CMS Enviro

Waste, Environment, Management

Swanscombe Landfills:
South Pit Phase 3 Landfill
South Pit & Surge Pile Landfill

Annual Report 2020

SWANSCOMBE DEVELOPMENT LLP
CMS Enviro

Hydrogeological consultancy has been provided by NSugg Ltd

Annual Report for South Pit Phase 3 and South Pit Surge Pile Landfill(s) has been produced by CMS-Enviro, on behalf of SDLLP, in compliance with condition 4.2.2 of the Permit.

Swanscombe Landfill(s) Site – Annual Report Document Control

Date	Detail	Initials	Approval
10.01.2021	Document review/LFG summary	RVT	RVT
11.01.2021	Hydrogeology review	NS	RVT
14.01.2021	RVT/BT technical review and LFG, executive summary, conclusions sections	RVT/BT	PC
26.01.2021	RVT/BT Review and submission draft to client	RVT/BT	RVT
29.01.2021	Submit to EA via drop box	RVT	PC

Contents

South Pit & Surge Pile EPR/EB3802FX Status log of the permit		
Description	**Date**	**Comments**
Permit determined as P/1/11A	14/06/1977	Original permit issued to the Associated Portland Cement Manufacturers Ltd
Modification issued	21/02/1984	Change of company name from the Associated Portland Cement Manufacturers Ltd to Blue Circle Industries Plc
Modification issued	01/06/1992	Condition 26 added – Environment Management Plan
Modification issued	27/11/1992	Condition 4 amended – Waste quantities for deposit: 900te of flue dust 100te of non-toxic and inert waste
Variation issued EAWML19373	05/05/1994	Condition 26.8 amended Conditions added: 27, 28,29
Closure Notice CN1	20/12/2005	Closure notice issued
Permit transfer EPR/KP3998HW/T001	08/11/2007	From: Blue Circle Industries Plc To: Lafarge Cement UK Plc (EAWML19373)
Closure Notice CN2	08/12/2008	Closure Notice
Notified of change of company name EPR/KP3998HW/V002	12/07/2012	Name changed to Lafarge Cement UK LIMITED
Variation issued EPR/KP3998HW/V002	30/07/2013	Varied permit issued to Lafarge Tarmac Cement UK LIMITED
Application for variation EPR/KP3998HW/V003 to change company name and registered office address	Duly made 23/09/2013	Name changed to Lafarge Tarmac Cement & Lime Limited
Variation issued EPR/KP3998HW/V003	22/11/2013	Varied permit issued to Lafarge Tarmac Cement and Lime LIMITED
Application for variation EPR/KP3998HW/V004 to change company name	Duly made 04/09/2015	Name changed to Tarmac Cement and Lime LIMITED
Variation issued EPR/KP3998HW/V004	19/10/2015	Varied permit issued to Tarmac Cement and Lime LIMITED
Application EPR/EB3802FX/T001 (full transfer of permit EPR/KP3998HW)	Duly made 14/11/2016	Application to transfer the permit in full to Swanscombe Development LLP
Transfer determined EPR/EB3802FX/T001	09/01/2017	Full transfer of permit complete
Notified of change of company details	07/03/2017	Registered office address changed to: Barton Hall, Copt Oak Road, Markfield LE67 9PJ
Variation issued EPR/EB3802FX/V002	20/03/2017	Varied permit issued to Swanscombe Development LLP
Definitely closed status confirmed	20/12/2016	CAR 19373/0276376 EA initiated permit variation to be issued

South Pit Phase 3 Permit number EPR/CP3238YX Status log of the permit		
Description	**Date**	**Comments**
Application EPR/RP3039SZ/A001	Duly made 29/11/04	Received 10/11/04
Permit determined EPR/RP3039SZ	04/11/05	Original permit issued to Lafarge Cement UK PLC.
Environment Agency Initiated Variation EPR/RP3039SZ/V002 Billing Ref: CP3433MC	Issued 29/02/08	
Variation application EPR/RP3039SZ/V003 Billing Ref: BP3033GY	Duly made 02/03/09	
Variation determined EPR/RP3039SZ	15/06/09	Change in the annual permitted tonnage from 10,000 to 40,000 and inclusion of revised monitoring trigger level.
Variation application EPR/RP3039SZ/V004	Duly made 12/07/12	Name changed to Lafarge Cement UK Limited.
Variation determined EPR/RP3039SZ	30/07/12	Varied permit issued to Lafarge Cement UK Limited.
Variation application EPR/RP3039SZ/V005	Duly made 23/09/13	Name changed to Lafarge Tarmac Cement and Lime Limited.
Variation determined EPR/RP3039SZ	22/11/13	Varied permit issued to Lafarge Tarmac Cement and Lime Limited.
Environment Agency Landfill Sector Review 2014 Permit reviewed Variation determined EPR/RP3039SZ/V006 Permit issued EPR/RP3039SZ	28/05/14	Varied and consolidated permit issued in modern condition format. Also incorporates an administrative application to reduce the annual tonnage of hazardous waste to zero but allow 9,400 tonnes per annum for restoration. Received 07/03/14.
Variation application EPR/RP3039SZ/V007 (variation and consolidation	Duly made 21/04/15	Application to add a leachate treatment activity, amend leachate assessment levels and groundwater monitoring points. This application also incorporates an additional administrative application to change the operator name from Lafarge Tarmac Cement and Lime Limited to Tarmac Cement and Lime Limited. Received 04/09/15.
Additional Information – Response to Schedule 5 dated 01/07/15	Received 30/07/15	Additional details on the conceptual model, details of borehole EW7/14.
Additional Information – Response to Schedule 5 dated 29/07/15	Received 06/08/15	Detail of the design leachate treatment plant and leachate treatment.
Variation determined EPR/RP3039SZ/V007 Billing Ref: DP3234AQ	16/11/15	Varied and consolidated permit issued in modern condition format to Tarmac Cement and Lime Limited.
Application EPR/CP3238YX/T001 (full transfer of permit EPR/ RP3039SZ)	Duly made 05/04/17	Application to transfer the permit in full to Swanscombe Development LLP.
Transfer and Environment Agency variation determined EPR/CP3238YX Billing Ref: CP3238YX	26/06/17	Full transfer and Environment Agency initiated variation

1. Executive Summary

This **AMR** combines results of environmental monitoring undertaken at both **South Pit Phase 3** landfill and **South Pit and Surge landfill** into one document; fulfilling the requirement of Southpit phase 3 Permit EPR/RP3039SZ/V007 condition 4.2.2 and Southpit and Surge Pile EPR/KP3998HW Closure Report Issue 1 Rev A FINAL Nov 2016. Both landfill Sites are located on the Swanscombe Peninsula and share an identical environmental setting and deposited waste type, cement kiln dust which is outlined in the **EMP Volume 1 – Background information and Risk Assessment.**

Monitoring suites and compliance parameters are different due to the Permitting regime they are regulated by, but sufficient similarities exist to make one document the preferred option.

This **2020 Annual Monitoring Report (AMR)** for **South Pit Phase 3** landfill concludes that the Site is in compliance with Permit Limits**.**

South Pit and Surge Landfill was confirmed as definitely closed in December 2016 and the requirements of the **Environmental Management Plan/Closure Report (EMP/CR)** were fully implemented in 2017. The **Hydrogeological Risk Assessment (HRA)** Review carried out in June 2017 for **South Pit Phase 3** landfill recommended assessment levels for a number of key parameters at **SSW2** and EW5/14 and EW6/14; these have been implemented into CMS Reporting system.

Leachate levels remained compliant throughout 2020 for both landfill units. For South Pit Phase 3 landfill the HRA, and its subsequent review in 2017, concluded that a leachate level compliance limit of 2.5m above the local groundwater level was appropriate. The revised mechanism for calculating leachate compliance has confirmed that leachate levels did not rise above this limit in 2019. For South Pit and Surge Pile landfill the leachate compliance limit is set at 4mAOD and this was not exceeded in 2019. Leachate quality is typical of a CKD waste leachate with elevated pH and high concentrations of potassium, chloride and sulphate. Leachate treatment is required for leachate collected in the perimeter drain at South Pit Phase 3 and is fully commissioned, closing IC8 of Table S1.3. Leachate quality monitored at South Pit and Surge Pile continues to report declining concentrations of many key indicator parameters.

Surface water quality remains generally consistent with previous years, with concentrations of leachate indicator parameters remaining relatively low at **SSW3** following introduction of the perimeter leachate collection drain. As in previous years, low rainfall and low flow in the surface water courses during 2020 have prevented sampling on a number of occasions at a number of points, and some samples are concluded to be non-representative with little or no flow.

The surface water compliance and assessment limits remain under review and will be fully implemented once works to improve the ditch network are completed; this work is due in 2021. There were no exceedances of the **SSW6** compliance limits and a single marginal exceedance of the **SSW2** assessment limit for hexavalent chromium in 2020.

Groundwater quality at South Pit and Surge Pile and Phase 3 landfill in 2020 remained comparable to previous years with evidence of impact from saline intrusion at down-gradient boreholes. There were no exceedances of groundwater compliance limits in 2020.

Landfill gas (**LFG**) monitoring has continued at the in-waste points for both landfills and the results confirm that LFG is not an issue for either Site. LFG production is inhibited by the high pH and low carbon content of the CKD wastes. Monitoring of trace gas concentrations is carried out annually at **South Pit Phase 3** landfill, in accordance with Permit conditions.

A leachate treatment plant **(LTP)** on **South Pit Phase 3** has been constructed and collects leachate from the perimeter drain. A **Construction Quality Assurance (CQA)** Report was submitted in July 2017. The plant continues to run automatically, working on leachate levels and treating as appropriate.

1.2 Limitations of the Review and Notable Restrictions to Monitoring

CMS-Enviro carry out the monitoring, collate and assess field and laboratory data for operational response and regulatory reporting. If it has not been possible to obtain a sample the reason is shown in table below. Laboratory results are provided by DETS and survey data is provided by JC White Geomatics Ltd.

Notable Restrictions to Monitoring 2021	
Point/Date	**Comment**
Leachate	**South Pit Phase 3 –** samples taken annually no sample for IW3BR/14 or IW3CR/14 insufficient leachate. No hazardous substance analysis for these points. **South Pit & Surge Pile** –IW1CR/14 no sample in September due to insufficient leachate.
Surface Water	SSW1 – no samples August, September – no flow SSW4 – no samples July, August, September, October - no flow SSW5 – no samples August, September, October - no flow SSW6 – no samples May, August - no flow

2 Site Characteristics

2.1 Site Location

The landfills are located within the Swanscombe Peninsula, near Dartford, Kent, which sits on the south bank of the River Thames. The Sites are accessed from the A226 in Swanscombe via an internal road network.

Entry to the internal road network is via a manned security unit and all visits are recorded. A robust metal barrier further minimises unauthorised entry to the Site access road and is kept locked when access is not required. A series of padlocked gates control entry to the landfill areas preventing unauthorised access from the public footpath that transects the two landfills. Security guards and dog patrols regularly visit the access roads and all areas of Swanscombe Peninsula.

2.2 Installation Details

The South Pit Landfill complex is constructed upon reclaimed marshland on the Swanscombe Peninsula, Kent. The peninsula is surrounded towards the north, from the east side to the west side, by the River Thames, while to the south the area is bordered by the towns of Swanscombe, Northfleet and Greenhithe. The peninsula is protected by a river wall embankment, which has a maximum elevation of 6 – 7mAOD, and is intersected by drainage channels across the area. The peninsula includes areas of marshland, waste disposal Sites, redundant industrial infrastructure and a Port of London Authority radar station, accessed by a network of tracks and footpaths.

The original South Pit and Surge Pile landfill Site was developed in **three phases, Phase 1, Phase 2** and **Phase 3**. **South Pit Phase 3** has been re-Permitted and now operates in accordance with an environmental Permit, as described in **Section 2.2.3** below. **Phase 1** and **Phase 2** are regulated by the South Pit and Surge Pile Landfill Permit, details given in **section 3** below,

Phase 3 was constructed on the low-lying marshland with an average ground level of just 4 to 5maOD. The area of the Site is approximately 7.9 hectares and the landraise extends to a maximum of 11 -13 mAOD. The Swanscombe Main Drain, which is classified as a main river, flows in a northerly direction adjacent to the western boundary of **Phase 3**. The original marsh drainage network located beneath the waste was infilled before landfill operations began. The Swanscombe Main Drain and marsh ditches meet at a point on the north west corner of **Phase 3** and flow through a culvert to a penstock valve and tidal flap discharge to the River Thames.

Phase 2, waste operations have not taken place on **Phase 2** and this remains as an area of marshland. **Phase 2** remains within the **South Pit & Surge Pile Landfill** boundary but is not considered within this Report.

Phase 1 is located to the west of **South Pit Phase 3** landfill and is an infilled clay quarry with CKD waste surcharged above. The footprint of this area is approximately 7.5ha with a maximum height of 11 – 12 mAOD. A surface water drainage ditch is located on the eastern boundary and runs parallel to the Swanscombe Main Drain. This enters a pond which discharges to the Swanscombe Main Drain and ultimately the River Thames as described above. **Drawing LTCLLtd.EMP_CR.3 – November 2016** shows the location of each phase and the Permit boundaries (Permit holder name and Permit references are to be updated).

