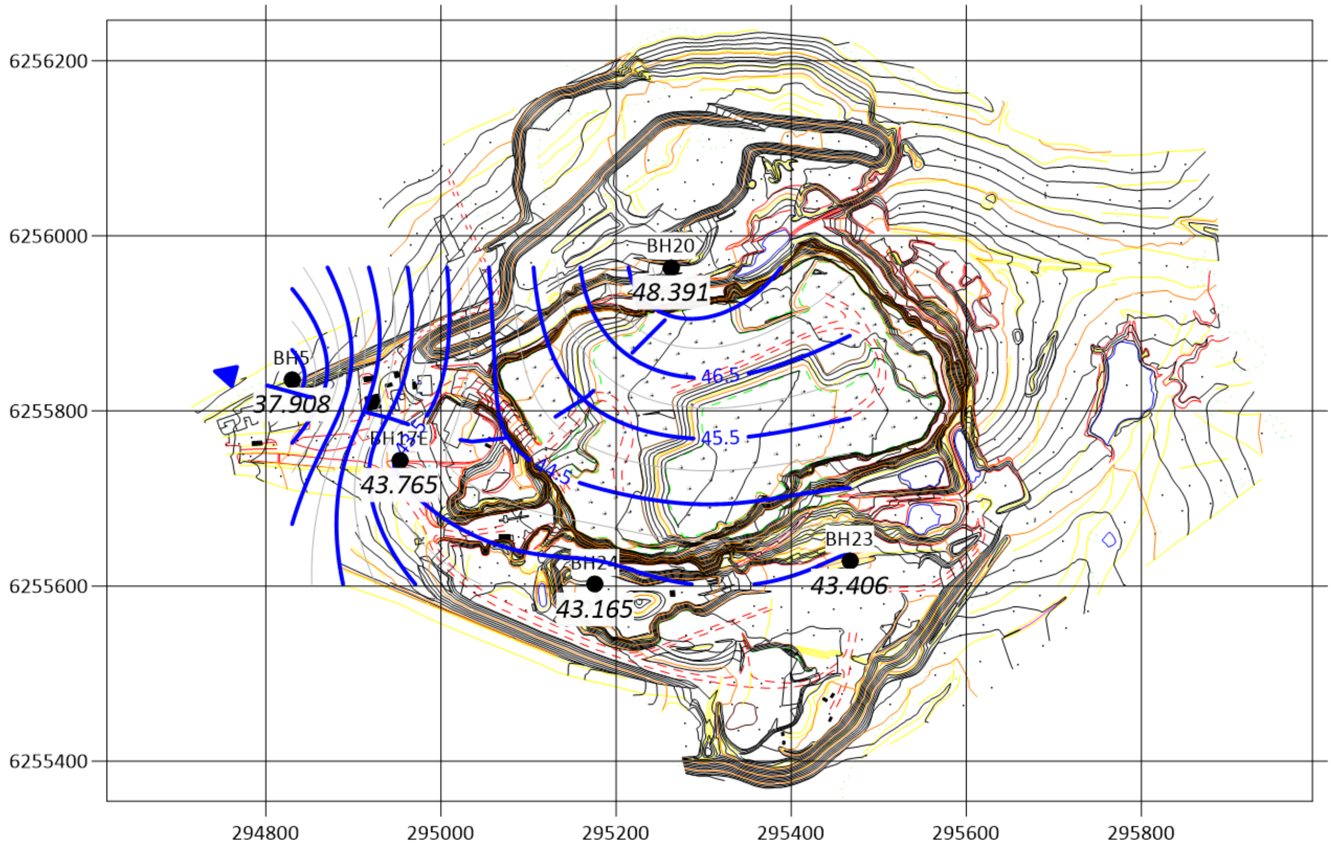

Figure 6: Shallow Monitoring Well Reduced Water Level Contours (m AHD) (March 2017)

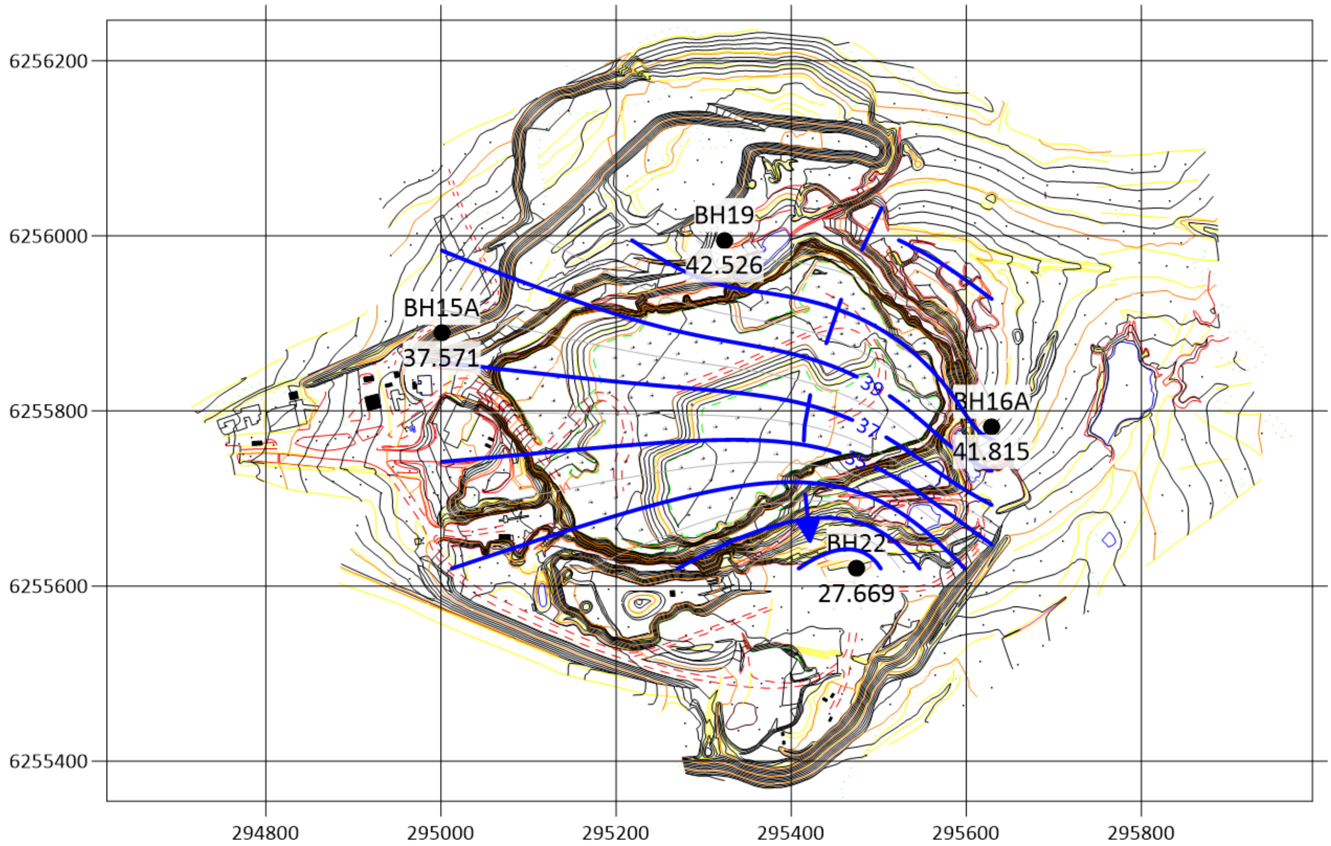

Figure 7: Intermediate Monitoring Well Reduced Water Level Contours (m AHD) (July 2019)

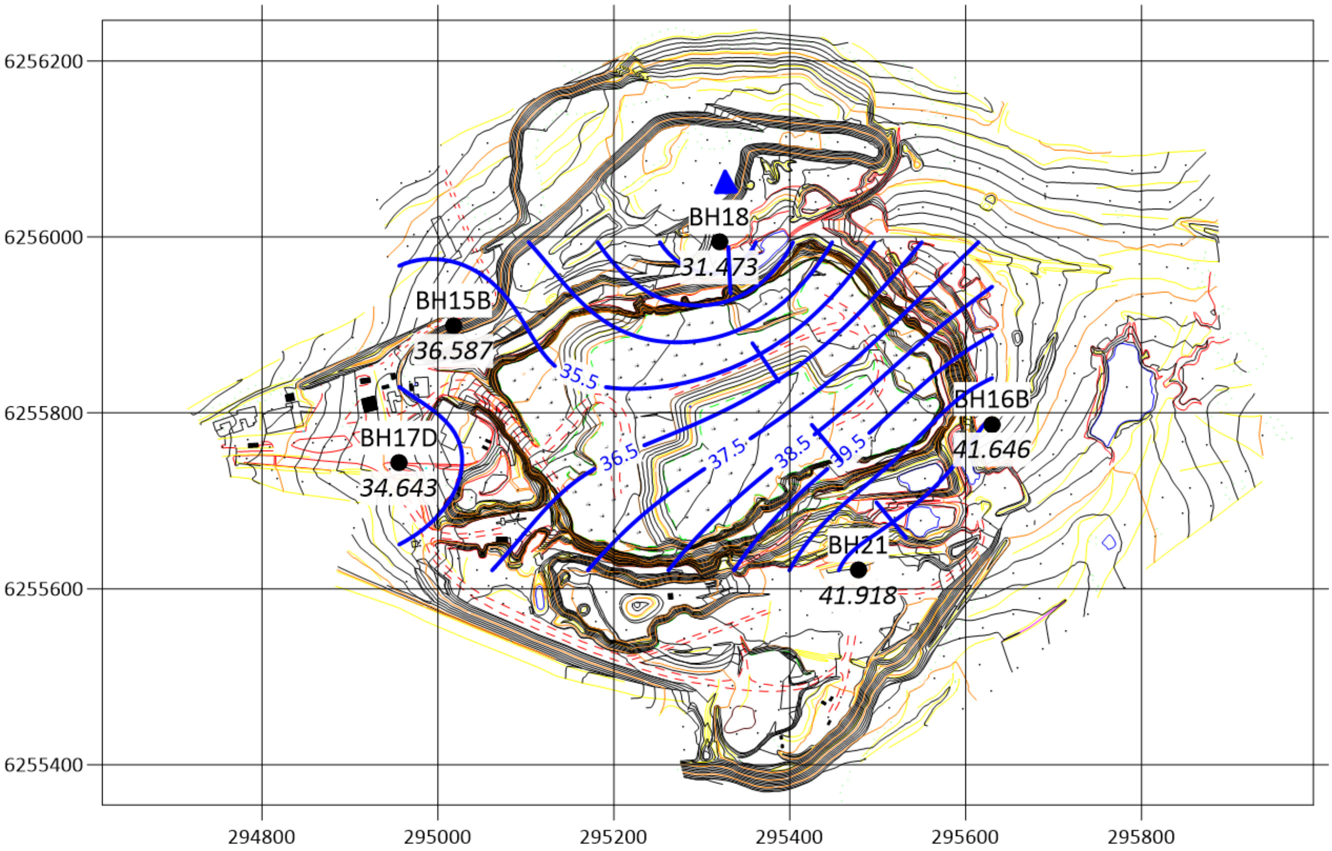

Figure 8: Deep Monitoring Well Reduced Water Level Contours (m AHD) (July 2019)

4.3.3 Potential for Groundwater Inflow and Leachate Outflow

Based on **Figure 5**, the groundwater elevations were compared to the most recent average leachate elevations (40.9 m AHD), to assess where groundwater may be inflowing to or leachate outflowing from the landfill.

Figure 9 graphically summarises these flow directions between leachate and the Shallow, Intermediate and Deep Aquifers, which are signified by orange, red and blue arrows respectively. The figure indicates that, in general, groundwater has the potential to flow into the landfill on the eastern side, and outflow on the western side, and to a lesser extent the southern side.

The monitoring wells with groundwater elevations lower than the current leachate level of 40.9 m AHD include BH15A, BH15B, BH18, BH17D, BH17E, and BH22.

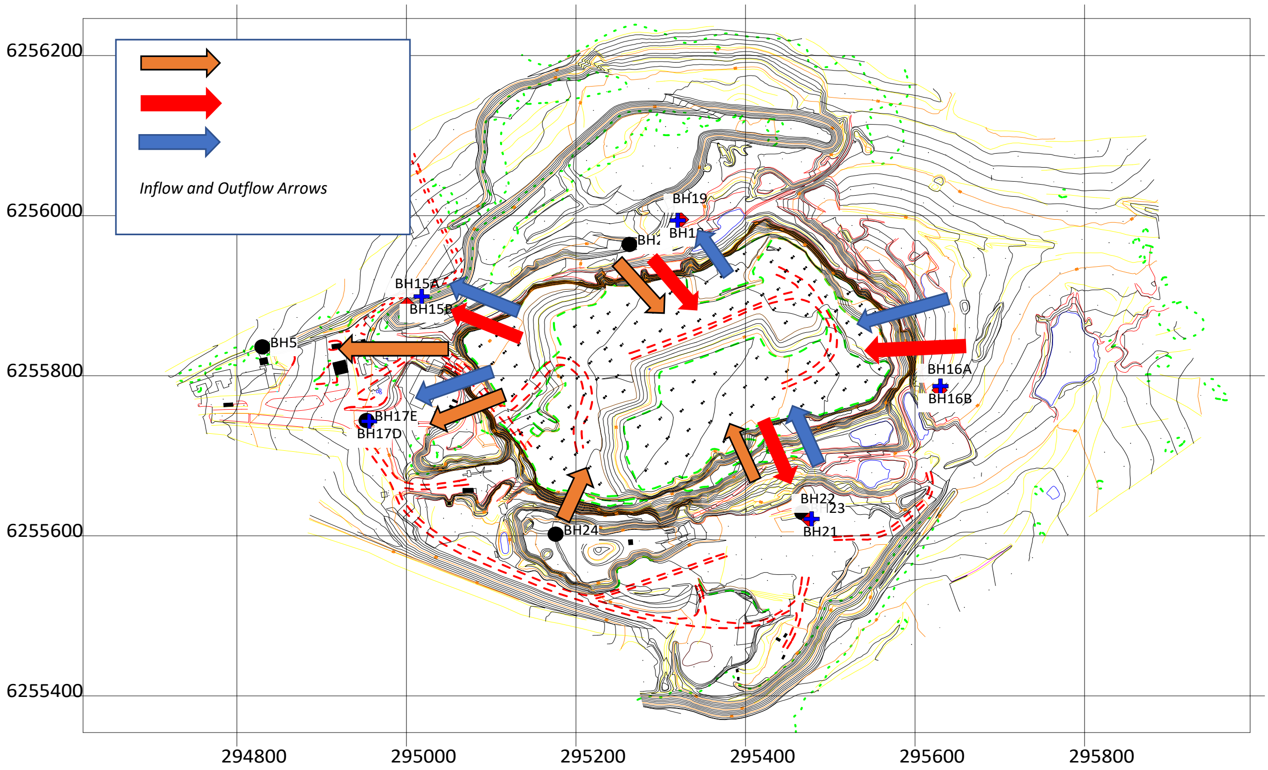

Figure 9: Inferred Flow Directions between Landfill and Surrounding Aquifers

4.3.4 Aquifer Permeability and Effective Porosity

Permeability tests were undertaken by Coffey & Partners in 1982 and later (in 1993) by AGC-Woodward Clyde in the monitoring wells surrounding the landfill area. The results of the tests are summarised in **Table 6** below. In addition, falling head permeability tests were undertaken by URS in 2003 in ten monitoring wells around the old quarry area in order to assess whether a liner was required to prevent leachate impact to groundwater (refer **Table 7**). All hydraulic testing indicated that the surrounding Bringelly and Ashfield Shales in contact with the landfill had low to very low permeabilities, in the order of 10^{-3} m/day to 10^{-4} m/day.

The effective porosity of the shale formation, although not quantified, is also likely to be very low, and based on published literature (Fetter, 1992; McWhorter and Sunada, 1977) is assumed to be in the order of 0.005 to 0.01.

Table 5: Permeability Test Results (after Coffey & Partners (1982) and AGC-Woodward Clyde (1997)

	Permeability (m/sec)	Permeability (m/day)
Falling Head Tests		
BH1	7.9×10^{-10}	7.0×10^{-5}
BH2	2.6×10^{-9}	2.3×10^{-4}
BH3	1.5×10^{-8}	1.3×10^{-3}
BH5	3.7×10^{-8}	3.2×10^{-3}
BH6	3.2×10^{-9}	2.8×10^{-4}

	Permeability (m/sec)	Permeability (m/day)
DB1	7.7 x 10^{-9}	6.7 x 10^{-4}
BH13	7.0 x 10^{-8}	6.1 x 10^{-4}
BH14	2.0 x 10^{-8}	1.7 x 10^{-5}
Geometric Mean	***3.8 x 10^{-9}***	***3.2 x 10^{-4}***
Packer test in Bore DB1		
5.95-12.7 m	$<10^{-8}$	$<10^{-4}$
12.7-18.8 m	$<10^{-8}$	$<10^{-4}$
18.8-24.8 m	5.0 x 10^{-8}	4.3 x 10^{-3}
24.8-30.8 m	1.0 x 10^{-8}	8.6 x 10^{-4}
30.8-36.8 m	1.5 x 10^{-7}	1.3 x 10^{-3}
36.8-45.4m	5.0 x10^{-8}	4.3 x 10^{-3}
45.4-54.7 m	1.0 x 10^{-8}	8.6 x 10^{-4}
54.7-66.7 m	5.0 x10^{-8}	4.3 x 10^{-3}
66.7-78.8 m	$<10^{-8}$	$<10^{-4}$
Geometric Mean	***2.3 x 10^{-8}***	***1.2 x 10^{-3}***

Table 6: Permeability Test Results (after URS Australia, 2003)

	Permeability (m/sec)	Permeability (m/day)
Falling Head Tests		
BH1	2.4 x 10^{-9}	6.8 x 10^{-5}
BH2	4.0 x 10^{-9}	2.3 x 10^{-4}
BH3	7.4 x 10^{-9}	1.3 x10^{-3}
BH4	4.6 x 10^{-8}	3.2 x10^{-3}
BH5	5.8 x 10^{-9}	2.8 x 10^{-4}
BH6	7.7 x 10^{-9}	6.7 x10^{-4}
BH8	1.9 x 10^{-7}	6.1 x 10^{-4}
BH9	5.3 x 10^{-8}	1.7 x 10^{-5}

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	Permeability (m/sec)	Permeability (m/day)
BH10	1.3×10^{-8}	6.8×10^{-5}
Geometric Mean	***1.4×10^{-8}***	***1.1×10^{-3}***
<u>All Testing</u>		
Geometric Minimum	**1.7×10^{-9}**	**7.1×10^{-5}**
Geometric Maximum	**1.0×10^{-7}**	**8.8×10^{-3}**
Geometric Mean	**1.1×10^{-8}**	**7.9×10^{-4}**

4.4 Groundwater Seepage Rates

The linear groundwater velocity (or seepage rate) can be estimated by Darcy's Law:

$$V_x = K.\ I / n_e$$

Where V_x = linear groundwater velocity (m/day)

K = aquifer permeability (m/day)

I = hydraulic gradient (m/m)

n_e = effective porosity (dimensionless)

A sensitivity analysis was completed to assess the range of groundwater velocity to be expected at the site. The sensitivity analysis was based on variations in the parameters as discussed in above sections and in **Table 7**: Aquifer permeability (8.8×10^{-3}, 7.1×10^{-5}, 7.9×10^{-4} m/day), hydraulic gradient (0.01, 0.025, 0.04 m/m), and effective porosity (0.005, 0.01, 0.05).

Table 8 summarises the results of sensitivity analysis for groundwater velocity calculations. The sensitivity matrix provides a minimum, mean and maximum range of calculated groundwater seepage rates.

Table 7: Summary of Groundwater Seepage Rate Sensitivity Analysis

Scenario	Aquifer Permeability (m/day)	Hydraulic Gradient (m/m)	Effective Porosity	Linear Velocity (m/day)	Linear Velocity (m/year)
Minimum	7.1×10^{-5}	0.01	0.05	1.4×10^{-7}	5.2×10^{-3}
Mean	7.9×10^{-4}	0.025	0.01	2.0×10^{-2}	7.2×10^{-1}
Maximum	8.8×10^{-3}	0.04	0.005	6.9×10^{-2}	2.5×10^{1}

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4.4.1 Potential for Interaction Between Groundwater and Surface Water

The drainage lines to the north of the Landfill were surveyed to check whether there was any potential for interaction between groundwater and surface water, in the form of groundwater migration and discharge. The creek invert was recently surveyed by Cleanaway and was found to be approximately 39 m AHD.

Based on groundwater elevation contouring (**Section 4.3**), only the Deep Monitoring Wells indicated a northerly flow direction, and the highest groundwater elevation to the north of the Landfill was in the order of 31.5 m AHD (BH18) - that is, at least 7.5 m below the creek invert. As such it is concluded that there was a very low likelihood that groundwater (and any associated leachate) from the landfill discharges to surface water.

The inverts of the South Creek tributaries to the west and south of the landfill were not included in the recent survey and this remains a data gap, not only in understanding the potential interaction between groundwater and surface water, but in understanding potential subsurface gas migration pathways.

4.5 Groundwater and Leachate Quality

4.5.1 Ammonia in Groundwater

Figure 10 below shows the temporal trends in ammonia concentrations in all groundwater monitoring wells for the period 2016-2019, and the 15 mg/L ammonia criterion (Condition U1.1 in EPL 4865).

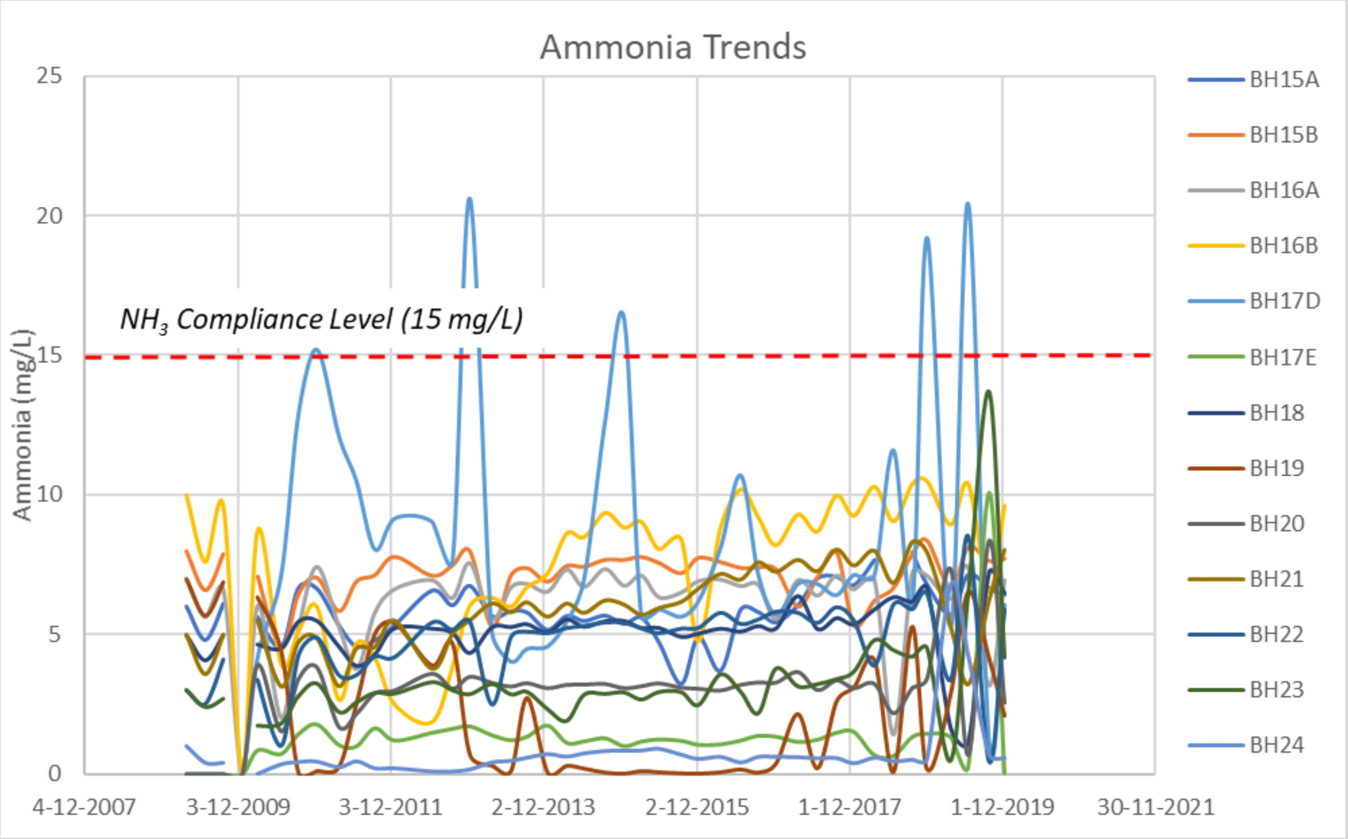

Figure 10: Ammonia (as N) in Groundwater Concentration Trends (2009 to date)

Figure 10 indicates that the EPL criterion of 15 mg/L has been exceeded on four occasions since 2009, and only in one well (BH17D). Observed variations in ammonia in BH17D may be due to its proximity to an operating wash bay, combined with its location within a bunded area. **Table 4b** in **Section 4.1.2** indicates the depth of the sampling pump within BH17D sits over 30 m above the screened interval of the groundwater bore, hence, samples of groundwater collected from this deep bore may not be representative of the groundwater in the area, and could be a combination of groundwater and infiltrated surface water collected within the bore's solid casing.

4.5.2 Groundwater Trend Analysis

Overall, ammonia (as N) concentrations in groundwater surrounding the Landfill appear relatively stable. Mann-Kendall statistical analysis was conducted in order to evaluate potential temporal concentration trends. **Table 9** below summarises the Mann-Kendall statistics and trend analysis.

The trend analysis indicates increasing trends in BH15A, BH16B, BH18, BH21, BH22, BH23 and BH24, although the concentrations are below the 15 mg/L EPL compliance concentration.

It is notable that groundwater elevations in the majority of the wells with increasing ammonia trends are below the current leachate level (refer Figure 9), and therefore the potential exists for leachate to outflow from the landfill towards these wells.

Table 8: Summary of Mann-Kendall Statistics and Trend Analysis

Well ID	Coefficient of Variation	Mann-Kendall Statistic (S)	Confidence Factor (%)	Concentration Trend
BH15A	0.16	174	98.3	Increasing
BH15B	0.12	90	85.6	No Trend
BH16A	0.21	132	94.4	Prob. Increasing
BH16B	0.33	337	>99.9	Increasing
BH17D	0.48	-37	68.7	Stable
BH17E	0.22	-17	58.6	Stable
BH18	0.16	282	>99.9	Increasing
BH19	1.15	-28	62.3	No Trend
BH20	0.38	35	65.9	No Trend
BH21	0.23	474	>99.9	Increasing
BH22	0.29	385	>99.9	Increasing
BH23	0.58	364	>99.9	Increasing
BH24	1.56	269	99.9	Increasing

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Another notable feature is that the majority of increasing ammonia trends appear to be associated with trends in increasing groundwater level. This is illustrated in **Figures 11, 12 and 13**, which are trend plots of ammonia concentration vs RWL for monitoring wells BH15A, BH21 and BH22 respectively.

The reasons behind the related increases are unclear at this stage. They may be related to gradual seepage of landfill leachate into the surrounding ground, but this is qualified by observed marked increases in RWL (up to 5 m in BH22) starting around early 2013, which suggest that leachate extraction activities may also have had an influence (for example, recovery of groundwater levels after extraction ceased, or decreased). In any case, the observed ammonia concentrations are still well below the reporting limit of 15 mg/L.

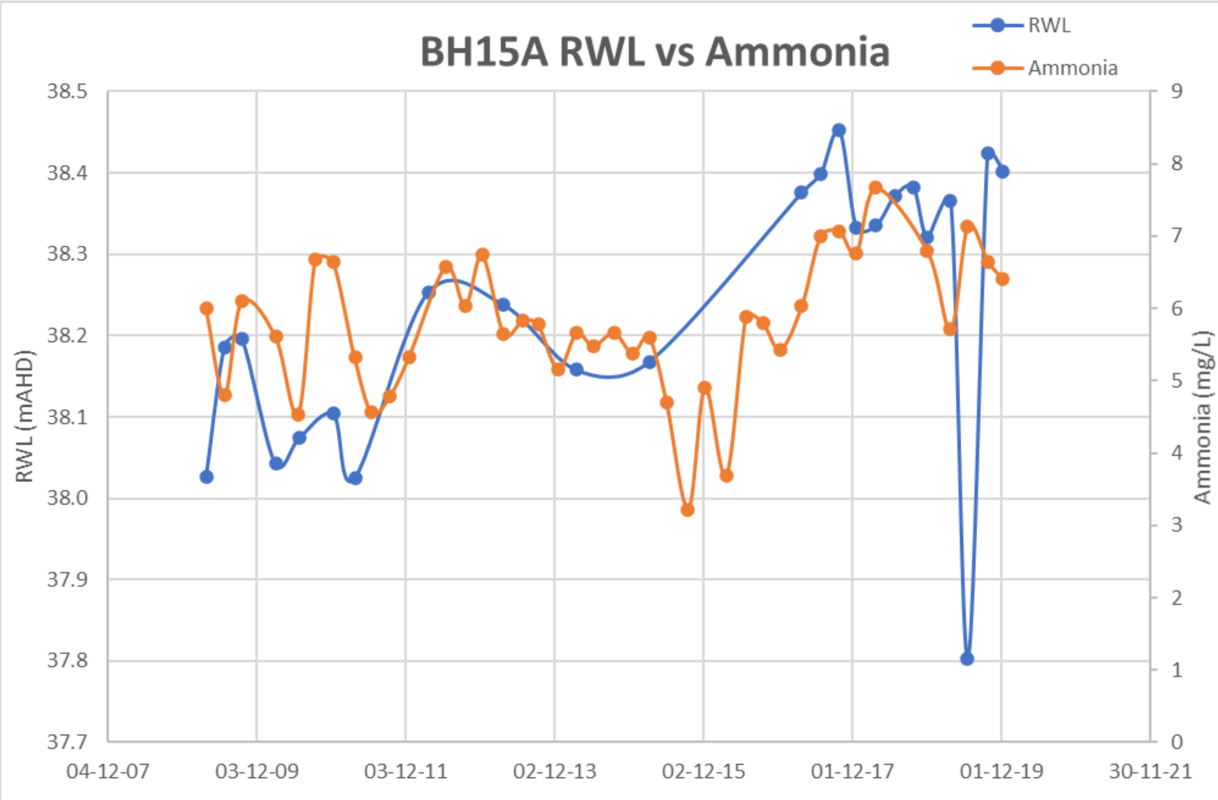

Figure 11: Ammonia vs RWL Trends (BH15A)

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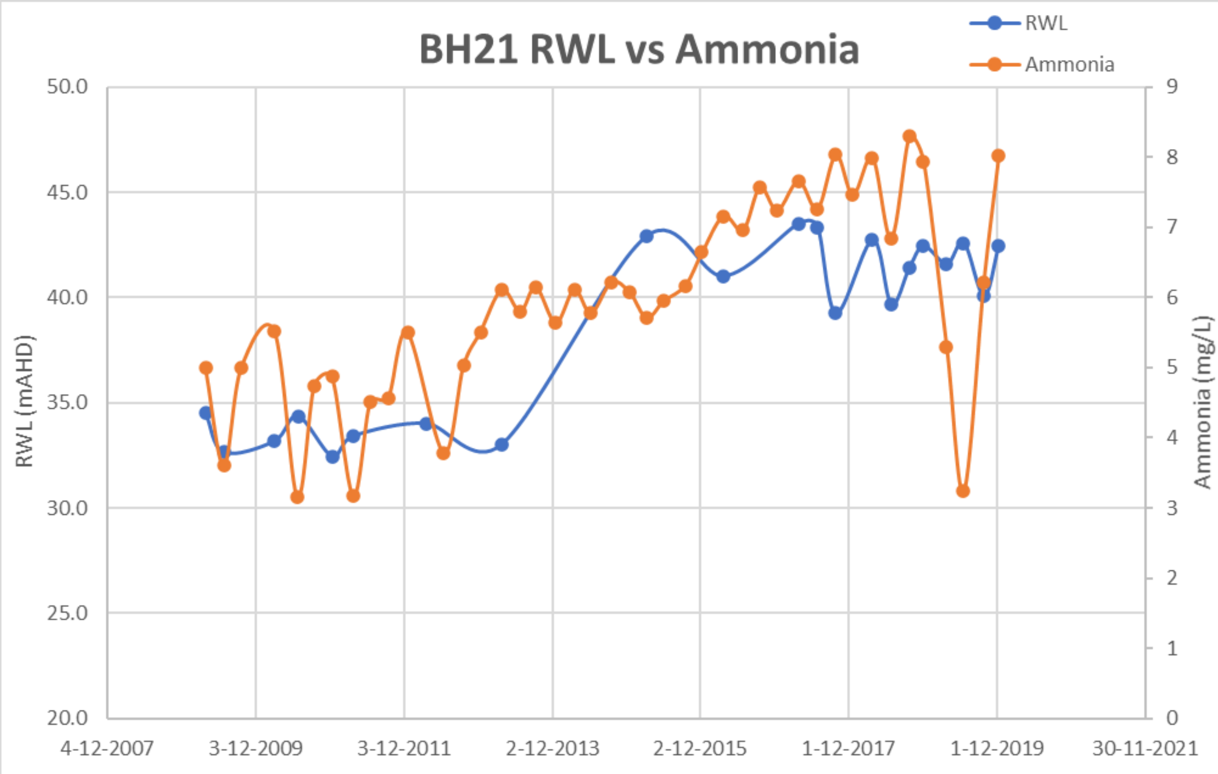


Figure 12: Ammonia vs RWL Trends (BH21)

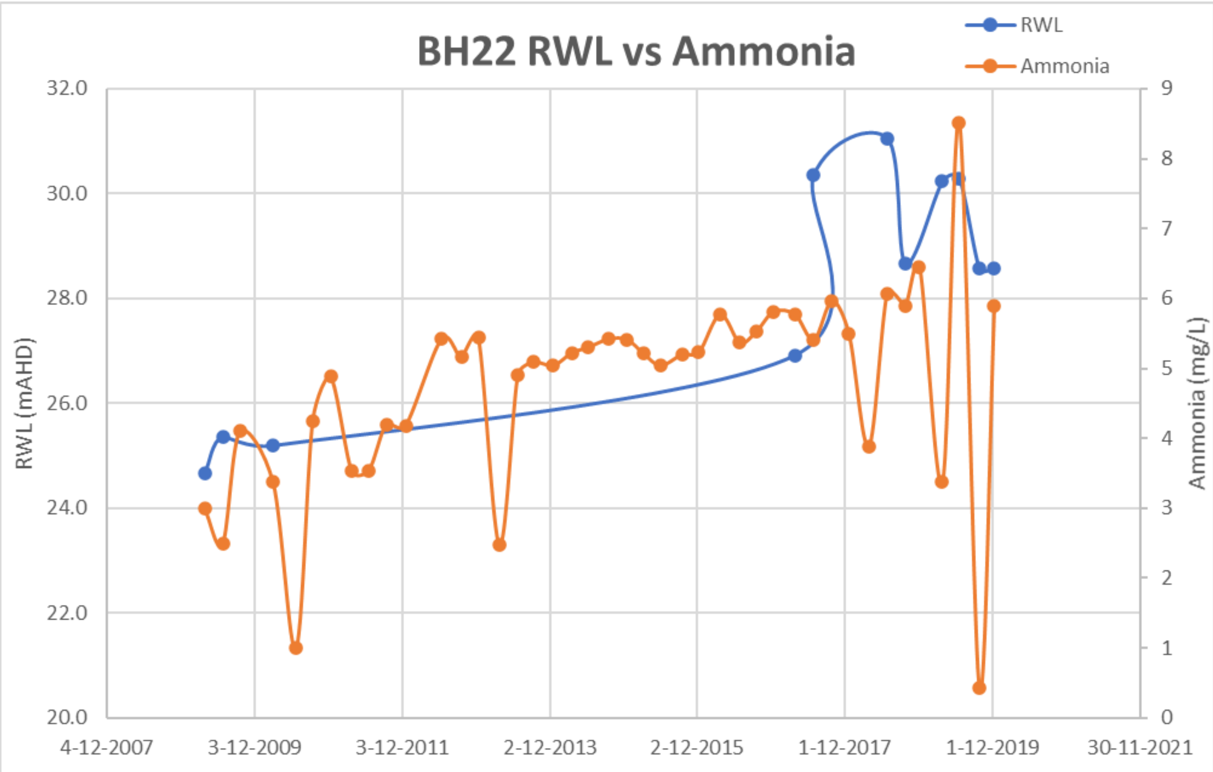


Figure 13: Ammonia vs RWL Trends (BH22)

As a separate task, Senversa has also prepared an improved conceptual site model (CSM) for the landfill, which can be found in **Appendix A**. As our understanding of the site over the last few months has grown as further information became available, Senversa identified that the site setting around the landfill perimeter and the landfill construction itself differs significantly along sections of the perimeter, and so it was agreed that one typical perimeter cross-section would not be sufficient to represent the landfill's CSM. Twenty cross-sections have been prepared, in order to best capture the various site features and sensitive receptors surrounding the landfill, including the clay side liner wall, various leachate drainage blankets, the first quarry bench, recent test pit information collected in late 2019, the average leachate elevation across the landfill, the surrounding groundwater elevations in the nearest monitoring bores, the buried Austral Bricks gas feed pipeline and the surface profile of the surrounding land, both on and off site, between the edge of waste and the closest on and off site buildings.

Within **Appendix A**, a covering memorandum outlines the information used to prepare the cross-sections, how it was used, and lists the findings. The location of the cross-sections is shown in the attached Figure 1, while the twenty cross-sections are attached as Figures 2 to 21, inclusive.

In the south east corner and the eastern half of the southern perimeter of the landfill, Senversa identified a second leachate drainage blanket had been installed along the first quarry bench, in addition to the drainage blanket installed along the quarry rim.

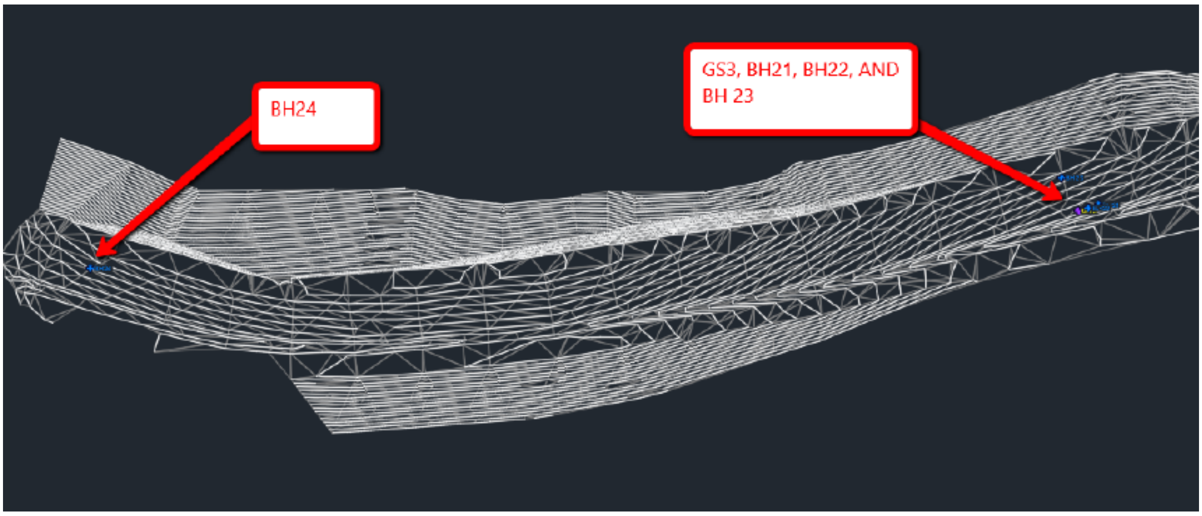
One of the findings of the improved CSM includes:

> *The leachate drainage blanket installed along the first quarry bench in the south, could potentially contribute to leachate migration from the waste into groundwater, as its elevation is in very close proximity to the average leachate elevation assumed when preparing the CSM cross-sections.*

The elevation of the leachate drainage blanket installed along the first quarry bench in the south and south east corner sits at approx. RL 41 m AHD to 42 m AHD. The current average leachate elevation is assumed to be approx. 40.89 m AHD. It appears the leachate drainage blankets were installed along the quarry rim and first quarry bench in sections where these areas appeared too flat, and it was considered potential leachate generated above these points required assistance to drain back into the landfill. They were designed and installed in late 2004, at a time when leachate extraction rates meant that the leachate elevation within the landfill was sitting below the current average leachate elevation of 40.89 m AHD, and most likely with the assumption that leachate extraction to achieve the required leachate elevation outlined in the EPA licence would continue indefinitely.

Another finding of the improved CSM includes:

> *Groundwater monitoring bores BH21 to BH24 have also been installed through the clay liner wall (as inferred in Figures 14 to 17: cross-sections N to Q). The screenshot below shows the extent of the southern clay wall versus the bore locations.*



Construction bore records indicate groundwater monitoring bores BH21 to BH23 drilled through approximately 6 m of fill before encountering natural material, while the bore record for BH24 indicates approximately 14 m of fill and overburden overlying natural material . While none of the bores screened through the fill material, they could potentially be influenced by runoff infiltration around the landfill perimeter, as the perimeter swale is located in very close proximity at the base of the clay wall.

4.5.3 Leachate Quality

Leachate quality trends were assessed by compiling time series data for selected leachate indicators (selected to comprise ammonia as N, potassium, alkalinity and BOD), which are summarised below in **Figure 14**.

It is important to emphasise that the trends in **Figure 14** are for three different locations (and depths) within the landfill, and therefore do not indicate leachate quality at a single point and depth.

Recent leachate sampling conducted in early 2020 on LP001, LP002 and LP003 confirmed that the leachate quality is similar to historical levels.

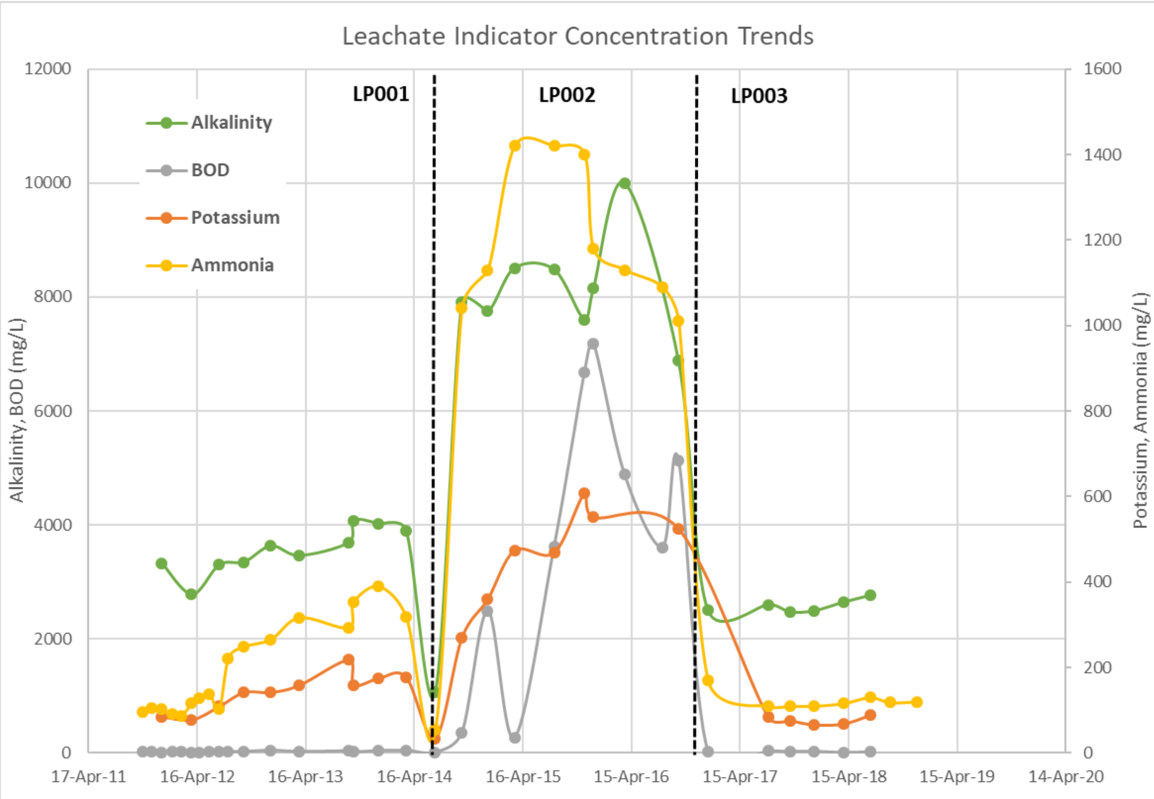


Figure 14: Leachate Indicator Concentration Trends

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Figure 14 indicates the following main features in relation to leachate chemistry:

- Between mid-2011 to mid-2014, leachate was being actively extracted from LP001, resulting in drawdown towards the 30 m AHD compliance level. Leachate strength at this stage was similar to current levels (i.e. in the order of 100 mg/L ammonia as N). The sampling depth from LP001 is unknown, but is inferred to be a similar depth to LP003 (45 m).
- Between mid-2014 to late-2016, leachate sampling was switched to LP002, after which a rapid and significant increase in leachate strength was observed (e.g. ammonia increased from approximately 200 mg/L to over 1400 mg/L). Based on previous reports, it had been assumed that LP002 was simply receiving leachate from LP001 until late 2016, at which point LP001 was buried under landfill, and leachate extraction was transferred to LP003 (Auxiliary Riser). Recent sampling of all leachate risers has, however, confirmed similar leachate composition to historical results. This suggests that leachate in LP002 was being extracted and sampled at a greater depth than LP001, and possibly in proximity to layers of organic waste deposited historically at the site.
- The switch to LP002 also saw an increase (i.e. recovery) in leachate RL, suggesting leachate extraction was curtailed or decreased during this period, possibly due to riser integrity issues.
- After late-2016, leachate sampling was switched to LP003, and leachate strength then decreased back to pre-LP002 levels, and similar to LP001.

The cause behind the observed trends is unclear, but is possibly due to the following factors:

- When LP001 was fully functional, low strength leachate at shallower depths was being extracted.
- As landfilling continued during 2014 to late-2016, the increasing overburden pressures around the main riser LP001 caused progressive failure of the concrete pipe, and likely made extraction progressively more difficult, resulting in a switch from LP001 to LP002.
- The switch from LP001 to LP002 changed the depth of extraction and sampling, with LP001 being relatively shallow, and LP002 being relatively deep.
- Anecdotal evidence from Cleanaway staff indicated that hydrocarbon-contaminated soils, timber logs and other bulk green waste were disposed at the landfill historically, the latter also being placed around the riser pipe as screening material in the latter stages of operation. This material would likely form preferential pathways for rainfall infiltration and decomposition of this organic material, combined with riser pipe failure (e.g. parting), resulted in high strength leachate entering the failed riser at depth, which was then recorded in samples from LP002 riser.
- Due to pipe failure, leachate extraction became more difficult, resulting in further recovery (i.e. increase) of leachate levels in LP002.
- When leachate extraction was switched to LP003 in late-2016, the leachate strength returned to lower concentrations typically reported prior to 2014. It is noted that the base of LP003 is at approximately 35 mAHD, so leachate cannot currently be drawn down to below this level with the existing infrastructure at the Site.

5.0 Provenance of Ammonia in Groundwater

The presence of elevated ammonia concentrations in groundwater surrounding landfills is often considered indicative of landfill leachate contamination, with background levels rarely exceeding 0.25 mg/L (Mikac, Cosovic et al. 1998) and leachate levels ranging from 3 mg/L to 3,000 mg/L. However, several other common sources of groundwater contamination, such as sewerage or septic system effluent and agricultural run-off containing organic or synthetic fertilisers, cemeteries and other organic sources may also contribute to ammonia in groundwater.

In the case of the Landfill, previous reports mention that the Wiannamatta Group, in particular the Ashfield and Bringelly Shales, contain naturally occurring ammonia, however, these are based on a dated report (Old, 1942). Some limited pre-landfilling groundwater monitoring data, collected by CSR during latter stages of quarry operations, also suggests that ammonia was present in groundwater prior to landfilling operations.

5.1 Lines of Evidence Approach

This issue was further investigated using a lines-of-evidence approach, consisting of the following tasks:

- Review and compilation of historical ammonia in groundwater data.
- Hydrochemical analysis of leachate and groundwater.
- Environmental isotopic (^{13}C-DIC, ^{15}N-NH_4) analysis of leachate and selected groundwater samples in the July 2019 monitoring event.

5.2 Review and Compilation of Historical Data

Tables 2 and 3 in **Section 3.2.5** summarise the limited groundwater analytical data from sampling conducted by CSR in 1981 and 1993, which was prior to commencement of landfilling operations. The data indicate the consistent presence of ammonia in groundwater at levels ranging between 0.9 mg/L to 7.1 mg/L. These levels are similar to levels measured since 2016.

The historical data indicates that ammonia was present in groundwater at the site prior to landfilling operations. While this may be regarded as *prima facie* evidence of naturally occurring ammonia, it may also have been due to some other, as yet unidentified, ammonia source(s) present at that time. As such, other lines of evidence were investigated.

5.3 Hydrochemical Analysis

Hydrochemical analysis consisted of evaluation of possible relationships between ammonia and groundwater quality, and trilinear plotting (i.e. Piper plots) of groundwater and leachate major cations and anion concentrations to assess for the potential of any mixing or separation.

5.3.1 Groundwater Salinity vs Ammonia Concentration

Figures 15 to 18 show a series of scatter plots showing the relationship between groundwater salinity (TDS) and ammonia (as N) concentrations for four separate monitoring events in summer and winter (June 2016, December 2016, June 2017, December 2017) to assess potential seasonal effects. The plots show a strong correlation between salinity and ammonia, which strongly suggests that ammonia, similar to salinity, is a feature of the connate nature of groundwater in the Wianamatta Group (Lovering, 1954). The exceptions to the observed correlation are BH17D and BH23, which form outliers to the general trend. BH17D is a deep well screened in brecciated volcanic material with low salinity (but high ammonia) groundwater, while BH23 is a shallow well with higher salinity (but low ammonia) groundwater.

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Both of these wells also exhibit an increasing ammonia trend and may simply be reflecting equilibration of the well water column with surrounding formation groundwater. BH23 also sits on the northern side of the perimeter drainage swale around the landfill footprint and may be influenced by shallow throughflow and infiltration in and around fissured landfill edges, as mentioned in the 2005 EIS, which indicated that compaction was difficult around the landfill edges, and that fissures were present where both LFG emissions and infiltration of rainfall and runoff was likely to be occurring. In addition, BH17D is located in close proximity to the wheel wash bay. A combination of these factors may have led to an ongoing accumulation of relatively fresh water in this more permeable material. This is supported by observed (possibly seasonal) shifts in BH17D salinity.

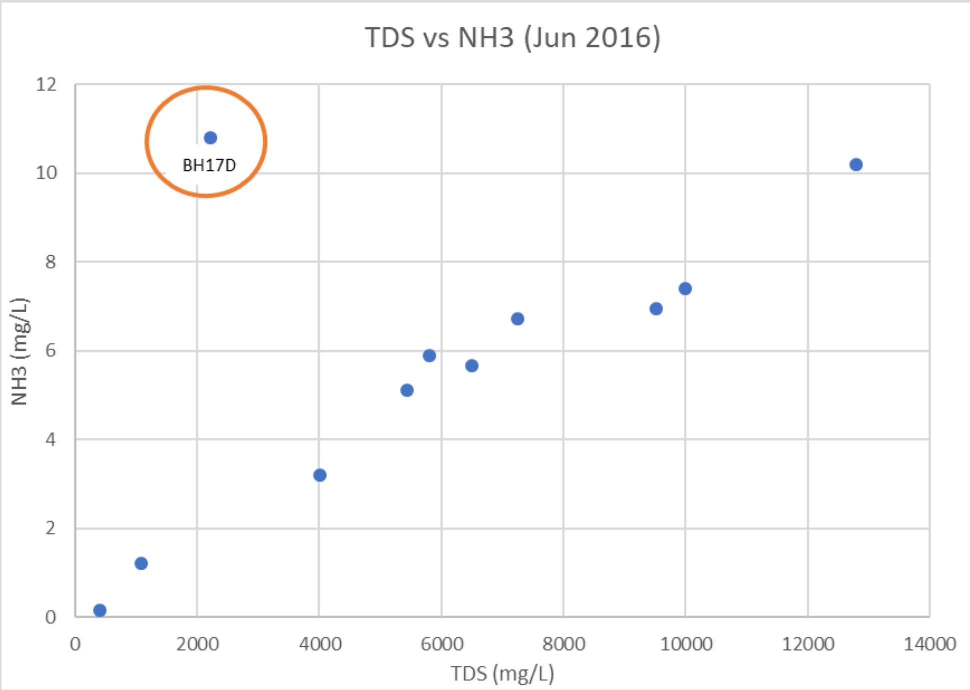

Figure 15: TDS vs Ammonia Concentrations (June 2016)

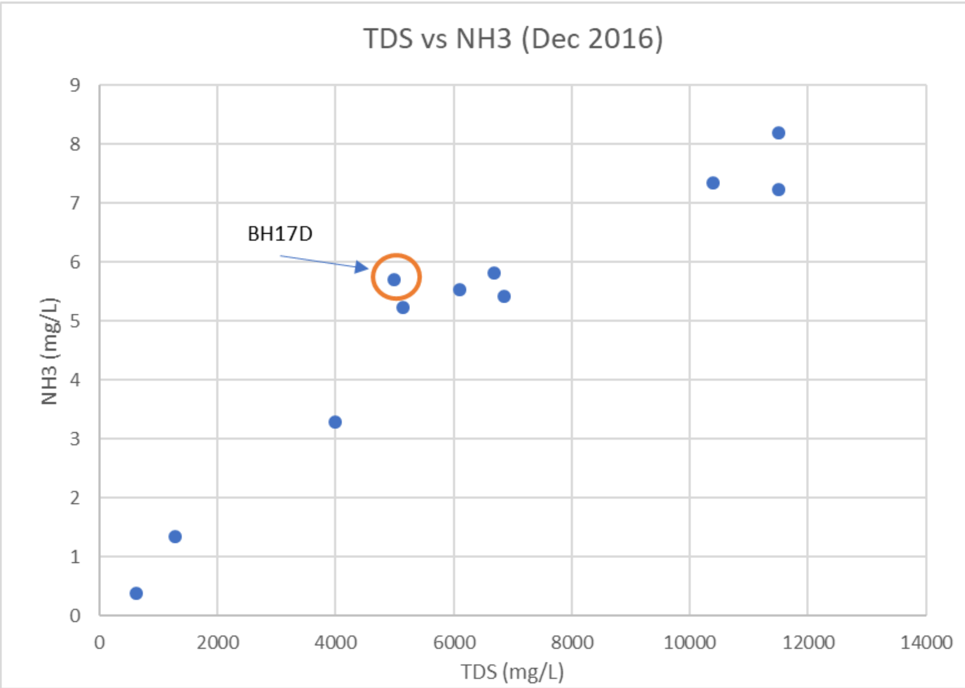

Figure 16: TDS vs Ammonia Concentrations (December 2016)

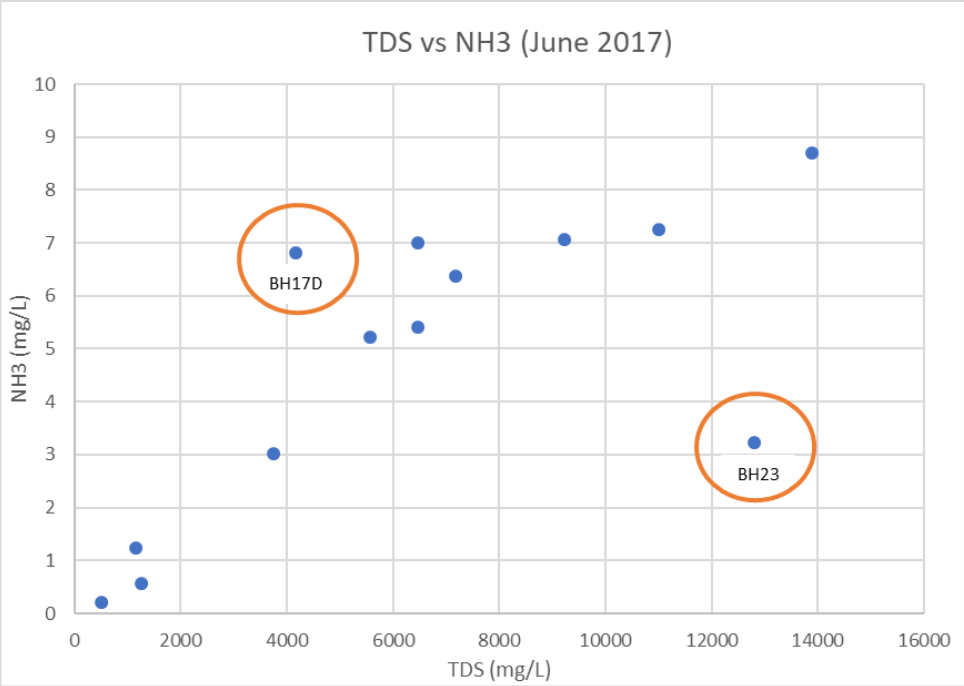

Figure 17: TDS vs Ammonia Concentrations (June 2017)

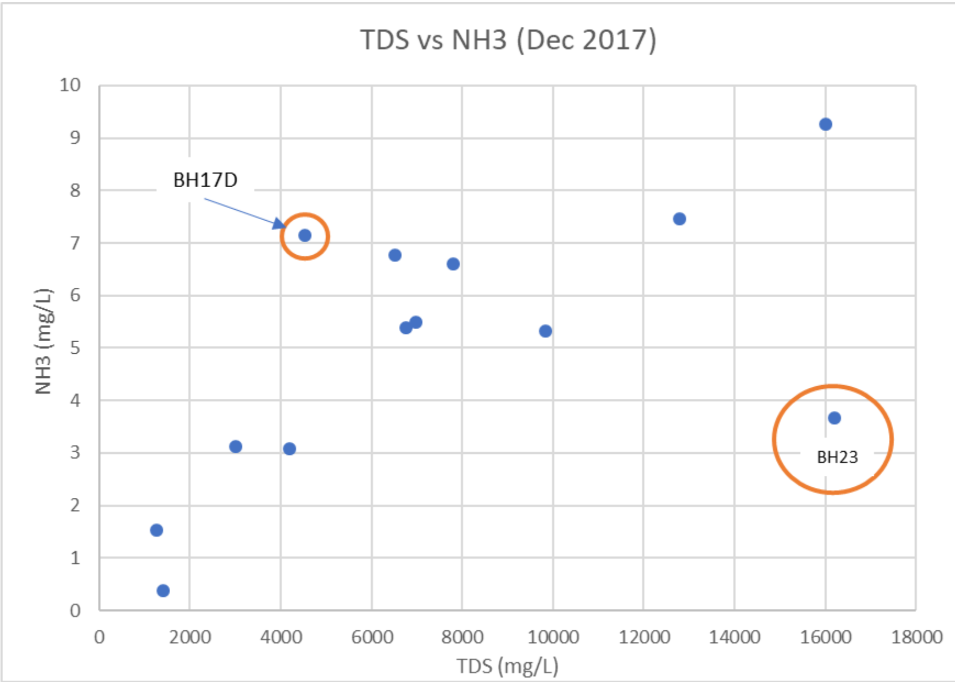

Figure 18: TDS vs Ammonia Concentrations (December 2017)

5.3.2 Well Depth vs Ammonia Concentration

Figures 19 to 22 are plots showing the well depth (in metres) vs ammonia concentrations in groundwater, and show a generally consistent correlation between bore depth and ammonia, which confirms that both salinity and ammonia increase with depth. This may be attributed to the connate (i.e. ancient) nature of groundwater in the Wiannamatta Group aquifers, as described in Lovering (1954). This correlation may also, however, possibly be attributed to density driven flow, or preferential migration from the base of the landfill, and so further lines of evidence were required (i.e. hydrochemistry, environmental isotopes).

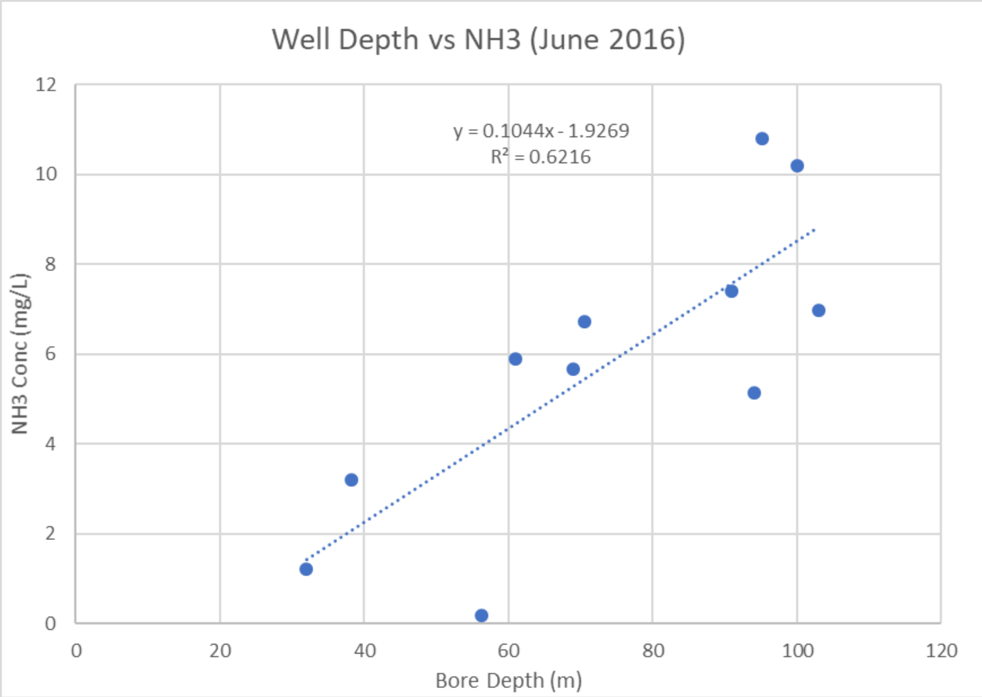

Figure 19: Bore Depth vs Ammonia Concentration (June 2016)

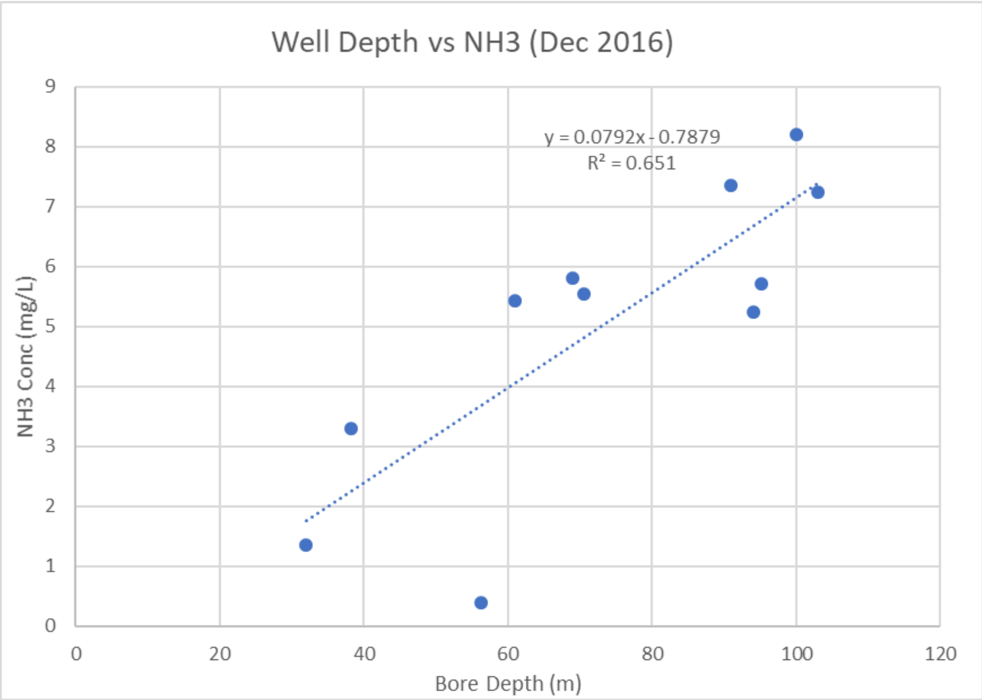

Figure 20: Bore Depth vs Ammonia Concentration (December 2016)

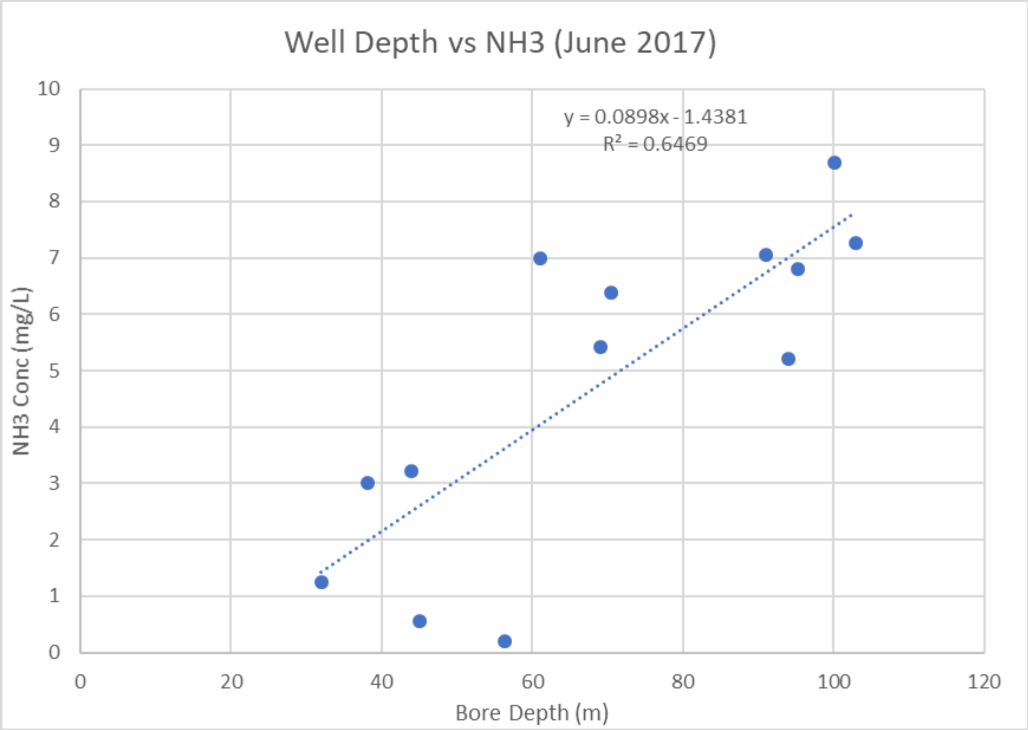

Figure 21: Bore Depth vs Ammonia Concentration (June 2017)

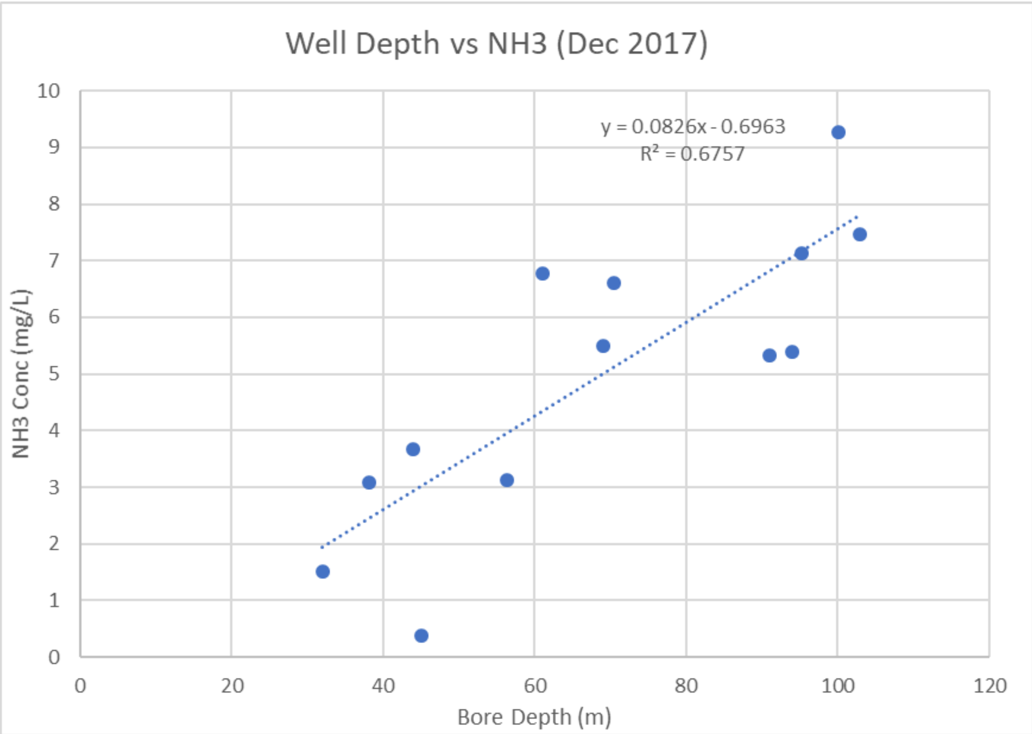

Figure 22: Bore Depth vs Ammonia Concentration (December 2017)

5.3.3 Piper Trilinear Plots

Figure 23 is a piper trilinear plot of groundwater ionic composition based on the 1993 data – the tight grouping (clustering) of data is readily apparent suggesting a consistent water type and origin.

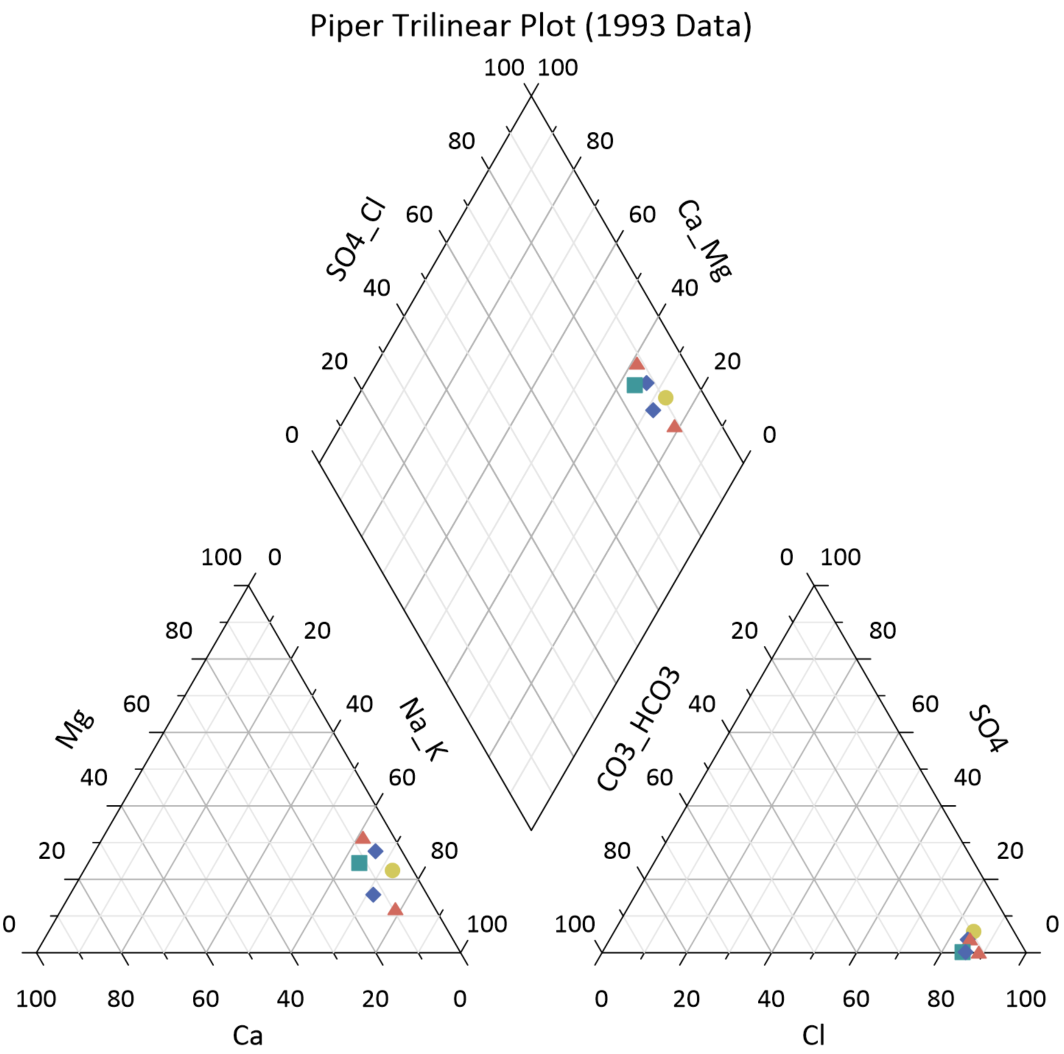

Figure 23: Piper Trilinear Plot (1993 data) (after CMPS&F, 1994) (note no leachate data available)

Figure 24 below is a piper plot based on July 2019 data, and includes both groundwater and leachate ionic data. The majority of wells plot within a hydrochemical grouping similar to that shown in 1993, with the exception that water quality at BH17D (and possibly BH20) appears to have some similarity to leachate at LP003.

BH17D intersected brecciated volcanic material similar to the quarried material (CES, 2009), and may be in hydraulic connection with the quarry walls and waste materials. The low salinity (and higher ammonia) in BH17D is difficult to explain but, as mentioned previously, possible explanations include more fissured ground and greater potential for infiltration, or its close proximity to an operational wheel wash bay, leading to an ongoing accumulation of a mixture of infiltrating wastewater and leachate in this more permeable material.