2.3 Geology

Regional geology is shown on **BGS Geological Map 271 Dartford**. This indicates that the sequence of geology at the Site is as follows: Head and Coombe Deposits (Thanet Sands) above; Upper Chalk dipping gently to the south east. The area surrounding South Pit has been extensively used for chalk extraction and Site investigations around the margins of the waste have confirmed a variable thickness of Thanet Sand above the underlying Chalk.

Local geology, from Site investigations confirm that the geology of the Site consists of superficial deposits in the form of Pleistocene and recent Alluvium overlying Terrace Gravels which in turn overlies Cretaceous Upper Chalk. The Alluvium is overlain by Made Ground, which includes CKD waste.

The Alluvium comprises soft to very soft greenish grey organic clays with peat layers and occasional deposits of fine silty sand and gravel in the order of 5 to 13.5 metres thick.

The Terrace Gravels are described as medium dense to dense grey or brown sandy to coarse angular to rounded flint gravel with occasional cobbles. The Upper Chalk is described regionally as soft micro porous fissured limestone containing tabular and nodular flints. However, the Chalk encountered beneath the Site is described as moderately weathered weak with medium density and closely spaced fractures.

2.4 Hydrogeology

The Landfills are underlain by Alluvium, which comprises predominantly clays and peats. The superficial deposits have been classified by the Environment Agency as a Secondary Aquifer (undifferentiated) which combines both former minor aquifer and non-aquifer properties. It is thought that this refers to the Alluvium (former non-aquifer) and the underlying Terrace Gravels (former minor aquifer). The Chalk (principal aquifer) underlies the Terrace Gravels. The Terrace Gravels and Chalk are hydraulically connected with each other and with the River Thames. Groundwater within the Terrace Gravels / Chalk aquifer is confined by the overlying, low permeability Alluvium. Previous Site investigations for the railway construction and the landfill boreholes indicate that any limited groundwater in the Alluvium is perched and possibly isolated in discrete horizons which are not laterally continuous.

Groundwater flow in the Chalk/Terrace Gravels is generally north / north-east towards the River Thames but is tidally influenced.

The Alluvium has a low permeability which limits potential downward migration of leachate. Swanscombe Peninsula has been defined by the Environment Agency as being within groundwater **Source Protection Zone 3 (SPZ3**) – Source Catchment Protection Zone for abstractions to the south/south-east. However, it is noted that background groundwater quality beneath the Site is poor suggesting saline intrusion and the inferred groundwater flow direction is away from the abstractions towards the River Thames.

2.5 Local Hydrology

The River Thames is directly hydraulically connected to the Terrace Gravels and the Chalk. The ditches and minor surface water courses that surround the landfills are not considered to be hydraulically connected with the underlying aquifers due to the presence of a significant thickness of low permeability alluvial peat and clays. According to the Environment Agency Flood Map the whole peninsula has been designated as being within a flood risk area but benefits from sea or river defences.

Surface water drainage over the Swanscombe Peninsula is via a network of ditches across the marshes. The ditches discharge to a piped culvert in the northern-most corner of the Site adjacent to the sea wall. Water levels in these ditches are controlled by a variety of inputs and outflows and are not influenced by landfill activities.

CAR RP3039SZ/0273906 issued 28th December 2016 required an action plan to be submitted by 20th February 2017 (submission date amended by agreement to 31st March 2017) to assess surface water quality and remediation proposals. The action plan was submitted and upon transfer of the Permit the requirement to carry out the works has been incorporated into the Permit, **Table S1.3 Improvement Programme Requirements (IC9).** This work relies on the ability to carry out clearance to Swansombe Main Drain which is a main river and, as such, requires a Flood Risk Assessment Permit which was issued in 2019. No works have yet been carried out and a revised completion date of 31 December 2020 is now agreed via CAR issues January 2020.

2.6 Conceptual Site Model

Table below presents the hydrogeological conceptual site model for Southpit Landfills and summarises the potential source-pathway-receptor.

Potential Receptor at Risk		Contaminant Source	Potential Pathway			Monitoring Priority		
Description	**Vulnerability**	**Mechanism**	**Description**	**Travel Time**	**Mitigation**	**Measurements**	**Locations**	**Risk**
Groundwater below and down-gradient of the Site	Low - local geology is Alluvium above confined Terrace Gravels and Chalk. Quality poor due to saline intrusion from tidal River Thames.	Leachate – leachate generated by infiltration through CKD waste. Characterised by high pH, potassium, chloride and sulphate concentrations.	Vertical flow through 5m to 12m of low permeability Alluvium beneath the Site to the underlying confined Terrace Gravels / Chalk aquifer. An outward hydraulic gradient exists from the Site to the aquifer and groundwater flow within the aquifer is towards the north, discharging to the River Thames.	Slow due to thickness of low permeability Alluvium	Dilution, degradation, retardation	Groundwater quality	**South Pit Phase 3** - Boreholes G11 and EW7/14 on the down-gradient boundary **South Pit & Surge Pile** – EW5R/14 and EW6/14 on the down gradient boundary	Medium
Surface water - Swanscombe Main Drain, marsh drainage ditches	Medium – the landfill Sites have been developed in close proximity to the surface water courses.	Leachate –leachate generated by infiltration through CKD. Characterised by high pH, potassium, chloride and sulphate concentrations.	**South Pit Phase 3** - Lateral seepage of leachate at the landfill surface around the perimeter of the landfill. **South Pit & Surge Pile** – lateral seepages not noted	**South Pit Phase 3** Rapid, in heavy rainfall conditions due to short pathway lengths and proximity of surface water course.	**South Pit Phase 3** - a leachate collection drain to intercept perimeter seepages.	Surface water quality	**South Pit Phase 3**- SSW2 at confluence of Swanscombe main Drain downstream of Phase 3. **South Pit & Surge Pile** – SSW6 Swanscombe Main Drain downstream of Phase 1 but upstream of Phase 3.	High
Atmosphere – surface emission of landfill gas	Low – significant volume of LFG not generated due to nature of waste.	LFG – characterised by elevated methane.	Emission of LFG via cracks and discontinuities in the surface and sides of the landfills.	NA	Non-required as LFG production inhibited by high pH and low carbon content of the waste	LFG quality at in waste points.	**South Pit Phase 3** - IW3AR/14; IW3BR/14 & IW3CR/14 **South Pit & Surge Pile** - IW1AR/14, IW1BR/14 & IW1CR/14	Low

3 Permit & Closure Report Requirements

3.1 Introduction

South Pit Phase 3 Landfill, Condition 3.5 and Schedule 3 Tables S3.1 to S3.9 of the Permit detail the monitoring currently required.

Monitoring locations are shown drawings **Reference: LTCCLLtd.MEPP_1-January 2017**

South Pit and Surge Pile Landfill EMP/CR Section 5 details the monitoring regime currently required.

Monitoring locations are shown on **drawing reference LTCLLtd.EMP_CR.3 –November 2016**

3.2 Leachate

3.2.1 South Pit & Surge Pile EMP/CR Requirements

Leachate level and quality samples are taken at **three** Leachate/LFG combined chambers for the suite and frequency shown in table **EMP/CR Table 12.**

3.2.2 South Pit Phase 3 Landfill Permit Requirements

Leachate level and quality samples are taken at **three** Leachate/LFG combined chambers for the suite and frequency shown in **Permit table S3.7**

3.2.3 South Pit Phase 3 Landfill Leachate Treatment Plant (LTP) Requirements

The Leachate Treatment Plant (**LTP**) was installed in 2014/2015 and **commissioning /CQA Report** submitted in March 2017. The Permit process monitoring requirements are shown in Permit **Table S3.9.**

3.2.4 Leachate Compliance Limits

South Pit & Surge Pile EMP/CR Table 13				**South Pit Phase 3 Table S3.1**		
Monitoring Point	**Frequency**	**Assessment Level**	**Compliance Limit**	**Monitoring Point**	**Frequency**	**Compliance Limit**
IW1AR/14 IW1BR/14 IW1CR/14	Quarterly	3.0mAOD	4.0mAOD	**IW3AR/14 IW3BR/14 IW3CR/14**	Monthly	2.5m above the average (arithmetic mean) groundwater potentiometric level calculated from boreholes G11 and EW7/14 as per NS_0111_39_FINAL 7 CMS-Enviro, **South Pit Phase 3** Landfill – Schedule 5 Response July 2015

3.3 Groundwater

3.3.1 South Pit & Surge Pile EMP/CR Requirements

There are **four** groundwater monitoring points, **three** are routinely monitored for level and quality, and **one** for level only, shown in **EMP/CR table 18.**

3.3.2 South Pit Phase 3 Landfill Permit Requirements

There are **4** monitoring points **SA5944** and **G13 upgradient** and **G11 and EW7/14** downgradient. All are routinely monitored as shown in **Permit Table S3.5.**

3.3.3 Groundwater Compliance Limits

South Pit & Surge Pile EMP/CR Table 20					South Pit Phase 3 Table S3.3				
Monitoring Point	Frequency	Control Level		Proposed Compliance Limit	Monitoring Point	Frequency	Compliance Limit		
EW5R/14 EW6/14	Quarterly	pH	8.7	9	G11 EW7/14	Quarterly		G11	EW7/14
							Cr(total)	0.007mg/l	0.050mg/l
		Alkalinity	725mg/l	854mg/l			K (total)	201mg/l	311mg/l
		K	200mg/l	380mg/l			Sulphate	770mg/l	842mg/l
		Se (filtered)	n/a	0.02mg/l			Se (total)	0.32mg/l	0.166mg/l
		As (filtered)	n/a	0.01mg/l					

EW5/14 and EW6/14 have interim compliance limits due to lack of background data for arsenic with review after 12 months of monitoring. These remain in place until ditch works completed to enable the review to be incorporated into the SSW6 compliance limits review, at one time.

3.4 Surface Water

3.4.1 South Pit & Surge Pile EMP/CR Requirements

There are **four** surface water monitoring points; The locations are described in **EMP/CR Table 16.**

CMS sample ALL surface waters on a monthly frequency for full comparison, extending further than the varying Permit or EMP/CR requirements.

3.4.2 South Pit Phase 3 Landfill Permit Requirements

There are **six** surface water monitoring locations **SSW1, SSW2, SSW3, SSW4, SSW5** and **SSW6.** The sampling points are located up and downstream of the landfill at points on the Swanscombe Main Drain and marsh ditch network. The location of the surface water monitoring points is described in **Permit Table S3.8.**

3.4.3 Surface Water Compliance Limits

South Pit & Surge Pile EMP/CR Table 17					South Pit Phase 3 Table 15 HRA Review 2017			
Monitoring Point	**Frequency**	**Proposed Assessment Level**	**Proposed Compliance Limit**		**Monitoring Point**	**Frequency**	**Assessment Level**	
SSW6	Quarterly	pH	8.6	9.0	**SSW2**	Monthly	NH4-N	1.29mg/l
		Cl	162mg/l	250mg/l			Cl	399mg/l
		Sulphate	296mg/l	400mg/l			Phenol	7.7mg/l
		As (filtered)	n/a	0.025mg/l			Sulphate	883mg/l
		Se (filtered)	n/a	0.03mg/l			Selenium	0.01mg/l
							Cr (VI)	0.002mg/l

Table Note: South Pit & Surge Pile Compliance Limits (EMP/CR Table 17) requested to be reviewed after 12 months of monitoring atSSW6 but the action plan submitted March 2017 required works to be completed. CMS recommends review of compliance limits after completion of the ditch clearance works, now due in 2020.

3.4 Landfill Gas (LFG)

3.4.1 South Pit & Surge Pile EMP/CR Requirements

LFG is monitored at **three** in waste locations on a quarterly basis. **IW1AR/14, IW1BR/14 and IW1CR/14 as in EMP/CR table 14.**

3.4.2 South Pit Phase 3 Permit Requirements

LFG is monitored at **three** in waste locations on a quarterly basis. **IW3AR/14, IW3BR/14 and IW3CR/14 as in Permit Table S3.6.**

3.4.3 LFG Compliance Limits

	South Pit & Surge Pile EMP/CR Table 15		South Pit Phase 3	
Compliance Point	**Action Level**	**Compliance Limit**	**Action Level**	**Compliance Limit**
In waste monitoring points IW1AR/14, IW1BR/14, IW1CR/14	Results are out of trend. CH_4% v/v above previous annual maximum		NA	NA

3.6. Restored Surface Monitoring

3.6.1 South Pit & Surge Pile EMP/CR Requirements

Due to dense vegetation on **South Pit & Surge Pile** settlement monitoring by direct comparison of topographical surveys is not proposed. Annual surveys of the survey pegs will be undertaken during the aftercare period and the data compared with the previous years and the 2010 Peg Survey. **EMP/CR Table 21** outlines the restored Surface Infrastructure Monitoring Program.

3.6.2 South Pit Phase 3 Permit Requirements

Permit condition 3.5.3 outlines the survey and Reporting requirements with topographical survey required annually. With settlement review requirements in condition 4.2.2 to be covered in AMR. See section 4.6 of this report.