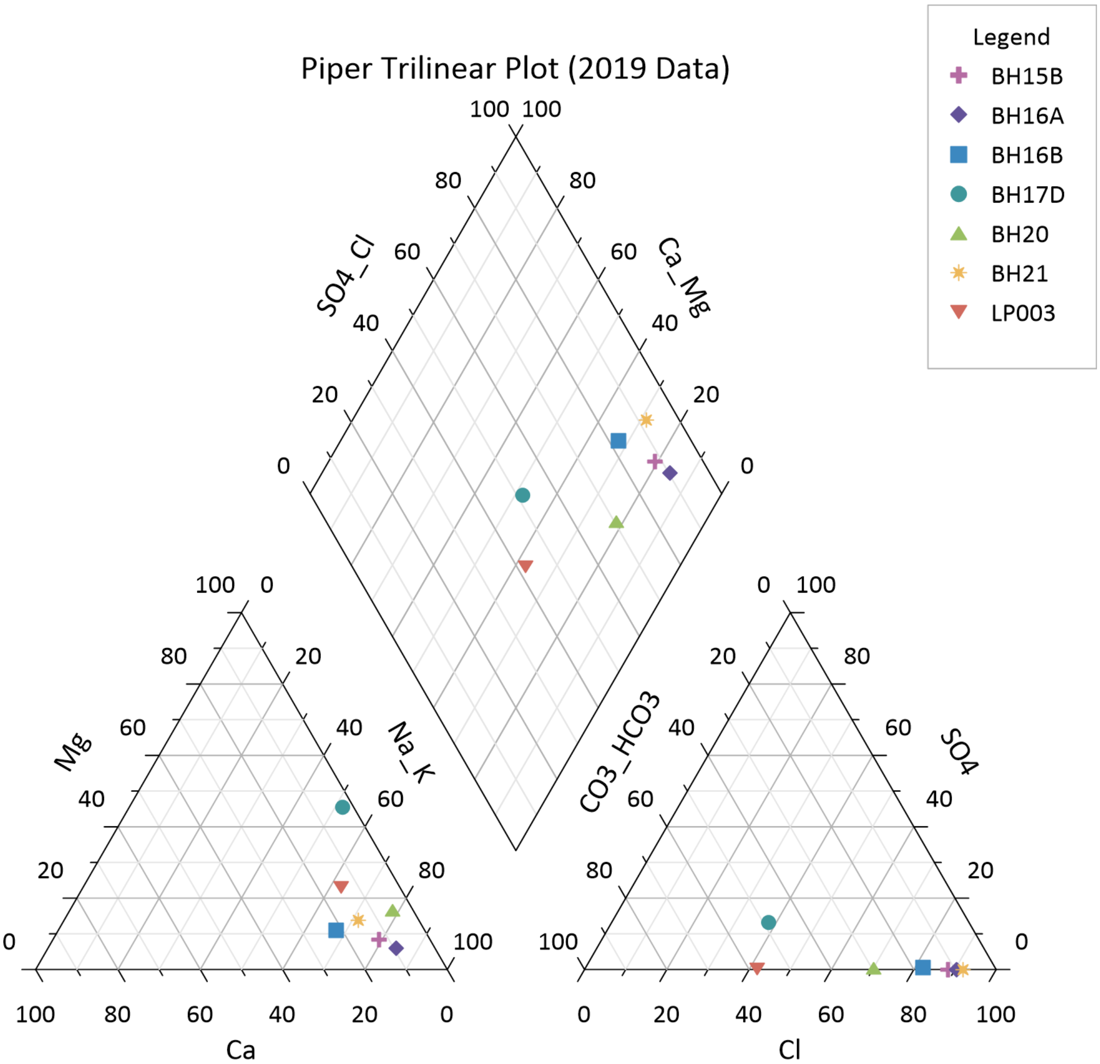

Figure 24: Piper Trilinear Plot (2019 data)

5.4 Environmental Isotopes

Hackley et al (1996) found that "*the stable and radiogenic isotope characteristics of carbon dioxide, methane, and associated leachates generated within municipal landfills are quite unique relative to the gaseous and aqueous media found in most surrounding environments*", and North and Frew (2007) found that "*the unique biochemical environment within a landfill gives rise to particularly extreme isotopic fractionation in certain microbial-mediated pathways, such as methanogenesis, and that results of analysis of ^{13}C in dissolved inorganic carbon (^{13}C-DIC), deuterium and ^{18}O in water D-H_2O and ^{18}O-H_2O), and ^{15}N of dissolved inorganic nitrogen components (^{15}N-NH_4^+ and ^{15}N-NO_3^-) for leachate collected from seven New Zealand landfills revealed three relatively distinct groups of leachate, based on the prevalent microbial activity (or landfill development phase) in the emplaced refuse generating the leachate sampled. These groups were defined as follows:*

- *Acetogenic phase leachate – characterised by relatively depleted ^{13}C-DIC (compared to typical values for methanogenic-generated leachate) with D-H_2O enriched relative to local, natural waters.*
- *Early stage methanogenic leachate – characterised by highly enriched ^{13}C-DIC (relative to organic matter ^{13}C) and D-H_2O, and ^{18}O-H_2O possibly enriched relative to local, natural waters; and*
- *Mature stage methanogenic leachate – characterised by enriched ^{13}C-DIC and D-H_2O".*

Based on the above, assessment of the provenance of ammonia in groundwater at the site was based on ^{13}C-DIC and ^{15}N-NH_4^+ isotopic analysis, to identify similar signatures or otherwise. **Table 10** below summarises the results of ^{13}C-DIC and ^{15}N-NH_4^+ isotopic analyses.

Table 9: **Summary of Isotopic Data**

Laboratory Sample ID	Well ID	Delta ^{13}C-DIC (‰)	Delta ^{15}N-NH_4 (‰)	NH_3 (mg/L)	Comment
C-1900038	BH15B	9.6	5.3	7.1	Groundwater
C-1900039	BH16A	-14.7	10.9	3.3	groundwater
C-1900040	BH16B	-6.7	10.7	7.1	groundwater
C-1900037	BH17D	-10.0	1.4	10.2	groundwater
C-1900043	BH17E	-6.9	5.6	7.3	groundwater
C-1900041	BH20	-3.7	7.4	3.4	groundwater
C-1900042	BH21	-5.9	4.6	7.6	groundwater
C-1900044	LP003	10.6	2.6	142	leachate
C-1900045	LP003_D	11.6	3.3	142	leachate

Figure 25 below is a plot of ^{13}C vs ^{15}N-NH_4, and it can be seen that LP003 (and duplicate LP003_D) are highly enriched in ^{13}C (mean of +10 ‰) relative to groundwater (mean of <-3 ‰), and a relative depletion in ^{15}N-NH_4, which varies widely relative to ^{13}C.

The exception is groundwater at BH15B, which is a deep monitoring well located immediately down hydraulic gradient of the Landfill, which has a similar ^{13}C signature to leachate at LP003. This suggests BH15B may be impacted to some degree by leachate, superimposed on background ammonia, however, even if this is occurring the concentrations are below the 15 mg/L criterion in the EPL and show a stable trend. Variations observed in TOC, EC and redox in BH15B suggest that, similar to BH17D, there may be some preferential infiltration of rainfall and entrained leachate around the landfill rim, resulting in a leachate/groundwater mixture, containing both naturally occurring and landfill derived ammonia. As previously discussed in relation to BH17D in **Section 4.5.2**, BH15B may also be impacted by runoff, as it is located within a ditch, where stormwater runoff can accumulate and seep into the bore.

Figure 26 is a plot of ^{15}N-NH_4 vs ammonia (as N) in groundwater, and there is a general inverse correlation which, based on previous analysis, means that ^{15}N-NH_4 decreases with depth. Gormly and Spalding (1979) identified a similar inverse correlation for ^{15}N-NO_3 and nitrate concentration beneath agricultural fields, and attributed this to increasing denitrification with depth. The degree of ^{15}N-NH_4 enrichment in groundwater at the site appears to be related to depth and, therefore, is possibly related to natural background (connate) conditions, with ^{13}C-DIC likely to be a better indicator of leachate impact.

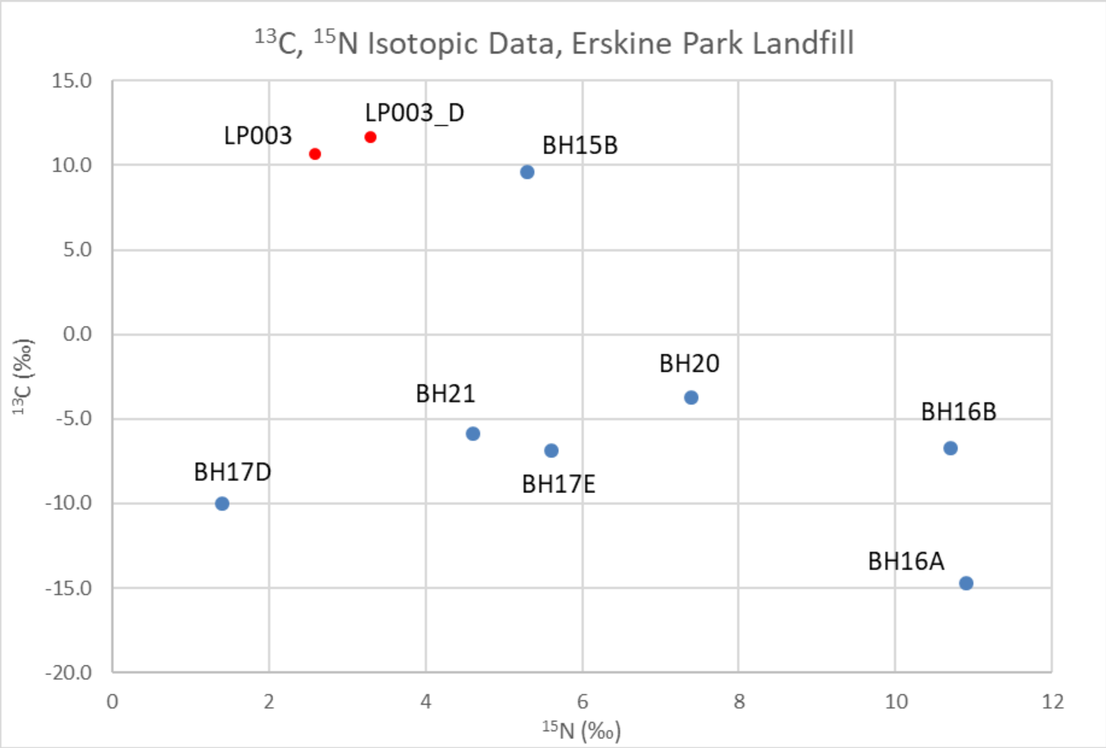

Figure 25: Isotopic Analysis (^{13}C vs ^{15}N-NH_4)

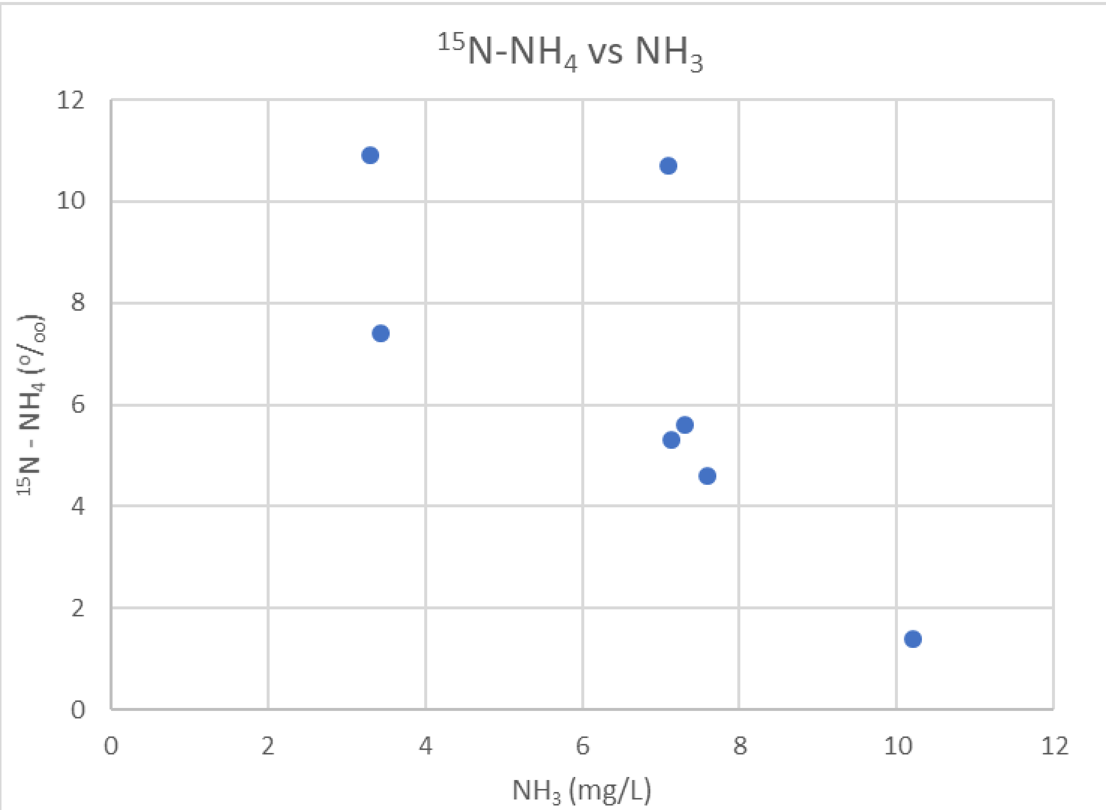

Figure 26: ^{15}N-NH_4 vs NH_3 in Groundwater

5.5 Summary of Findings

Several lines of evidence were compiled regarding the provenance of ammonia in groundwater surrounding the Landfill at the site, including:

- Review and compilation of historical ammonia in groundwater data.
- Hydrochemical analysis of leachate and groundwater.
- Environmental isotopic analysis (^{13}C, $^{15}N\text{-}NH_4$) of leachate and groundwater samples.

The lines of evidence suggest reported ammonia in existing site groundwater wells is predominantly naturally occurring, based on the following findings:

- Published literature relating to naturally occurring ammonia in the formation, dating back to Old (1942).
- Ammonia present in groundwater in wells located around the (then future) Landfill in 1981 and 1993, prior to commencement of landfilling activities.
- Relatively distinct hydrochemical signatures between groundwater and leachate (except for BH17D).
- Strong correlations between increasing depth, groundwater salinity and ammonia, suggesting a connate water source.
- Distinct isotopic signatures between groundwater and leachate, particularly ^{13}C-DIC. One outlier (BH15B) may be impacted by leachate based on:
  - Its location immediately down hydraulic gradient of the landfill.
  - Increasing water level and ammonia trends.
  - Isotopic signature.

Based on the above, it is concluded that any leachate seepage and associated ammonia impacts to the surrounding groundwater would be superimposed over pre-existing, background ammonium. Isotopic analysis offers a promising tool for separating out any potential landfill impacts from background ammonia.

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6.0 Conceptual Site Model

A conceptual site model (CSM) generally consists of the elements shown in **Figure 27**:

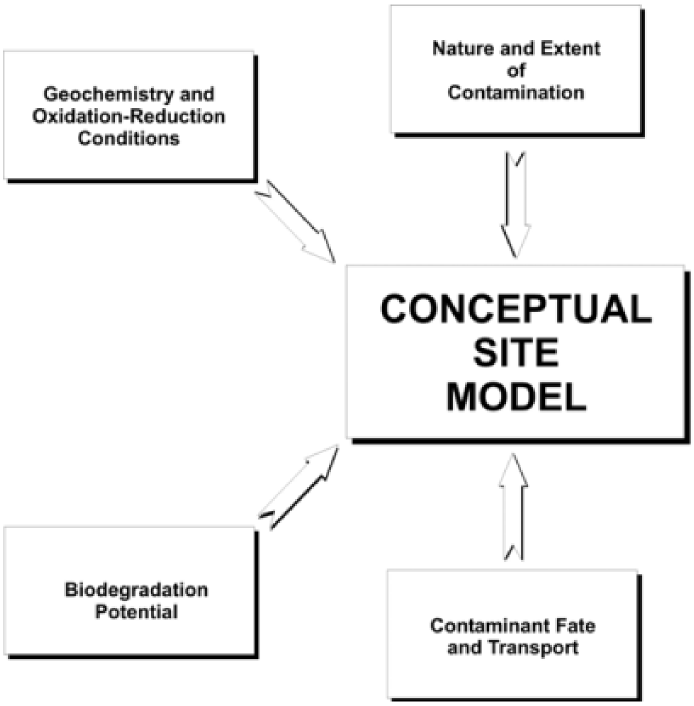

Figure 27: Typical CSM Elements

6.1 Leachate

Based on the previous findings, the CSM for the Landfill is considered to consist of the following key elements:

- Stratified waste and leachate quality, with high strength leachate present at depth, and low strength leachate at shallower depths, due to dilution from infiltrating rainfall.
- Sub-watertable setting, but with leachate mounding within landfill boundaries.
- Low permeability (10^{-8} m/sec to 10^{-9} m/sec) and low effective porosity aquifer characteristics.
- An overall westerly groundwater flow, with localised variations to the south and north.
- Generally low to very low groundwater seepage rates (< 1 m/year).
- Reducing groundwater conditions, due to naturally high organic content of Wiannamatta shales.
- Naturally occurring ammonia in groundwater, which persist due to the highly reducing conditions in connate, saline (>5,000 mg/L TDS) groundwater. Any leachate seepage would be superimposed over this background ammonia
- Possible localised influence on groundwater quality due to preferential infiltration around poorly compacted edges of landfill waste and adjacent unquarried, brecciated rock.

Figure 28 presents a schematic graphically illustrating the CSM.

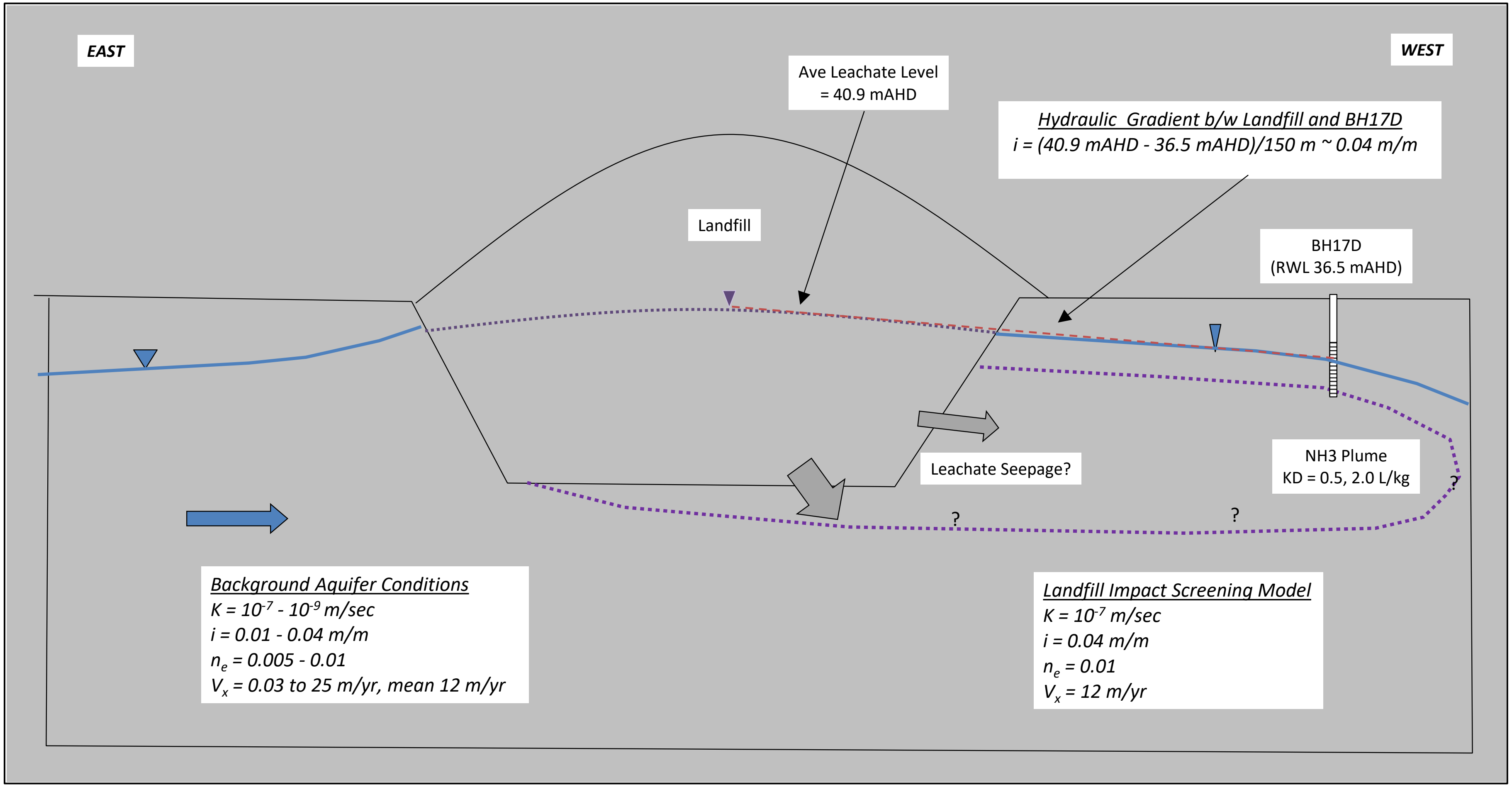

Figure 28: Erskine Park Landfill Conceptual Site Model

6.2 Landfill Gas

As displayed in **Figure 28**, the current leachate level in the landfill shows some mounding, however, its flatter than originally thought, and close to equilibrium levels with groundwater.

If Cleanaway was to draw the leachate level within the landfill down to RL 30 m AHD, approximately 25 m below the surrounding ground level, this would likely result in:

- An increase in landfill gas (LFG) generation from the unsaturated waste mass.
- An increased likelihood of significant LFG subsurface migration beyond the site premises unless additional controls were implemented.

Once the final landfill cap is installed, this is likely to:

- Prevent LFG emissions escaping into the atmosphere through the landfill surface.
- Increase LFG pressure within the landfill and force it to move laterally through the subsurface.
- Stop surface water recharge into the landfill.
- Cause leachate levels to decrease and equilibrate with the surrounding groundwater levels either with or without active leachate extraction, however, it will most likely take longer without active leachate extraction.
- Trigger an increase in LFG generation as more waste is exposed i.e. as more waste becomes unsaturated.

6.3 Sensitive Receptors

6.3.1 Groundwater receptors and users

There appears to be an absence of groundwater receptors due to the lack of the following characteristics:

- No records of private groundwater users within 500 m of the site (as based on search of Australian Groundwater Explorer).
- Difference in groundwater elevations and drainage line levels mean that groundwater / surface water interactions are unlikely to occur; and
- Highly saline groundwater and likely low bore yields, which indicate groundwater is likely to be of limited beneficial use.

6.3.2 Landfill Gas Receptors & Surrounding Land Uses

Until recently, the site was mostly surrounded by low density rural residential land zoned Rural 1A, however, in recent years several commercial/industrial estates have been constructed around the site (refer **Figure 1**), as it sits within the Erskine Business Park Precinct; including uses such as warehousing, logistics and manufacturing operations.

The landfill is fully surrounded by approximately 14 different parcels of land, all of which appear to include industrial uses, apart from two parcels of land which manage water entering the South Creek tributary to the north west of the site (i.e. north west dam and channel to the creek) and water flowing through the South Creek tributary to the south of the site. Buildings and underground services both on site and in the surrounding properties are potential landfill gas receptors.

The edge of the nearest residential area is approximately 600 m to the north of the site, known as the suburb of St. Clair. Transmission lines occupy vacant land to the south of the residential area, approximately 500 m north of the landfill.

A number of sensitive receptors are located approximately 800 m south of the landfill including a retirement village, early learning centre, primary school and college.

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6.4 Improved Conceptual Site Model

As a separate exercise, Cleanaway required the preparation of the landfill perimeter cross-sections, primarily to assist in the location of additional landfill gas (LFG) extraction wells within the waste footprint and to finalise the future cap tie-in details (subject of a separate report).

The cross-sections were also required to better understand whether a potential LFG subsurface migration pathway exists between the source of landfill gas, i.e. the waste, and surrounding sensitive receptors such as on and off site buildings. This information has been included in **Appendix A**.

As our understanding of the site over the last few months has grown as further information became available, Senversa identified that the site setting around the landfill perimeter and the landfill construction itself differs significantly along sections of the perimeter, and it was agreed that one typical perimeter cross-section would not be sufficient to represent the landfill's CSM. Twenty cross-sections have been prepared, in order to best capture the various site features and sensitive receptors surrounding the landfill, including the clay side liner wall, various leachate drainage blankets, the first quarry bench, recent test pit information collected in late 2019, the average leachate elevation across the landfill, the surrounding groundwater elevations in the nearest monitoring bores, the buried Austral Bricks gas feed pipeline and the surface profile of the surrounding land, both on and off site, between the edge of waste and the closest on and off site buildings.

The location of the cross-sections is shown in the attached Figure 1, while the twenty cross-sections are referred to as Figures 2 to 21, inclusive.

The main groundwater related findings included:

- The leachate drainage blanket installed along the first quarry bench in the south, could potentially contribute to leachate migration from the waste into groundwater, as its elevation is in very close proximity to the average leachate elevation assumed when preparing the CSM cross-sections.

The elevation of the leachate drainage blanket installed along the first quarry bench in the south and south east corner sits at approx. RL 41 m AHD to 42 m AHD. The current average leachate elevation is assumed to be approx. 40.89 m AHD. It appears the leachate drainage blankets were installed along the quarry rim and first quarry bench in sections where these areas appeared too flat, and it was considered potential leachate generated above these points required assistance to drain back into the landfill. They were designed and installed in late 2004, at a time when leachate extraction rates meant that the leachate elevation within the landfill was sitting below the current average leachate elevation of 40.89 m AHD, and most likely with the assumption that leachate extraction to achieve the required leachate elevation outlined in the EPA licence would continue indefinitely.

The main findings from the CSM relating to the potential subsurface migration of landfill gas include:

- Unsaturated waste zones and unsaturated fill/natural soil zones outside the landfill indicate that potential gas migration pathways exist between nearly all sections of the landfill perimeter, i.e. the landfill waste and surrounding sensitive receptors such as on and off site buildings. While these pathways may not be realised in the current site setting, they may be realised in future when the landfill is fully capped, with an increased potential for lateral gas migration.
- The closest buildings, structures and underground services are at greatest risk from potential subsurface landfill gas migration, such as the on site transfer station, the leachate treatment plant, associated underground pipes, pits, trenches etc. and the workshop. The three stormwater pits approx. 20 m north of the edge of waste could transfer migrating landfill gas directly toward the stormwater pit sitting just outside the workshop. The workshop itself is approx. 30 m from the waste edge. The leachate treatment plant is approx. 20 m from the waste edge and the transfer station building is approx. 65 m from the edge of waste.
- Off site buildings and buried drainage pipes and pits within industrial premises to the north and east of the landfill are also at greatest risk from potential subsurface gas migration, potentially more so than on site buildings, with buildings sitting within approx. 30 m to 50 m of the waste edge, and underground drainage infrastructure potentially closer, between approx. 20 m to 40 m away.

- Off site buildings and buried drainage pipes and pits within industrial premises to the south and south west of the landfill are also at risk from potential subsurface gas migration, with buildings situated approx. 120 m from the waste edge, and underground drainage infrastructure potentially closer, between approx. 60 m to 100 m away.
- Off site buildings and buried drainage pipes and pits within industrial premises to the west of the landfill are also at risk from potential subsurface gas migration, with buildings situated approx. 90 m from the waste edge, and underground drainage infrastructure potentially closer, between approx. 80 m to 90 m away.

The imminent changes to site conditions, i.e. falling leachate level, installation of the final cap and an increase in LFG generation, will increase the likelihood of off site LFG subsurface migration. The short distance to some of the neighbouring buildings, structures and possibly underground services and infrastructure, i.e. less than 30 m away, further exacerbates this risk.

It would appear, given the circumstances described above, that lowering the leachate level within the landfill some 25 m below ground level (to meet EPA licence criterion), would be detrimental to the ongoing management of LFG generated by the site, and would create an unacceptable risk to nearby receptors, i.e. neighbouring sites. Senversa has recently prepared a Landfill Gas Risk Assessment (LFG RA) Report for the site, which describes the current status of the LFG extraction system and monitoring network (report reference S17375_RPT_004_Rev0_LFGRA).

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7.0 Solute Transport Modelling

The current leachate compliance level in the EPL is based on the principle of creating an inward hydraulic gradient to the landfill. Given that the lowest groundwater elevations were in the order of 31 m AHD (BH18, BH19), the compliance level was set at 30 m AHD.

This section provides an assessment of the effect of the current leachate level (assumed to be the average leachate level as measured in 2020 (40.9 m AHD) on the landfill risk profile with respect to groundwater impacts. The assessment is based on one-dimensional analytical solute transport modelling using BIOSCREEN (USEPA, 1996).

The solute transport screening modelling adopted a conservative approach by assessing potential ammonia plume migration from the landfill to BH17D, which has the highest hydraulic gradient between the landfill and bore, and is located on the western side of the landfill (i.e. where leachate seepage is most expected to occur). The entire plume domain is assumed to be in the surrounding natural rock, i.e. the leachate source head and concentration terms (40.9 mAHD, 140 mg/L NH_3) are located at the edge of the landfill, and waste permeability is ignored.

7.1 Objectives

The objectives of the solute transport modelling are to:

- Provide estimates of ammonium in groundwater travel times.
- Provide predictive estimates of the future extent and concentration of the dissolved ammonium plume by simulating the combined effects of contaminant loading (i.e. mounded leachate), and advection, dispersion, adsorption and decay processes.

7.2 Model Input Parameters

The model input parameters are summarised in the Data Input Sheet at the end of this section. To provide a level of conservatism, the source was modelled as a continuous source of infinite mass. The hydrogeological parameters have been discussed in previous sections. Other, model-specific parameters are discussed in the following sections.

The solute transport modelling was based on many simplifying assumptions regarding sources, the aquifer and ammonium behaviour, does not consider preferential flow paths (e.g. interaction with drains) and is for screening purposes only.

7.2.1 Dispersion

The model requires an estimate of longitudinal dispersivity (LD) and ratios of LD to transverse dispersivity (TD) and vertical dispersivity (VD). LD may be estimated based on the known plume length, which in this case is the distance between the landfill edge and monitoring well BH5, estimated at approximately 250 m, or 820 feet. Gelhar et al (1987) conducted statistical analysis of dispersion and produced the following algorithm:

$$LD = 0.83\,(\log_{10}(\text{plume length}))^{2.414}$$

Based on an assumed plume length of 150 m (~500 feet) the estimated LD is around 18 feet (~5.5 m). The transverse dispersivity is assumed to be 0.1*LD, while vertical dispersivity (typically orders of magnitude smaller than LD) is ignored.

7.2.2 Retardation

Sorption is an important attenuation mechanism for ammonium, with the predominant mechanism being cation exchange occurring at mineral surfaces. Sorption of dissolved ionic contaminants can occur as a result of:

- Electrostatic forces leading to cation exchange – the replacement of a previously sorbed cation such as Na^+ or Ca^{2+}, by another positively charged ionic species.
- The action of van der Waals forces, hydrogen bonding, ligand exchange, surface complexation, dipole forces and hydrophobic forces which cause adsorption (attachment of a contaminant to a solid surface).
- Diffusion of a contaminant into the structure of a porous particle, termed absorption. For practical purposes, these processes are often grouped and assessed with a single sorption parameter. The term sorption is used to cover partitioning processes in general (that is, partitioning between solute and solid) and the process of attachment to the soil or aquifer matrix (retardation).

UKEA (2003) reported that the degree of ammonium attenuation is strongly dependent on the clay mineralogy of the strata and the chemical composition of the contaminated fluid. Based on the limited literature available, UKEA (2003) provided guidance on the rates, under representative conditions, of ammonium attenuation in soil and groundwater by retardation and nitrification. The retardation in the migration of ammoniacal-nitrogen in relation to chloride and organic carbon is due to the effect of cation exchange on clay minerals present within the rock or, in the case of the site, the Wiannamatta Group shales, which are known to be weathered and high in organic content.

Table 11 summarises the results of ammonium partition coefficients (Kd's) for the Sherwood Sandstone (UKEA, 2003).

Table 10: **Ammonium Partition Coefficients (Kd's) in Sherwood Sandstone (after UKEA, 2003)**

Reference	Scale	Solution	CEC (meq/100 g)	Concentration Range (mg/L)	Kd (ml/g)
Davison and Lerner (1998a)	Batch	Spiked Groundwater	N/A	0-500	0.4-0.6
Colley (1991)	Batch	Leachate	0.7	185	0.61
Erskine (2000)	Field (15 m)	Leachate	N/A	1-100	0.16-0.24
UKEA (2000b)	Batch	Spiked artificial	4.55	10-40	1.33
UKEA (2000b)	Batch	Spiked artificial	8.66	10-40	1.75
Jackson (1989)	Batch	Leachate	21.7	493	0.42
Thornton et al (2000)	Column	Leachate	1.63	0-1400	0.076
Thornton et al (2000)	Column	Leachate	1.63	0-1980	0.106
Thornton et al (2000)	Column	Leachate	3.24	0-1030	0.394
Butler et al (2003)	Field/Model	Leachate	1.63	0-1000	0.12

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UKEA (2003) also reported the following:

- Kd results for an aquifer within the range 0.23 ml/g to 0.57 ml/g, with no apparent scale dependency.
- A Kd value from groundwater plume concentrations was estimated at between 0.08 ml/g and 0.11 ml/g.
- Using artificial sewage effluent in batch tests, Kd values of 0.66 ml/g and 0.88 ml/g were obtained.
- Using column experiments, Kjeldsen and Christensen (1984) observed increasing Kd values with increasing clay content in a series of four soils. These are reported as between 0.047 ml/g and 0.080 ml/g for a medium sand with 1.3% clay to between 0.39 ml/g and 0.67 ml/g for a clayey silty sand with 13.4% clay.

Table 12 presents a compilation of suggested Kd values for general assessment of ammonium attenuation in different lithologies for dilute mixed solutions.

Table 11: Guideline Kd values for Ammonium in Dilute Solutions (after UKEA, 2003)

Lithology	Kd range (ml/g)	Comments
Chalk	0 – 0.03	Low confidence as isotherms have not been identified
Triassic Sherwood Sandstone	0 – 0.2 – 0.6	Reasonable confidence as there have been several independent tests, though most values are from one site only (Burntstump).
Lincolnshire Limestone	0.065 – 0.65	Low confidence as isotherms have not been identified
Lower Greensand 'Hassock'	0.18 – 1.8	Low confidence as no isotherms have been found. Measurements have been on the 'Hassock' lithology only. A lower bound of zero should be used for Lower Greensand in general.
Red Crag	0.05 – 0.5	Low confidence as isotherms have not been identified
Oxford Clay	0.15 – 1.5	Low confidence as isotherms have not been identified
Mercia Mudstone	0.5 – 5	Low confidence as isotherms have not been identified
Gault Clay	0.65 – 6.5	Low confidence as isotherms have not been identified
Lias Clay	1.2 – 2.6	Low confidence as isotherms have not been identified.
Coal Measures Clay	0.018 – 0.18	Reasonable confidence as these values are probably very pessimistic, being derived from clay-sand mixtures.
Sand and gravel, clean	0 – 0.4 – 0.9	Reasonable confidence as there have been several independent tests.
Cohesive Boulder Clay (Glacial Till)	2 – 4	Low confidence as isotherms have not been identified. Glacial Till is naturally a very heterogeneous lithology so a full site characterisation should be made and the risk assessor must be very confident that there are no sandy sequences in the Till.

Figure 29 graphically summarises the results of the above tabulated ammonium partition data.

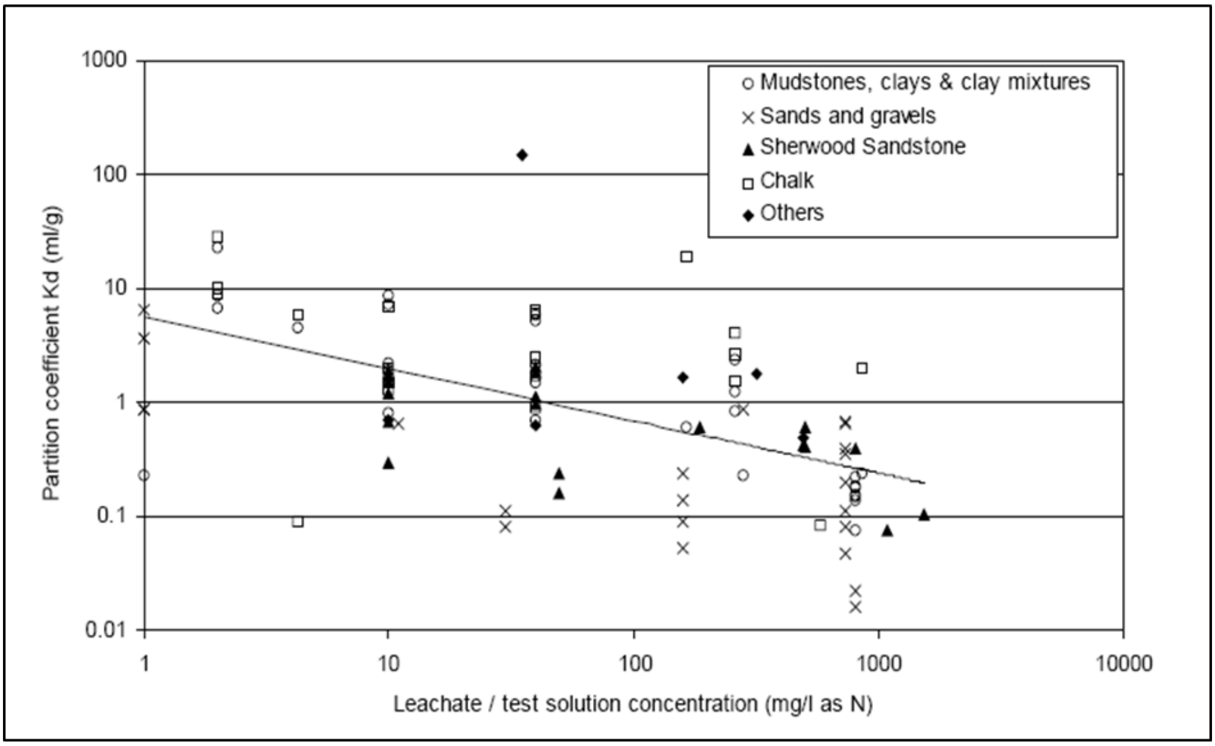

Figure 29: Ammonium Partition Coefficients According to Lithology (after UKEA, 2003)

7.2.3 Ammonium Half Life

Table 13 summarises the UKEA (2003) review of ammonium biodegradation (i.e. nitrification) in different lithologies under aerobic and anaerobic conditions, in terms of ammonium half-life. Ammonia is known to rapidly nitrify to nitrate in aerobic conditions, but persist in anaerobic conditions. This is reflected in the 'infinity' value for ammonium half-lives in anaerobic conditions, and may explain the persistence of ammonium (and relatively low concentrations of nitrate at the site) in the Wiannamata Group shales. The shale rocks would also have a very small pore size which would prevent the entry of nitrifying bacteria.