3.6.3 Restored Surface Compliance Limits

Compliance Limits do not apply to restored surface monitoring. An assessment level test is included within the **South Pit & Surge Pile EMP/CR** and **Table 22**. Further works are proposed to restore the perimeter areas of **South Pit Phase 3** therefore an assessment level test for this Site is not currently proposed but is included in the **Closure Report Table 22.**

3.7. Performance Parameters

3.7.1 South Pit & Surge Pile EMP/CR Requirements

The **South Pit & Surge Pile EMP/CR** does not require any performance parameters to be reported.

3.7.2 South Pit Phase 3 Permit Requirements

Schedule 4 of the Permit requires the following performance parameters to be reported. **Table S4.2** is required by the end of February each year and **Table S4.3** is included within this annual Report.

Permit Table S4.2: Annual Production/Treatment	
Leachate:	**Cubic metres/year**
Disposed of offsite	NA
Disposed of to any onsite leachate treatment plant	2483
'Disposed of offsite' = Volume of any leachate disposed of by tanker.	
'Disposed of to any onsite leachate treatment plant' = Volume of discharge from plant to sewer	

Permit Table S4.3 Performance Parameters			
Parameter	**Frequency of assessment**	**Annual total**	**Unit**
Energy used (including for leachate treatment)	Annually	N/A	MWh of electricity or natural gas
Raw material usage	Annually	105.1 tonnes	tonnes or m3
Treatment efficiency	Annually	1.6%	%

4 Monitoring Data Discussion

4.1 Introduction

4.1.1 Data and Graphical Representation

Data is presented in **Appendix 1**. Key parameters are included in this section, as agreed with the Environment Agency. All data required by the Permit and EMP/CR is submitted to the Environment Agency on a quarterly basis.

Within **Appendix 1** results below the laboratory Reporting limit (**LRL**) are shown as blue font. The less than symbols are removed for graphical representation and statistical analysis as Excel will recognise these as formula and show the **value as '0'.** Unit conversions are shown where appropriate. Unit conversions are detailed as appropriate.

4.1.2 Operational Events

South Pit and Surge Pile Landfill is fully restored and definitely closed. **South Pit Phase 3** is fully restored and in the process of ensuring compliance with all permit conditions in order to apply for definitely closed status. The issue delaying closure is that of fugitive leachate emissions which are to be addressed by the completion of the Surface Water Action Plan.

Operations at the landfills are limited to maintenance of the pollution control systems and environmental monitoring. Significant events are tracked using a variety of recording mechanisms, these include **Exception Reports (ER) and Compliance Exception Reports (CER)**. A **CER/ER** index is included in **Appendix 4.**

4.2 Landfill Gas

4.2.1 Perimeter Landfill Gas Monitoring

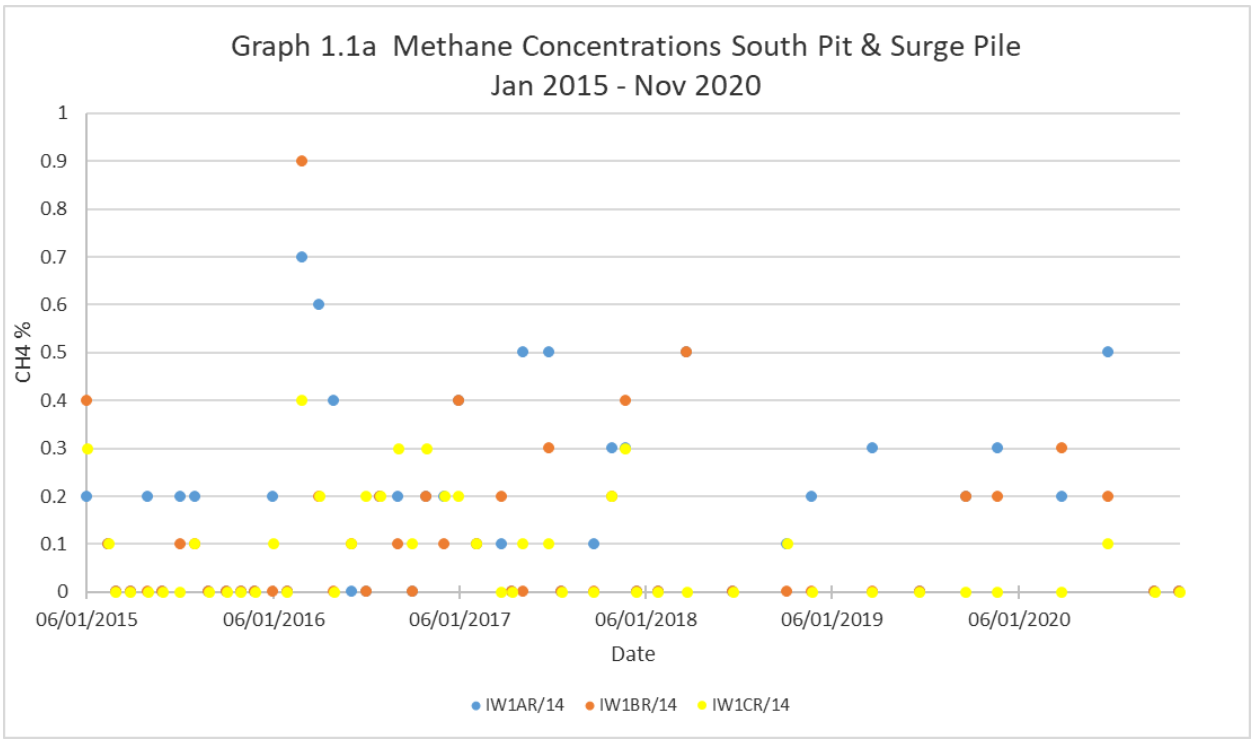
Monitoring of landfill gas at locations outside the waste mass is not required for either landfill. Perimeter monitoring was undertaken at adapted groundwater monitoring points from January 2006 to June 2014. Elevated levels of methane were recorded but not attributable to landfill gas generation within the waste mass. Therefore, discontinued for **South Pit Phase 3** and not included within the South Pit and Surge Pile closure requirements.

4.2.2 In-Waste Landfill Gas Monitoring

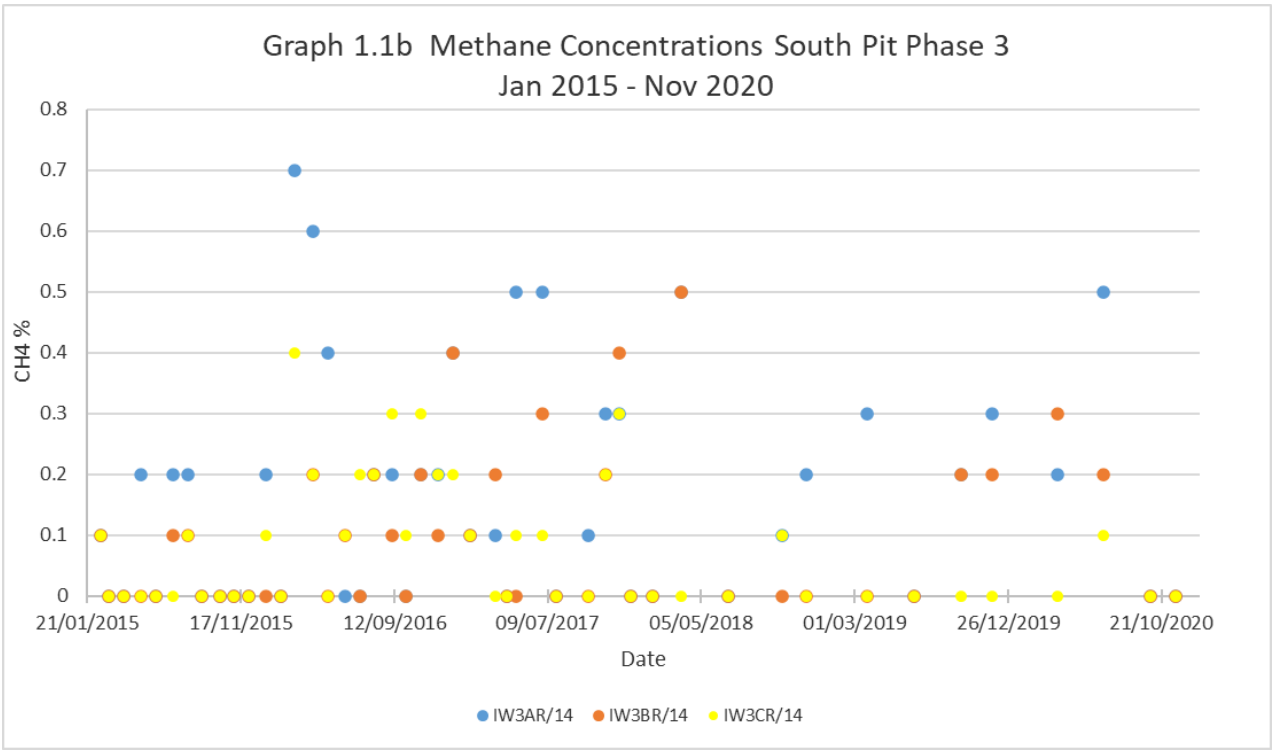
For the purposes of this report to illustrate the condition of the landfill Site and provide a comparison to assumptions and conclusions within the risk assessment, selected parameters only are included within this Section. Landfill gas monitoring is required quarterly, and all measurements were taken in 2020. All data is submitted to the Environment Agency on a quarterly basis.

Table 1.1 Landfill Gas monitoring Statistics 2020 - South Pit & Surge Pile							
Monitoring Point	**Parameter**	**Count**	**Methane**	**Carbon Dioxide**	**Oxygen**	**Relative Pressure**	**Atmospheric Pressure**
	Units		**% v/v**	**% v/v**	**% v/v**	**mb**	**mb**
IW1AR/14	Minimum	4	0	0	4.9	-0.48	1008
	Average		0.1	0.1	15.3	0.0	1019
	Maximum		0.5	0.2	20.9	0.28	1032
IW1BR/14	Minimum	4	0	0	4.9	-0.48	1008
	Average		0.1	0.1	15.0	0.0	1019
	Maximum		0.5	0.2	20.9	0.28	1032
IW1CR/14	Minimum	4	0	0	4.9	-0.48	1008
	Average		0.1	0.1	15.3	0.0	1019
	Maximum		0.5	0.2	20.9	0.28	1032

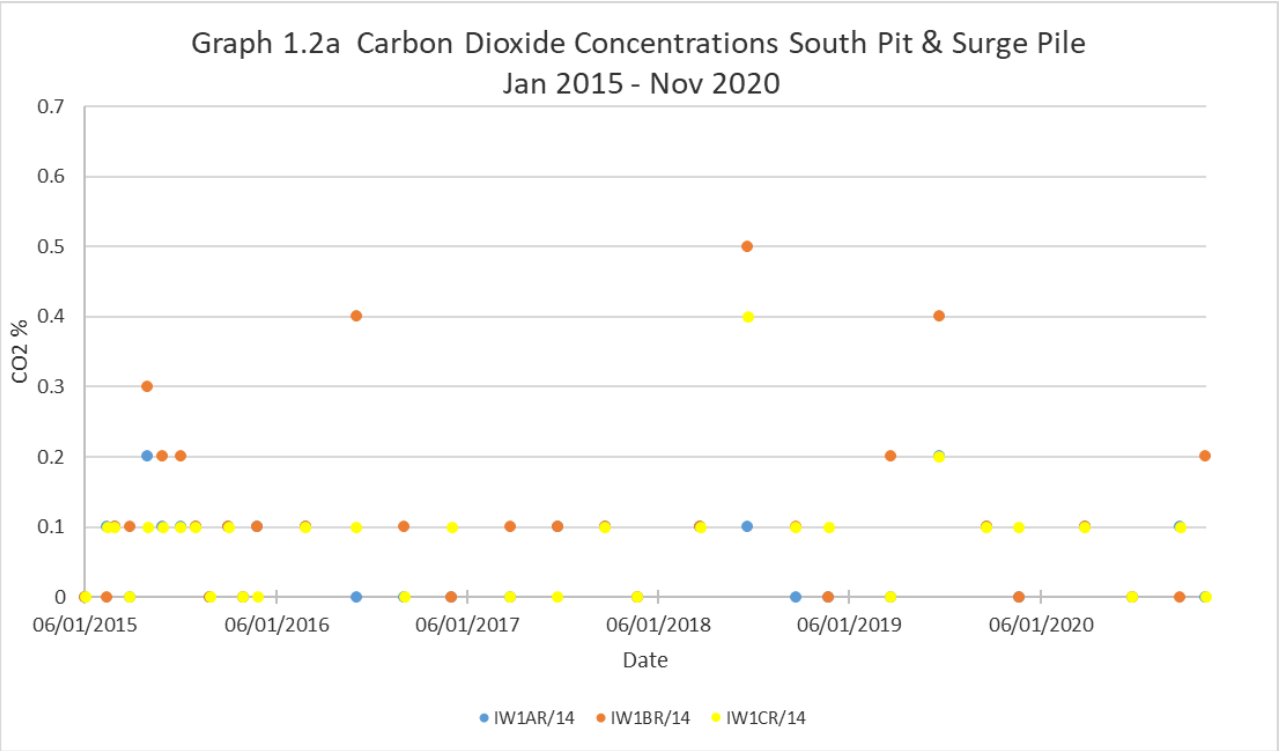
Table 1.2 Landfill Gas monitoring Statistics 2020 - South Pit Phase 3							
Monitoring Point	**Parameter**	**Count**	**Methane**	**Carbon Dioxide**	**Oxygen**	**Relative Pressure**	**Atmospheric Pressure**
	Units		**% v/v**	**% v/v**	**% v/v**	**mb**	**mb**
IW3AR/14	Minimum	4	0	0	4.9	-0.48	1008
	Average		0.1	0.1	15.6	0.0	1018
	Maximum		0.5	0.2	20.9	0.28	1032
IW3BR/14	Minimum	4	0	0	4.9	-0.48	1008
	Average		0.1	0.1	15.9	0.0	1018
	Maximum		0.5	0.2	20.9	0.28	1032
IW3CR/14	Minimum	4	0	0	4.9	-0.48	1008
	Average		0.1	0.1	15.2	0.0	1016
	Maximum		0.5	0.2	20.9	0.28	1031