Based on the half-life data, a very large ammonium half-life (999 years) was applied to ammonium solute transport modelling.

Table 12: **Guideline Half-lives for Ammonium Biodegradation (Nitrification) (after UKEA, 2003)**

Lithology	Ammonium half-life under aerobic conditions (years)	Ammonium half-life under anaerobic conditions (years)	Comments
Sands and gravels	1 - 6	Infinity	Based on range of literature derived values (<1-6 years) in unsaturated subsoil and aquifers
Unfissured Chalk and other strata with mean pore size of ≤1 μm	Infinity	Infinity	No degradation – pore size excludes entry of bacteria
Strata with mean pore size of >1 μm or showing a significant degree of fissure flow	5 - 10	Infinity	No kinetic data exist but attenuation has been demonstrated to take place. Suggested range (5-10 yrs) is considered reasonably conservative.

7.2.4 Model Input Summary

Figure 30 below is a reproduction of the model data input used for the model run based on mean seepage rate, low retardation (Kd = 0.1 ml/g) and the mean groundwater seepage rate.

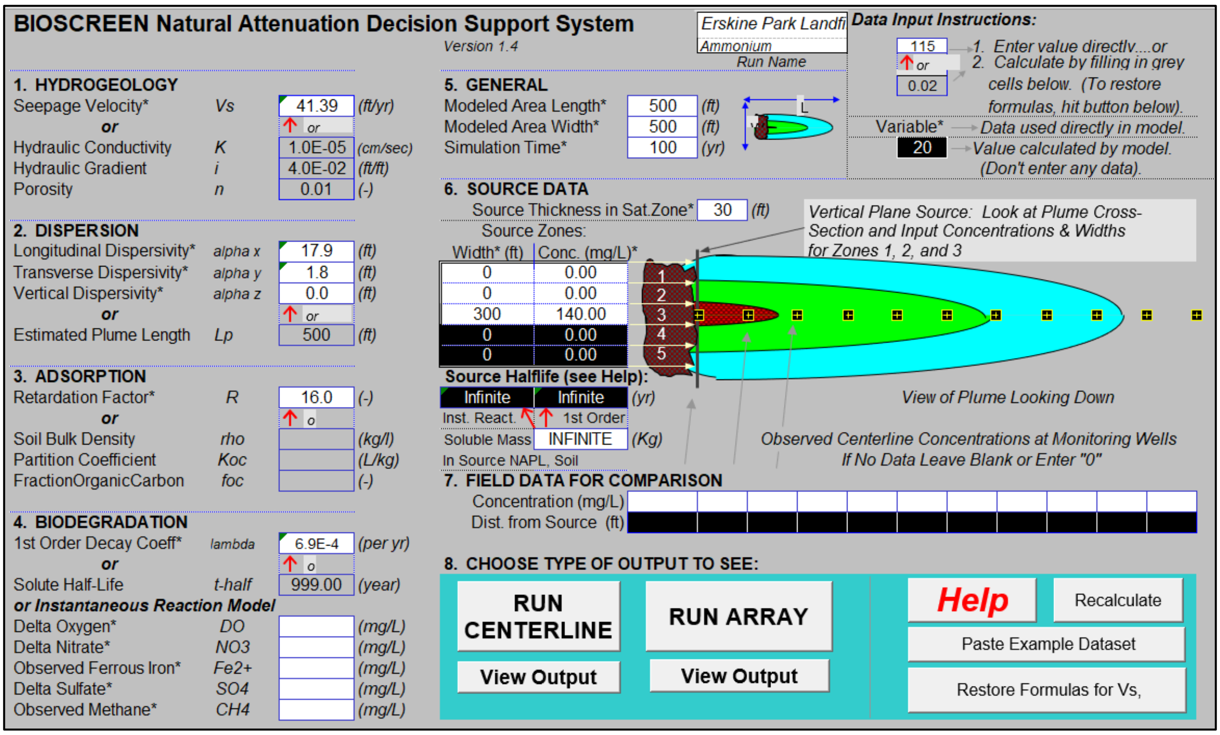

Figure 30: Model Data Input Summary

7.3 Modelling Results

7.3.1 Time of Travel Estimates

Based on the above, the ammonium partition coefficients for similar lithology to that at the site (mudstones, clays, clay mixtures) ranges between 0.1 ml/g and 2 ml/g. The retardation factor is calculated by the following equation:

$$R = 1+(BD/n)*Kd$$

Where: BD = bulk density (g/cc)

n = porosity

Kd = partition coefficient (ml/g)

Based on a Kd range of 0.1 ml/g to 2 ml/g (which covers the majority of published literature values), a bulk density of 1.5 and total porosity of 0.01, retardation factors for ammonia were derived, and ranged between 75 and 300. Based on groundwater seepage rates in **Section 4.4** (**Table 7**), the retarded ammonium seepage rates were estimated, and summarised in **Table 14** below.

Table 13: Estimated Retarded Ammonium Seepage Rates and Travel Times to BH17D (x = 150 m)

Estimated Groundwater Seepage Rate (m/year)	Retarded Ammonium Seepage Rate (m/year) (Kd = 0.1 ml/g)	Retarded Ammonium Seepage Rate (m/year) (Kd = 2 ml/g)	Estimated Ammonium ToT to BH17D (years) (Kd = 0.1 ml/g)	Estimated Ammonium ToT to BH17D (years) (Kd = 2 ml/g)
5.2×10^{-3}	2.9×10^{-4}	1.5×10^{-5}	5.2×10^{5}	9.9×10^{6}
7.2×10^{-1}	4.0×10^{-2}	2.1×10^{-3}	3.8×10^{3}	7.1×10^{4}
2.5×10^{1}	1.4×10^{0}	7.4×10^{-2}	1.1×10^{2}	2.0×10^{3}

Based on the above, it is estimated that an ammonium plume would take between 110 to 9,900,000 years to migrate from the landfill to BH17D. These very long travel time frames suggest a low risk of significant off site impacts to groundwater quality due to ammonium migration.

7.3.2 Solute Transport Modelling

Figures 31 and **32** below are reproductions of the model outputs for the following scenarios:

- Mean groundwater seepage rate (12 m/year), mean retardation (1 l/mg), simulation time = 100 years.
- Maximum groundwater seepage rate (25 m/year), low retardation (0.1 l/mg), simulation time = 100 years.

The modelling scenarios are intended to provide for reasonable and worst-case transport scenarios.

DISSOLVED AMMONIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	50	100	150	200	250	300	350	400	450	500
No Degradation	140.000	26.962	0.731	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											

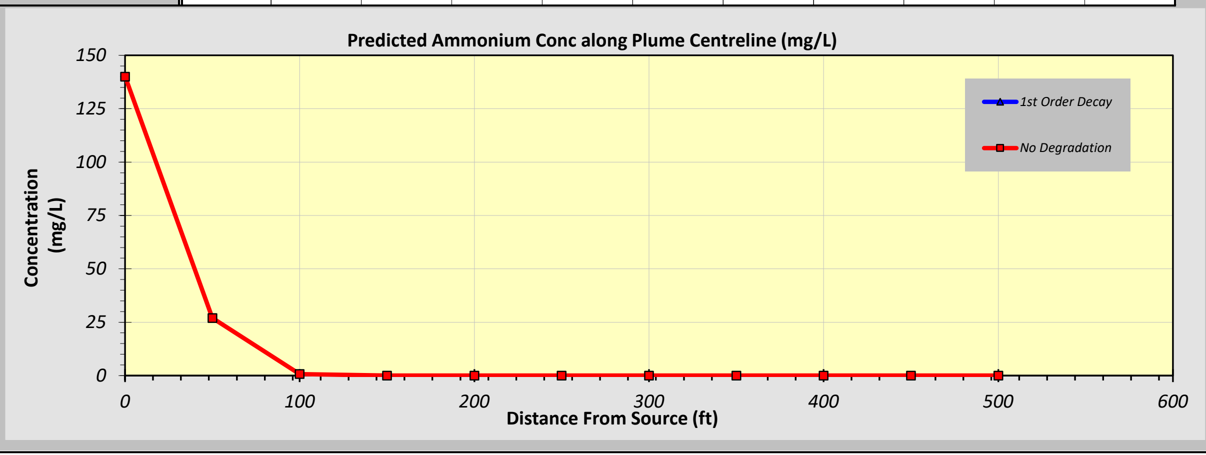

Figure 31: Predicted Ammonia Plume Migration (mean groundwater seepage rate, mean retardation, 100 years simulation time)

DISSOLVED AMMONIUM CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	100	200	300	400	500	600	700	800	900	1000
No Degradation	140.000	130.322	91.568	34.325	5.304	0.295	0.006	0.000	0.000	0.000	0.000
Field Data from Site											

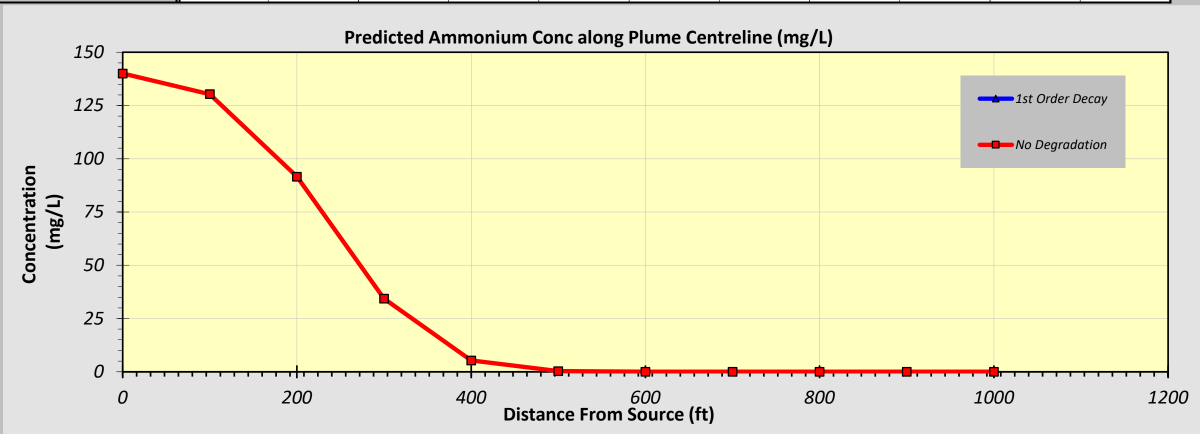

Figure 32: Predicted Ammonia Plume Migration (maximum groundwater seepage rate, low retardation, 100 years simulation time)

The modelling results indicate a limited potential extent for ammonium migration, even under the conservative scenario (maximum seepage rate, low retardation), where 140 mg/L NH_3 is predicted to migrate approximately 180 m (~600 feet) in groundwater after 100 years. The reasonable case model results in potential ammonia migration of only 50 m (150 feet) over 100 years.

Given that landfilling commenced approximately 25 years ago, it is feasible that some slight increasing trends in ammonia in groundwater are observed in wells located very close to the landfill edge (e.g. BH21, BH22 and BH23), however, the potential for plume migration may still be regarded as low.

8.0 Conclusions

Based on the investigation and modelling results, the following conclusions were made:

- The current monitoring well network is considered fit for purpose, with the exception of a few wells which were either lost, deployed faulty sampling pumps, sampling pumps are not installed within the bore's screened interval, have potentially silted up or have been compromised, or were found to be dry. BH5 requires replacement.
- The landfill's physical setting consists of low to very low permeability (10^{-7} m/sec to 10^{-9} m/sec) shale bedrock, high in natural organic matter, hosting connate, saline and highly reduced groundwater.
- Groundwater seepage rates are calculated to be low to very low, ranging between a minimum of 0.03 m/year to maximum of 25 m/year.
- The leachate compliance level (30 m AHD) is inferred to be based on the principle of creating an inward hydraulic gradient to the landfill, which is only relevant if leachate migration presents a potential risk to surrounding groundwater beneficial uses and sensitive receptors.
- The groundwater beneficial uses surrounding the landfill are very limited, due to low to very low aquifer yield and high salinity and there are no sensitive receptors within 1 km of the landfill.
- Groundwater levels to the north of the landfill are below the drainage line inverts and as such, groundwater discharge to surface water is unlikely in this direction.
- Over the course of leachate monitoring since 2016, there have been sporadic exceedances of the EPL 4865 Condition U1.1 (ammonia reporting compliance concentration of 15 mg/L) and occurring only in samples from BH17D. Whether these exceedances are due to leachate seepage is unclear, and there may be other factors involved (surface water runoff, seepage from wheel wash bay).
- Various lines of evidence indicate that ammonia reported to be present in groundwater surrounding the Landfill is present as background, including:
  - Published literature relating to naturally occurring ammonia, dating back to Old (1942).
  - Groundwater analysis conducted in the early 1980s and 1990s, indicating the presence of ammonia in groundwater prior to commencement of landfilling activities.
  - Relatively distinct hydrochemical signatures between groundwater and leachate, with the exception of BH17D, which is similar to leachate - this is either attributed to BH17D being screened in similar (previously quarried) brecciated material, potential bore damage, or landfill surface water runoff ingress into the bore from ground level.
  - A correlation between depth, groundwater salinity and ammonia, suggesting a connate water source.
  - Distinct isotopic signatures between groundwater and leachate, particularly for ^{13}C-DIC. One outlier (BH15B) may be impacted by leachate, based on its location immediately down hydraulic gradient of the landfill. This bore may also be showing signs of impact from surface water runoff ingress into the bore from ground level. Further monitoring and isotopic analysis is required to confirm. The isotopic signature of BH17D suggests the ammonia in this well is not related to leachate.
- There are increasing ammonia concentration trends in some groundwater wells, mostly those with groundwater elevations lower than the leachate elevation. These increasing concentration trends appear to be related to increasing groundwater levels. Reported ammonia concentrations remain, for the most part, well below the 15 mg/L EPA licence limit, however, this may simply reflect a gradual equilibration of well water with surrounding formation groundwater.

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- Time of travel and solute transport screening modelling was completed to assess travel times of ammonium in the landfill to reach BH17D, located approximately 150 m down hydraulic gradient, via groundwater migration. The modelling was based on several different scenarios, based on variations in groundwater seepage rate and retardation factors. The results indicate that travel times for ammonium in groundwater are very long (over 100 years for ammonium to migrate from the Landfill to BH17D using worst case assumptions).
- Based on the above lines of evidence and recognising the many simplifying assumptions involved with screening modelling, it is concluded that the Erskine Park Landfill, even without active leachate extraction and continued leachate mounding, presents a low risk to surrounding and off site groundwater quality and beneficial uses, including groundwater dependent ecosystems.

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9.0 Recommendations

Based on the above conclusions, the following recommendations are made:

- Conduct an inspection and condition survey of the existing groundwater monitoring well network, dedicated sampling pumps and associated infrastructure.
- Based on the outcomes of the above, maintain or replace damaged, lost or dry wells, and sampling pumps as required. Assess current sampling pump depth, if it does not sit within the screened interval of the bore, then an assessment should be made as to whether another pump could be identified to sample at the required depth.
- Continue a reliable and regular leachate and groundwater monitoring program.
- The inverts of the South Creek tributaries to the west and south of the landfill were not included in the recent survey coordinated by Cleanaway and this remains a data gap, not only in understanding the potential interaction between groundwater and surface water, but in understanding potential subsurface gas migration pathways. The inverts of the tributaries to the west and south should be surveyed.
- Groundwater bores BH17D and BH19 display large variations in reduced water levels, salinity and ammonia. A separate review of the management of stormwater runoff from the landfill has also highlighted some inconsistencies/unknowns in relation to whether all landfill surface water runoff is captured by the perimeter swale drain around the landfill footprint at ground level or whether some runoff flows beyond the perimeter swale drain in certain areas, particularly to the east of groundwater monitoring bore BH17D, where the perimeter swale drain appears disjointed. Senversa has observed some diverted runoff being redirected to the wheel wash water source to the west of the landfill. BH23 also sits on the northern side of the perimeter drainage swale around the landfill footprint and may be influenced by surface water runoff. It is also very close to the edge of waste along the south side of the landfill. BH15B may also be impacted by runoff as it sits within a ditch that can retain stormwater runoff. An investigation of preferential stormwater runoff pathways should be conducted to confirm the adequacy of the stormwater runoff management system and its potential impact on the above-mentioned bores.
- Distinct isotopic signatures exist between groundwater and leachate, particularly for ^{13}C-DIC. Further monitoring and isotopic analysis is required to confirm which groundwater bores may be impacted by runoff and which may be impacted by leachate. These may include, but not be limited to, BH17D, BH15B, BH19 etc. Groundwater bores showing an increasing trend in ammonia concentrations should also be included.
- Consider seeking an amendment from the regulator regarding the removal of the current leachate compliance level and replacement of active leachate extraction with a combined capping, LFG extraction and leachate monitoring regime.
- As seen at other unlined landfills that have been filled below the natural water table, once capped, leachate mounding within the landfill will drop and flatten out to the same level as the surrounding groundwater level (even without active extraction). We recommend any alternative leachate conditions focus on maintaining current leachate extraction rates from LP003, in order to prevent leachate springs through the surface at ground level, followed by the cessation of leachate extraction all together once the landfill is capped.
- Leachate and groundwater levels should continue to be monitored post closure in order to assess when the leachate and groundwater levels have reached equilibrium.

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10.0 Principles and Limitations of Investigation

10.1 General Principles and Limitations of Investigation

The following principles (summarised in **Table 15** below) are intended to be referred to in resolving any ambiguity or exercising such discretion.

Table 14: Summary of General Principals and Limitations

Area	Principle and Limitation
Elimination of Uncertainty	Some uncertainty is inherent in all site investigations and modelling. Furthermore, any sample, either surface or subsurface, taken for chemical testing may or may not be representative of a larger population or area. Professional judgment and interpretation are inherent in the process, and even when exercised in accordance with objective scientific principles, uncertainty is inevitable. Additional assessment beyond that which was reasonably undertaken may reduce the uncertainty.
Failure to Detect	Even when site investigation work is executed competently and in accordance with the appropriate Australian guidance, such as the National Environment Protection (Assessment of Site Contamination) Amendment Measure ('the NEPM'), it must be recognised that certain conditions present especially difficult target analyte detection problems. Such conditions may include, but are not limited to, complex geological settings, unusual or generally poorly understood behaviour and fate characteristics of certain substances, complex, discontinuous, random, or heterogeneous distributions of existing target analytes, physical impediments to investigation imposed by the location of services, structures and other man-made objects, and the inherent limitations of assessment technologies.
Limitations of Information	The effectiveness of any site investigation may be compromised by limitations or defects in the information used to define the objectives and scope of the investigation, including inability to obtain information concerning historic site uses or prior site assessment activities despite the efforts of the user and assessor to obtain such information.
Chemical Analysis Error	Chemical testing methods have inherent uncertainties and limitations. Senversa routinely seeks to require the laboratory to report any potential or actual problems experienced, or non-routine events which may have occurred during the testing, so that such problems can be considered in evaluating the data.
Level of Assessment	The investigations herein should not be considered to be an exhaustive assessment of environmental conditions on a property. There is a point at which the effort required to obtain information is outweighed by the time required to obtain that information, and, in the context of private transactions and contractual responsibilities, may become a material detriment to the orderly conduct of business. If the presence of target analytes is confirmed on a property, the extent of further assessment is a function of the degree of confidence required and the degree of uncertainty acceptable in relation to the objectives of the assessment.
Comparison with Subsequent Inquiry	The justification and adequacy of the findings of this investigation in light of the findings of a subsequent inquiry should be evaluated based on the reasonableness of judgments made at the time and under the circumstances in which they were made.
Data Useability	Investigation data generally only represent the site conditions at the time the data were generated. Therefore, the usability of data collected as part of this investigation may have a finite lifetime depending on the application and use being made of the data. In all respects, a future reader of this report should evaluate whether previously generated data are appropriate for any subsequent use beyond the original purpose for which they were collected, or are otherwise subject to lifetime limits imposed by other laws, regulations or regulatory policies.
Nature of Advice	The investigation works herein are intended to develop and present sound, scientifically valid data concerning actual site conditions. Senversa does not seek or purport to provide legal or business advice.

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10.2 Project Specific Uncertainties

Specific uncertainties and limitations noted for this investigation are as follows:

- This report presents the results of an assessment of groundwater flow processes, contaminant transport in groundwater, and risks to groundwater quality, and was produced specifically for Cleanaway Solid Waste Pty Ltd for the purposes of this commission. Senversa accepts no responsibility for other use of the data. No warranties, expressed or implied, are offered to any third parties and no liability will be accepted for use of this report by any third party.
- The information provided in this report is in part based on data supplied by third parties on groundwater contamination, aquifer properties and other relevant data at the site, taken at certain locations. Groundwater contamination is often highly variable, and it is possible that the contamination data used for the assessment may not reflect the conditions that may be encountered elsewhere on the site.
- Senversa’s approach was limited to a focus on key leachate indicators (including ammonia) based on leachate quality and the EPL conditions (e.g. ammonia criterion).
- The inverts of the South Creek tributaries to the west and south of the landfill were not included in the recent survey coordinated by Cleanaway and this remains a data gap, not only in understanding the potential interaction between groundwater and surface water, but in understanding potential subsurface gas migration pathways.
- The work conducted by Senversa under this commission has been to the standard that would normally be expected of professional environmental consulting firm practising in this field in the State of New South Wales. Effort has been made to identify and assess the risk to groundwater quality associated with possible future contamination from the facility, however, there is a high level of uncertainty in such estimates as indicated in this report. It is possible that variations in the contaminant concentrations and their nature, soil conditions, and toxicity of chemicals may vary from those assumed, and this could give rise to variations in the site risk profile.
- This report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by Senversa. Senversa accepts no responsibility for any circumstances that arise from the issue of the report that has been modified other than by Senversa.

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11.0 References

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Appendix A: Improved Conceptual Site Model – Figures 1 to 21: Layout Plan and Cross-sections

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Memorandum

Date:	1 April 2020	**Project:**	Erskine Park Landfill – Task 8
To:	Paul Antony	**Project No:**	S17375
From:	Nadia Verga / Neil Thomson		

Re: Improved Conceptual Site Model (CSM) – Landfill Perimeter Cross-sections

Dear Paul,

This memorandum outlines the approach taken to prepare landfill perimeter cross-sections for the Erskine Park Landfill, located at 50 Quarry Road, Erskine Park, NSW.

1. Background

Cleanaway required the preparation of the landfill perimeter cross-sections, primarily to assist in the location of additional landfill gas (LFG) extraction wells within the waste footprint and to finalise the future cap tie-in details (subject of a separate report).

The LFG extraction wells will be located within waste, closer to the understood waste edge boundary, in an effort to assess the potential for subsurface LFG migration and to implement management measures, if required, particularly in advance of landfill closure and prior to the final cap installation. This information is required to minimise the risk of puncturing the clay side liner, associated leachate drainage blankets and the quarry wall during bore drilling works.

The cross-sections were also required to better understand whether a potential subsurface LFG migration pathway exists between the source of landfill gas, i.e. the waste, and surrounding sensitive receptors such as on and offsite buildings.

As our understanding of the site over the last few months has grown as further information became available, Senversa identified that the site setting around the landfill perimeter and the landfill construction itself differs significantly along sections of the perimeter, and it was decided that one typical perimeter cross-section would not be sufficient to represent the landfill's CSM. Twenty cross-sections have been prepared, in order to best capture the various site features and sensitive receptors surrounding the landfill, including the clay side liner wall, various leachate drainage blankets, the first quarry bench, recent test pit information collected in late 2019, the average leachate elevation across the landfill, the surrounding groundwater elevations in the nearest monitoring bores, the buried Austral Bricks gas feed pipeline and the surface profile of the surrounding land, both on and offsite, between the edge of waste and the closest on and off site buildings.

The location of each cross-section is shown on the attached **Figure 1**, while the twenty cross-sections are referred to as **Figures 2** to **21**, inclusive.

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2. Input Information

The following sources of information were provided by Cleanaway. Numerous data gaps existed surrounding the history of landfill construction. Senversa has utilised the information made available, and made assumptions using the most reliable information, in order to further improve its understanding of the site to fulfill the task objectives, which were to build an improved CSM to provide guidance for the installation of new gas extraction wells closer to the landfill perimeter, consider construction issues that might need addressing prior to closure and capping, and provide further clarity as to whether subsurface gas migration pathways existed between the landfill edge and surrounding sensitive receptors.

Item	Information Type	How the information was used
1999 landfill surface survey data	DWG file (without aerial image)	Aerial survey flown on 30 November 1999. This surface profile is shown in the cross-sections in Figures 2 to 21 to provide an indication of where the shallower quarry benches are located, in order to avoid drilling perimeter gas extraction wells through waste and the quarry wall i.e. natural material. Without the aerial image taken at the time of survey, in some instances, it was difficult to distinguish between quarry bench surfaces and deposited waste. The 1999 profile was also used in conjunction with the 2005 surface profile, to approximate the location of the inferred quarry rim. We note that the approximate quarry rim boundary shown on the layout plan is not always consistent with the “inferred quarry rim” shown on the cross-sections. The quarry rim boundary on the layout plan is taken from Brown Consulting design drawings for the Perimeter Access Road and North Western Basin dated 22 December 2006 (refer Note 6 on **Figure 1**). The quarry rim appears to have changed over time. In most cross-sections, we have chosen the point where the 1999 profile and the 2005 profile intersect, or the profile displaying the outermost lateral excavation. And lastly, the surface profile outside the landfill proved useful in providing an understanding of the cut and fill that has occurred over the years around the landfill, both on and off site.
2005 landfill surface survey data	DWG file (without aerial image)	Aerial survey flown on 4 December 2005. This surface profile was used in conjunction with the 1999 surface profile, to approximate the location of the inferred quarry rim shown in the cross-sections in Figures 2 to 21.

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Item	Information Type	How the information was used
2019 landfill surface survey data	DWG file	Source: Australian UAV (Surveyors) Aerial survey flown on 4 December 2019. This surface profile is shown in the cross-sections in Figures 2 to 21 to provide a visual indication of the likely depth of new gas extraction wells that may be installed soon within waste around the perimeter of the landfill. The elevation of the surrounding properties was also captured in order to map potential subsurface gas migration pathways and the need to monitor for potential subsurface gas in these areas, if required, in future. The inferred property boundary was also marked on the cross-sections, to provide an indication of the proximity of some underground services in abutting properties, particularly subsurface drainage infrastructure, which generally seems to run around the perimeter of industrial properties/developments, and could sit within 50 m to 100 m from the edge of waste in some neighbouring properties.
Assumed Inside Edge of Clay Side Liner	DWG file	Source: Senversa Agreed assumed inside edge of clay side liner with Cleanaway via email on 7 February 2020, including associated information used to compile the assumed inside edge of clay side liner, replicated in the following table. The “Inferred Inside Face of the Clay Side Liner” shown on the cross-sections in Figures 2 to 21, is assumed by extrapolating the assumed inside edge of clay side liner (partly exposed during testing pitting works in November 2019) down to the leachate drainage blanket or quarry rim. The slope of the “Inferred Inside Face of the Clay Sideliner” shown on the cross-sections may not be an accurate representation of the as-built clay sideliner.
As Built Southern Clay Side Liner Survey	DWG file	Survey dated 27 September 2006. The elevation for the inside edge of the sideliner shown in cross-sections K to Q is assumed to be the top of the clay side liner. “Inferred Inside Face of the Sideliner” in these cross-sections is not labelled, as the as-built clay sideliner survey includes the inside face.
As Built North Leachate Drainage Blanket Survey	PDF file (digitised in AutoCAD C3D by Senversa)	Survey dated 19 May 2008. The elevation for the north leachate blanket shown in cross-sections B to E is assumed to be the top of the aggregate layer.

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Item	Information Type	How the information was used
As Built South Leachate Drainage Blanket Survey	DWG file	Survey dated 27 November 2004. The elevation for the south leachate blanket shown in cross-sections K to O is assumed to be the top of the aggregate layer. At section K, a second leachate drainage blanket was found to be installed along the first quarry bench, in addition to the drainage blanket installed along the quarry rim. In sections M and O, the leachate drainage blanket runs down a steep section of the quarry wall and over the inferred first quarry bench. In section N, the blanket runs down a steep section of the quarry wall.
As Built South Subgrade Survey	DWG file	Survey dated 27 November 2004. The elevation for the subgrade shown in cross-sections K to O is assumed to be the top of the subgrade underneath the aggregate i.e. quarry bench or quarry rim.
Austral Bricks Gas Pipeline Location: Plan of Proposed Gas Easement dated 1 July 2014, prepared by Cardno Hard & Forrestor Pipeline Works As Executed Longsection dated 5 December 2014, prepared by Cardno Hard & Forrestor	Separate PDF files. Long section missing layout plan to match chainage locations. (digitised in AutoCAD C3D by Senversa)	Gas pipe obvert and base of trench elevations used to include the location of the gas pipeline within cross-sections M to T. We note the Obvert elevation refers to sections of the pipe which were not buried when originally installed, however, when shown in the cross-sections, they mostly appear buried. Cleanaway has indicated the pipe was subsequently buried approx. 0.5 m below the haul road it currently sits under. The location of the pipeline and/or trench is marked on the cross-sections – detail of the pipe or trench dimensions is not shown.
URS Northern Batter Design Drawings dated 5 February 2007: Site Layout Plan (43346014_C-501) Northern Batter Liner Typical Section (Sheet 1) (43346014_C-502) Northern Batter Liner Typical Section (Sheet 2) (43346014_C-503)	PDF files	Source: AECOM (formerly URS) Used to check the construction details of the leachate drainage blanket installed. Consists of 300 mm of aggregate and 900 mm of clay beneath it. No further specifications on the clay requirements apart from being a minimum 900 mm in thickness. We have assumed the blanket was constructed as per the design. The subgrade referred to in these drawings is the ground beneath the clay (not the clay itself).
URS South Eastern Batter and Water Quality Pond Design drawings dated 9 September 2004: Drainage Blanket Extent (45767-004-C-103) Typical Sections and Details (45767-004-C-104)	PDF files	Source: AECOM (formerly URS) Used to check the construction details of the leachate drainage blanket installed. Consists of 300 mm of aggregate, placed on subgrade and a geofabric protection layer over the aggregate. We have assumed the blanket was constructed as per the design. It appears the subgrade is the quarry rim or bench beneath the aggregate layer, and there is no indication that a clay layer formed part of this drainage blanket.

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Item	Information Type	How the information was used
2019 Stormwater Management Features	PDF and DWG files	Source: Keatley Surveyors Ground survey taken between 20 and 22 September 2019, capturing stormwater management features around the landfill (excluding the transfer station and leachate treatment plant areas), however, including landfill perimeter swales, perimeter drains, stormwater pits, North West Dam and South East Dam.

Information used to derive the agreed inside edge of the clay side liner with Cleanaway is listed below:

Document Title	Document Date	Prepared By	Document Type
Southern End of Western Batter Erskine Park Landfill - Western Batter Construction - Works as Executed Drawings	15/01/2008	Shepherd Group Services Pty Ltd	PDF
South Batter Enviroguard South Batter Geotech Clay WAX 270906	27/09/2006	Provided by AECOM on USB in Dec 2019 – PDFs of the east and west south batter issued as works as executed include a Kelly & Shepherd P/L title boundary.	DWG
East Batter Erskine park 060609	6/06/2009	Landair Surveys	DWG
North Batter Erskine park 060609 (used for estimating alignment and elevation) Enviroguard Erskine Park Landfill - Northern Batter Construction - Works as Executed Plan (used for estimating slope of the inside batter)	6/06/2009 19/05/2008	Landair Surveys Shepherd Group Services Pty Ltd	DWG PDF
Northern End of Western Batter Works as Executed Plan - Perimeter Access Road Alignment	12/12/2013	Keatley Surveyors	PDF
Central Section of Western Batter - Quarry Wall Works as Executed Plan - Perimeter Access Road Alignment	12/12/2013	Keatley Surveyors	PDF

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3. Summary of Groundwater, Leachate and Landfill Gas Inputs

Summary of groundwater monitoring network information:

ID	Easting	Northing	EPA #	Targeted Groundwater Interval	RLNS (m AHD)[1]	RL Top of Casing (TOC) (m AHD)[3]	Depth to Groundwater as at Dec 2019 (m BTOC)[2]	Groundwater Elevation as at Dec 2019 (m AHD)[2]	Bore Depth (m)	RL Base of Well (m AHD)	Groundwater Sampling Pump Depth (m)[2]	Screen Interval (m bgl)	Screen Interval (m AHD)	Screen Length (m)	Sample Frequency
5	294830	6255836	N/A2	Shallow	43.6		Bore not found		12.5	31.1	Bore not found	6.0 to 12.6	37.6 to 31.1	6.5	Yearly
15A	295001	6255889	10	Intermediate	48.9	49.776	11.374	38.402	61	-12.1	37.870	40.4 to 58.2	8.5 to -9.3	17.8	Quarterly
15B	295018	6255899	11	Deep	49.2	49.805	12.578	37.227	91	-41.8	40.395	70.5 to 88.3	-21.3 to -39.1	17.8	Quarterly
16A	295629	6255782	12	Intermediate	59.1	59.788	17.301	42.487	70.5	-11.4	28.714	49.9 to 67.7	9.2 to -8.6	17.8	Quarterly
16B	295630	6255787	13	Deep	59.3	60.053	17.738	42.315	100.1	-40.8	29.541	79.5 to 97.3	-20.2 to -38.0	17.8	Quarterly
17D	294956	6255743	N/A6	Deep	51	49.797	17.329	32.468	95	-41	41.552	74.0 to 91.5	-23.0 to -40.5	17.5	Quarterly
17E	294953	6255744	N/A6	Shallow	51	49.327[4]	8.725	40.602	32	19	29.510	24.0 to 31.5	17.0 to 24.5	7.5	Quarterly
18	295320	6255994	9	Deep	55.79	56.539	24.392	32.147	94	-38.2	26.969	76.0 to 94.0	-20.2 to -38.2	18.0	Quarterly
19	295324	6255995	19	Intermediate	55.73	56.435	13.254	43.181	56.3	-0.6	40.474	36.3 to 56.3	19.4 to -0.6	20	Quarterly
20	295263	6255964	N/A2	Shallow	58	58.342	10.115	48.227	38.2	19.8	29.554	25.2 to 38.2	32.8 to 19.85	12	Quarterly
21	295478	6255621	20	Deep	59.67	60.409	17.939	42.470	103	-43.3	30.476	90.0 to 103.0	-30.3 to -43.3	13.0	Quarterly
22	295475	6255620	21	Intermediate	59.73	60.359	31.777	28.582	69	-9.3	Not recorded (total well depth reported as 56.357 m)	57.0 to 69.0	2.73 to -9.3	12.03	Quarterly

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ID	Easting	Northing	EPA #	Targeted Groundwater Interval	RLNS (m AHD)[1]	RL Top of Casing (TOC) (m AHD)[3]	Depth to Groundwater as at Dec 2019 (m BTOC)[2]	Groundwater Elevation as at Dec 2019 (m AHD)[2]	Bore Depth (m)	RL Base of Well (m AHD)	Groundwater Sampling Pump Depth (m)[2]	Screen Interval (m bgl)	Screen Interval (m AHD)	Screen Length (m)	Sample Frequency
23	295467	6255629	22	Shallow	62.69	63.411	19.379	44.032	44	18.7	22.165	24.0 to 44.0	38.7 to 18.7	20	Quarterly
24	295176	6255602	28	Shallow	68.26	68.88	Unable to gauge in Dec 2019 ~26.36[5]	42.52	45	23.3	Not recorded	18.0 to 45.0	50.3 to 23.3	27	Quarterly

Notes to table: 1. As reported by Arcadis (2018); RLNS = reduced level of natural surface

2. As reported by Arcadis December 2019 Quarterly Groundwater Monitoring Event, the depth to the groundwater sampling pump in each bore is included in the field sheets in Appendix B.

3. As reported in previous Arcadis monitoring reports.

4. As surveyed by Keatley Surveyors on 24 June 2019.

5. As reported by Arcadis during 19 June 2019 monitoring round.

The table above has been extracted from the Hydrogeological Assessment (HA) prepared by Senversa. Further detail has been included, including the latest groundwater levels measured by Arcadis in the December 2019 groundwater monitoring event (GME).

We have included the groundwater elevation measured in the nearest groundwater bore to each cross-section location. Where there is more than one groundwater bore nearby, we have used the shallowest groundwater elevation recorded, which is generally measured from the shallowest bores (i.e. the groundwater elevations measured from the deeper bores may not be representative of the true groundwater elevation in the area, as they may be influenced by the depth of the bore).