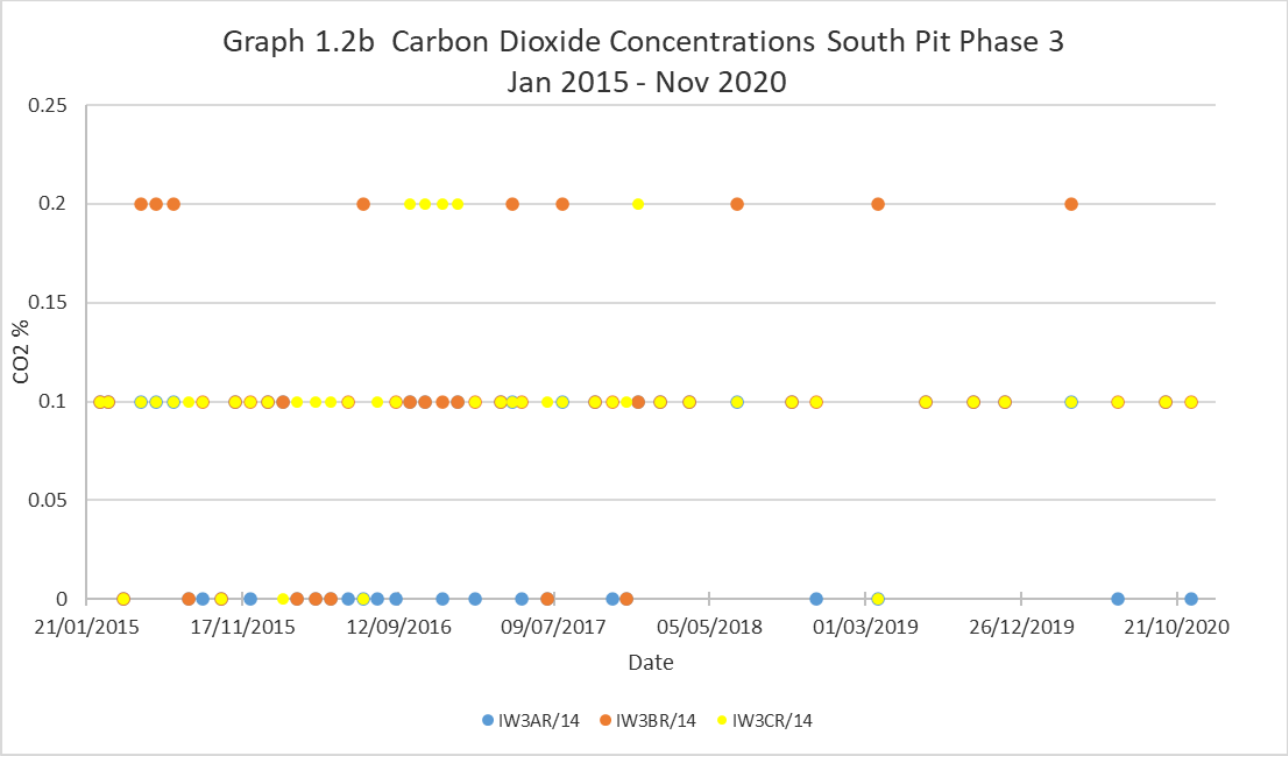


Methane – methane was not recorded at a concentration above 0.5% at either site during the reporting year. This is comparable to previous years and as expected due to waste type.

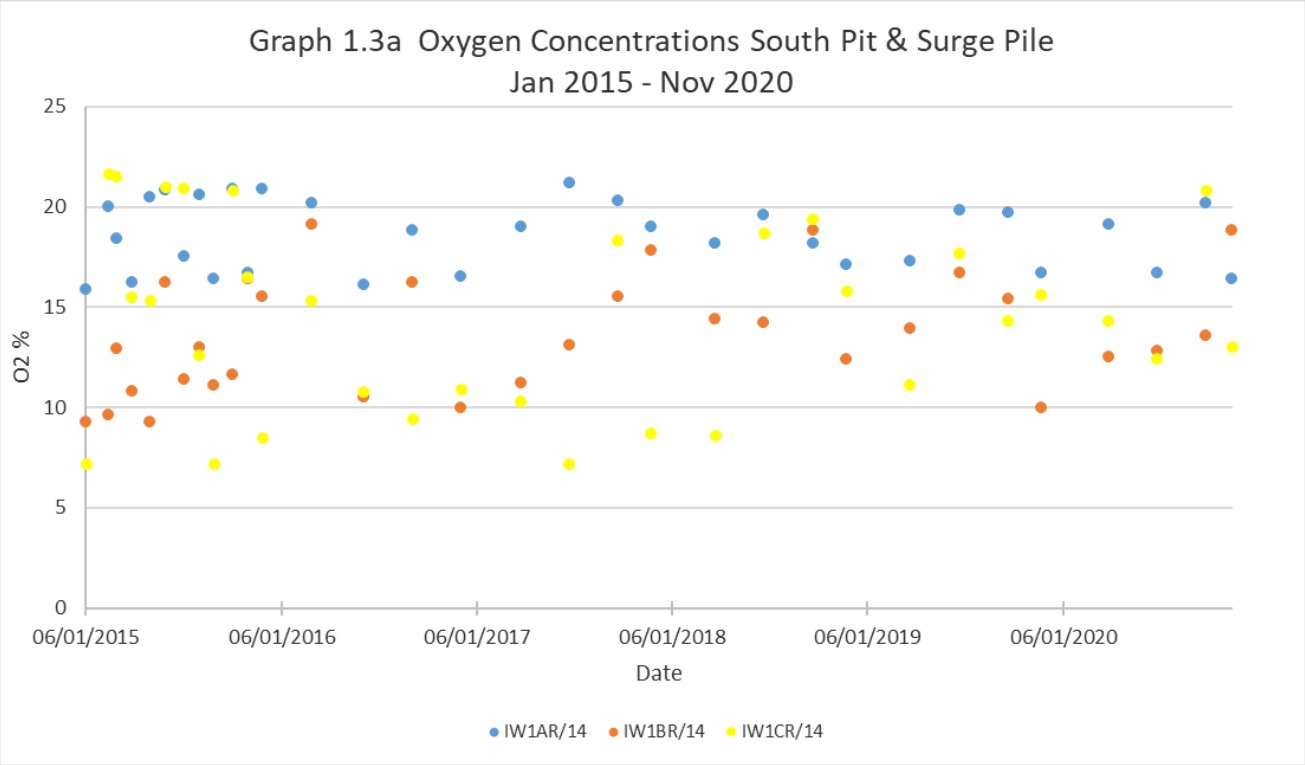


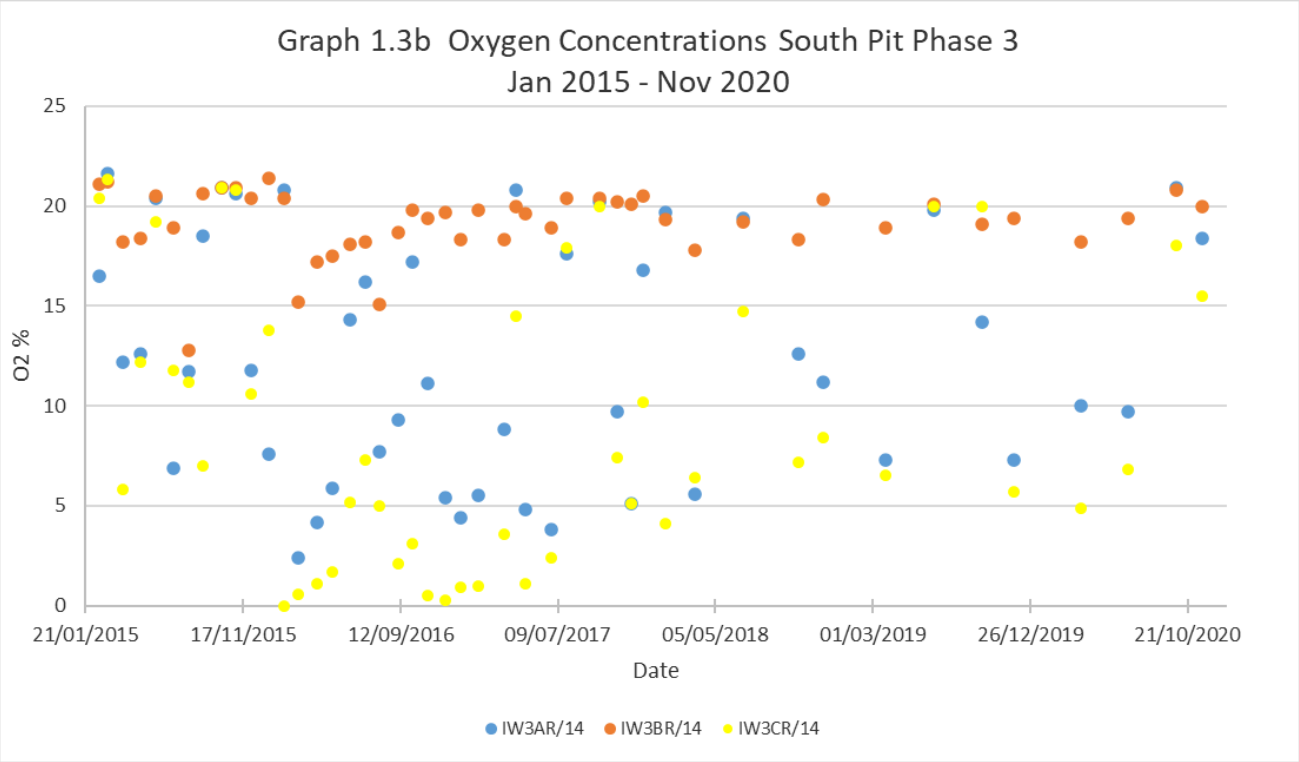
Carbon dioxide – carbon dioxide was not recorded at a concentration above 0.2% at either site during the Reporting year. As for methane this is comparable to previous years and as expected given the waste type.





Oxygen – depleted oxygen is evident in all internal monitoring points during the Reporting year and is within previously observed trends.





Hydrogen sulphide and hydrogen – **Table S3.6** of the **South Pit Phase 3** Permit requires quarterly monitoring of hydrogen sulphide and hydrogen**.** This is carried out using a calibrated handheld monitoring instrument. Only two results of 1ppm hydrogen sulphide were recorded during June 2020, all other results did not record the presence of hydrogen sulphide. Hydrogen is sampled quarterly via a High, Medium or Low result from a handheld gas analyser, all recorded low in 2020. Annually Hydrogen is tested for during the trace gas analysis, this had a result of 0%.

Trace gas analysis – trace gas analysis was carried out by Envirodat Ltd on 2nd November 2020. The Report is included in **Appendix 4**. Envirodat concluded that the levels of trace gas within the landfill were undetectable overall, except for a few notable examples.