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Summary of leachate sump detail and latest average leachate elevation calculated:

ID	Easting	Northing	Notes	RL Top of Casing (TOC) (m AHD)[3]	Latest Depth to Leachate (m BTOC)[2]	Latest Leachate Elevation (m AHD)[2]	Sump Depth (m)	RL Base of Sump (m AHD)	Screen Interval (m bgl)	Screen Interval (m AHD)	Screen Length (m)	Sample Frequency
LP001 (located in Jan 2020)	295277.748	6255817.191	Former leachate extraction location Gas extraction only	5/02/20 89.316	23/01/20 50.162	23/01/20 39.154	23/01/20 51.700	23/01/20 37.616	na	na	na	Ad hoc
LP002 (located in Jan 2020)	295284.884	6255803.267	Gas extraction only Sump riser likely to be inclined as approx. 7 m difference in Northing value	5/02/20 89.63	23/01/20 49.602	23/01/20 40.028	23/01/20 59.000	23/01/20 30.63	na	na	na	Ad hoc
LP002 (as per EPL coordinates)	295285.021	6255810.009										
LP003 Auxillary Riser Leachate Riser	295164.987	6255733.875	Leachate extraction Leachate level gauging location N & E coordinates in EPL likely to be erroneous	21/06/19 79.214	2/12/19 35.5 (recovered leachate level) 9/12/19 38.539 (pump off for 4 days)	2/12/19 43.714 (recovered leachate level) 9/12/19 40.675 (pump off for 4 days)	2/12/19 45.02 (pump pulled out 19//02/20 and sump depth measured the same)	2/12/19 34.194 (similar elevation to first quarry bench)	na	na	na	Quarterly
LP003 (as per EPL coordinates)	295200.015	6255749.982										
LP003 (leachate sampling tap on inlet pipe at treatment plant)			Leachate sampling conducted at this point	na								Quarterly
					Average leachate elevation:	**40.893**						

Summary of Gas Monitoring Bore Information:

Gas monitoring Bore Id	Installation Date	EASTING	NORTHING	RL (AHD) TOP OF PIPE	RL (AHD) GROUND	Date bore last surveyed	Bore depth (m BGL) when installed	Elevation of base of bore (m AHD)	Screened interval (m AHD)	Depth to water (m BTOC)	Elevation of water (m AHD)	Date depth to water last checked	Water elevation consistent with nearest groundwater bore	
GS1	1/12/06	295455.617	6256020.143	58.944	57.967	1/03/18	11.0	44.3	53.3 to 44.3	9.086	49.858	27/03/19	~1.6 m higher in GS1	BH20
GS2	30/11/06	295632.704	6255693.33	53.049	52.625	1/03/18	11.6	40.9	51.5 to 40.9	5.578	47.471	27/03/19	~5 m higher in GS2	BH16A
GS3	1/12/06	295471.889	6255619.158	60.285	59.622	1/03/18	20.3	39.4	58.4 to 39.4	16.322	44.503	27/03/19	~0.5 m higher in GS3	BH23
GS4	6/12/06	295224.975	6255568.846	67.505	66.772	1/03/18	32.6	34.3	65.3 to 34.3	22.749	44.756	27/03/19	~2 m higher in GS4	BH24
GS6	15/10/08	295257.284	6255959.192	58.628	57.902	1/03/18	20.2	37.8	55.8 to 37.8	5.927	52.701	27/03/19	~4.5 m higher in GS6	BH20
GS7	21/09/09	295056.92	6256001.832	49.638	49.033	1/03/18	11.00	41.0	51.0 to 41.0	*		27/03/19		
GS8	21/09/09	295546.563	6255573.327	61.461	60.707	1/03/18	14.00	40.9	51.0 to 38.5	11.914	49.547	27/03/19	~5.5 m higher in GS8	BH23
GS9	22/09/09	294959.104	6255740.468	51.981	51.351	1/03/18	8.50	42.5	*** 51.00 to 44.0	** 8.891	43.09	26/09/18	~2 m higher in GS9	BH17E
GS9		294958.97	6255740.375	49.741	48.78	24/06/19				**				

* GS7 well length reported by Arcadis in March 2019 as 1.830 m (potentially blocked). Elevation of ground when installed on 21 Sep 2009 was 52.00 m AHD and on 1 Mar 2018 was 49.033 m AHD. Cut and fill in this area during development of the neighbouring property and erection of the workshop to the south of the area might have damaged this bore. Previous Cleanaway monitoring of GS7 reported depth to water in the vicinity of 5.1 m to 5.6 m between Jan 2013 and March 2016.

** GS9 well length reported by Arcadis in March 2019 as 5.611 m (possibly in the process of being shortened due to transfer station construction works in the area). It was reported by Arcadis as dry in December 2017. Last water level check in Sep 2018 reported the water level just above the bore base and below the screened interval, therefore may not be accurate.

*** The screened interval in GS9 appears to commence too close to the current ground elevation, i.e. only 0.3 m below ground level. Readings may be affected by ambient air.

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4. Improved CSM Findings

The following points summarise the findings of the improved CSM:

Groundwater and Leachate

1. Groundwater monitoring bore BH17D appears compromised – the bore was reduced in height in mid-2018 and continues to produce grey water while it is being sampled by Arcadis.
2. Groundwater monitoring bore BH22 is potentially compromised – it has silted up and almost the entire screened interval is blocked.
3. Groundwater monitoring bore BH24 – a recent groundwater level has not been taken, as Arcadis reports the sampling pump itself may be obstructing the water level dipper.
4. Groundwater monitoring bore BH5 is reported as missing by Arcadis.
5. The average leachate elevation of 40.89 m AHD is lower than previously anticipated, inferring a shallower and flatter hydraulic gradient between the leachate and the surrounding groundwater levels.
6. The leachate drainage blanket installed along the first quarry bench in the south, could potentially contribute to leachate migration from the waste into groundwater, as its elevation is in very close proximity to the average leachate elevation assumed when preparing the CSM cross-sections.

Landfill Gas

7. Gas monitoring bore GS7 is potentially compromised (silted up), however, its current location north west of the landfill and south of the north west dam is not ideal and will unlikely be required in future.
8. Gas monitoring bore GS9 is potentially compromised (top of bore casing screen within 1 m of the ground surface) and there is limited usefulness in its current location (i.e. the bore is currently not positioned between the landfill gas source and a sensitive receptor at risk, e.g. an onsite building) and will unlikely be required in future. The screened interval starts 0.3 m below the current ground elevation, which means gas checks from the bore are more likely to be influenced by ambient air, i.e. potential landfill gas presence may not be detected. The screened interval should start 1 m to 2 m below ground level.
9. Six of the eight gas monitoring bores screen through fill (GS1 and GS2 not included) before screening through natural material. These bores can contribute to gas migration between various layers. The screened fill is more likely to pick up gas migrating from the landfill as it is more porous, and also contributes to surface water runoff entering the bore, hence why water elevations measured in the gas monitoring bores are consistently higher than those measured in the nearest groundwater bore. Bores that screen through fill and natural material should be decommissioned.
10. Existing landfill gas monitoring bores GS1, GS2, GS3, GS4 and GS6 are located very close to the edge of waste, i.e. approx. 30 m or less, and GS3, GS4 and GS6 screen through fill material. It is not surprising for these bores to detect landfill gas as the landfill is unlined, and the clay wall liner does not extend deep enough to prevent gas migration. It is not considered best practice to install gas monitoring bores so close to the edge of waste, however, given the limited space around the landfill perimeter, and the fact that they already exist, it may be worthwhile retaining GS1 and GS2, but decommissioning GS3, G4 and GS6.
11. GS8 is in a good location to monitor potential gas migration from the landfill and from the section of the Austral Bricks pipeline and/or trench that is located closest to the waste edge. It's over 120 m away from the waste edge and approx. 90 m south east of GS3 and screens the full unsaturated zone in the area. However, the Austral Bricks pipeline has been installed so that it runs around the south west dam and then heads south towards the main road, therefore GS8 may not pick up gas leaks from the buried pipeline itself, once the pipeline heads south.

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12. Arcadis has stopped checking the water level in each gas monitoring bore during the quarterly monitoring rounds. It was last checked in March 2019. This should recommence and continue at the next scheduled monitoring round.
13. Are existing gas monitoring bores deep enough? GS1 appears too shallow when we compare groundwater elevations taken in BH19. GS7 appears too shallow when compared to groundwater elevations measured in BH15A. Both GS1 and GS7 are not deep enough to monitor the full unsaturated zone above the local groundwater elevations.
14. Existing gas monitoring bores GS2 and GS8 appear to be the only monitoring bores that are functional, and located and constructed to accurately monitor LFG concentrations.

Landfill Gas Extraction

15. It is unlikely that new gas extraction wells will need to extend deeper than the current average leachate elevation of 40.89 m AHD, because it is very similar to the surrounding groundwater levels.
16. Increasing the unsaturated waste depth in the landfill by drawing the leachate elevation down to the required 30 m AHD, will increase gas generation within the landfill, will require installation of deeper gas extraction wells, and will increase the likelihood of offsite subsurface gas migration.
17. New perimeter gas extraction wells must avoid drilling through the clay side liner wall, the north and south leachate drainage blankets, and the leachate drainage blanket along the first quarry bench in the south. The AutoCAD C3D model prepared by Senversa as part of this task to improve the CSM, should be provided to Cleanaway's contracted surveyor in order to confirm each new gas extraction well's location and approved depth.

Potential Landfill Gas Migration Pathways

18. Unsaturated waste zones and unsaturated fill/natural soil zones outside the landfill indicate that potential gas migration pathways exist between nearly all sections of the landfill perimeter, i.e. the landfill waste and surrounding sensitive receptors such as on and offsite buildings. While these pathways may not be realised in the current site setting, they may be realised in future when the landfill is fully capped, with an increased potential for lateral gas migration.
19. The closest buildings, structures and underground services are at greatest risk from potential subsurface landfill gas migration, such as the onsite transfer station, the leachate treatment plant, associated underground pipes, pits, trenches, etc. and the workshop. The three stormwater pits approx. 20 m north of the edge of waste could transfer migrating landfill gas directly toward the stormwater pit sitting just outside the workshop. The workshop itself is approx. 30 m from the waste edge. The leachate treatment plant is approx. 20 m from the waste edge and the transfer station building is approx. 65 m from the edge of waste.
20. Offsite buildings and buried drainage pipes and pits within industrial premises to the north and east of the landfill are also at greatest risk from potential subsurface gas migration, potentially more so than onsite buildings, with buildings sitting within approx. 30 m to 50 m of the waste edge, and underground drainage infrastructure potentially closer, between approx. 20 m to 40 m away.
21. Offsite buildings and buried drainage pipes and pits within industrial premises to the south and south west of the landfill are also at risk from potential subsurface gas migration, with buildings situated approx. 120 m from the waste edge, and underground drainage infrastructure potentially closer, between approx. 60 m to 100 m away.
22. Offsite buildings and buried drainage pipes and pits within industrial premises to the west of the landfill are also at risk from potential subsurface gas migration, with buildings situated approx. 90 m from the waste edge, and underground drainage infrastructure potentially closer, between approx. 80 m to 90 m away.
23. Possible gas migration from the landfill itself through the Austral Bricks buried pipeline and trench is likely to vent to atmosphere before reaching an offsite building to the south and south east due to its elevation. However, if the pipeline itself were to leak as it extends further away from the landfill, then

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Version: 1, Version Date: 16/04/2020

offsite buildings to the south east and their associated underground services could be at risk of impact from subsurface gas. Cleanaway should confirm with Austral Bricks that the underground gas pipe is checked and tested for leaks on a regular basis, and provide such evidence to Cleanaway, after every routine check.

24. The 1999 and 2005 survey profiles of the land around the landfill highlight that over the years, the surface profile outside the landfill has continued to change, with cut and fill evident around the landfill, both on and offsite. While the surrounding natural material may be highly impermeable, fractures within the material caused by previous quarrying activities could act as preferential subsurface gas migration pathways. Fill material deposits around the landfill, both on and offsite may also act as potential gas migration pathways, including the interface between natural and fill material deposits.

25. Other preferential subsurface gas migration pathways which are likely to be difficult to pinpoint, include:

    a. The interface between the base of the clay side liner and the surrounding ground,

    b. The leachate drainage blanket installed around the quarry rim to the north;

    c. The leachate drainage blanket installed around the quarry rim to the south (we note sections M, N and O indicate the clay side liner constructed in 2006 extended down to the elevation of the leachate drainage blanket installed in 2004),

    d. The leachate drainage blanket installed around the quarry rim in the south eastern corner (we note sections K and L indicate the clay side liner wall installed in 2006, was only extended down to the existing waste surface, and did not extend down to, or intersect with, the leachate drainage blanket, which was installed in 2004), and

    e. The leachate drainage blanket installed along the first quarry bench in the south (we note in section K that the clay side liner did not extend this far down).

26. Cleanaway should consider monitoring underground services in abutting properties, particularly subsurface drainage infrastructure, which generally seems to run around the perimeter of industrial properties/developments, and could sit within 50 m to 100 m of the edge of waste in some neighbouring properties. The marked inferred property boundary provides an indication in the sections of the proximity of the subsurface drainage infrastructure in neighbouring properties.

27. Further gas monitoring bores will be required, both on and off site, in order to monitor for potential subsurface migration, in the direction of sensitive receptors, such as on and offsite buildings and underground services. Future gas monitoring bores should screen through only one type of soil or geological layer, e.g. they should not screen through fill material and the underlying natural soil/rock. If initial gas monitoring results indicate that potential gas migration has not occurred, then the monitoring frequency could be reduced, until final capping commences, and then the frequency increased again.

Landfill Construction and Future Capping Works

28. Sections of the clay liner wall appear to have been compromised:

    a. Gas monitoring bore GS3 has been installed through the clay liner wall (inferred in Figure 14: cross-section N). The screenshot below shows the extent of the southern clay wall versus the bore location.

    b. Groundwater monitoring bores BH21 to BH24 have also been installed through the clay liner wall (as inferred in Figures 14 to 17: cross-sections N to Q). The screenshot below shows the extent of the southern clay wall versus the bore locations.

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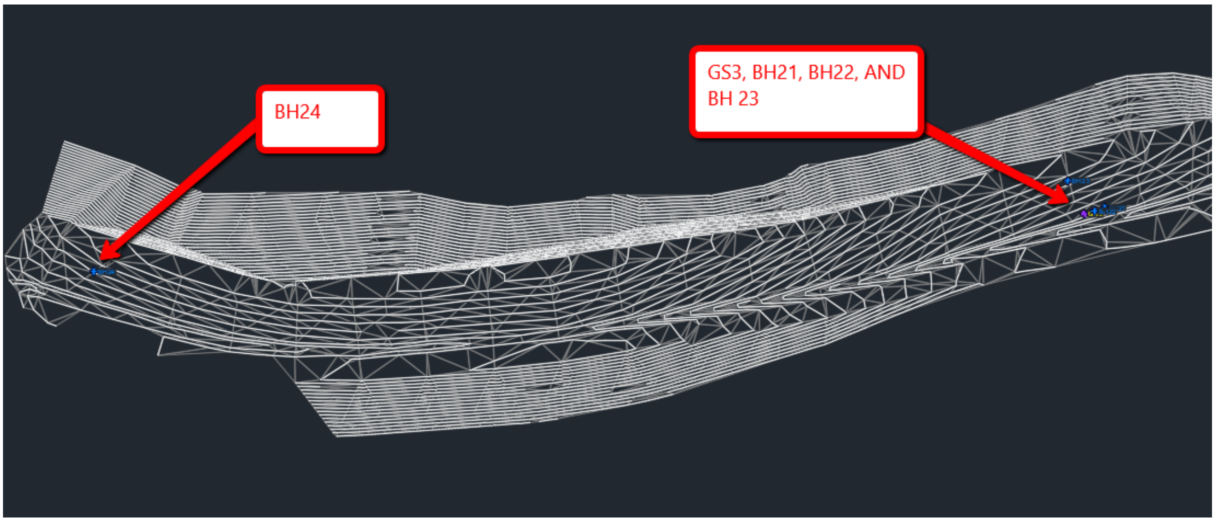

c. It appears the installation of the Austral Bricks Gas feeder pipeline has gone through part of the clay wall in cross-section M, and is potentially sitting on the clay liner wall in the vicinity of cross-section R.

d. The perimeter swale and/or metal drain cuts through the clay liner wall as displayed in cross-sections H, J, N, S and T.

29. In the vicinity of cross-section U, the perimeter swale sits on the waste surface of the landfill and will likely interfere with the final cap tie in, into the inside edge of the clay side liner. It will require relocation outside the landfill surface to achieve the current SLR cap tie in design and to fill to the approved final contours. In cross-sections R, S and T, the perimeter swale appears to sit on the clay side liner, and may need to be moved slightly off the landfill, away from the assumed inside edge of the clay side liner, to facilitate cap tie in works.

30. At cross-section B, the perimeter swale sits outside the landfill, however, a second swale exists approximately 20 m south, sitting on the landfill surface. It appears to sit approximately 2 m vertically above the assumed inside edge of the side liner and will likely interfere with the final cap tie in. It will need to be temporarily removed during cap tie in works, and either placed back in the same location or in the vicinity, to blend in with the approved final contours.

31. At cross-section C, the elevation of the existing perimeter swale and the ground around it will need to be reduced by approx. 1 m to expose the assumed inside edge of the clay side liner to allow cap tie in to occur. If this occurs, without other controls put in place, stormwater runoff from the neighbouring property will run into the Cleanaway site. There is approximately 20 m between the fence and the swale, i.e. there is very limited space for additional stormwater controls. Similar issues are likely to be encountered in the vicinity of cross-section D (potentially reducing the elevation of the swale and surrounding ground to a lesser extent).

32. The elevation of the perimeter swale appears it will need to be dropped around cross-section E and potentially moved further north, away from the inside edge of the clay side liner. These works appear possible without redirecting stormwater runoff from the neighbouring site into the Cleanaway site. The same can be said in the vicinity of cross-sections F and G.

33. The metal drain in the vicinity of cross-sections H and J (used as a substitute to an open swale) appears it can remain in its current location during and after cap tie in works.

34. The elevation of the perimeter swale appears it will need to be dropped over 1 m around cross-section K. These works appear possible without redirecting stormwater runoff from the neighbouring site into the Cleanaway site. However, the as-built survey information available for the clay side liner in the south east indicates that if the swale and ground elevations were reduced around cross-section K, then Cleanaway is likely to excavate the clay side liner and compromise it. An alternative

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may be to amend the approved final contours and raise the cap tie in point along the inside edge of the liner (assuming the wall is still intact and has not moved, settled or slipped).

35. It appears the perimeter swale could stay in its current location around cross-section L, with minor works to tidy up the ground elevation between the swale and the assumed inside edge of the clay side liner. The same can be said for areas in the vicinity of cross-sections M, N, O, P and Q.

36. The location of the assumed inside edge of the clay side liner at cross-section J appears disjointed. This suggests the agreed inside edge of clay side liner may need to be altered in this area. On 29 January 2020, we discussed the draft model of the inside edge of the clay side liner and Cleanaway confirmed via email that it wanted us to adjust the northern and eastern perimeter edges of waste/side liner slightly more to align with the test pit data collected. Our recollection was that *Nearmap* images available at the time the eastern section of the clay wall was constructed indicated the haul road in the same area had not been relocated. The as-built information relating to the clay wall in the south eastern corner infers the inside edge of the clay wall follows the assumed direction we have chosen in the vicinity of cross-section J. The 2007 aerial image provided by Cleanaway further supports the current assumed inside edge of the clay wall, i.e. that it runs along the inside edge of the haul road in the same area.

5. Limitations

The following limitations are noted:

- The location of the sewer line connected to the leachate treatment plant on site was not provided to allow an assessment of its potential to become a potential gas migration pathway.
- Details of other underground services were not provided, such as stormwater drainage infrastructure around the transfer station area, underground tanks, pipes, pits, etc. located at the transfer station and which may run between the transfer station and the leachate treatment plant.
- Details of underground pipes or drainage lines (if any) around the south eastern dam (SD002) were not provided.
- As built information relating to the clay side liner construction along the northern and southern perimeters of the landfill was limited to the wall's extent, location and associated elevation. No evidence was made available to confirm the materials used to construct the clay wall or the leachate drainage blankets installed.
- Buried gas extraction infrastructure installed by Run Energy has not been included in the site layout plan or cross-sections. Whilst Cleanaway was able to provide an infrastructure plan created by Run Energy in 2017 in PDF and DWG format, the accuracy of the location of the buried infrastructure is questionable and was difficult to match up with the location of other known site features. The location of the perimeter gas ring main may be of relevance for the following reasons:
    - It sits in very close proximity to the inside edge of the clay side liner in most areas and will most likely need to be relocated for cap tie in to occur.
    - It may be sitting on top of, or in the clay side liner, or may have intercepted it in the south eastern section of the landfill opposite the south east dam.
    - It may have intercepted the clay side liner along the western side of the landfill where it feeds extracted gas to the onsite flare.
- Anecdotal evidence suggests the leachate extraction pipe, which runs from leachate sump LP003 to the leachate treatment plant inlet, is buried in waste. The exact location of the buried pipe was not provided, however, Cleanaway should confirm if the buried pipe has cut through the clay side liner along the north eastern perimeter of the landfill, or anywhere else, as this may compromise the wall and create a preferential gas migration pathway toward the onsite leachate treatment plant. Associated power lines with the leachate extraction pump in LP003 may also be buried and could lead to the same issues.

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6. Figures

Figures 1 to 21 listed below, are attached to this memorandum and should not be used and/or distributed without first reading the information and limitations outlined within this document:

Figure 1 – General Layout Plan

North western landfill perimeter

Figure 2 – Section A

Northern landfill perimeter

Figure 3 – Section B

Figure 4 – Section C

Figure 5 – Section D

Figure 6 – Section E

North eastern landfill perimeter

Figure 7 – Section F

Figure 8 – Section G

Eastern landfill perimter

Figure 9 – Section H

Figure 10 – Section J

South eastern landfill perimeter

Figure 11 – Section K

Figure 12 – Section L

Figure 13 – Section M

Figure 14 – Section N

Figure 15 – Section O

South western landfill perimeter

Figure 16 – Section P

Figure 17 – Section Q

Figure 18 – Section R

Western landfill perimeter

Figure 19 – Section S

Figure 20 – Section T

Figure 21 – Section U

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Figures 1 to 21: General Layout Plan & Cross-sections A to H and J to U

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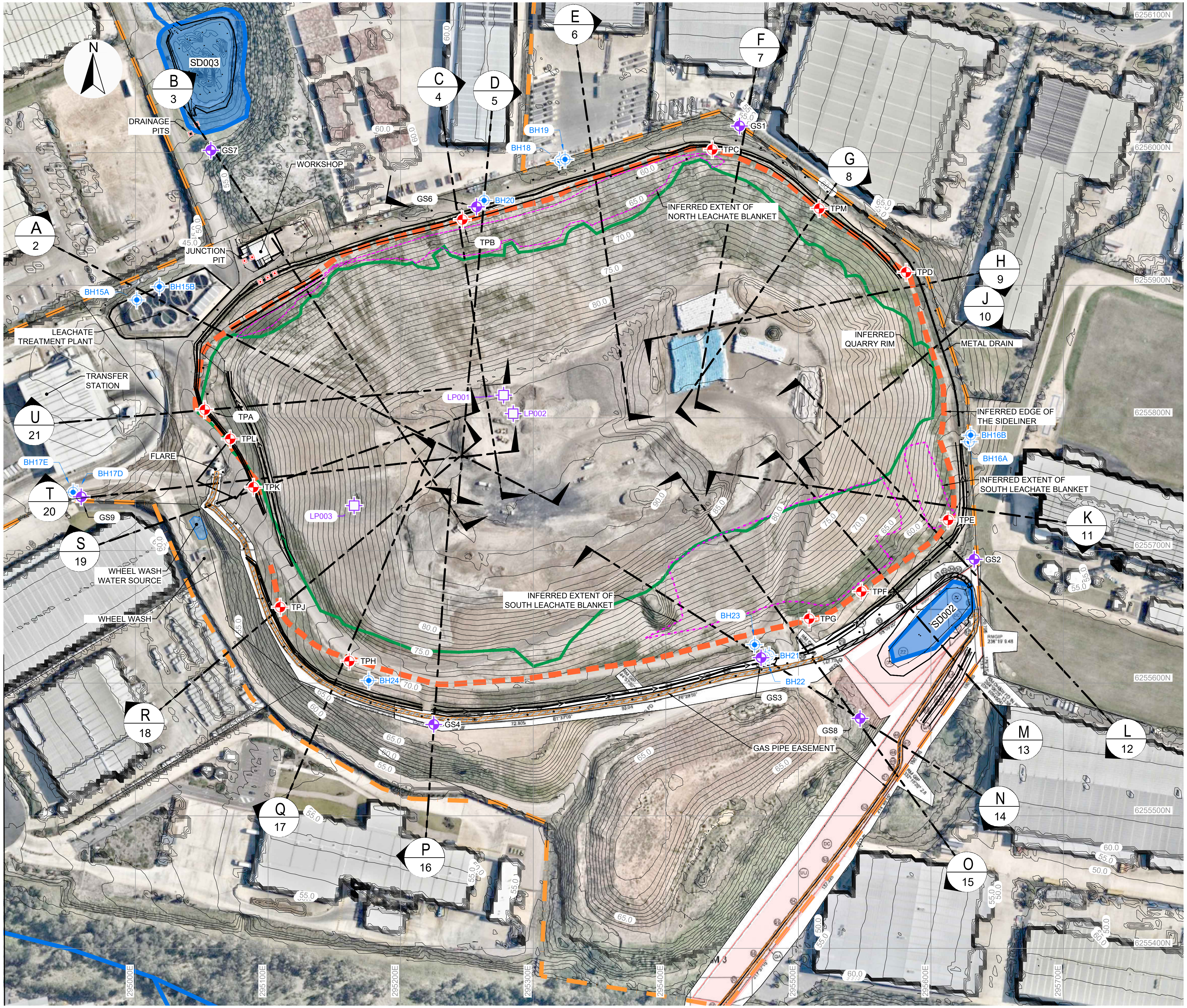

LEGEND

- APPROXIMATE LOCATION OF 2013 LICENCE BOUNDARY
- EXISTING SURFACE AT 1 m INTERVAL
- INFERRED QUARRY RIM BOUNDARY
- ASSUMED INSIDE EDGE OF SIDELINER
- EXISTING CREEKS AND DAMS
- EXISTING PERIMETER LANDFILL GAS MONITORING BORE LOCATIONS
- EXISTING GROUNDWATER MONITORING BORE LOCATIONS
- EXISTING DRAINAGE PIT AND JUNCTION PIT LOCATIONS
- EXISTING LEACHATE SUMP LOCATIONS
- APPROXIMATE GAS PIPE EASEMENT TO AUSTRAL BRICKS SITE - REFER AS PIPE OBVERT IN SECTIONS
- APPROXIMATE GAS PIPE EASEMENT TO AUSTRAL BRICKS SITE - REFER AS TRENCH BOTTOM IN SECTIONS
- EASEMENT TO DRAIN SURFACE WATER
- SWALE DRAIN LOCATIONS
- TEST PIT INVESTIGATION -ROUND 2 LOCATION
- A 2 — LOCATION OF DETAILED PERIMETER CROSS- SECTION
- INFERRED NORTH LEACHATE BLANKET EXTENT
- INFERRED SOUTH LEACHATE BLANKET EXTENT

REFERENCES

1. AERIAL PHOTOGRAPH SOURCED FROM NEARMAP, ON 11 DECEMBER 2019, IMAGE DATED 29 OCTOBER 2019.
2. EXISTING CREEKS AND DAMS APPROXIMATE ALIGNMENTS AND LOCATIONS ARE SHOWN FROM COMBINED GOOGLE MAP AND NEARMAP AERIAL PHOTOGRAPH INFORMATION SOURCED ON 25 JULY 2019, IMAGE DATE 20 JULY 2019.
3. 2013 LICENCE BOUNDARY COORDINATES PROVIDED AND SHOWN FROM KEATLEY SURVEYORS, PLAN SHOWING CO-ORDINATES OF ENVIRONMENT PROTECTION AREA LICENSE NO. 4865, QUARRY ROAD ERSKINE PARK PERINTH CITY COUNCIL (PDF FORMAT), SURVEY DATED 7/6/13.
4. EXISTING SURVEY CONTOURS REGENERATED FROM AUAV DRONE SERVICES AND DATA SOLUTION DATA PROVIDED IN CONFIDENCE TO SENVERSA ON 24 JANUARY 2020, FILE REF: *2019_12_04_ERSKINE_PARK_3M_GRID_FACES.DWG*
5. QUARRY BOUNDARY SHOWN FROM BROWN CONSULTING , DATA PROVIDED BY CLEANAWAY TO SENVERSA, DRAWING NO. C1010 REV04, TITLED "OVERALL PLAN", DATED 22.12.06. FILE REF : W03033.35-C101.DWG
6. ASSUMED INSIDE EDGE OF THE SIDELINER SHOWN FROM THE COMBINED AS-BUILT SURVEY AND SENVERSA TEST PIT INVESTIGATION (ROUND 2).
7. SWALE DRAINS, METAL DRAINS, DAMS, PITS ALIGNMENT SHOWN FROM KEATLEY SURVEYORS, PLAN SHOWING DETAIL;, LOCATION OF MONITORING WELLS & DAM VOLUMES, CLEANAWAY QUARRY ROAD, ERSKINE PARK PENRITH CITY COUNCIL, FILE REF : 2220det06.DWG.
8. ELEVEN PLANS SHOWING THE GAS EASEMENT WERE PROVIDED TO SENVERSA BY CLEANAWAY ON 16 SEPTEMBER 2019, IN PDF, TITLED "PLAN OF PROPOSED GAS EASEMENT , SHEETS 1 -11" , SURVEY DATE 01 JULY 2014, FILE REF: DBYD EASEMENT MAPS. PDF
9. 2005 SURVEY PLAN DATA PROVIDED IN CONFIDENCE TO SENVERSA BY CLEANAWAY IN NOVEMBER 2019, FILE REF: ERSKINE PARK LANDFILL 041205_MGA 94.DXF, SURVEY DATE 04.12.2005
10. 1999 SURVEY PLAN DATA PROVIDED IN CONFIDENCE TO SENVERSA BY *CLEANAWAY IN NOVEMBER 2019, FILE REF: ERSKINE PARK LANDFILL 301199_MGA 94.DXF, SURVEY DATE 30.11.1999.*
11. AS BUILT NORTH BLANKET SURVEY MAY 2008 SHOWN FROM SGS , DRAWING TITLE " ENVIROGUARD ERSKINE PARK LANDFILL NORTHERN BATTER CONSTRUCTION WORKS AS EXECUTED PLAN - OVER ALL PLAN" SHEET 1 OF 19. PLAN NO. 234-NB/WAX. CONTOURS FROM SCANNED DOCUMENT WERE DIGITISED TO REGENERATE INFERRED SURFACE.

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PLAN VIEW

SCALE 1:3 000

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FINAL

0 30 60 90m

SCALE 1:3000 AT ORIGINAL SIZE

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Client	CLEANAWAY SOLID WASTE PTY LTD	Project Title	ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)
Reviewed: N. VERGA	Drawn: M. LUI LAM	Figure Title	GENERAL LAYOUT PLAN
Approved: N. THOMSON	Date: 01.04.2020	A3	Scale: AS SHOWN
File No	S17375_011_RPT_001	Figure No 1	Rev 0

Plotted By: Isaiah Hay

Plot Date: 1 April 2020 - 2:35:16 PM

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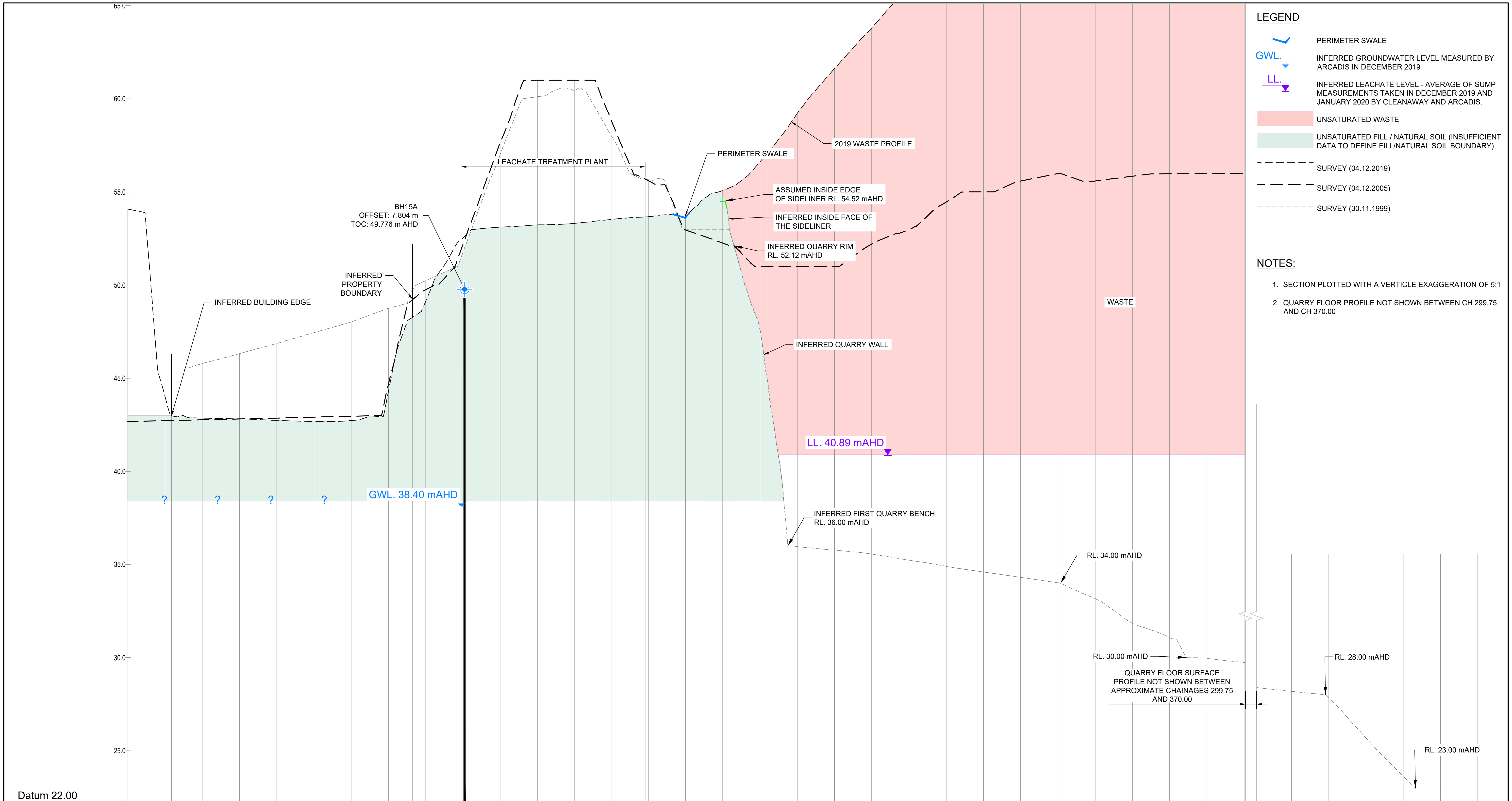
Version: 1, Version Date: 16/04/2020



NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. QUARRY FLOOR PROFILE NOT SHOWN BETWEEN CH 299.75 AND CH 370.00

Datum 22.00

SURVEY (04.12.2019)	54.08	44.00	42.98	42.86	42.82	42.74	42.68	42.73	44.30	48.27	49.14	52.54	53.11	53.23	53.32	53.53	53.66	53.67	53.64	55.08	56.62
SURVEY (04.12.2005)	42.68	42.72	42.73	42.77	42.82	42.86	42.91	42.96	44.68	49.22	49.75	52.18	57.66	61.00	61.00	58.77	55.71	55.61	52.96	52.25	51.00
SURVEY (30.11.1999)				45.79	46.32	46.87	47.45	48.02	48.76	49.76	50.24	51.76	57.00	60.11	60.41	57.96	55.68	55.66	53.00	53.00	47.59
CHAINAGE	0.00	10.00	11.73	20.00	30.00	40.00	49.98	60.00	70.00	76.48	80.00	90.00	99.98	110.00	120.00	130.00	139.16	140.00	149.75	160.00	170.00

SURVEY (04.12.2019)	59.22	61.63	63.81	66.10	68.44	70.69	73.04	75.28	77.61	79.91	82.14	84.49	85.78	88.53	88.59	88.72	88.81	88.88	88.97
SURVEY (04.12.2005)	51.00	51.00	52.21	52.97	54.46	55.00	55.59	55.98	55.59	55.85	55.98	55.99	56.00	60.77	62.00	62.00	61.98	62.00	61.91
SURVEY (30.11.1999)	35.96	35.77	35.56	35.24	34.90	34.60	34.31	34.02	33.16	31.83	31.08	29.96	29.74	28.19	27.83	25.69	23.63	23.00	23.00
CHAINAGE	180.00	190.00	199.75	210.00	220.00	230.00	240.00	249.75	260.00	270.00	280.00	290.00	299.75	370.00	380.00	390.00	399.75	410.00	420.00

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SECTION A
1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

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SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION A

Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020

A3 | Scale: AS SHOWN | File No S17375_011_RPT_001 | Figure No 2 | Rev 0

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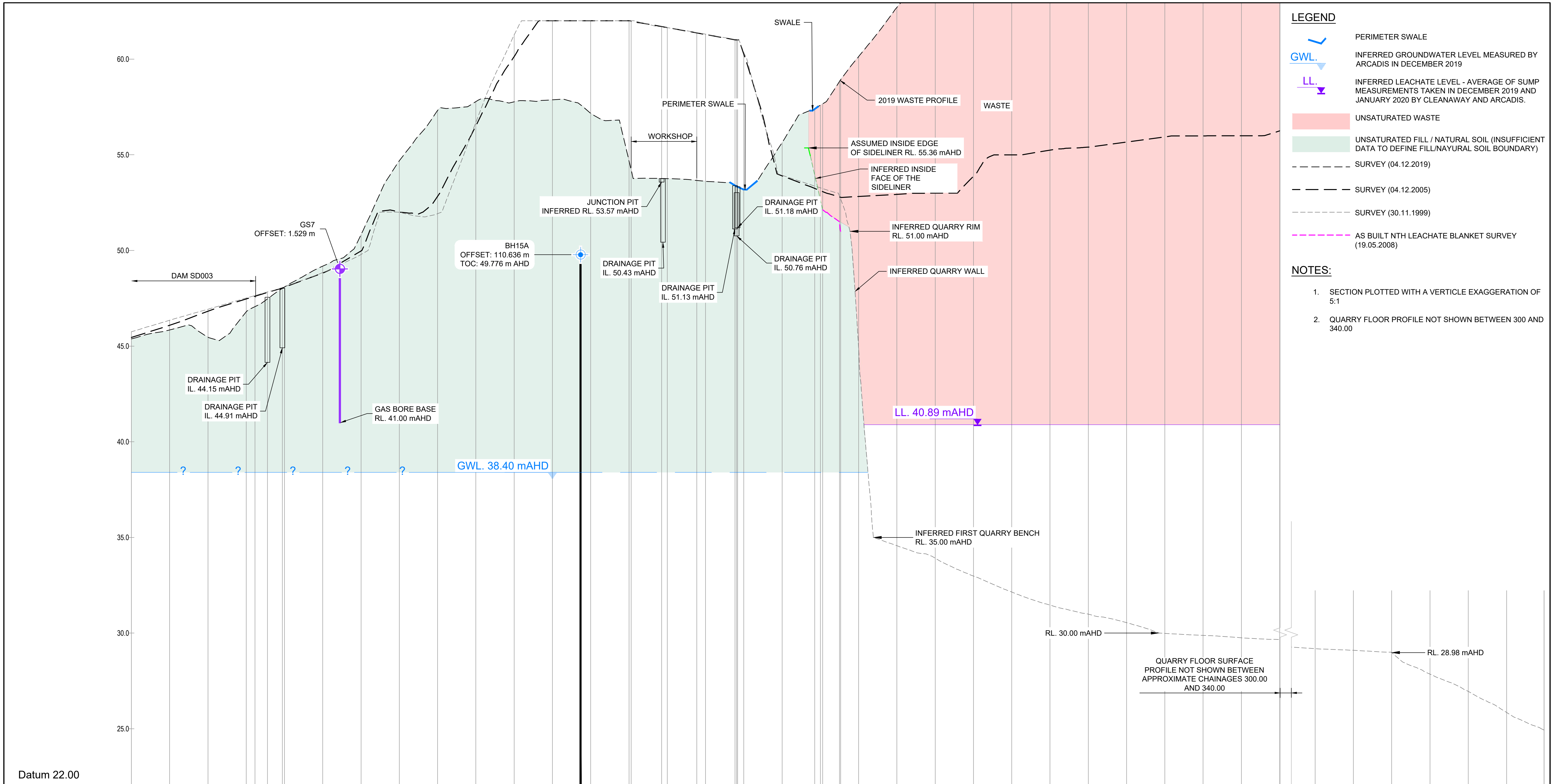

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. QUARRY FLOOR PROFILE NOT SHOWN BETWEEN 300 AND 340.00

Datum 22.00

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10.00	45.85	46.09	46.35	
20.00	45.47	46.82	46.93	
30.00	46.79	47.46	47.51	
32.29	47.06	47.60	47.64	
35.57	47.47	47.80	47.83	
39.45	48.02	48.04	48.06	
40.00	48.09	48.08	48.10	
50.00	49.18	48.82	48.84	
60.00	50.83	49.97	49.79	
70.00	54.69	52.01	52.00	
80.00	57.31	52.83	51.92	
90.00	57.78	56.50	56.69	
100.00	57.76	60.13	61.27	
110.00	57.87	62.00	62.00	
120.00	57.17	62.00	62.00	
130.00	54.69	62.00	62.00	
130.57	54.21	61.99	62.00	
138.52	53.76	61.70	61.68	
140.00	53.75	61.65	61.64	
147.72	53.66	61.37	61.39	
150.00	53.61	61.29	61.31	
157.70	53.39	61.01	61.03	
158.13	53.35	61.01	61.01	
158.36	53.33	61.01	61.01	
160.00	53.19	60.26	60.36	
170.00	55.63	53.90	53.93	
178.52	57.39	53.24	53.36	
180.00	57.59	53.12	53.27	
180.59	57.66	53.08	53.23	52.13
185.00	58.83	52.80	52.84	51.50
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190.00	60.13	52.82	44.84	
200.00	62.71	52.93	34.57	
210.00	65.18	52.99	33.92	
220.00	67.57	53.87	32.98	
230.00	69.96	55.00	32.15	
240.00	72.37	55.24	31.46	
250.00	74.75	55.40	30.99	
260.00	77.37	55.67	30.55	
270.00	79.83	55.94	29.98	
280.00	82.43	55.99	29.88	
290.00	85.23	55.99	29.76	
300.00	85.62	56.25	29.66	
340.00	86.41	59.00	29.19	
350.00	86.84	59.10	29.10	
360.00	87.34	59.40	28.98	
370.00	88.37	59.29	27.85	
380.00	88.58	59.29	26.95	
390.00	89.80	59.47	25.85	
399.79	90.34	59.78	24.93	

SECTION B

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

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ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION B

Reviewed: N. VERGA | Drawn: M. LUI LAM
Approved: N. THOMSON | Date: 01.04.2020

A3 | Scale: AS SHOWN | File No S17375_011_RPT_001 | Figure No 3 | Rev 0

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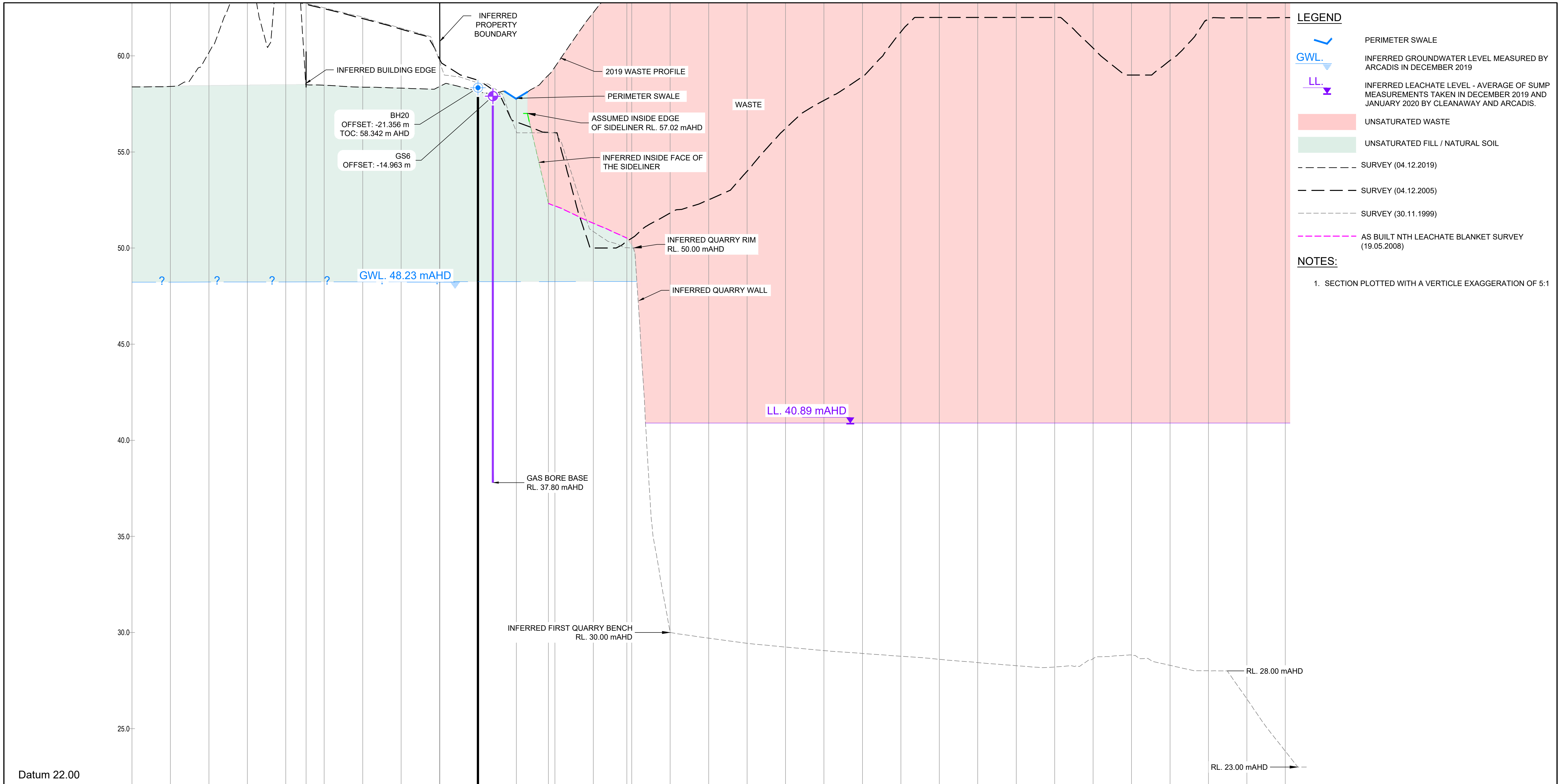
Version: 1, Version Date: 16/04/2020



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SURVEY (04.12.2019)	58.39	58.41	60.17	65.11	67.79	58.50	58.47	58.37	58.32	58.40	58.41	58.15	57.78	59.00	59.42	62.25	64.25	64.55
SURVEY (04.12.2005)	64.41	64.22	64.06	63.87	62.96	62.68	62.45	61.94	61.39	59.84	59.80	58.73	56.56	56.02	56.00	50.00	50.35	50.52
SURVEY (30.11.1999)	64.29	64.05	64.01	63.90	62.92	62.73	62.50	62.01	61.44	59.70	59.65	58.59	56.05	56.00	56.00	50.86	50.02	50.01
AS-BUILT NTH LEACHATE BLANKET SURVEY (19.05.2008)														52.33	52.19	51.29	50.52	

CHAINAGE	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	300.00
SURVEY (04.12.2019)	66.77	69.15	71.44	73.76	76.30	78.74	81.22	83.68	86.30	87.42	88.06	88.53	88.69	88.74	88.76	88.75	88.82
SURVEY (04.12.2005)	51.82	52.51	54.00	56.22	57.68	58.92	61.25	62.00	62.00	62.00	62.00	60.41	59.00	59.77	61.86	61.98	61.99
SURVEY (30.11.1999)	30.00	29.71	29.44	29.24	29.06	28.91	28.77	28.60	28.43	28.27	28.20	28.64	28.82	28.29	28.01	26.54	23.83
AS-BUILT NTH LEACHATE BLANKET SURVEY (19.05.2008)																	

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SECTION C

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Address: Level 6, 15 William Street Melbourne Victoria 3000
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Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION C

Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020

A3	Scale	AS SHOWN	File No	S17375_011_RPT_001	Figure No	4	Rev	0

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Plot Date: 1 April 2020 - 2:35:49 PM
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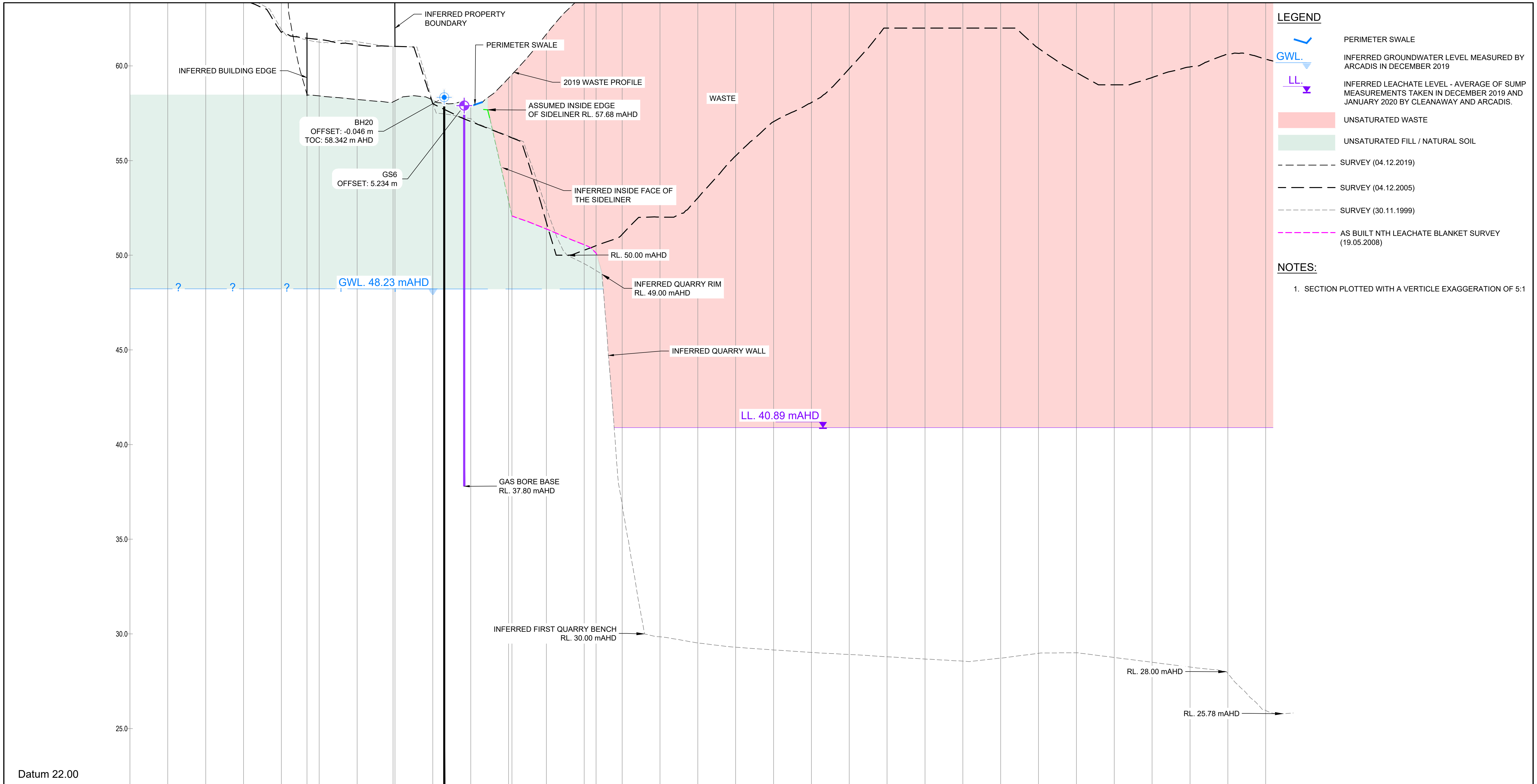
Document Set ID: 9100740
Version: 1, Version Date: 16/04/2020



Datum 22.00

CHAINAGE	SURVEY (04.12.2019)	SURVEY (04.12.2005)	SURVEY (30.11.1999)	AS-BUILT NTH LEACHATE BLANKET SURVEY (19.05.2008)
0.00	71.80	64.40	64.42	
10.00	71.83	64.23	64.25	
20.00	71.87	64.06	64.07	
30.00	71.86	63.49	63.76	
40.00	68.91	61.77	61.93	
46.76	58.49	61.47	61.37	
50.00	58.42	61.40	61.26	
60.00	58.23	61.12	61.28	
69.48	58.10	61.04	61.03	
70.00	58.15	61.03	61.03	
80.00	58.20	58.00	58.04	
90.00	57.89	57.07	57.22	
100.00	59.36	56.27	56.30	
100.88	59.54	56.20	56.23	52.08
110.00	61.68	51.73	52.50	51.38
120.00	63.87	50.26	49.55	50.55
123.14	64.57	50.51	49.19	50.12
130.00	66.21	51.10	36.85	
140.00	68.31	52.02	29.84	
150.00	70.50	53.03	29.52	
160.00	72.52	55.25	29.29	
170.00	74.93	57.05	29.15	
180.00	77.29	58.07	29.02	
190.00	79.60	59.85	28.91	
200.00	81.92	62.00	28.79	
210.00	84.17	62.00	28.67	
220.00	86.40	62.00	28.56	
230.00	87.43	62.00	28.72	
240.00	88.15	60.93	28.97	
250.00	88.52	59.65	29.00	
260.00	88.45	59.00	28.75	
270.00	88.40	59.39	28.50	
280.00	87.96	59.95	28.25	
290.00	88.04	60.61	27.91	
300.00	88.55	60.36	25.96	

SECTION D
1

HOR. SCALE 1:1 000
VER. SCALE 1:200

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ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION D

Reviewed: N. VERGA | Drawn: M. LUI LAM
Approved: N. THOMSON | Date: 01.04.2020

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No: 5 | Rev: 0

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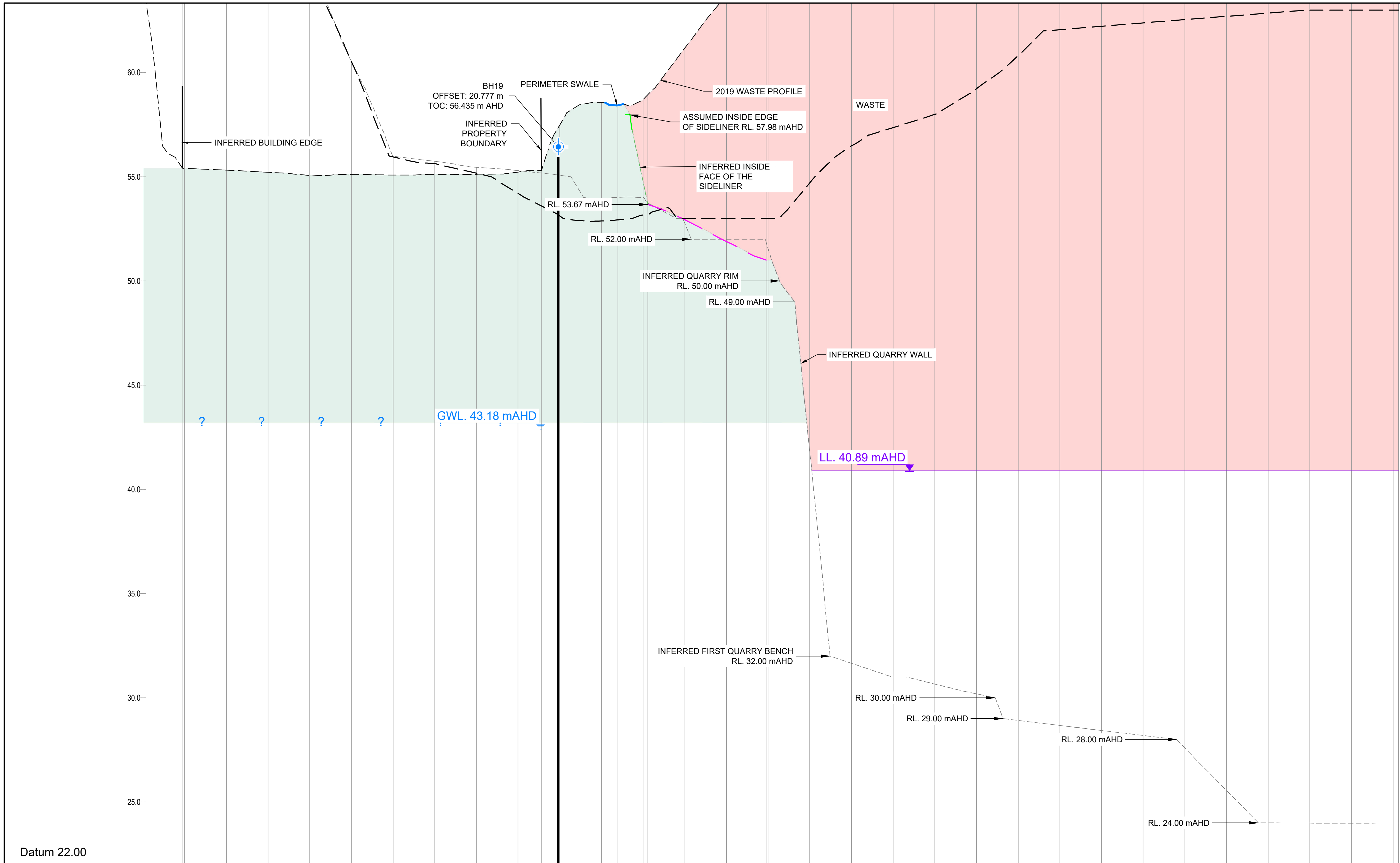
Plot Date: 1 April 2020 - 2:35:56 PM
...5_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg



Datum 22.00

SURVEY (04.12.2019)	64.28	55.42	55.41	55.32	55.21	55.06	55.12	55.08	55.12	55.12	55.22	55.30	57.48	58.57	58.43	58.71	58.94	61.18	63.71	65.96	66.08	68.46	70.87	73.28	75.64	77.92	80.10	82.98	86.20	87.30	88.02	87.45	86.52	86.38	86.44	85.90	85.61
SURVEY (04.12.2005)	64.16	64.18	64.18	64.13	64.08	64.01	60.53	55.95	55.63	55.17	54.20	53.60	53.12	52.88	52.93	53.16	53.19	53.00	53.00	53.00	53.00	54.71	56.48	57.36	58.00	59.22	60.81	62.06	62.22	62.38	62.54	62.70	62.85	63.00	63.00	63.00	63.00
SURVEY (30.11.1999)	64.03	64.08	64.08	64.12	64.06	64.00	60.55	56.00	55.74	55.46	55.30	55.18	55.07	53.88	54.01	54.00	53.73	52.77	52.00	51.87	51.54	41.75	31.66	31.00	30.66	30.19	28.91	28.67	28.43	28.19	27.59	25.55	24.00	23.99	23.98	23.99	23.99
AS-BUILT NTH LEACHATE BLANKET SURVEY (19.05.2008)																	53.67	52.94	51.89	51.00																	
CHAINAGE	0.00	9.40	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	95.58	100.00	110.00	113.93	120.00	121.15	130.00	140.00	149.52	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	300.00	301.30

LEGEND

- PERIMETER SWALE
- GWL. — INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. — INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)
- AS BUILT NTH LEACHATE BLANKET SURVEY (19.05.2008)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1

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SECTION E

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

ISSUED

FINAL

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Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION E

Reviewed: N. VERGA | Drawn: M. LUI LAM
Approved: N. THOMSON | Date: 01.04.2020

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No 6 | Rev 0

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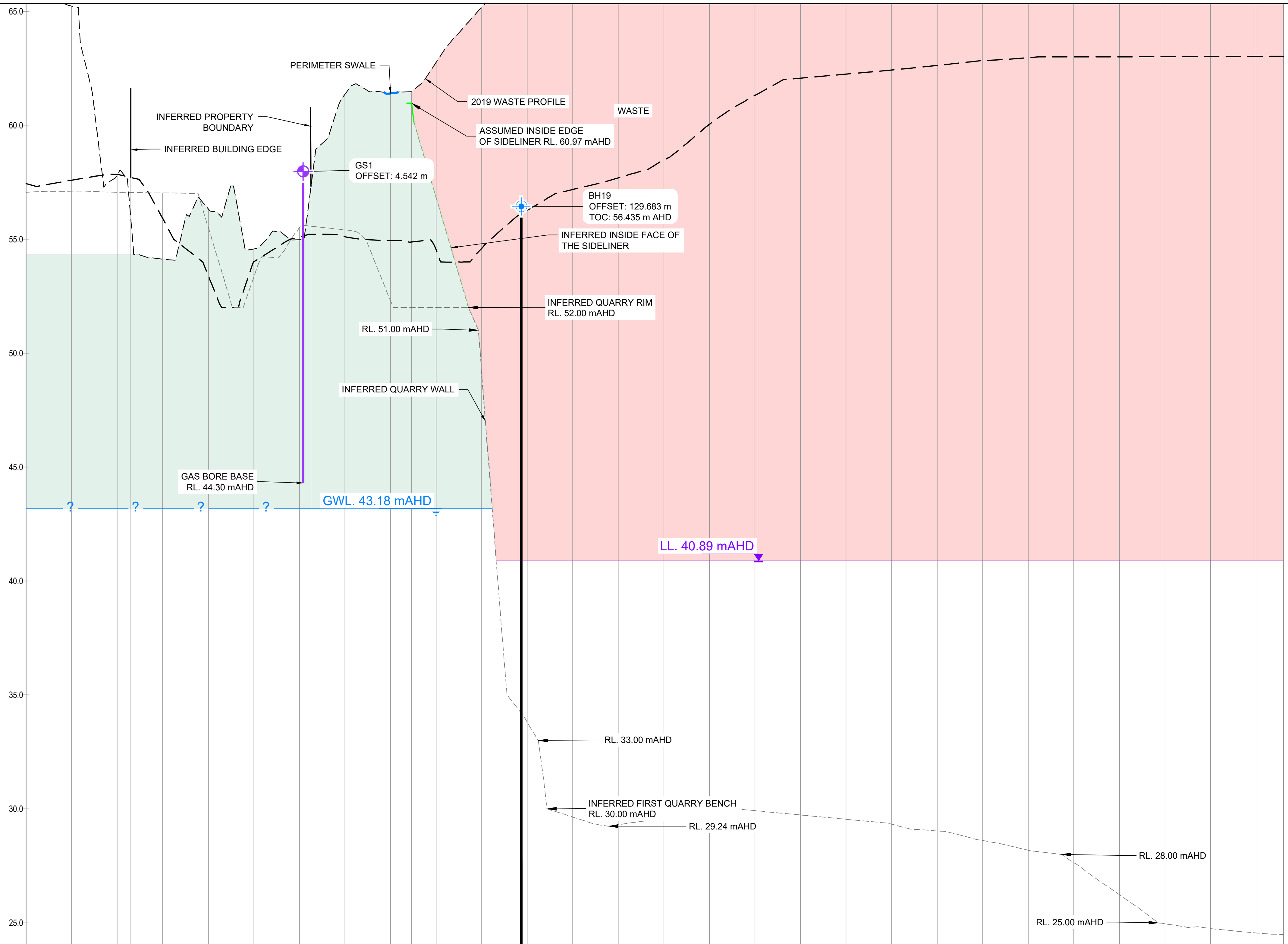

SURVEY (04.12.2019)	65.74	65.23	57.82	55.83	54.13	56.32	54.57	54.97	57.32	61.36	61.40	61.47	62.75	65.18	67.58	69.89
SURVEY (04.12.2005)	57.44	57.59	57.84	57.71	55.91	53.40	54.01	55.10	55.21	55.11	54.94	54.88	54.54	54.59	56.27	57.18
SURVEY (30.11.1999)	57.06	57.10	57.06	57.05	57.03	55.52	53.34	55.51	55.57	55.41	52.30	52.00	52.00	49.05	33.81	29.64
CHAINAGE	0.00	10.00	20.00	23.02	30.00	40.00	50.00	60.00	62.55	70.00	80.00	84.62	90.00	100.00	110.00	120.00

SURVEY (04.12.2019)	72.49	74.98	76.96	78.88	80.52	80.84	81.14	81.45	81.77	82.05	82.22	82.49	82.78	83.09	83.25	83.26
SURVEY (04.12.2005)	57.69	58.45	60.04	61.31	62.07	62.24	62.42	62.62	62.83	62.96	63.00	63.00	63.01	63.01	63.02	63.03
SURVEY (30.11.1999)	29.31	29.60	29.89	29.92	29.73	29.54	29.33	29.03	28.61	28.19	27.64	26.24	24.96	24.75	24.56	24.49
CHAINAGE	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	276.01

LEGEND

- PERIMETER SWALE
- GWL. — INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. — INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1

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SECTION F 1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION F

Reviewed: N. VERGA | Drawn: M. LUI LAM
Approved: N. THOMSON | Date: 01.04.2020

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No: 7 | Rev: 0

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Plotted By: Isaiah Hay
Plot Date: 1 April 2020 - 2:36:10 PM
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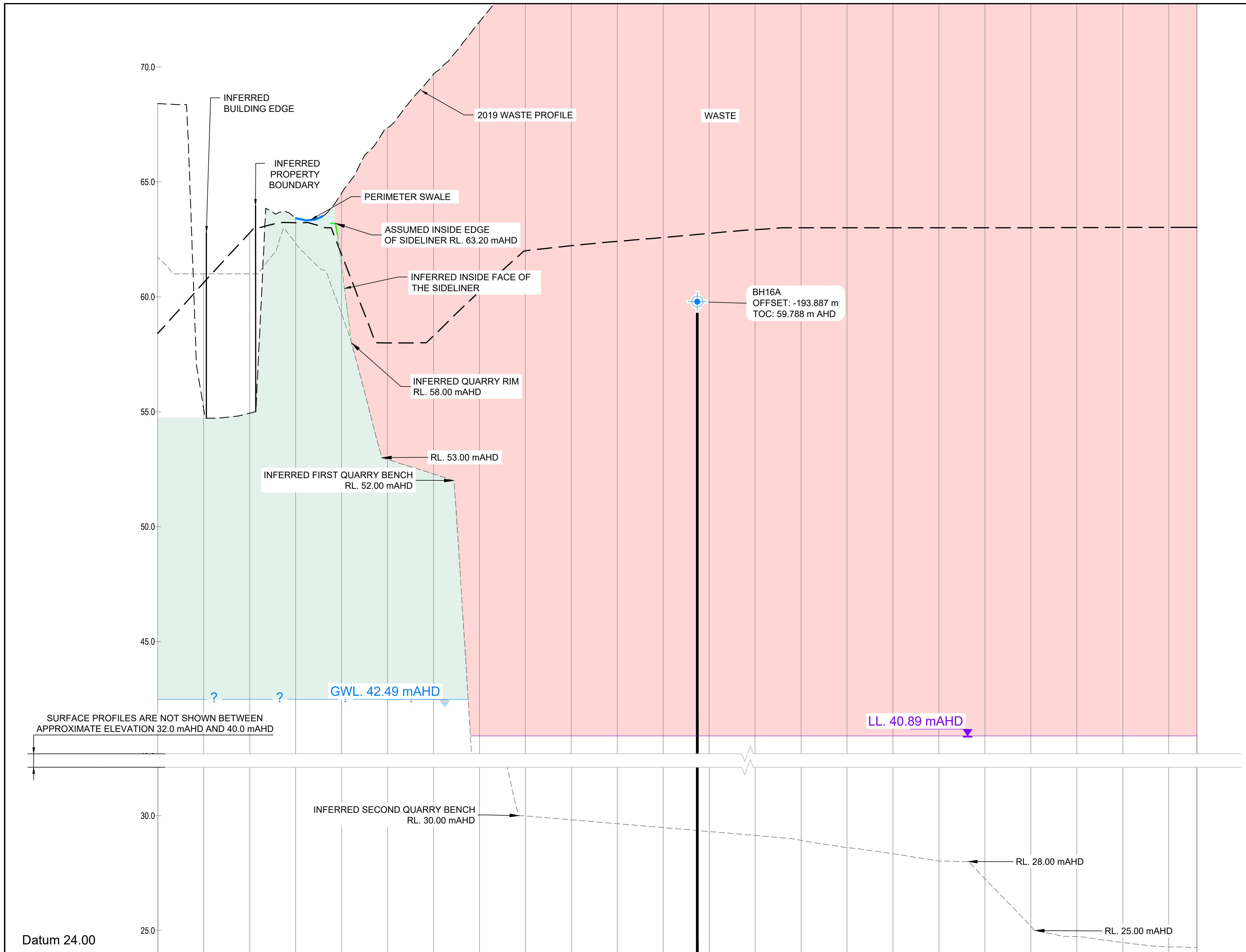

Datum 24.00

SURVEY (04.12.2019)	68.40	55.13	54.93	63.42	64.51	67.35	69.68	71.96	74.61	76.79	79.17	81.67	84.11
SURVEY (04.12.2005)	58.41	60.62	62.78	63.22	61.84	58.00	58.30	60.23	62.00	62.22	62.41	62.58	62.76
SURVEY (30.11.1999)	61.72	61.00	61.00	62.34	59.29	52.92	52.29	36.80	29.99	29.82	29.65	29.48	29.31
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00

SURVEY (04.12.2019)	83.13	81.84	82.17	82.37	82.41	82.58	82.77	83.01	83.17	83.25	83.20
SURVEY (04.12.2005)	62.92	63.00	63.00	63.00	63.00	63.01	63.01	63.01	63.02	63.02	63.02
SURVEY (30.11.1999)	29.14	28.93	28.60	28.34	28.03	27.25	25.19	24.74	24.48	24.29	24.26
CHAINAGE	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	226.15

LEGEND

- PERIMETER SWALE
- GWL. INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. SURFACE PROFILES ARE NOT SHOWN BETWEEN APPROXIMATE ELEVATION 32.0 mAHD AND 40.0 mAHD

Plotted By: Isaiah Hay

Plot Date: 1 April 2020 - 2:36:20 PM

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SECTION G

HOR. SCALE 1:1 000
VER. SCALE 1:200

G
1

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Phone: (03) 9606 0070
Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Reviewed: N. VERGA | Drawn: M. LUI LAM

Approved: N. THOMSON | Date: 01.04.2020

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION G

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No: 8 | Rev: 0

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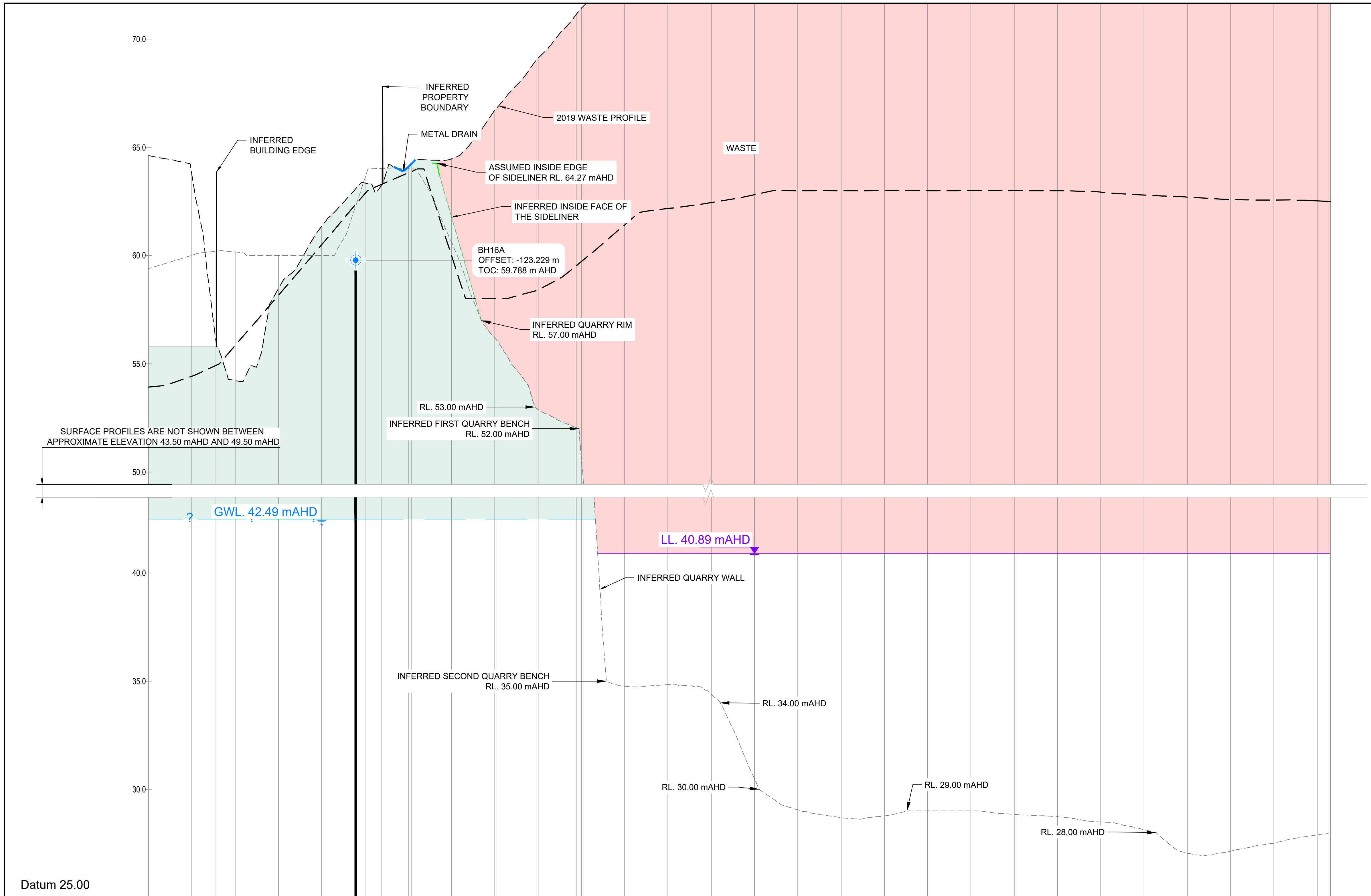

Datum 25.00

SURVEY (04.12.2019)	64.61	63.74	56.00	54.22	58.47	61.34	63.35	63.22	64.09	64.23	64.47	66.72	69.12	71.17	71.43	73.72	76.06
SURVEY (04.12.2005)	53.92	54.43	54.93	55.85	58.16	60.50	62.87	63.28	63.82	63.88	60.01	58.00	58.41	59.55	59.72	61.41	62.18
SURVEY (30.11.1999)	59.40	60.01	60.20	60.16	60.00	60.00	63.59	64.02	64.01	64.01	60.62	56.18	52.89	52.04	50.61	34.77	34.84
CHAINAGE	0.00	10.00	15.59	20.00	30.00	40.00	50.00	53.74	60.00	60.70	70.00	80.00	90.00	98.95	100.00	110.00	120.00