4.2.3 Summary

Landfill gas is not an issue at Swanscombe landfills. The high pH and low carbon content of the CKD waste inhibit landfill gas production. Trace gas concentrations are not significant and as samples are taken from a sub-surface point within the landfill the results are not representative of actual or potential emission to atmosphere

4.3 Leachate

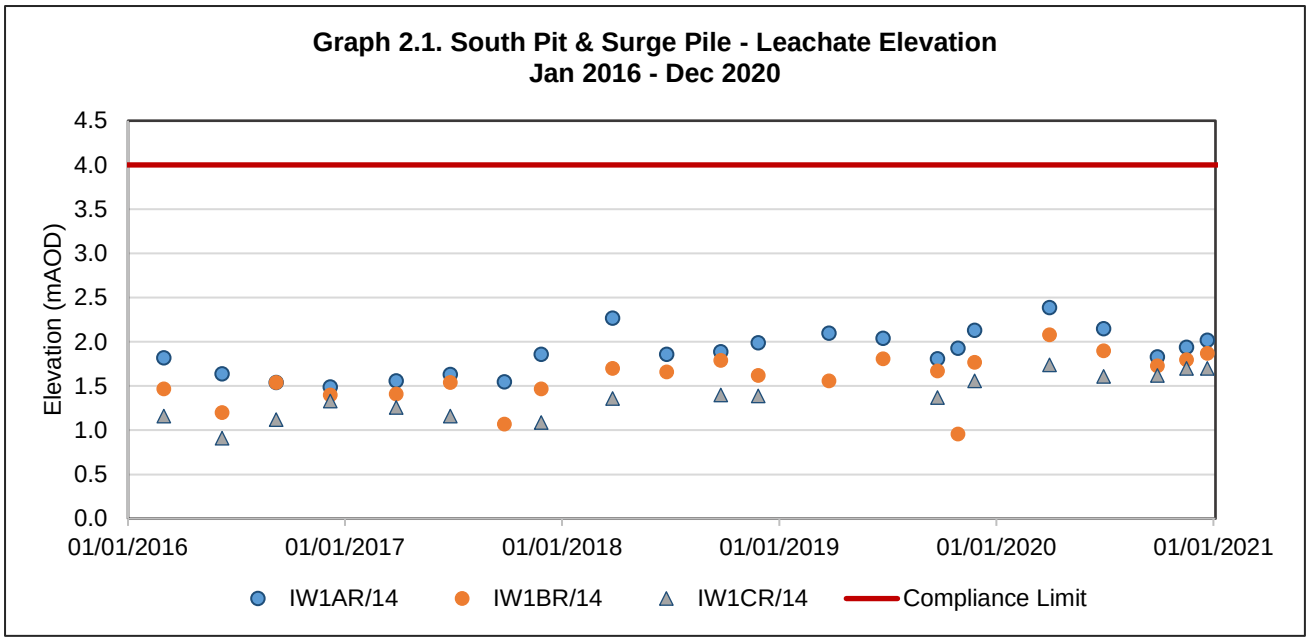
4.3.1 Elevation

South Pit and Surge Pile – leachate levels are monitored quarterly at the three in waste points: **IW1AR/14**, **IW1BR/14** and **IW1CR/14**. Elevated leachate levels present a risk of perimeter leachate seepages with the leachate level compliance limit of 4.0mAOD based on the site geometry and hydrogeological conceptual site model. The assessment limit of 3.0mAOD provides an early warning of increasing leachate levels.

Graph 2.1 below presents leachate level data for South Pit & Surge Pile from 2016 to 2020 and confirms that leachate levels in 2020 remained low and consistent with recent years. Table 2.1 presents summary statistics for leachate levels in 2020. There were no exceedances of the leachate assessment or compliance limit in 2020, with leachate levels ranging 1.61mAOD (**IW1CR/14**, June 2020) to 2.39mAOD (**IW1AR/14**, March 2020).

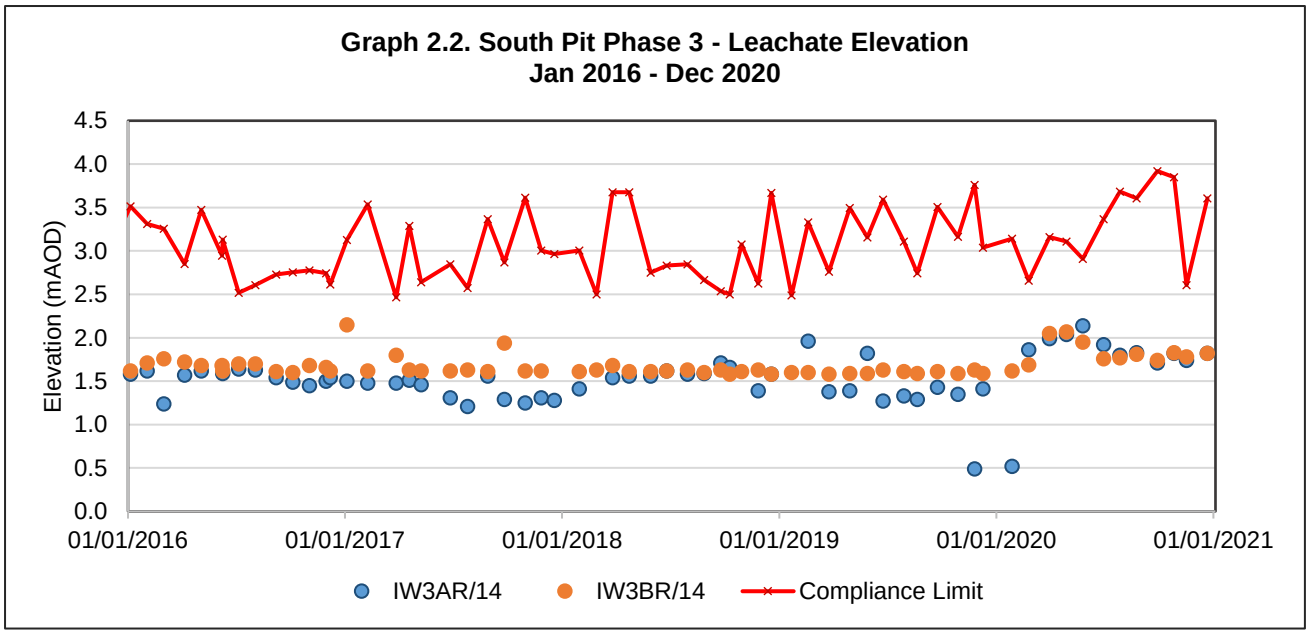
Table 2.1 – South Pit & Surge Pile: 2020 Leachate Elevation Statistics (Quarterly Monitoring)

Monitoring Point	Compliance Limit (mAOD)	2020 Leachate Elevation Statistics (mAOD)		
		Minimum	Mean	Maximum
IW1AR/14	4.00	1.83	2.07	2.39
IW1BR/14		1.73	1.88	2.08
IW1CR/14		1.61	1.67	1.74



South Pit Phase 3 - the management of leachate levels within **South Pit Phase 3** and the issue of historic perimeter leachate outbreaks are being addressed via a Leachate Management Project. The project has involved the construction of a perimeter leachate collection drain with leachate sumps pumping to a holding tank for subsequent treatment and discharge to sewer. The leachate management system was installed in 2014/15 and currently discharges approximately 20m^3/day of treated leachate to foul sewer.

Leachate levels are monitored monthly at three in-waste points: **IW3AR/14, IW3BR/14 and IW3CR/14**. Monitoring point **IW3CR/14** has consistently been reported as 'dry' since installation, representing a leachate level of <3.2mAOD. Leachate level compliance is based on a comparison of leachate level (mAOD) against average groundwater level (mAOD). The Hydrogeological Risk Assessment for the site derived a leachate level compliance limit of 2.5m above the average groundwater level. Average groundwater level is calculated as the arithmetic mean of groundwater level measurements at G11 and EW7/14 carried out on the same monitoring visit as the leachate level. Graph 2.2 below presents leachate level data for South Pit Phase 3 from 2016 to 2020.



In 2020, monitoring point **IW3CR/14** remained dry and the depth of leachate within **IW3BR/14** remained low (<0.5m), as observed in previous years. This confirms leachate levels of <3.2mAOD at **IW3CR/14.** Graph 2.2 confirms that leachate levels recorded at **IW3AR/14** and **IW3BR/14** in 2020 were generally comparable to previous years but peaked in Spring 2020 following a period of prolonged rainfall. Leachate levels remained below the leachate level compliance limit. Summary statistics for 2020 are included within **Table 2.2**.

Table 2.2 – South Pit Phase 3: 2020 Leachate Elevation Statistics (Monthly Monitoring)

Monitoring Point	2020 Leachate Elevation Statistics (mAOD)		
	Minimum	Mean	Maximum
IW3AR/14	Dry (leachate level <0.5mAOD)	-	2.14
IW3BR/14	Dry (leachate level <1.6mAOD)	-	2.07
IW3CR/14	Dry (leachate level <3.2mAOD)		

4.3.2 Leachate Quality - Key Parameters

South Pit and Surge Pile – Leachate quality is monitored quarterly at the three in-waste monitoring wells: **IW1AR/14, IW1BR/14** and **IW1CR/14**, when sufficient depth of leachate is available. A more comprehensive annual monitoring schedule is also undertaken. In 2020, samples were only obtained from **IW1CR/14** on three occasions, due to insufficient depth of leachate during the September 2020 monitoring event. A summary of the 2020 quarterly leachate quality statistics is presented in **Table 2.3** below.

Table 2.3 – South Pit and Surge Pile: 2020 Leachate Quality Statistics

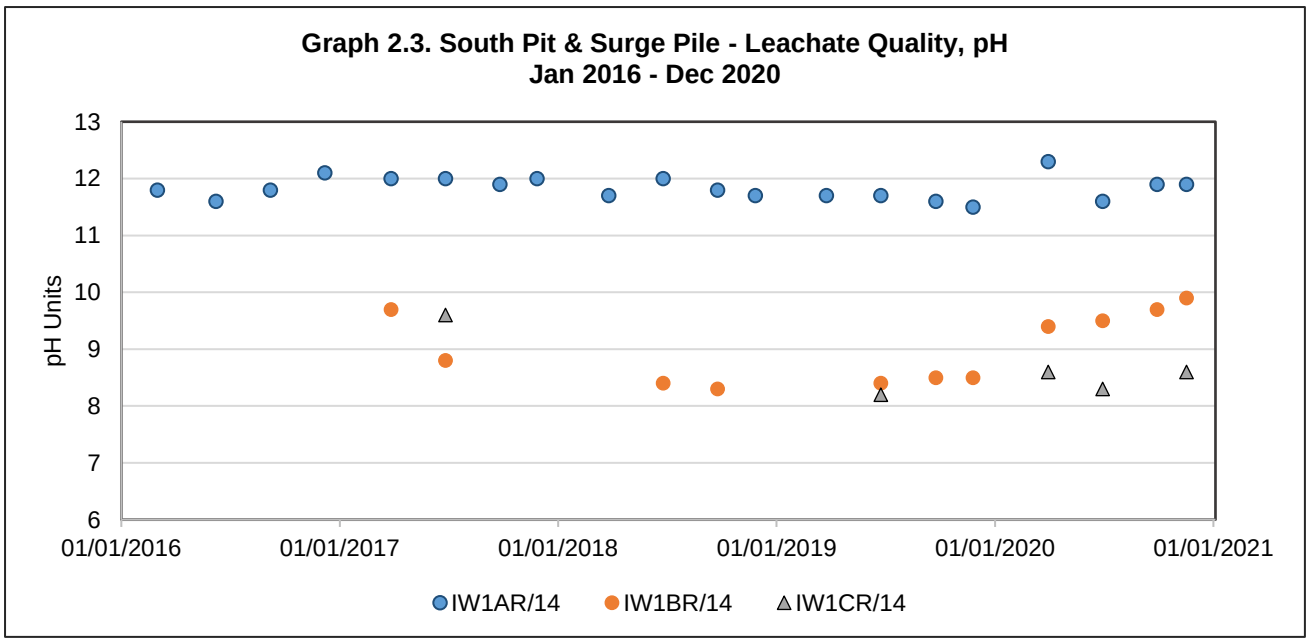
Monitoring Point: IW1AR/14				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, filtered (mg/l)	4	3640	4518	5850
Sodium, filtered (mg/l)	4	829	998	1150
pH (units)	4	11.6	11.9	12.3
Electrical Conductivity (µS/cm)	4	13400	20650	28500
Alkalinity as CaCO3 (mg/l)	4	1540	1803	2050
Ammoniacal-Nitrogen as N (mg/l)	4	5.53	8.19	9.85
Chloride (mg/l)	4	3520	4253	5120
Sulphate as SO4 (mg/l)	4	2000	2753	4210
BOD (mg/l)	4	<5	-	9
COD (mg/l)	4	280	330	366

Monitoring Point: IW1BR/14				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, filtered (mg/l)	4	3860	4995	6190
Sodium, filtered (mg/l)	4	885	1107	1370
pH (units)	4	9.4	9.6	9.9
Electrical Conductivity (µS/cm)	4	17900	25325	30200
Alkalinity as CaCO3 (mg/l)	4	110	366	1090
Ammoniacal-Nitrogen as N (mg/l)	4	3.41	5.57	6.41
Chloride (mg/l)	4	3490	4070	4380
Sulphate as SO4 (mg/l)	4	4720	5553	5910
BOD (mg/l)	4	<5	<5	<5
COD (mg/l)	4	193	227	282

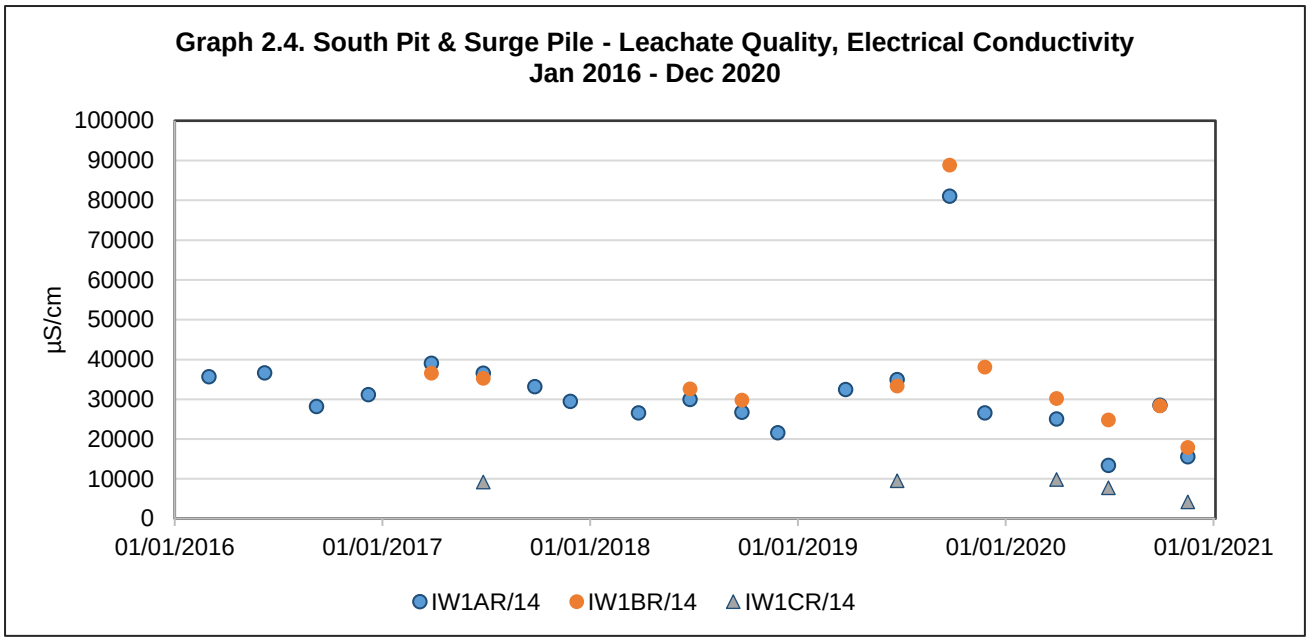
Monitoring Point: IW1CR/14				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, filtered (mg/l)	3	1090	1180	1310
Sodium, filtered (mg/l)	3	259	269	289
pH (units)	3	8.3	8.5	8.6
Electrical Conductivity (µS/cm)	3	4260	7307	9860
Alkalinity as CaCO3 (mg/l)	3	320	339	350
Ammoniacal-Nitrogen as N (mg/l)	3	0.413	1.52	2.33
Chloride (mg/l)	3	821	884	972
Sulphate as SO4 (mg/l)	3	914	1161	1400
BOD (mg/l)	3	<5	<5	<5
COD (mg/l)	3	71	85	94

Time-series plots are presented below for concentrations of the following key parameters in leachate from 2016 to 2020: pH, electrical conductivity, potassium, sulphate, ammoniacal-nitrogen, chloride, alkalinity, arsenic and selenium. These parameters are either compliance parameters for groundwater and/or surface water, or noted to be indicative of CKD leachate quality.

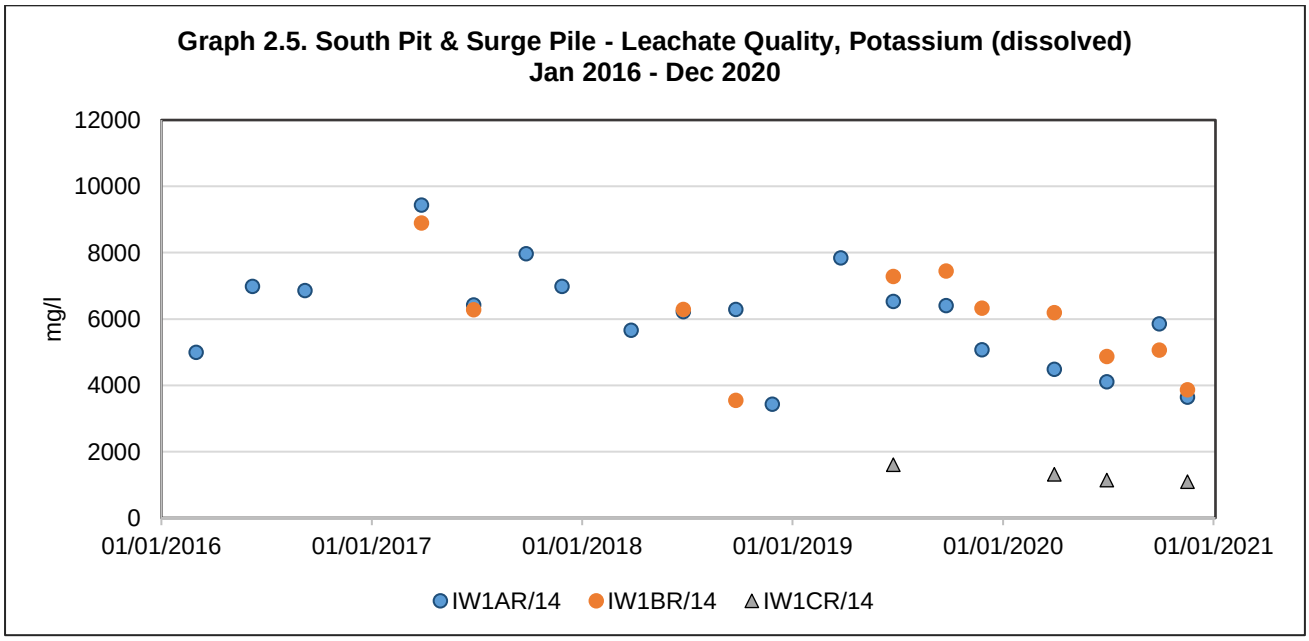
pH – Graph 2.3 presents the pH of leachate samples from 2016 to 2020. CKD leachate is characterised by high pH, usually above 12 and this is evident in samples taken from **IW1AR/14** which reported an average pH of 11.9 in 2020. Leachate pH was notably lower, (in the range pH8.3 - pH8.6), in the samples obtained from **IW1CR/14** in 2020, as observed in 2019. The pH of leachate samples obtained from **IW1BR/14** followed a gradual rising trend in 2020, from pH9.4 to 9.9; slightly higher than recorded in 2019.



Electrical conductivity – Graph 2.4 presents electrical conductivity levels for leachate from 2016 to 2020. Electrical conductivity is extremely high in CKD leachate, indicative of high levels of inorganic dissolved solids. In 2020, the electrical conductivity of leachate remained elevated but at slightly lower levels than observed in previous years, ranging from 13,400µS/cm to 30,200µS/cm at **IW1AR/14** and **IW1BR/14**. The 2020 leachate samples from **IW1CR/14** continued to record a significantly lower conductivity range of 4260µS/cm to 9860µS/cm; this monitoring point does not appear to be fully representative of the site leachate probably due to groundwater seepage / dilution.

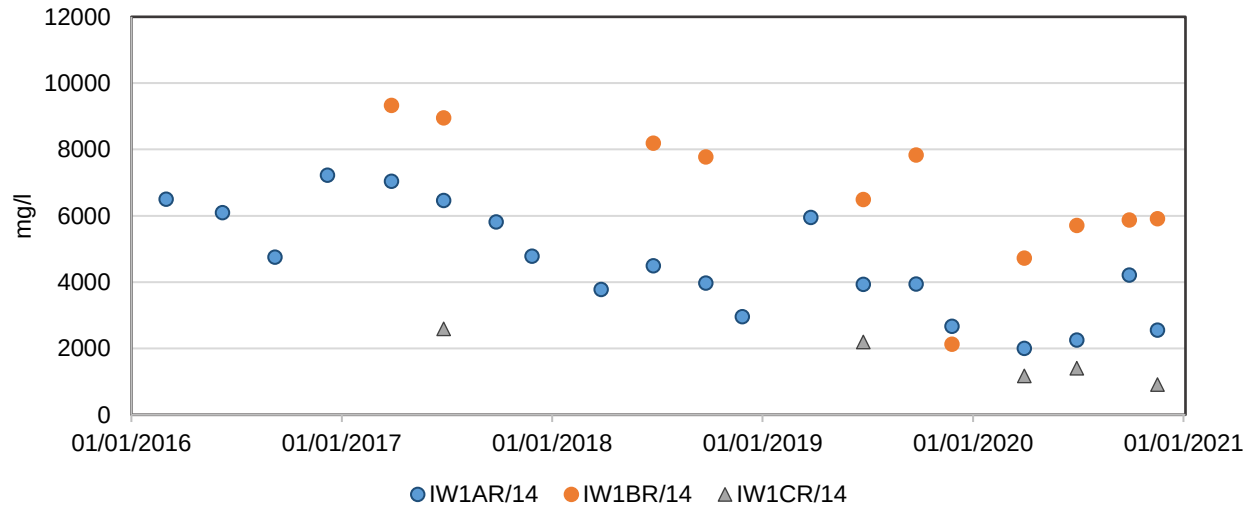


Potassium – Graph 2.5 presents potassium concentrations in leachate from 2016 to 2020. Potassium is a key CKD indicator parameter and is a compliance parameter for the groundwater compliance points. In 2020 potassium concentrations in leachate at **IW1AR/14** and **IW1BR/14** remained elevated but followed a declining trend, as observed for conductivity, ranging from 3860mg/l to 6190mg/l. As observed for other parameters, the potassium concentrations recorded at **IW1CR/14** were significantly lower (maximum: 1310mg/l) in 2020 and not considered representative of the site leachate.



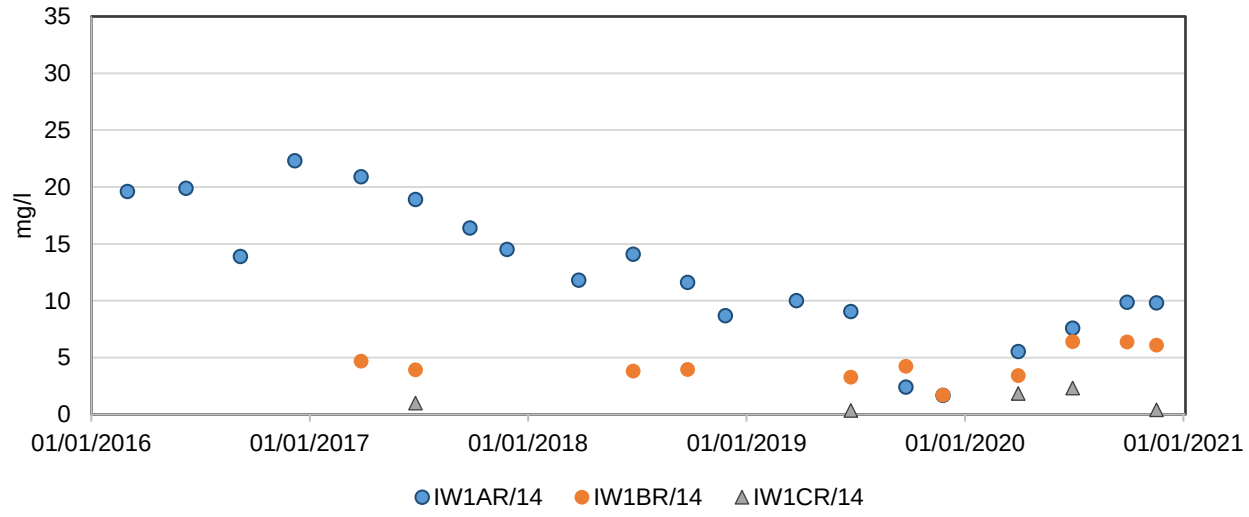
Sulphate – Graph 2.6 presents sulphate concentrations in leachate from 2016 to 2020. Elevated sulphate levels are another indicator of CKD leachate and concentrations at South Pit and Surge Pile (**IW1AR/14** and **IW1BR/14**) ranged from 2000mg/l to 5910mg/l in 2020. As for other parameters, sulphate concentrations at **IW1CR/14** remained relatively low in 2020 (in the range 914mg/l to 1400mg/l).