SURVEY (04.12.2019)	78.28	80.30	81.68	85.09	84.26	82.68	81.88	81.95	81.96	81.91	81.83	81.69	81.61	81.97	83.88	84.66
SURVEY (04.12.2005)	62.45	62.82	63.00	63.00	63.00	63.00	63.00	63.00	63.00	62.93	62.79	62.70	62.59	62.56	62.53	62.50
SURVEY (30.11.1999)	34.40	30.49	29.05	28.70	28.77	29.00	29.00	28.84	28.73	28.50	28.14	27.05	27.14	27.52	27.89	27.99
CHAINAGE	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	273.01

LEGEND

- PERIMETER SWALE
- GWL. — INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. — INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. SURFACE PROFILES ARE NOT SHOWN BETWEEN APPROXIMATE ELEVATION 43.50 mAHD AND 49.50 mAHD

Plotted By: Isaiah Hay

Plot Date: 1 April 2020 - 2:36:31 PM

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SECTION H

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Phone: (03) 9606 0070
Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION H

Reviewed: N. VERGA | Drawn: M. LUI LAM
Approved: N. THOMSON | Date: 01.04.2020

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No: 9 | Rev: 0

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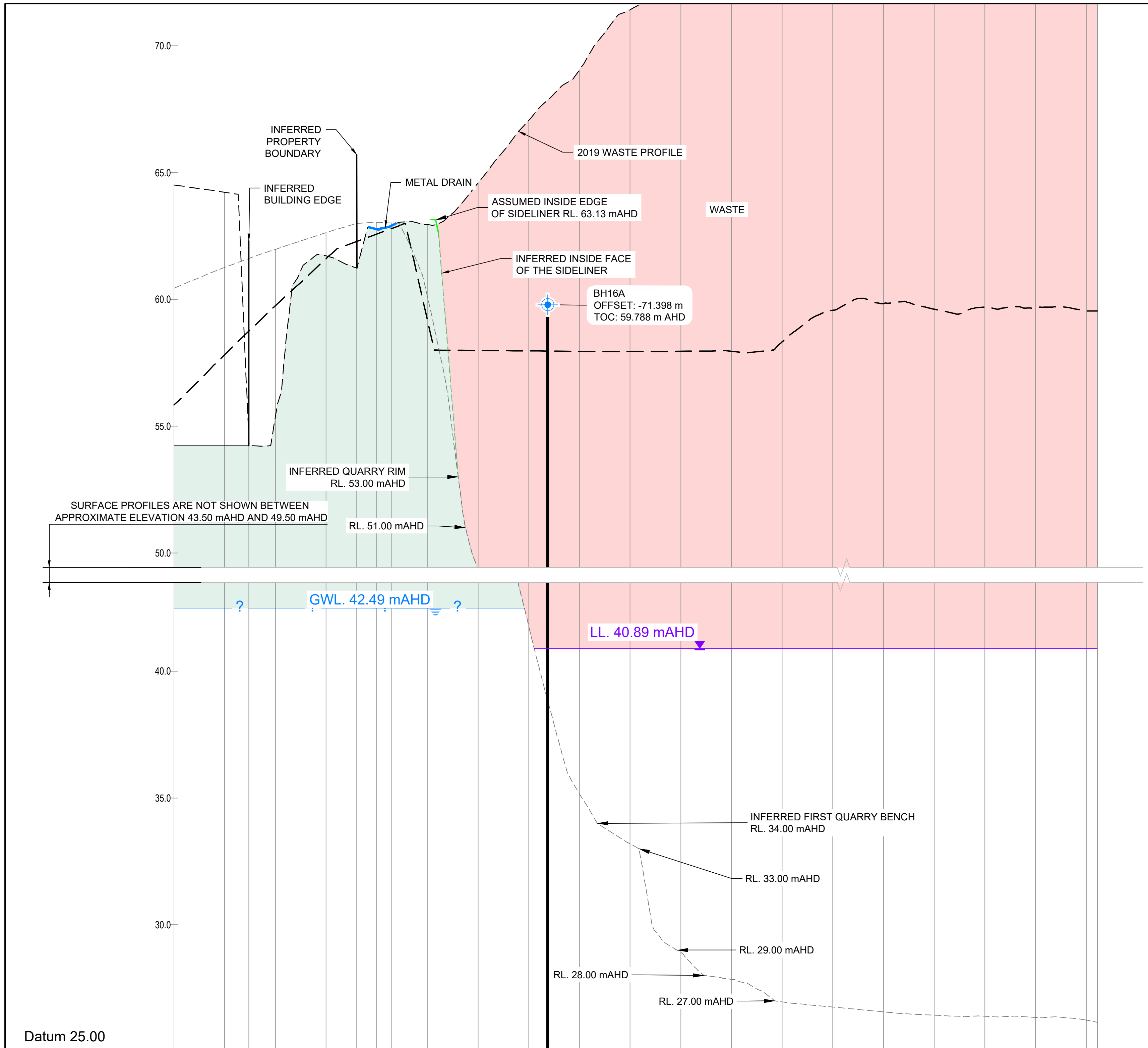

Datum 25.00

SURVEY (04.12.2019)	64.51	64.23	54.35	55.35	61.72	61.24	62.77	62.90	62.95	64.59	67.06	69.05
SURVEY (04.12.2005)	55.84	57.81	58.75	59.75	61.60	62.28	62.58	62.79	59.20	57.99	57.97	57.95
SURVEY (30.11.1999)	60.44	61.26	61.62	61.97	62.63	62.99	63.04	63.02	60.13	49.31	41.78	35.17
CHAINAGE	0.00	10.00	14.79	20.00	30.00	36.04	40.00	42.86	50.00	60.00	70.00	80.00

SURVEY (04.12.2019)	71.42	73.24	75.49	77.66	79.68	81.30	82.45	83.13	82.49	82.14	82.20
SURVEY (04.12.2005)	57.95	57.95	57.95	58.33	59.57	59.83	59.61	59.69	59.68	59.55	59.54
SURVEY (30.11.1999)	33.19	28.91	27.85	26.96	26.75	26.57	26.43	26.39	26.35	26.24	26.16
CHAINAGE	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	182.16

LEGEND

- PERIMETER SWALE
- GWL. — INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. — INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. SURFACE PROFILES ARE NOT SHOWN BETWEEN APPROXIMATE ELEVATION 43.50 mAHD AND 49.50 mAHD

SECTION J 1

HOR. SCALE 1:1 000
VER. SCALE 1:200

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ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Phone: (03) 9606 0070
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Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS - SECTION J

Reviewed: N. VERGA | Drawn: M. LUI LAM
Approved: N. THOMSON | Date: 01.04.2020

A3 | Scale: AS SHOWN | File No S17375_011_RPT_001 | Figure No 10 | Rev 0

Plotted By: Isaiah Hay
Plot Date: 1 April 2020 - 2:36:42 PM

..._CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg

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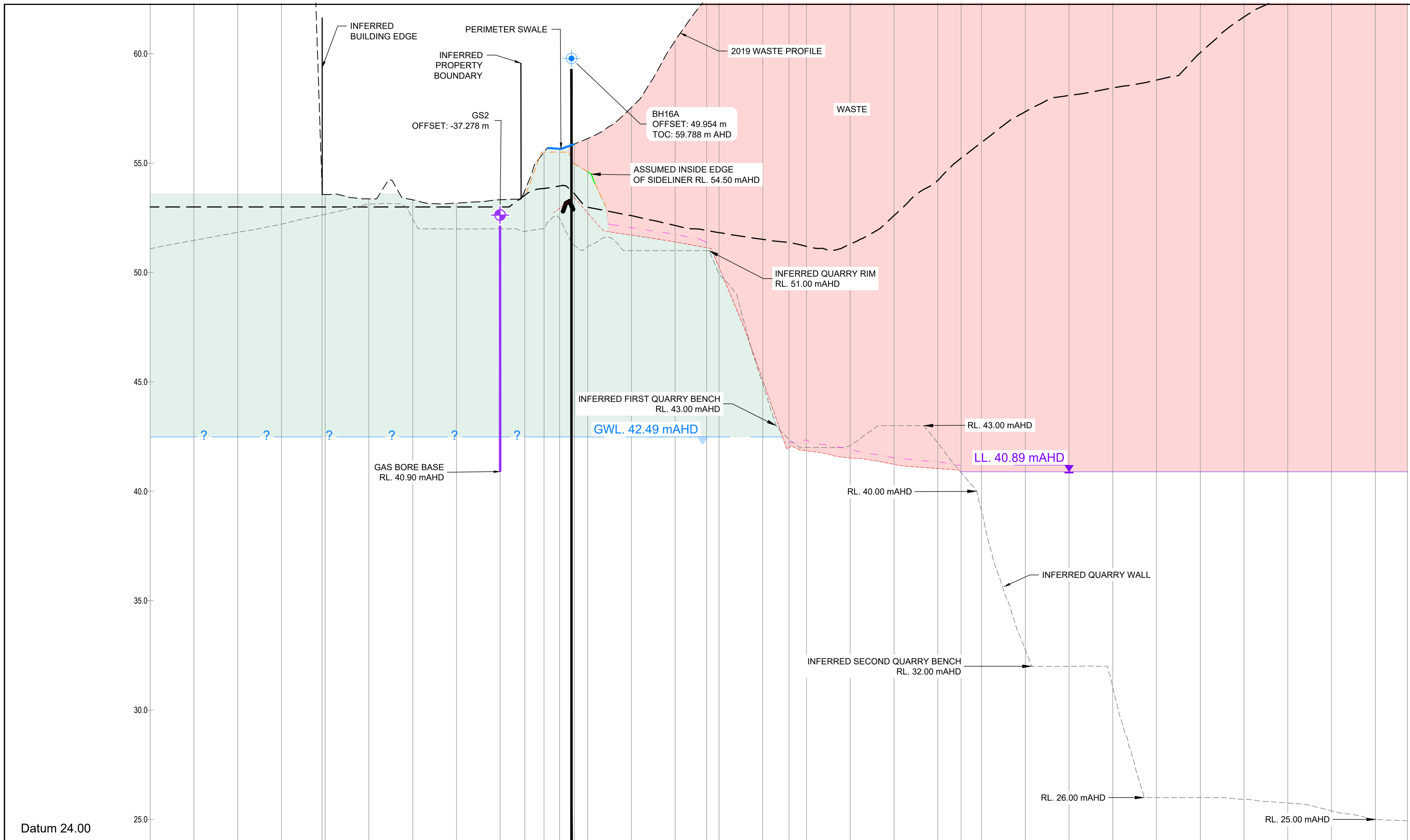

Datum 24.00

CHAINAGE	SURVEY (04.12.2019)	SURVEY (04.12.2005)	SURVEY (30.11.1999)	ENVIRO CLAY WAX (27.09.2006)	AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)	AS-BUILT SUBGRADE SURVEY (27.11.2004)
0.00	73.47	53.00	51.08			
10.00	73.06	53.00	51.47			
20.00	72.64	53.00	51.84			
30.00	72.25	53.00	52.21			
39.26	53.96	53.00	52.63			
40.00	53.57	53.00	52.66			
50.00	53.37	53.00	53.12			
60.00	53.32	53.00	52.46			
70.00	53.17	53.00	51.99			
80.00	53.32	53.00	52.00			
85.62	53.76	53.54	51.89			
90.00	55.50	53.84	52.00	55.50		
93.56	55.66	53.96	52.47	55.50		52.94
96.95	55.87	53.61	51.25	54.97		53.41
100.00	56.13	52.98	51.20	54.60		52.72
110.00	57.55	52.60	51.00		52.05	51.71
120.00	60.60	52.15	51.00		51.73	51.39
127.18	62.56	51.93	51.00		51.35	51.14
130.00	63.25	51.82	49.95			50.23
140.00	65.85	51.51	44.93			45.09
146.02	67.33	51.38	42.36		42.24	42.00
150.00	68.29	51.20	42.00		42.33	41.85
160.00	70.45	51.30	42.10		41.91	41.52
170.00	72.89	52.60	43.00		41.53	41.23
180.00	75.07	54.22	42.22		41.34	41.04
185.35	76.26	55.24	40.86		41.17	
190.00	77.37	55.95	39.12			
200.00	79.71	57.35	32.76			
210.00	78.96	58.09	32.00			
220.00	80.29	58.44	31.02			
230.00	81.96	58.80	26.00			
240.00	82.55	60.05	26.00			
250.00	82.33	61.68	25.92			
260.00	82.15	62.64	25.75			
270.00	83.37	63.00	25.39			
280.00	83.65	63.01	25.00			
287.33	84.72	63.01	24.94			

LEGEND

- PERIMETER SWALE
- GWL. INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)
- ENVIRO CLAY WAX (27.09.2006)
- AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)
- AS-BUILT SUBGRADE SURVEY (27.11.2004)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1

Plotted By: Isaiah Hay

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SECTION K

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION K

Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020

A3 | Scale: AS SHOWN | File No S17375_011_RPT_001 | Figure No 11 | Rev 0

Plot Date: 1 April 2020 - 2:36:48 PM

...5_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg

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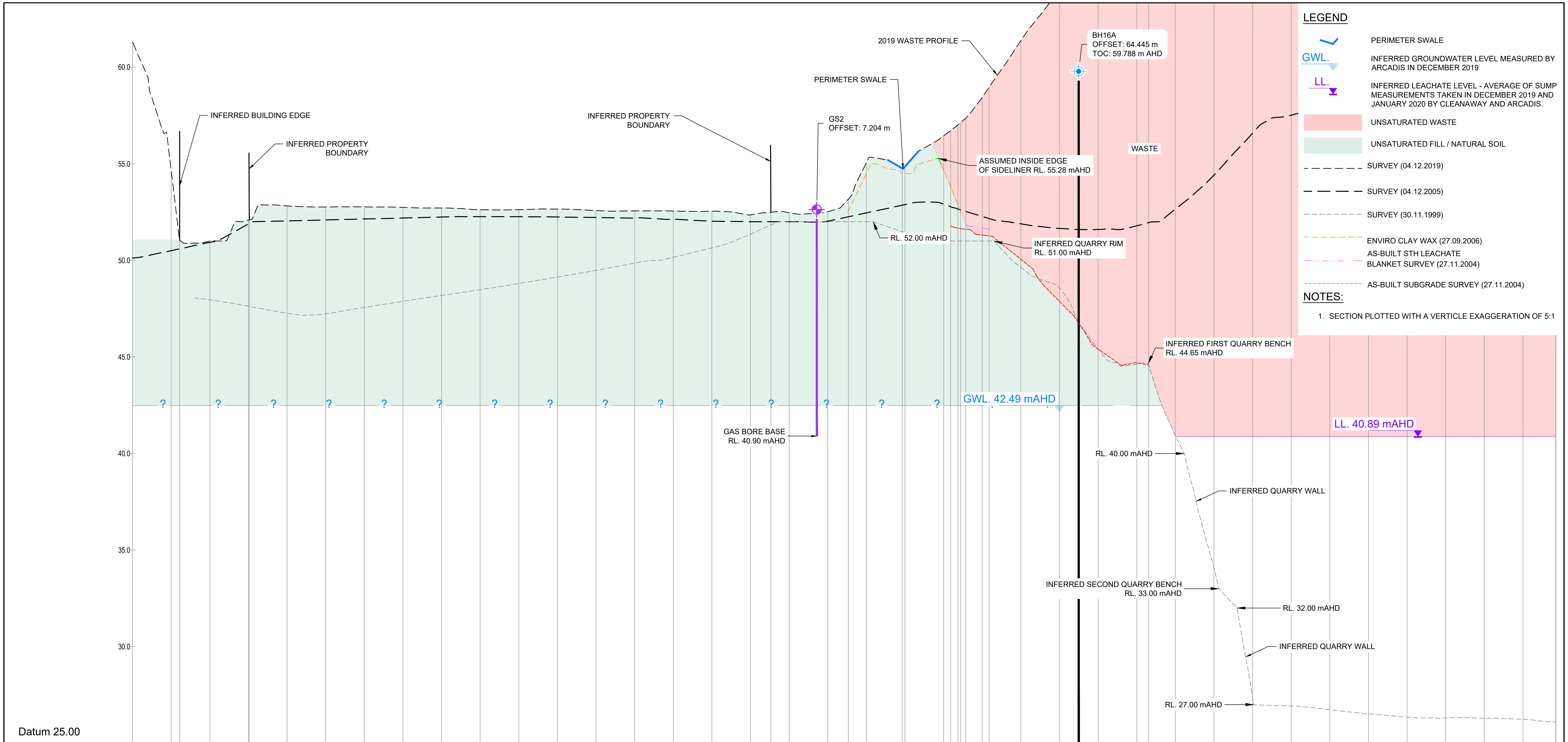

Datum 25.00

CHAINAGE	SURVEY (04.12.2019)	SURVEY (04.12.2005)	SURVEY (30.11.1999)	ENVIRO CLAY WAX (27.09.2006)	AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)	AS-BUILT SUBGRADE SURVEY (27.11.2004)
0.00	61.29	50.12				
10.00	54.64	50.50				
12.17	51.04	50.59				
20.00	51.00	50.93	47.96			
30.00	52.09	51.89	47.63			
30.21	52.10	51.91	47.62			
40.00	52.82	52.04	47.26			
50.00	52.76	52.09	47.23			
60.00	52.77	52.14	47.56			
70.00	52.74	52.19	47.88			
80.00	52.71	52.24	48.18			
90.00	52.62	52.26	48.48			
100.00	52.63	52.26	48.81			
110.00	52.66	52.25	49.14			
120.00	52.58	52.22	49.48			
130.00	52.56	52.19	49.86			
140.00	52.55	52.13	50.16			
150.00	52.54	52.03	50.65			
160.00	52.36	52.00	51.36			
165.28	52.49	52.00	51.84			
170.00	52.46	52.00	52.00			
180.00	52.52	52.03	52.00			
185.33	53.17	52.26	52.00	52.56		
190.00	55.06	52.46	52.00	54.51		
199.31	54.76	52.86	51.48	54.50		
200.00	54.85	52.89	51.44	54.50		
210.00	56.45	52.91	51.00	54.67		
211.84	56.72	52.78	51.00	53.80		
213.71	57.02	52.65	51.00			51.67
214.39	57.14	52.61	51.00	52.85	51.85	51.64
215.75	57.36	52.53	51.00			51.61
220.00	58.45	52.27	51.00		51.68	51.31
221.80	58.97	52.16	51.00		51.61	51.26
230.00	61.38	51.90	49.63			50.05
240.00	63.96	51.66	48.55			47.87
250.00	66.18	51.60	45.41			45.41
260.00	68.30	51.79	44.63			44.69
263.08	68.93	51.95	44.58			44.58
270.00	70.28	52.66	40.93			
280.00	72.37	54.42	34.07			
290.00	74.45	56.59	27.35			
300.00	76.87	57.52	26.93			
310.00	79.42	57.99	26.73			
320.00	81.63	59.98	26.53			
330.00	82.72	62.00	26.35			
340.00	84.53	62.30	26.31			
350.00	84.48	62.57	26.29			
360.00	85.68	62.78	26.24			
368.54	83.24	63.02	26.09			

Plotted By: Isaiah Hay

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SECTION L

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Website: www.senversa.com.au

Client	CLEANAWAY SOLID WASTE PTY LTD	Project Title	ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)
Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020
Figure Title	CROSS SECTION L		
A3	Scale AS SHOWN	File No S17375_011_RPT_001	Figure No 12 — Rev 0

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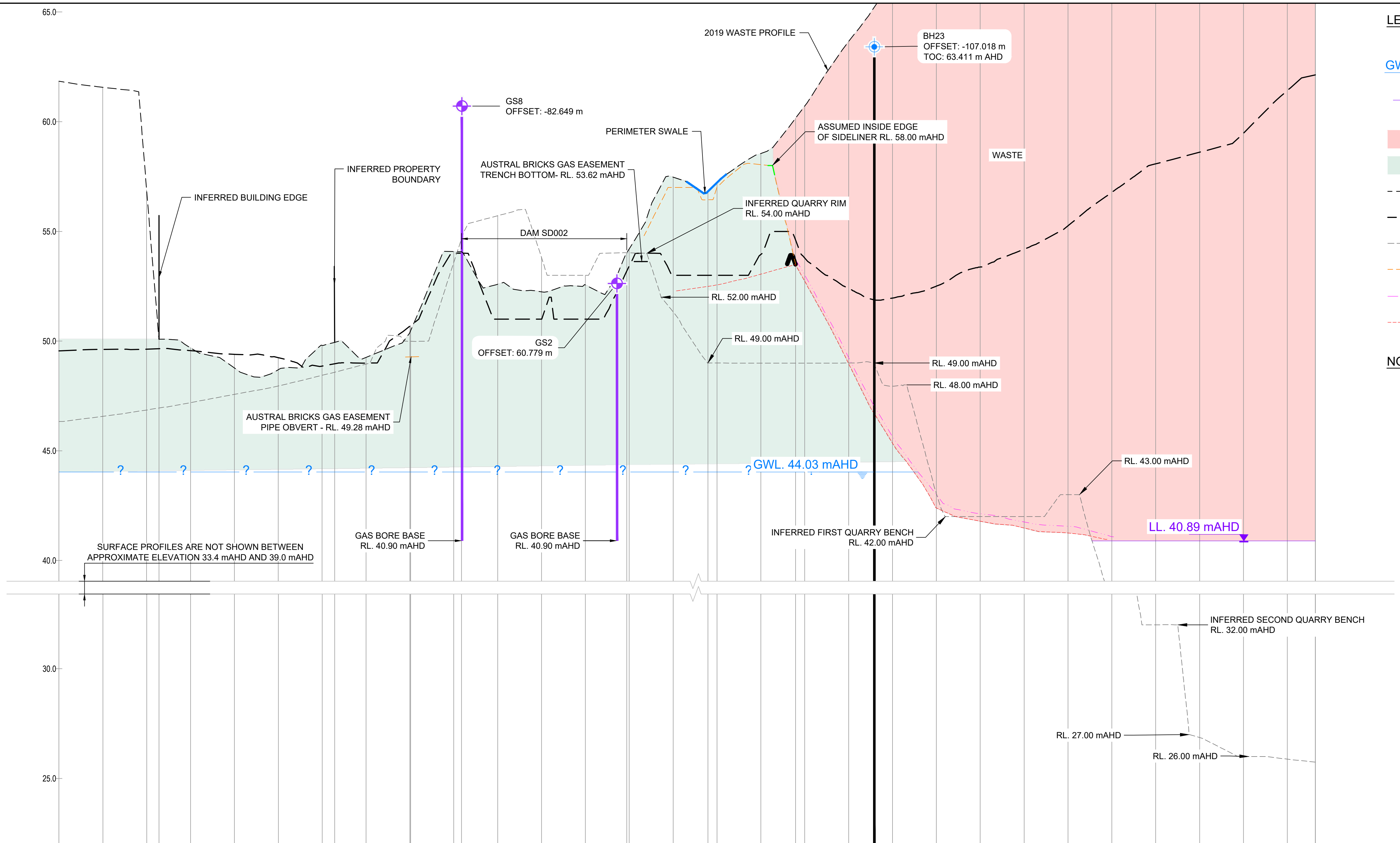
Plot Date: 1 April 2020 - 2:36:54 PM
File Name: ...S17375_011_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg

Document Set ID: 9100740
Version: 1, Version Date: 16/04/2020



Datum 22.00

SURVEY (04.12.2019)	61.85	61.57	56.88	50.09	49.69	48.77	48.69	49.81	49.94	49.26
SURVEY (04.12.2005)	49.56	49.62	49.63	49.65	49.56	49.39	49.24	48.86	48.96	49.00
SURVEY (30.11.1999)	46.34	46.57	46.86	46.95	47.19	47.57	47.95	48.44	48.58	48.95
ENVIRO CLAY WAX (27.09.2006)										
AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)										
AS-BUILT SUBGRADE SURVEY (27.11.2004)										
CHAINAGE	0.00	10.00	20.00	22.81	30.00	40.00	50.00	60.00	62.87	70.00

SURVEY (04.12.2019)	50.39	50.47	54.08	54.07	52.59	52.25	52.56	54.02	54.20	57.47	56.83
SURVEY (04.12.2005)	50.68	50.71	54.00	54.00	51.00	51.00	51.00	53.19	53.42	53.00	53.00
SURVEY (30.11.1999)	49.99	49.99	53.59	54.65	55.71	53.82	53.00	54.02	54.02	51.33	49.00
ENVIRO CLAY WAX (27.09.2006)										57.00	56.44
AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)											
AS-BUILT SUBGRADE SURVEY (27.11.2004)											52.49
CHAINAGE	80.00	80.18	90.00	91.76	100.00	110.00	120.00	129.44	130.00	140.00	147.94

SURVEY (04.12.2019)	57.22	58.55	60.15	60.72	63.66	66.52	69.44	72.04	74.64	77.23	78.53	78.74	80.95	82.55	82.95	82.95
SURVEY (04.12.2005)	53.00	53.95	54.60	53.78	52.40	51.96	52.51	53.38	54.19	55.25	56.78	58.08	58.61	59.48	61.42	62.13
SURVEY (30.11.1999)	49.00	48.99	48.99	48.99	49.00	47.95	43.05	42.00	42.00	43.00	38.03	32.00	26.86	26.01	25.88	25.74
ENVIRO CLAY WAX (27.09.2006)	57.00	58.04	53.51													
AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)				53.01	49.25	45.64	42.99	42.13	41.75	41.56	41.08					
AS-BUILT SUBGRADE SURVEY (27.11.2004)	52.56	53.05	53.47	52.72	48.97	45.34	42.39	41.79	41.48	41.26						
CHAINAGE	150.00	160.00	167.91	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	286.39

LEGEND

- PERIMETER SWALE
- GWL. INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)
- ENVIRO CLAY WAX (27.09.2006)
- AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)
- AS-BUILT SUBGRADE SURVEY (27.11.2004)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. LEACHATE BLANKET INSTALLED NEAR QUARRY RIM AND OVER FIRST QUARRY BENCH.
3. SURFACE PROFILES ARE NOT SHOWN BETWEEN APPROXIMATE ELEVATION 33.4 mAHD AND 39.0 mAHD

Plotted By: Isaiah Hay

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SECTION M

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION M

Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020

A3	Scale AS SHOWN	File No S17375_011_RPT_001	Figure No 13	Rev 0

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Plot Date: 1 April 2020 - 2:37:05 PM
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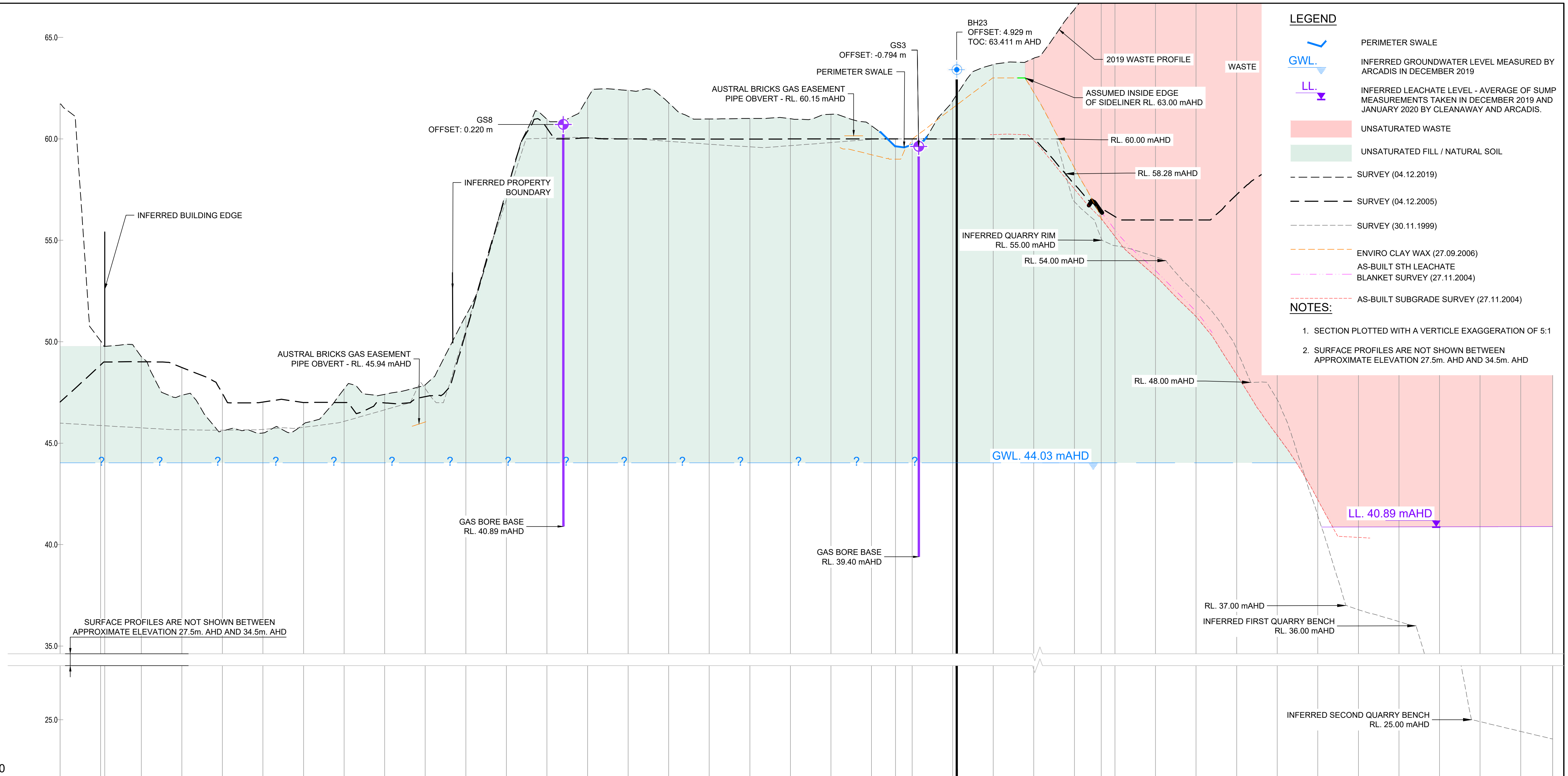

Datum 22.00

CHAINAGE	0.00	10.00	11.01	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00	180.00	190.00
SURVEY (04.12.2019)	61.71	50.04	49.77	49.27	47.36	45.60	45.51	45.94	47.67	47.41	47.88	51.28	57.50	60.97	62.00	62.39	61.77	60.98	61.01	60.99	61.21
SURVEY (04.12.2005)	47.03	48.85	49.00	49.01	48.73	47.45	47.03	47.01	47.00	46.99	47.29	50.45	57.40	60.53	60.05	60.00	60.00	59.99	59.99	60.00	60.00
SURVEY (30.11.1999)	45.99	45.87	45.86	45.76	45.66	45.64	45.68	45.79	46.08	46.64	47.70	50.57	57.00	60.03	60.05	60.00	59.88	59.74	59.61	59.67	59.82
ENVIRO CLAY WAX (27.09.2006)																					
AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)																					
AS-BUILT SUBGRADE SURVEY (27.11.2004)																					

CHAINAGE	200.00	205.92	210.00	220.00	230.00	240.00	250.00	256.62	260.00	270.00	280.00	290.00	300.00	310.00	320.00	330.00	340.00	350.00	360.00	367.90
SURVEY (04.12.2019)	60.64	59.64	59.71	61.88	63.66	63.98	66.38	67.82	68.44	70.63	72.71	74.75	77.55	79.73	80.53	83.90	86.49	87.45	87.95	88.53
SURVEY (04.12.2005)	60.00	60.00	60.00	60.00	60.00	60.00	57.76	56.58	56.17	56.00	56.00	57.25	58.72	59.12	59.28	59.42	59.33	59.21	59.21	59.34
SURVEY (30.11.1999)	59.98	60.00	60.00	60.00	60.00	60.00	56.91	55.09	54.74	54.19	52.35	49.63	47.15	41.44	36.80	36.21	32.06	24.90	24.42	24.05
ENVIRO CLAY WAX (27.09.2006)	59.22	59.00	59.97	61.52	63.00	62.28	58.57	56.07												
AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)									55.52	53.50	51.49									
AS-BUILT SUBGRADE SURVEY (27.11.2004)					60.21	59.92	57.53	56.07	55.19	53.23	51.24	48.37	45.38	42.21	40.36					

Plotted By: Isaiah Hay

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SECTION N
1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Phone: (03) 9606 0070
Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION N

Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No: 14 | Rev: 0

Plot Date: 1 April 2020 - 2:37:16 PM

...5_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg

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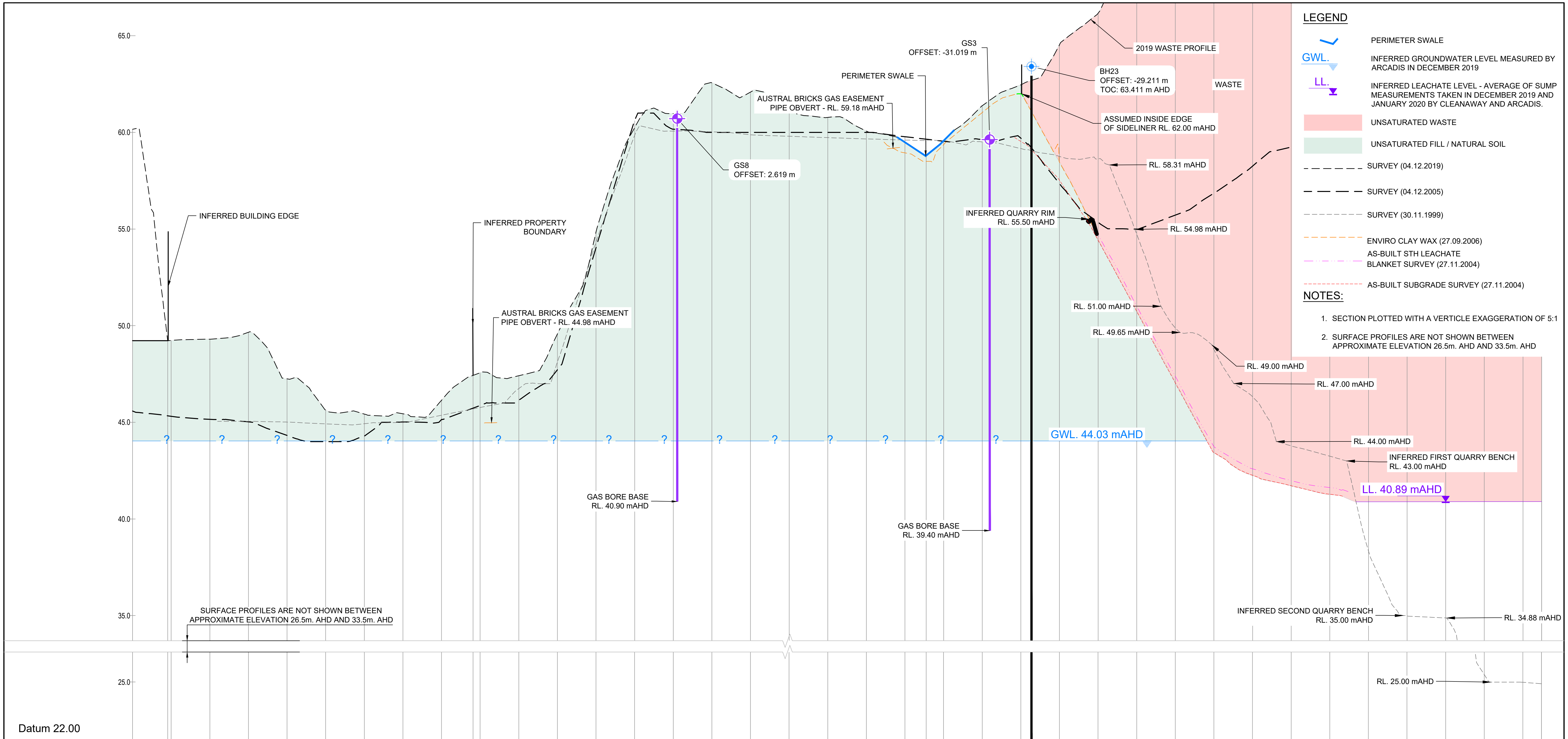
Version: 1, Version Date: 16/04/2020



Datum 22.00

SURVEY (04.12.2019)	60.16	49.23	49.24	49.30	49.66	47.25	45.63	45.43	45.44	46.14	47.43	47.56	47.41	49.57	54.85	60.25	60.97	62.56	62.09	61.54
SURVEY (04.12.2005)	45.59	45.34	45.31	45.15	45.02	44.32	44.00	44.29	45.01	45.15	45.73	45.87	46.15	47.72	54.04	60.60	60.16	60.00	60.00	60.00
SURVEY (30.11.1999)					45.05	45.01	44.92	44.93	44.99	45.36	45.69	45.77	46.74	48.11	54.32	59.84	60.07	60.03	59.88	59.80
ENVIRO CLAY WAX (27.09.2006)																				
AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)																				
AS-BUILT SUBGRADE SURVEY (27.11.2004)																				
CHAINAGE	0.00	9.10	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	88.17	90.00	100.00	110.00	120.00	130.00	140.00	150.00	160.00	170.00

SURVEY (04.12.2019)	60.77	60.06	59.51	58.81	59.55	61.38	62.46	64.53	66.16	69.58	72.12	74.67	77.06	79.48	81.05	81.16	83.90	89.25	89.07	87.62	88.29
SURVEY (04.12.2005)	60.00	60.00	59.78	59.65	59.54	59.63	59.70	57.34	55.35	55.00	55.72	56.85	58.25	59.23	59.64	60.00	61.64	63.00	63.01	63.01	63.01
SURVEY (30.11.1999)	59.73	59.66	59.60	59.60	59.57	59.51	59.16	58.75	58.63	54.73	49.88	48.76	46.32	43.78	43.25	38.35	34.98	34.88	25.39	24.99	24.91
ENVIRO CLAY WAX (27.09.2006)			58.94	58.50	59.36	61.03	62.00	58.46													
AS-BUILT STH LEACHATE BLANKET SURVEY (27.11.2004)									54.68	51.00	47.37	43.73	42.59	41.99	41.63						
AS-BUILT SUBGRADE SURVEY (27.11.2004)							59.53	57.52	54.42	50.74	47.03	43.44	42.26	41.72	41.28						
CHAINAGE	180.00	190.00	200.00	205.50	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	300.00	310.00	320.00	330.00	340.00	350.00	360.00	364.83

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SECTION O

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED
FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Address: Level 6, 15 William Street Melbourne Victoria 3000
Phone: (03) 9606 0070
Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION O

Reviewed: N. VERGA | Drawn: M. LUI LAM
Approved: N. THOMSON | Date: 01.04.2020

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No 15 | Rev 0

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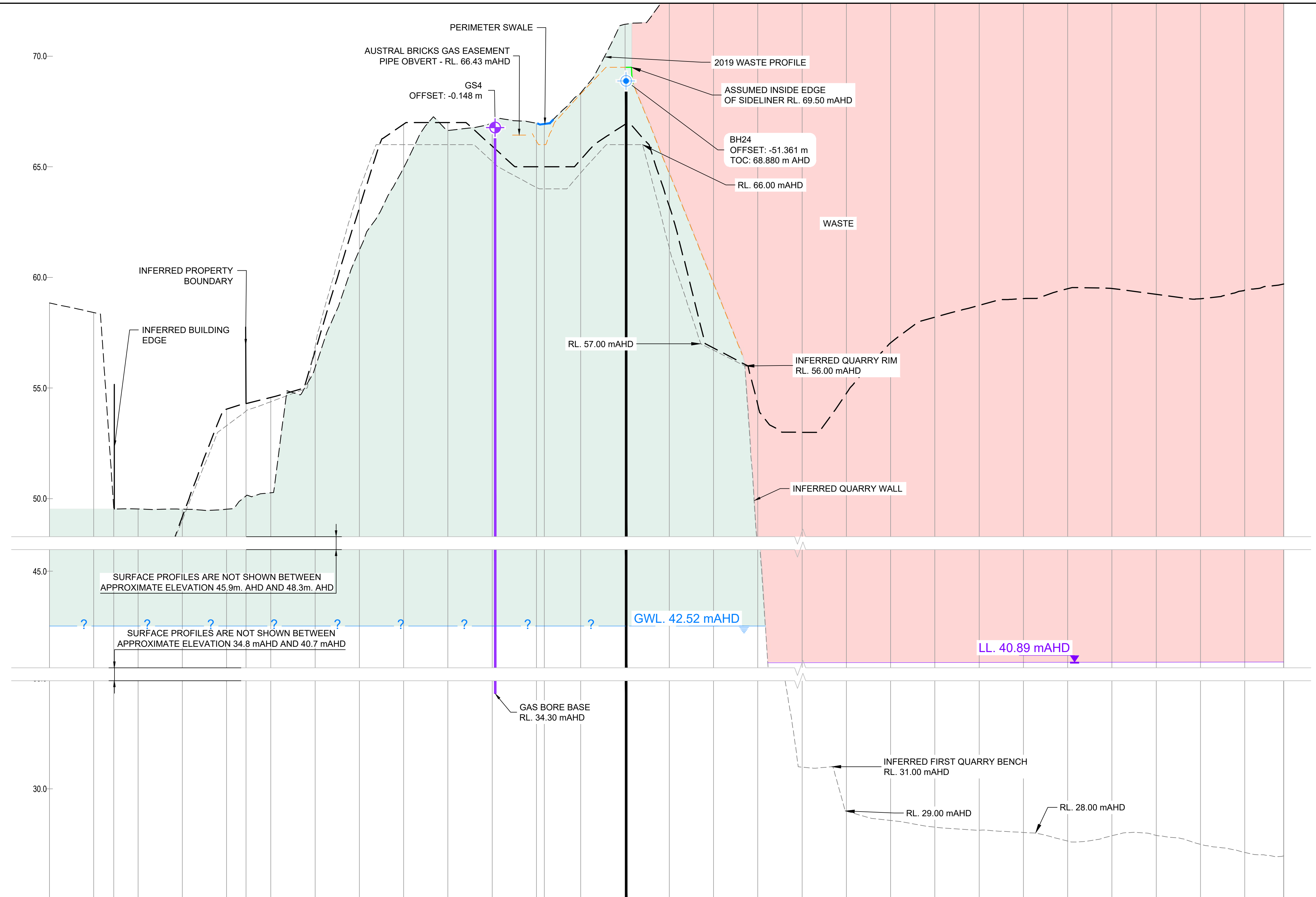
Plotted By: Isaiah Hay
Plot Date: 1 April 2020 - 2:37:27 PM

...5_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg



Datum 25.00

SURVEY (04.12.2019)	58.85	58.42	49.53	49.54	49.53	49.53	50.13	50.26	55.92	61.23	64.96	66.64	67.01	66.97	66.94	68.34
SURVEY (04.12.2005)					49.19	54.05	54.30	54.57	56.67	63.14	66.93	67.00	65.93	65.00	65.00	65.32
SURVEY (30.11.1999)		47.97	47.96	47.95	49.02	53.30	53.97	54.38	56.88	63.97	66.00	66.00	65.24	64.07	64.00	64.73
ENVIRO CLAY WAX (27.09.2006)														66.16	66.00	68.29
CHAINAGE	0.00	10.00	14.53	20.00	30.00	40.00	44.38	50.00	60.00	70.00	80.00	90.00	100.00	110.00	111.80	120.00

SURVEY (04.12.2019)	71.44	73.04	74.08	77.02	79.43	81.94	84.48	86.89	88.06	88.59	89.10	89.59	89.81	89.55	88.77	88.31
SURVEY (04.12.2005)	66.91	63.23	56.81	54.23	53.00	54.76	57.04	58.21	58.74	59.04	59.49	59.50	59.24	59.04	59.43	59.71
SURVEY (30.11.1999)	66.00	61.34	56.71	47.51	30.98	28.99	28.57	28.27	28.13	28.03	27.64	27.88	27.90	27.49	27.12	26.97
ENVIRO CLAY WAX (27.09.2006)	69.50	64.69	59.72													
CHAINAGE	130.00	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	278.79

LEGEND

- PERIMETER SWALE
- GWL. INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)
- ENVIRO CLAY WAX (27.09.2006)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. SURFACE PROFILES ARE NOT SHOWN BETWEEN APPROXIMATE ELEVATION 34.8 mAHD AND 40.7 mAHD
3. SURFACE PROFILES ARE NOT SHOWN BETWEEN APPROXIMATE ELEVATION 45.9m. AHD AND 48.3m. AHD

Plotted By: Isaiah Hay

Plot Date: 1 April 2020 - 2:37:43 PM

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SECTION P

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

senversa
Address: Level 6, 15 William Street Melbourne Victoria 3000
Phone: (03) 9606 0070
Website: www.senversa.com.au

Client	CLEANAWAY SOLID WASTE PTY LTD	Project Title	ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)
Reviewed	N. VERGA	Drawn	M. LUI LAM
Figure Title	CROSS SECTION P		
Approved	N. THOMSON	Date	01.04.2020
A3	Scale: AS SHOWN	File No: S17375_011_RPT_001	Figure No 16 / Rev 0

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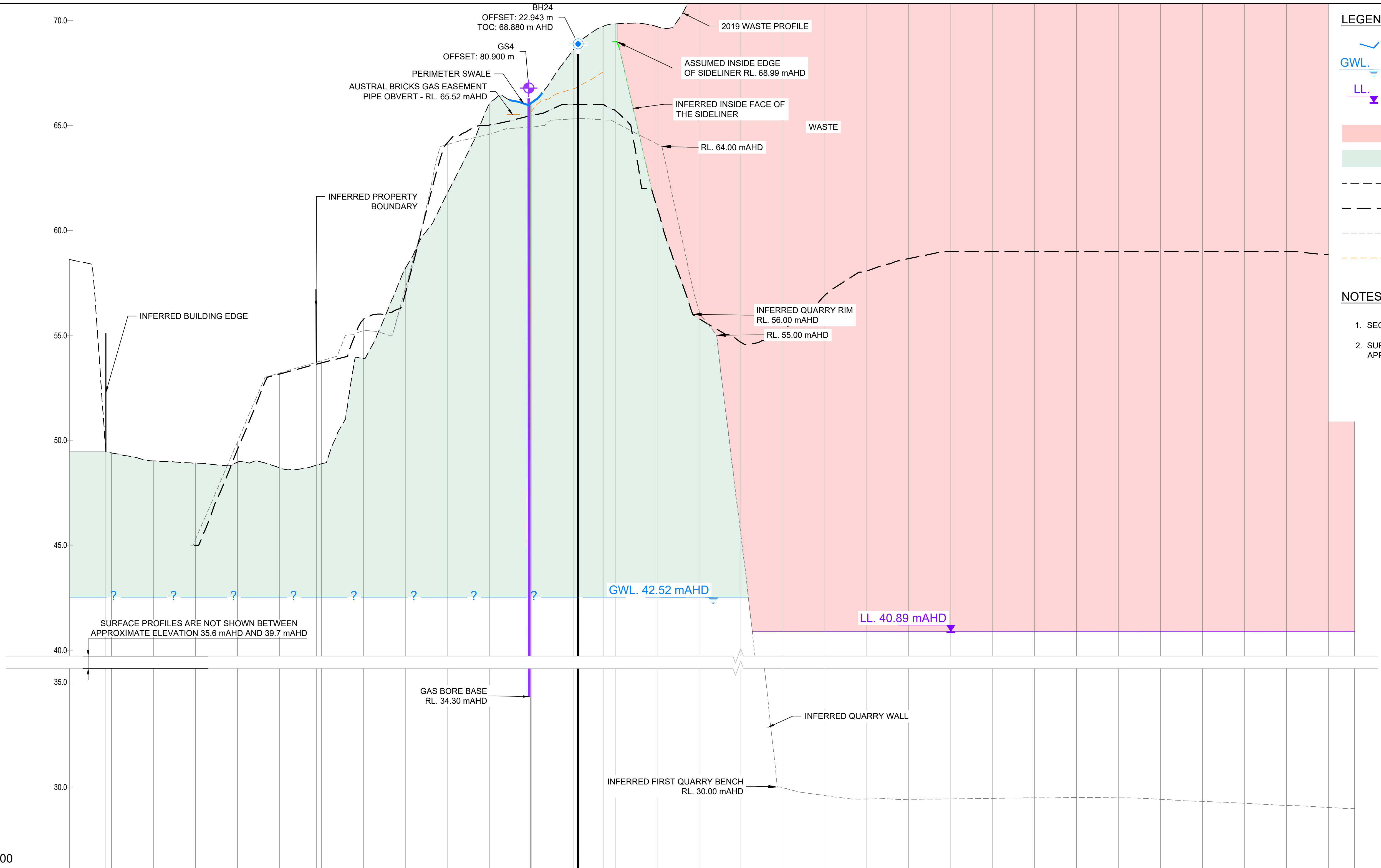
...\S17375_011_ERSKINE PARK CSM\5_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg

Document Set ID: 9100740
Version: 1, Version Date: 16/04/2020



LEGEND

- PERIMETER SWALE
- GWL. — INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. — INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)
- ENVIRO CLAY WAX (27.09.2006)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. SURFACE PROFILES ARE NOT SHOWN BETWEEN APPROXIMATE ELEVATION 35.6 mAHD AND 39.7 mAHD

Datum 26.00

CHAINAGE	SURVEY (04.12.2019)	SURVEY (04.12.2005)	SURVEY (30.11.1999)	ENVIRO CLAY WAX (27.09.2006)
0.00	58.61			
8.62	49.45			
10.00	49.39			
20.00	49.01			
30.00	48.91	45.00	45.27	
40.00	48.96	49.56	49.92	
50.00	48.69	53.16	53.20	
58.80	48.81	53.62	53.71	
60.00	48.87	53.68	53.78	
70.00	53.90	55.76	55.22	
80.00	58.18	56.96	57.24	
90.00	61.77	64.16	64.09	
100.00	66.02	65.01	64.58	
109.85	66.03	65.46	64.93	
110.00	66.06	65.46	64.93	65.66
120.00	68.59	66.00	65.30	66.74
127.14	69.71	65.99	65.26	67.54
130.00	69.83	65.71	65.15	
140.00	69.70	61.07	64.11	
150.00	71.94	55.78	56.18	
160.00	76.00	54.66	45.44	
170.00	78.39	55.27	29.96	
180.00	80.02	56.90	29.59	
190.00	81.30	58.06	29.43	
200.00	82.55	58.65	29.41	
210.00	83.92	59.00	29.43	
220.00	85.20	59.00	29.46	
230.00	86.58	59.00	29.48	
240.00	87.47	59.00	29.50	
250.00	87.37	59.00	29.48	
260.00	86.48	59.00	29.41	
270.00	86.42	59.00	29.31	
280.00	86.50	59.00	29.22	
290.00	86.44	58.99	29.12	
300.00	86.33	58.85	29.02	
306.26	86.21	58.88	28.98	

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SECTION Q 1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION Q

Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No: 17 | Rev: 0

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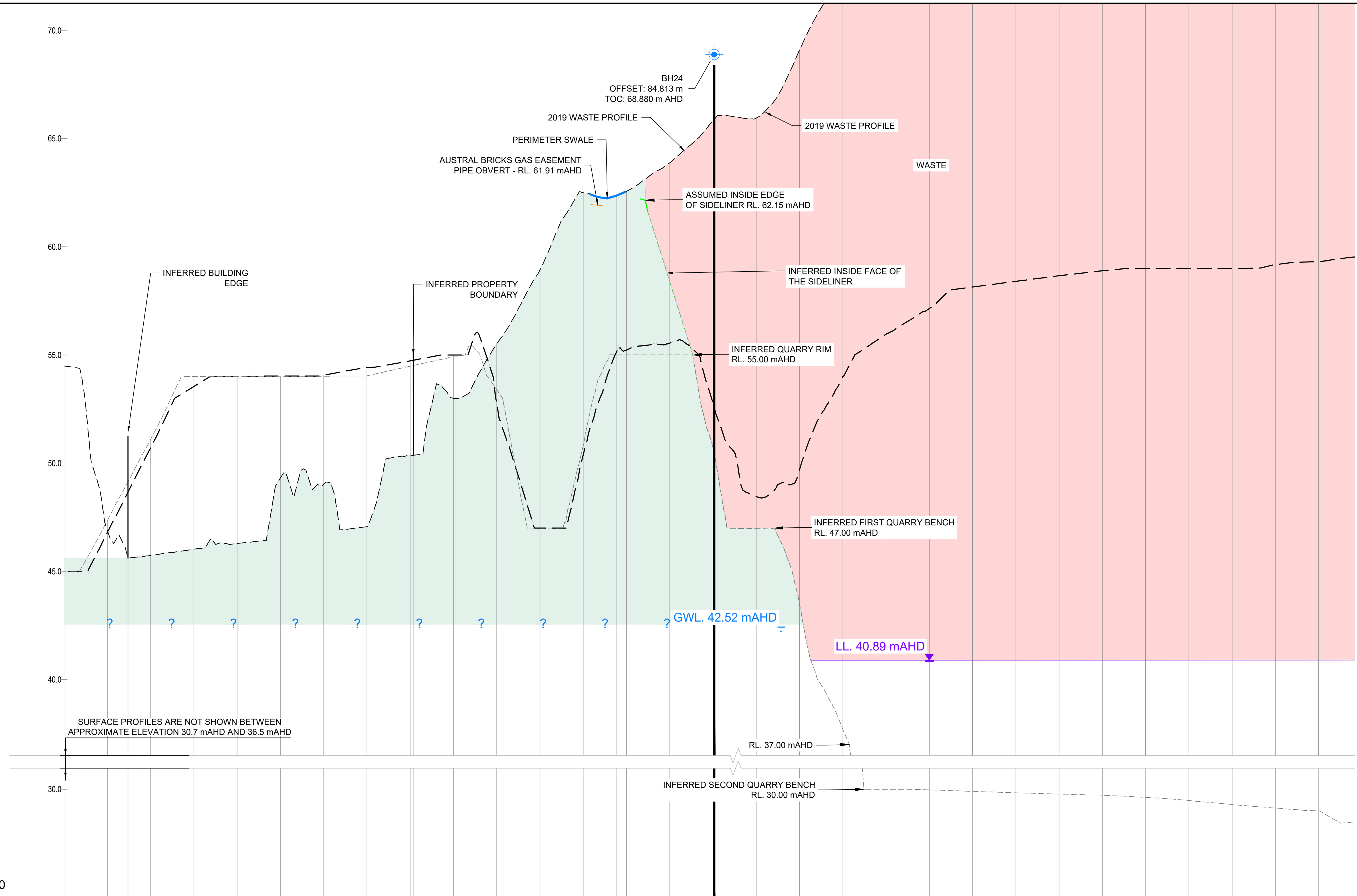
Plot Date: 1 April 2020 - 2:37:53 PM
File: ...5_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg

Document Set ID: 9100740
Version: 1, Version Date: 16/04/2020



LEGEND

- PERIMETER SWALE
- GWL. — INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. — INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1
2. SURFACE PROFILES ARE NOT SHOWN BETWEEN APPROXIMATE ELEVATION 30.7 mAHD AND 36.5 mAHD

Datum 25.00

SURVEY (04.12.2019)	54.49	46.89	45.61	45.73	46.02	46.29	49.31	49.03	47.06	50.36	50.37	53.00	55.52	58.93	62.50	62.35	62.56
SURVEY (04.12.2005)		46.80	48.66	50.71	53.54	54.01	54.02	54.06	54.42	54.73	54.76	55.00	52.81	47.00	50.39	55.10	55.22
SURVEY (30.11.1999)		47.35	49.14	51.10	54.00	54.01	54.01	54.02	54.04	54.48	54.52	54.94	53.39	47.00	50.81	55.00	55.01
CHAINAGE	0.00	10.00	14.78	20.00	30.00	40.00	50.00	60.00	70.00	80.00	80.85	90.00	100.00	110.00	120.00	127.61	130.00

SURVEY (04.12.2019)	63.88	65.82	65.95	69.10	72.48	74.71	76.87	79.08	81.29	83.31	85.24	86.36	86.38	86.56	86.80	87.15	[illegible]
SURVEY (04.12.2005)	55.54	52.77	48.46	49.70	53.99	55.96	57.14	58.14	58.40	58.66	58.89	59.00	59.00	59.00	59.17	59.31	[illegible]
SURVEY (30.11.1999)	55.00	50.66	46.99	43.47	37.71	30.00	29.97	29.90	29.84	29.78	29.73	29.63	29.48	29.30	29.13	29.00	[illegible]
CHAINAGE	140.00	150.00	160.00	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	[illegible]

Plotted By: Isaiah Hay

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SECTION R

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Website: www.senversa.com.au

Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION R

Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020

A3 | Scale: AS SHOWN | File No: S17375_011_RPT_001 | Figure No: 18 | Rev: 0

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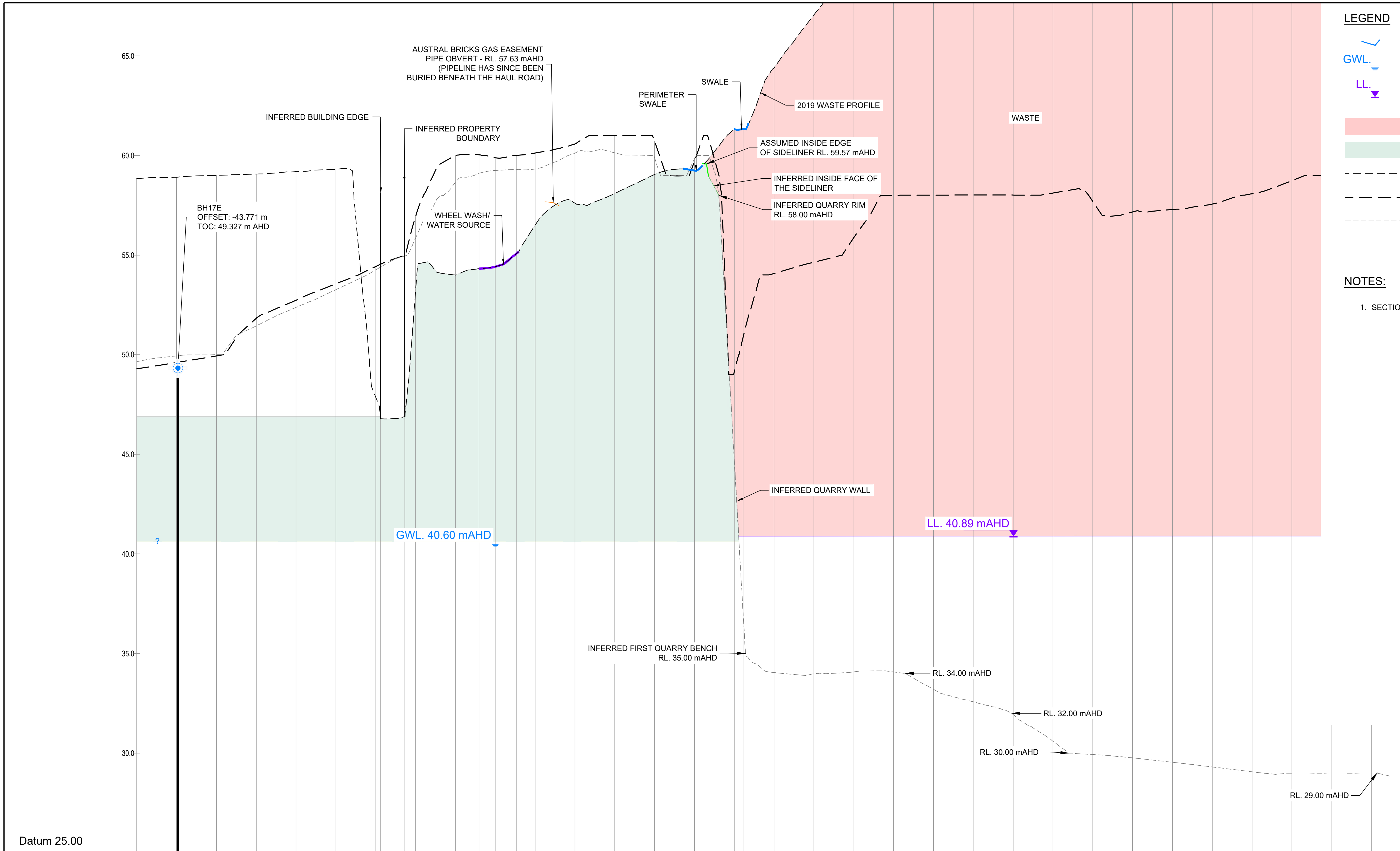
Plot Date: 1 April 2020 - 2:38:03 PM

...\5_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg

Document Set ID: 9100740
Version: 1, Version Date: 16/04/2020



SURVEY (04.12.2019)	58.84	58.91	59.00	59.07	59.19	59.31	47.86	46.78	46.90	53.19	53.99	54.32	54.42
SURVEY (04.12.2005)	49.29	49.61	49.94	51.83	52.74	53.56	54.43	54.55	54.99	56.94	60.00	60.03	59.88
SURVEY (30.11.1999)	49.65	49.94	50.00	51.45	52.38	53.27	54.26	54.41	54.96	55.85	58.67	59.11	59.25
CHAINAGE	0.00	10.00	20.00	30.00	40.00	50.00	60.00	61.25	67.28	70.00	80.00	85.93	90.00

SURVEY (04.12.2019)	55.06	56.49	57.61	58.09	59.04	59.24	59.24	61.32	61.33	64.40	67.06	69.59	72.10
SURVEY (04.12.2005)	60.01	60.12	60.58	61.01	60.72	59.71	59.75	49.13	50.87	54.08	54.65	55.87	58.00
SURVEY (30.11.1999)	59.30	59.32	60.12	60.13	59.89	59.84	59.87	44.74	37.03	34.04	33.98	34.08	34.07
CHAINAGE	95.27	100.00	110.00	120.00	130.00	140.00	140.07	150.00	152.22	160.00	170.00	180.00	190.00

SURVEY (04.12.2019)	74.63	77.15	79.69	82.20	84.59	84.94	85.16	85.36	85.67	85.73	87.19	88.41
SURVEY (04.12.2005)	58.01	58.02	58.01	58.11	57.69	57.17	57.29	57.56	58.08	58.74	59.00	60.21
SURVEY (30.11.1999)	33.20	32.58	31.94	30.59	29.93	29.76	29.54	29.31	29.06	28.99	29.00	29.00
CHAINAGE	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	300.00	310.00

LEGEND

- PERIMETER SWALE
- GWL. — INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. — INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1

Plotted By: Isaiah Hay

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SECTION S
1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED
FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Website: www.senversa.com.au

Client	CLEANAWAY SOLID WASTE PTY LTD	Project Title	ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)
Reviewed: N. VERGA	Drawn: M. LUI LAM	Figure Title	CROSS SECTION S
Approved: N. THOMSON	Date: 01.04.2020	A3 — Scale: AS SHOWN	File No S17375_011_RPT_001 — Figure No 19 — Rev 0

Plot Date: 1 April 2020 - 2:38:09 PM

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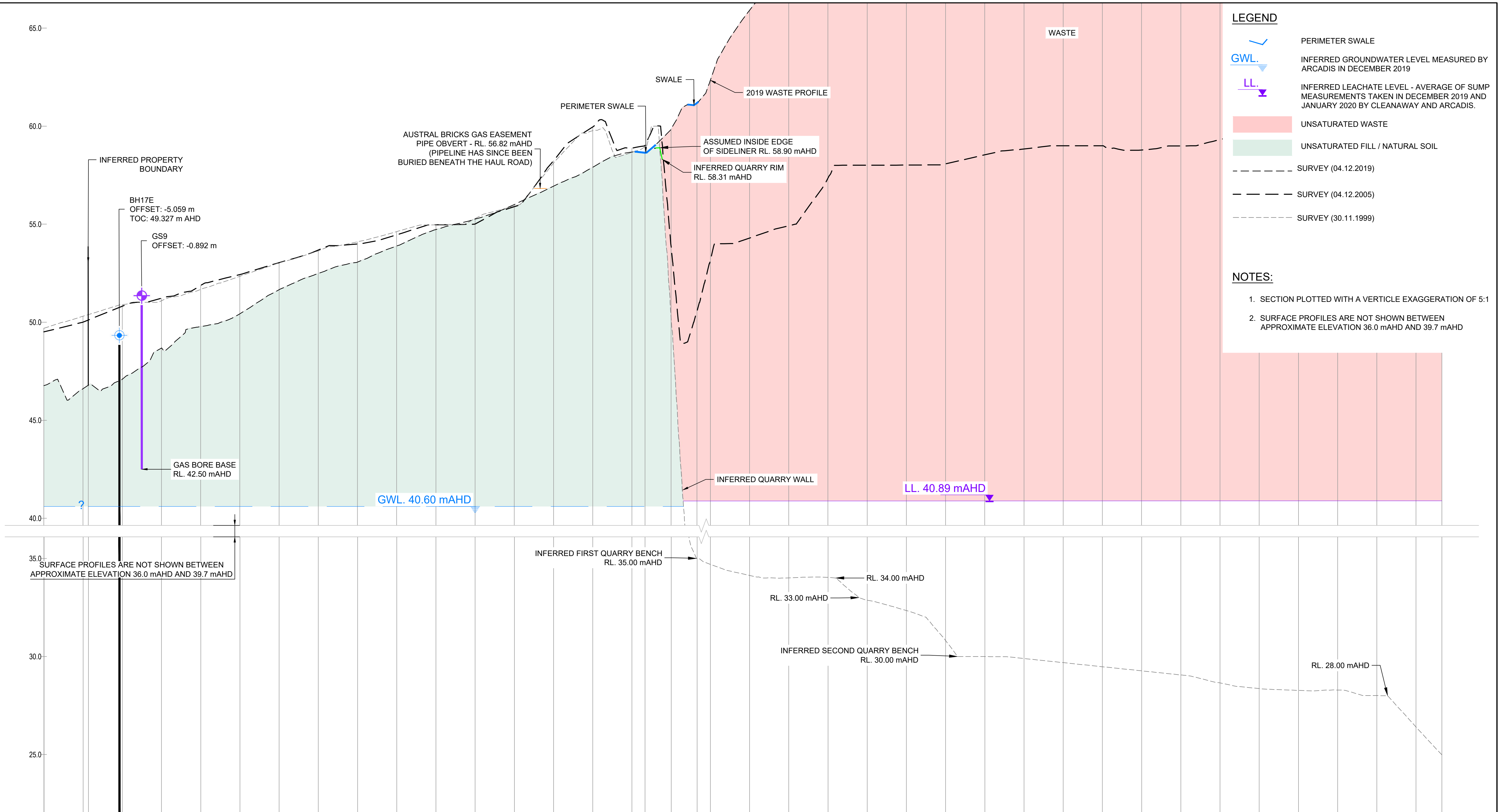
Version: 1, Version Date: 16/04/2020
File Name: ...\5_CLEANAWAY_ERSKINE PARK_CL-GEO COMBINED\5_Dwgs_Figs\1_CADD\S17375_011_RPT_001.dwg



Datum 22.00

CHAINAGE	0.00	10.00	11.36	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	153.35	160.00	166.60	170.00
SURVEY (04.12.2019)	46.77	46.61	46.79	47.09	48.68	49.78	50.43	51.66	52.49	53.06	53.89	54.72	55.26	56.00	56.93	57.90	58.68	58.64	59.85	61.18	62.34
SURVEY (04.12.2005)	49.51	50.00	50.11	50.81	51.22	51.87	52.43	53.04	53.68	53.99	54.46	54.97	55.00	55.89	58.24	59.96	58.88	59.03	53.85	50.58	53.16
SURVEY (30.11.1999)	49.69	50.30	50.39	50.90	51.10	51.67	52.34	53.03	53.64	54.10	54.62	54.97	55.28	55.92	58.11	59.77	58.66	58.95	50.18	35.00	34.70

CHAINAGE	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	300.00	310.00	320.00	330.00	340.00	350.00	356.61
SURVEY (04.12.2019)	65.90	68.42	70.95	73.51	76.05	78.58	81.14	83.71	85.39	85.74	86.15	86.46	86.97	87.60	88.57	88.67	88.77	88.87	88.89
SURVEY (04.12.2005)	54.29	54.91	57.34	58.01	58.01	58.08	58.54	58.83	59.00	59.00	58.78	58.99	59.31	59.76	60.17	61.09	61.77	61.40	61.79
SURVEY (30.11.1999)	34.13	34.01	34.03	32.86	32.34	30.81	29.99	29.90	29.69	29.48	29.27	29.06	28.65	28.36	28.27	28.29	28.00	26.40	24.99

Plotted By: Isaiah Hay

Plot Date: 1 April 2020 - 2:38:20 PM

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SECTION T

1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Website: www.senversa.com.au

Client	CLEANAWAY SOLID WASTE PTY LTD	Project Title	ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)
Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020
Figure Title	CROSS SECTION T		
A3	Scale: AS SHOWN	File No: S17375_011_RPT_001	Figure No 20 — Rev 0

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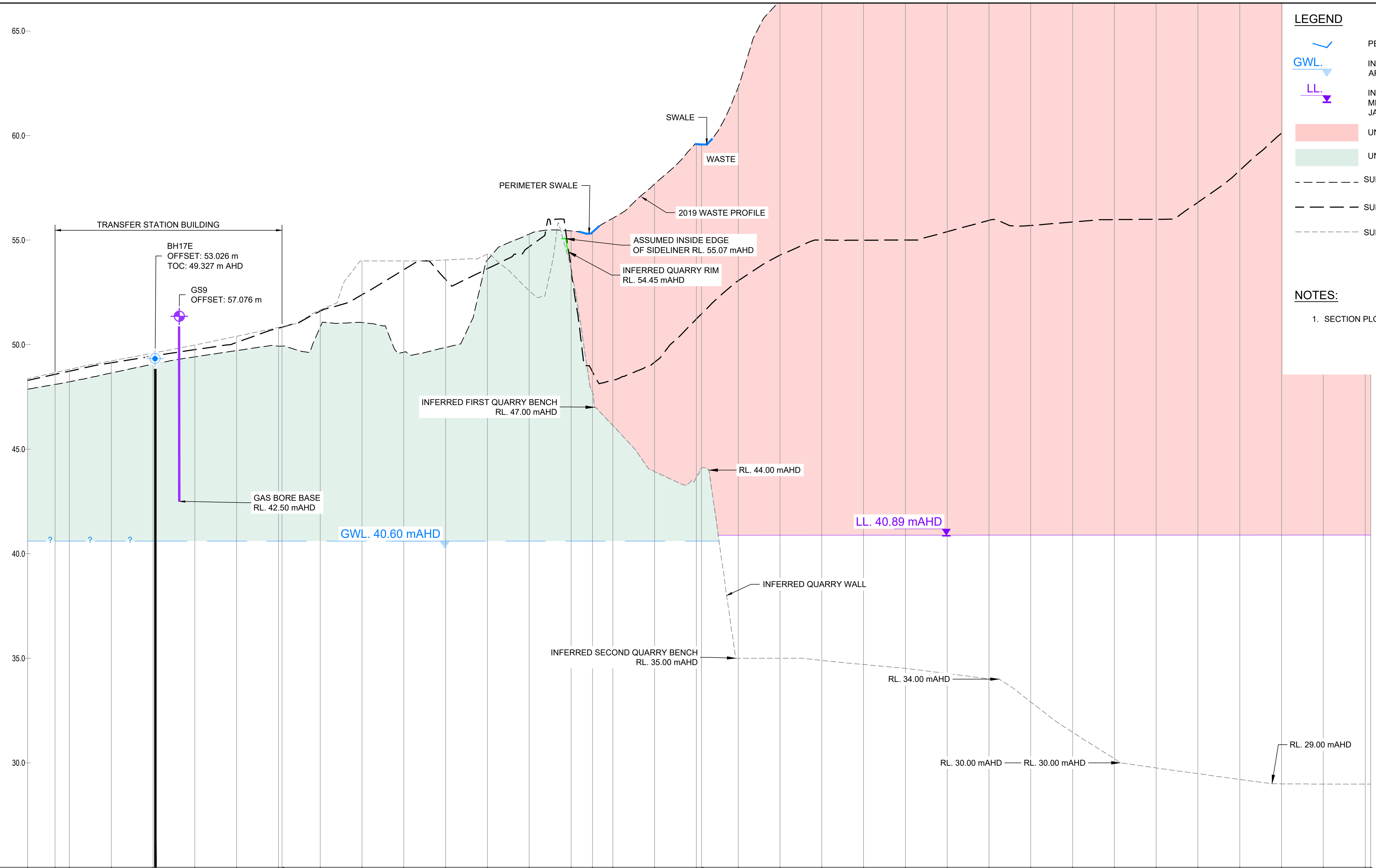

LEGEND

- PERIMETER SWALE
- GWL. — INFERRED GROUNDWATER LEVEL MEASURED BY ARCADIS IN DECEMBER 2019
- LL. — INFERRED LEACHATE LEVEL - AVERAGE OF SUMP MEASUREMENTS TAKEN IN DECEMBER 2019 AND JANUARY 2020 BY CLEANAWAY AND ARCADIS.
- UNSATURATED WASTE
- UNSATURATED FILL / NATURAL SOIL
- SURVEY (04.12.2019)
- SURVEY (04.12.2005)
- SURVEY (30.11.1999)

NOTES:

1. SECTION PLOTTED WITH A VERTICLE EXAGGERATION OF 5:1

Datum 25.00

CHAINAGE	0.00	6.55	10.00	20.00	30.00	40.00	50.00	60.00	60.86	70.00	80.00	90.00	100.00	110.00	120.00	130.00	135.12	140.00	150.00
SURVEY (04.12.2019)	47.87	48.09	48.22	48.64	49.06	49.41	49.71	49.93	49.93	50.84	51.06	49.64	49.87	54.04	55.29	55.44	55.37	56.04	57.68
SURVEY (04.12.2005)	48.29	48.58	48.73	49.13	49.45	49.76	50.10	50.78	50.83	51.60	52.39	53.58	53.12	53.63	54.68	53.68	48.71	48.29	49.16
SURVEY (30.11.1999)	48.37	48.66	48.82	49.22	49.59	49.98	50.40	50.82	50.86	51.66	54.00	54.00	54.05	54.33	52.57	53.58	47.73	46.13	43.92

CHAINAGE	160.00	161.20	170.00	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	300.00	310.00	320.00	321.33
SURVEY (04.12.2019)	59.59	59.57	62.32	66.44	68.55	70.64	72.69	74.72	76.75	78.58	79.66	80.98	82.38	83.43	84.57	86.19	86.68	86.55	86.52
SURVEY (04.12.2005)	51.22	51.46	53.06	54.28	55.00	54.99	55.00	55.40	55.95	55.70	55.86	55.98	55.99	56.81	58.33	60.11	61.24	61.77	61.84
SURVEY (30.11.1999)	43.65	44.10	35.00	35.00	34.90	34.70	34.52	34.27	34.01	32.91	31.46	30.20	29.75	29.48	29.21	28.99	28.98	28.98	28.98

Plotted By: Isaiah Hay

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SECTION U 1

HOR. SCALE 1:1 000
VER. SCALE 1:200

ISSUED

FINAL

0 2 4 6m
SCALE 1:200 AT ORIGINAL SIZE

0 10 20 30m
SCALE 1:1000 AT ORIGINAL SIZE

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Client: CLEANAWAY SOLID WASTE PTY LTD

Project Title: ERSKINE PARK LANDFILL IMPROVED CONCEPTUAL SITE MODEL (CSM)

Figure Title: CROSS SECTION U

Reviewed	N. VERGA	Drawn	M. LUI LAM
Approved	N. THOMSON	Date	01.04.2020

A3 | Scale: AS SHOWN | File No S17375_011_RPT_001 | Figure No 21 | Rev 0

Plot Date: 1 April 2020 - 2:38:26 PM

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