Graph 2.6. South Pit & Surge Pile - Leachate Quality, Sulphate
Jan 2016 - Dec 2020

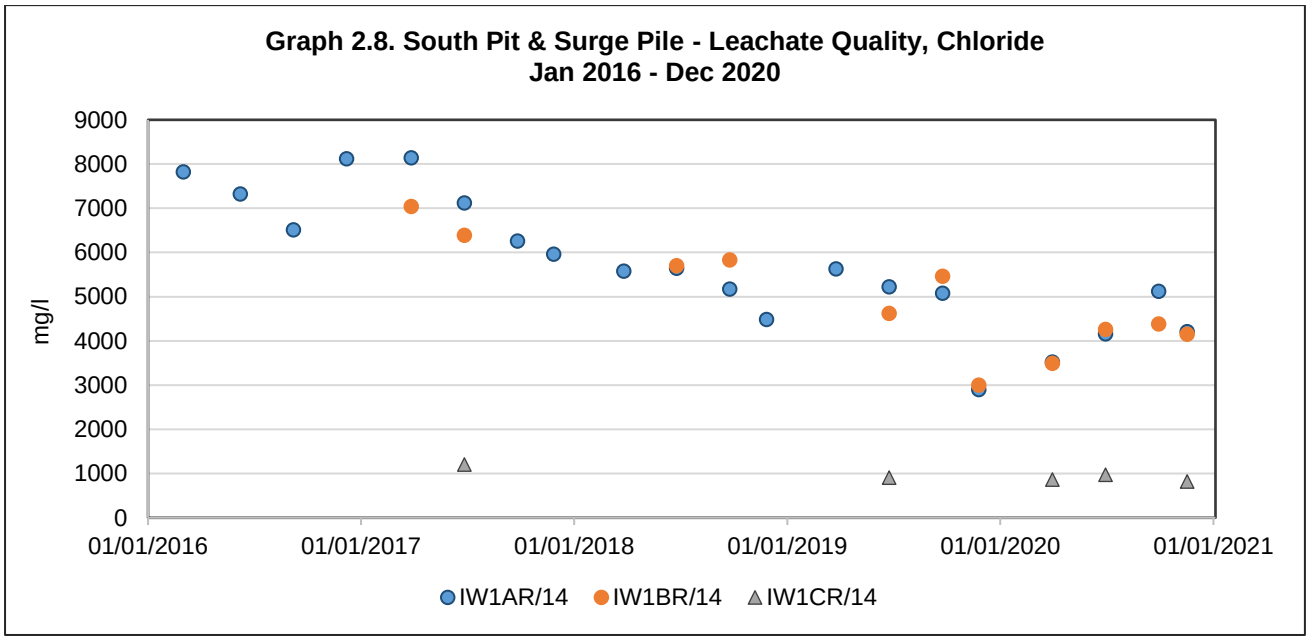


Ammoniacal nitrogen – Graph 2.7 presents ammoniacal-nitrogen concentrations in leachate from 2016 to 2020. Ammoniacal-nitrogen concentrations at **IW1AR/14** followed a long-term declining trend from 2017 to 2019, but concentrations rose slightly in 2020, from 5.53mg/l to 9.85mg/l. Ammoniacal-nitrogen concentrations at **IW1BR/14** were also slightly higher in 2020 than recent years (maximum: 6.41mg/l), and concentrations at **IW1CR/14** remained relatively low (<2.5mg/l).

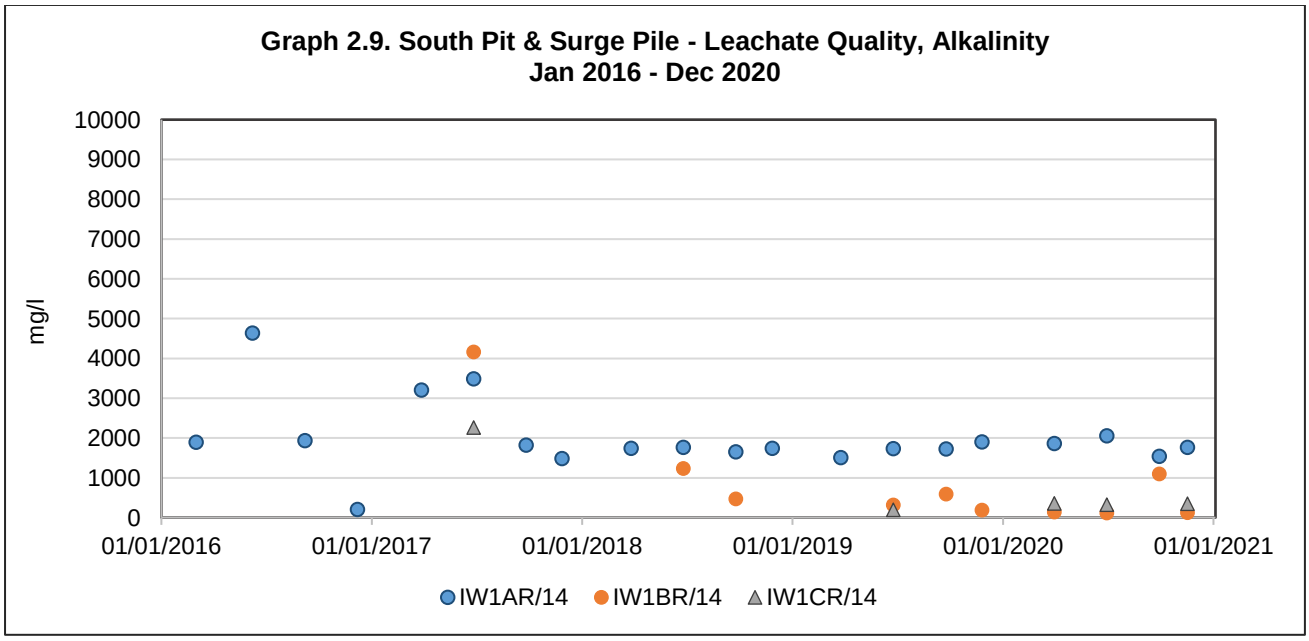
Graph 2.7. South Pit & Surge Pile - Leachate Quality, Ammoniacal-Nitrogen
Jan 2016 - Dec 2020



Chloride – Graph 2.8 presents chloride concentrations in leachate from 2016 to 2020. Chloride is elevated in CKD leachate and the average chloride concentrations at **IW1AR/14** and **IW1BR/14** in 2020 were 4253mg/l and 4070mg/l respectively, slightly lower than in recent years. The 2020 chloride concentrations recorded at **IW1CR/14** remained consistent and significantly lower (<1000mg/l).

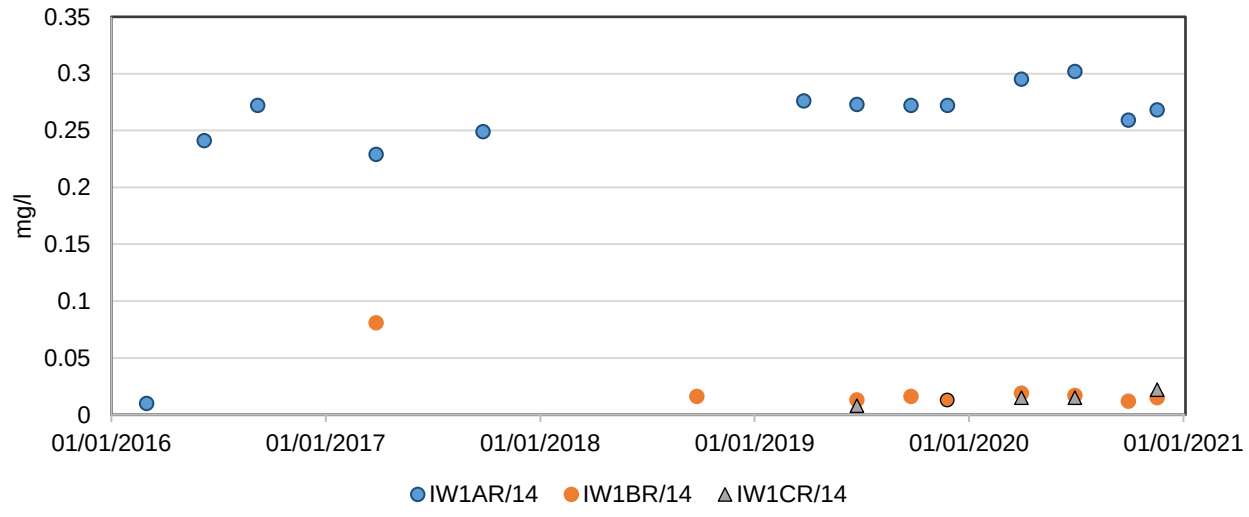


Alkalinity – Graph 2.9 presents the alkalinity of leachate from 2016 to 2020. The 2020 results at **IW1AR/14** were in the range 1540mg/l – 2050mg/l and comparable to 2018 and 2019 data. Alkalinity levels at **IW1BR/14** and **IW1CR/14** remained lower (generally <500mg/l) in 2020.



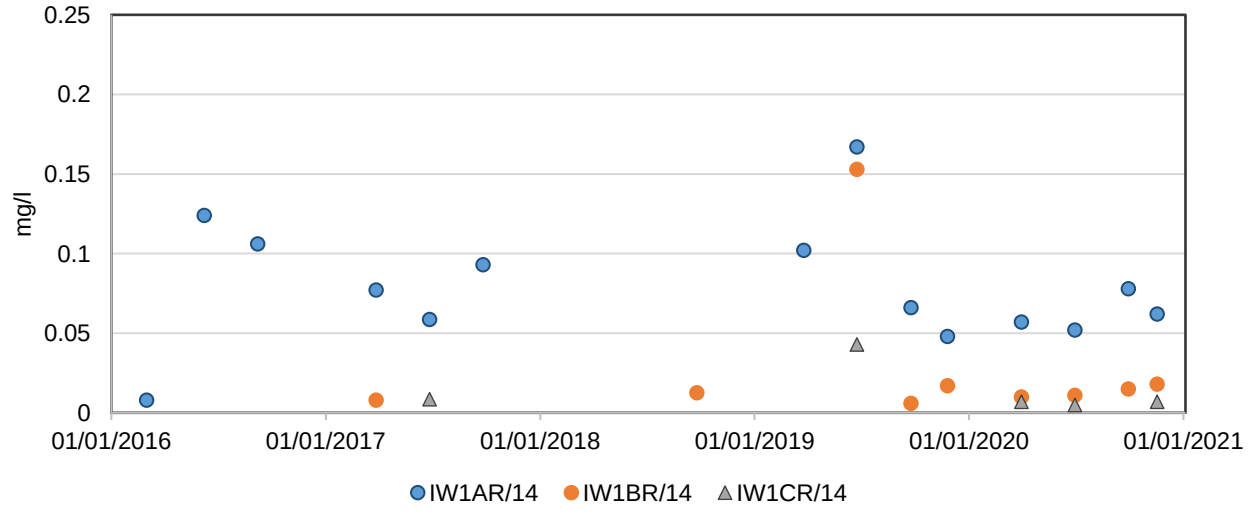
Arsenic – arsenic has been included within the quarterly monitoring schedule since 2019 because it is a groundwater compliance parameter. Graph 2.10 presents the 2016 to 2020 dataset; the 2020 results for **IW1AR/14** range from 0.259mg/l to 0.302mg/l and are comparable to previous years. Arsenic concentrations at **IW1BR/14** and **IW1CR/14** remained consistently low in 2020 (<0.05mg/l), as observed in 2019.

Graph 2.10. South Pit & Surge Pile - Leachate Quality, Arsenic (dissolved)
Jan 2016 - Dec 2020



Selenium – selenium was also added to the quarterly leachate monitoring schedule in 2019 and the 2016 to 2020 dataset is presented on Graph 2.11. Selenium concentrations in 2020 were more consistent than in previous years, ranging from 0.052mg/l to 0.078mg/l at **IW1AR/14** and remaining below 0.02mg/l at **IW1BR/14** and **IW1CR/14.**

Graph 2.11. South Pit & Surge Pile - Leachate Quality, Selenium (dissolved)
Jan 2016 - Dec 2020



Hexavalent Chromium – concentrations of hexavalent chromium, a priority hazardous substance in South Pit and Surge Pile leachate, remained below the laboratory reporting limit of 0.02mg/l in 2020, as observed in 2019.

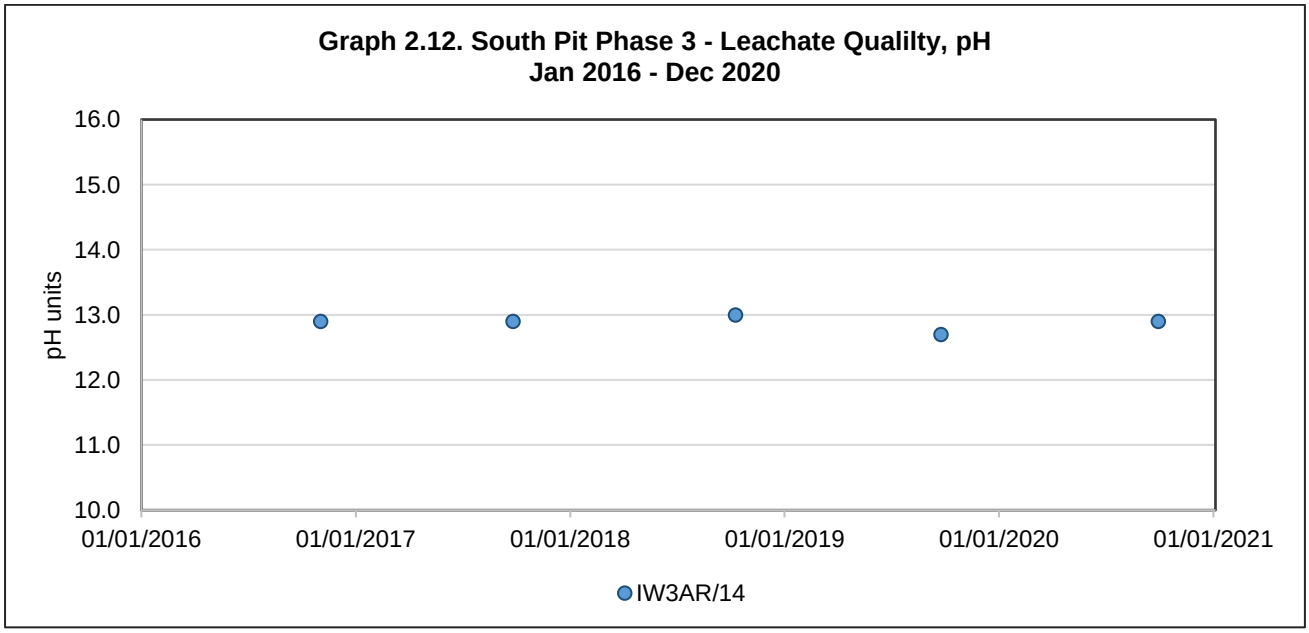
Hazardous Substances – leachate samples were taken for hazardous substance analysis from **IW1AR/14** and **IW1BR/14** on 29/09/2020. Only arsenic and mercury were detected above the relevant Environment Agency recommended laboratory reporting limit (10µg/l for volatiles and semi-volatiles; 1µg/l for mercury). The 2020 concentrations are comparable to previous years:

Arsenic (filtered)	0.259mg/l	(IW1AR/14)
Arsenic (filtered)	0.012mg/l	(IW1BR/14)
Mercury (filtered)	1.07µg/l	(IW1AR/14)

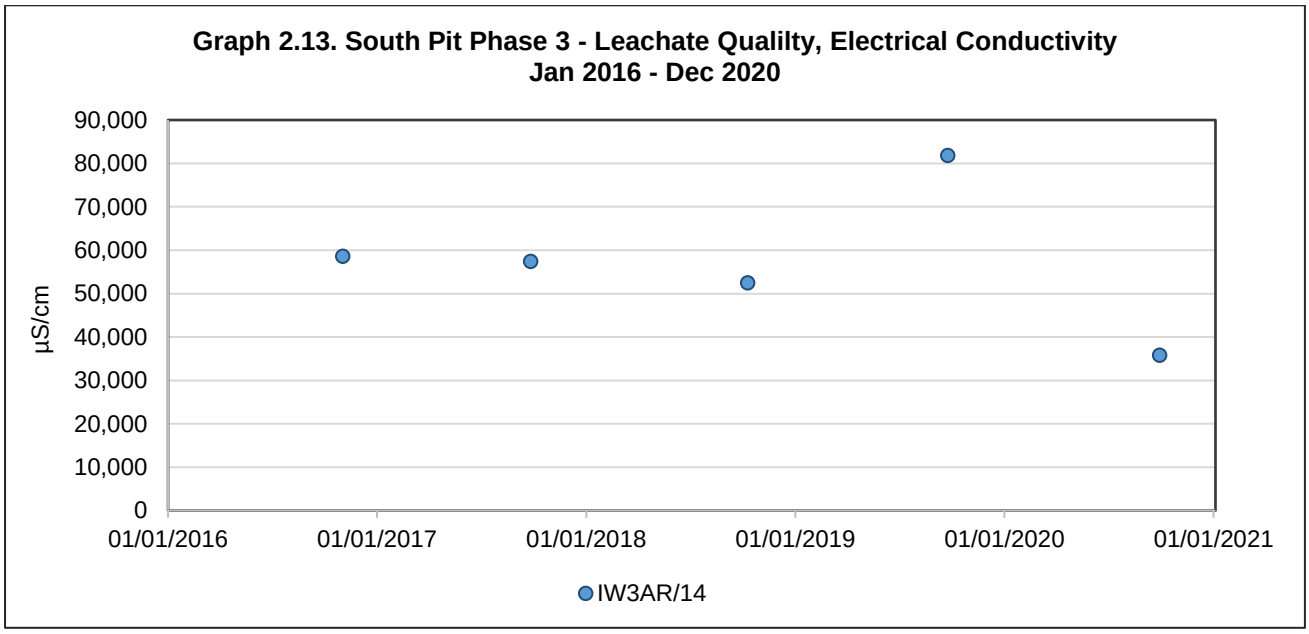
South Pit Phase 3 - in accordance with Permit, **Table S3.7** requirements for a non-operational landfill, leachate quality samples are obtained annually at South Pit Phase 3. There are no permit compliance limits associated with leachate quality. Leachate samples could not be obtained from **IW3BR/14** and **IW3CR/14** in 2020 due to insufficient depth of leachate, as observed in previous years. Therefore, in 2020 a single leachate sample was obtained in September from **IW3AR/14**; the results are compared with previous years' data in the discussion below.

Time-series plots of the priority contaminants within Phase 3 leachate are presented below as **Graphs 2.12 to 2.21**. The graphs show concentrations of the following parameters from 2016 to 2020: pH, electrical conductivity, potassium, ammoniacal-nitrogen, chloride, alkalinity, sulphate, hexavalent chromium, arsenic and selenium.

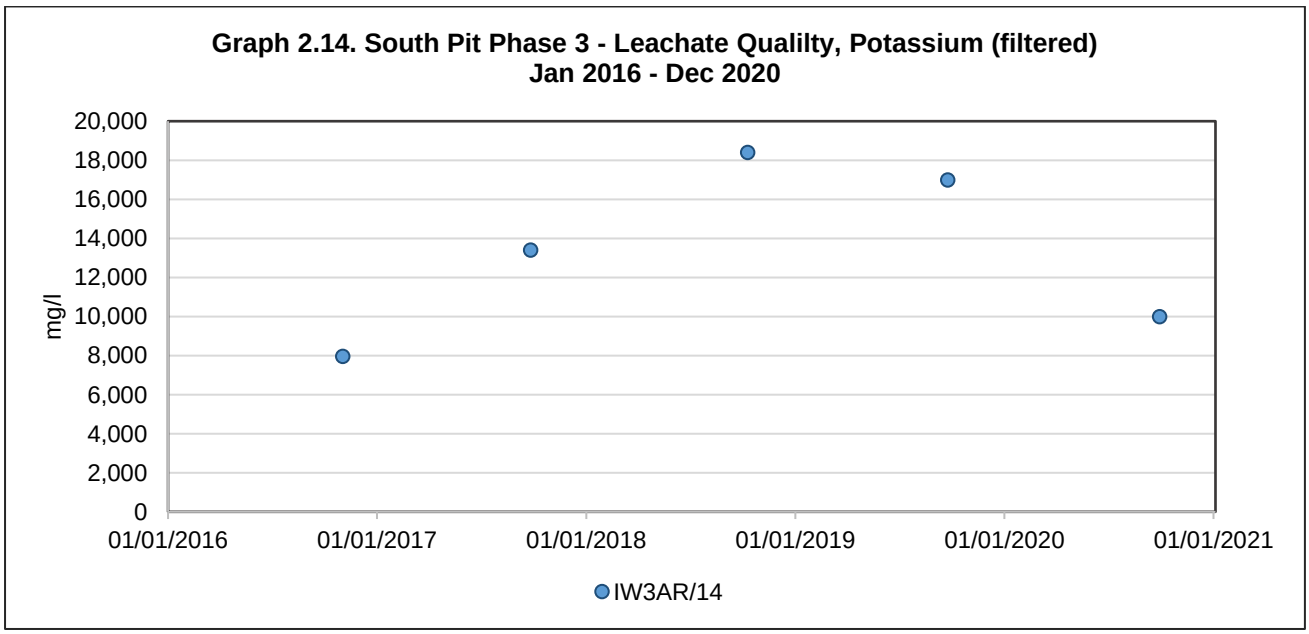
pH – Graph 2.12 presents the pH of leachate samples from 2016 to 2020 and confirms that the pH has remained consistent and elevated at around pH13, which is characteristic of CKD leachate. The pH of leachate from **IW3AR/14** in September 2020 was pH12.9.



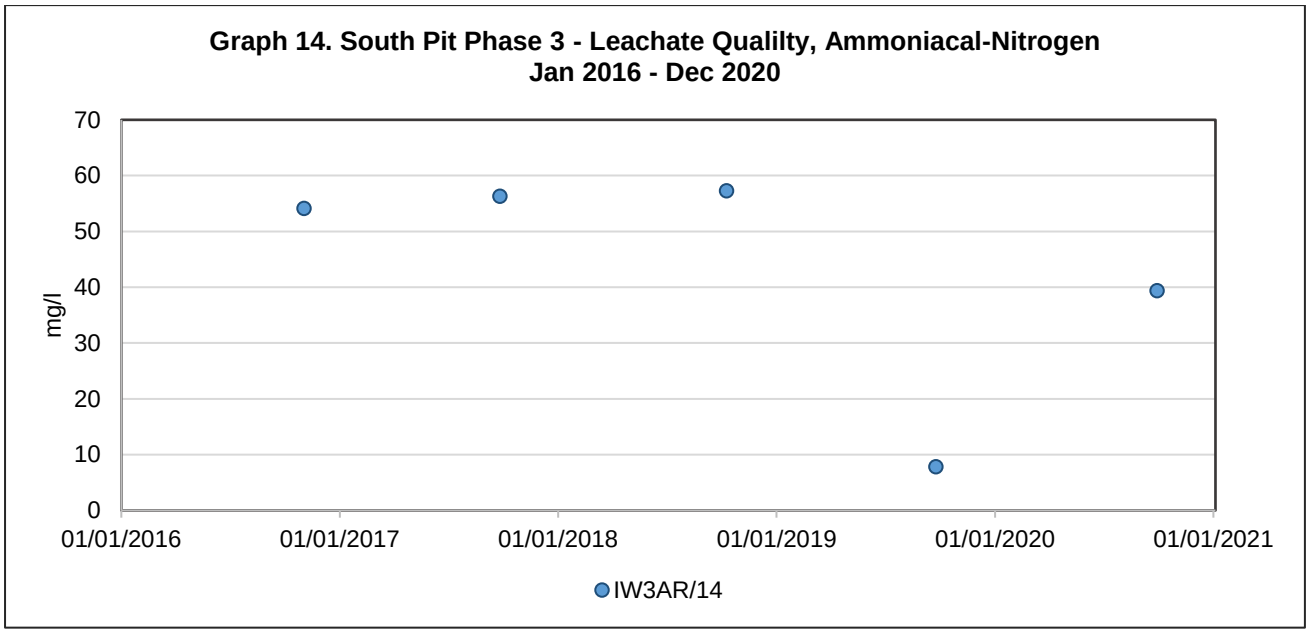
Electrical conductivity – Graph 2.13 presents the electrical conductivity of leachate, which is characteristically high in CKD leachate. The electrical conductivity of leachate at **IW3AR/14** is variable over the five-year review period 2016 to 2020, with the September 2020 value of 35,800µS/cm representing the five-year minimum.



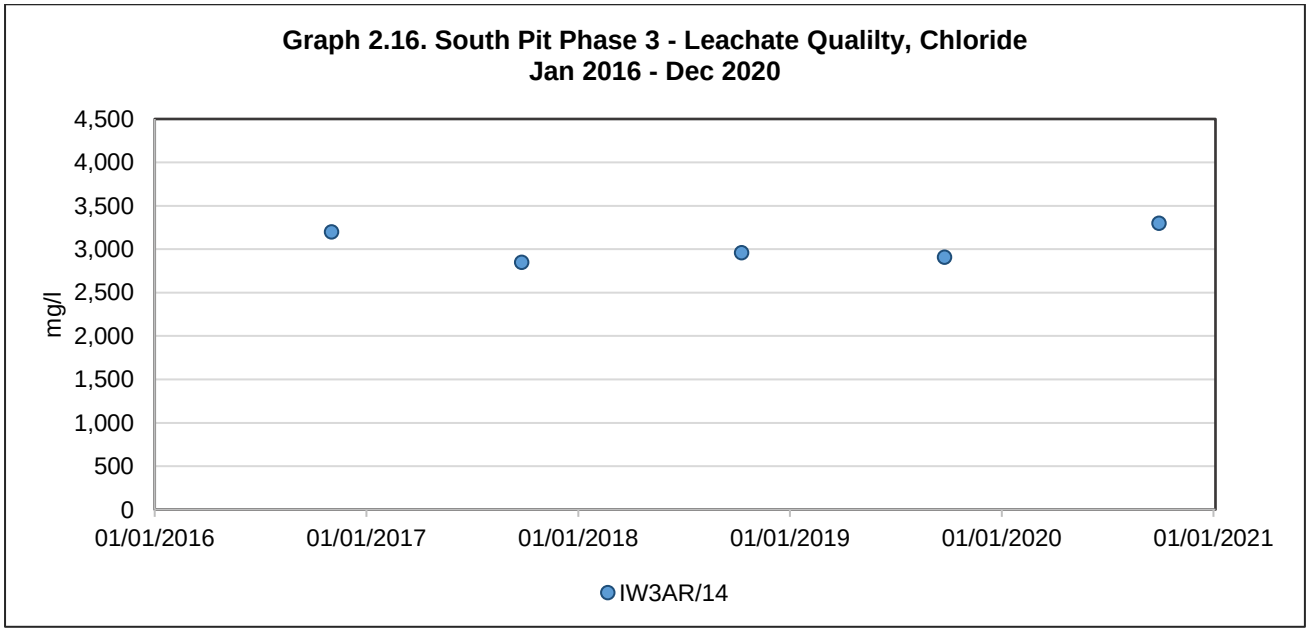
Potassium – Graph 2.14 presents potassium concentrations in leachate from 2016 to 2020; potassium is a key indicator of CKD leachate. The potassium concentration of leachate in 2020 was 10,000mg/l which is within the range previously observed.



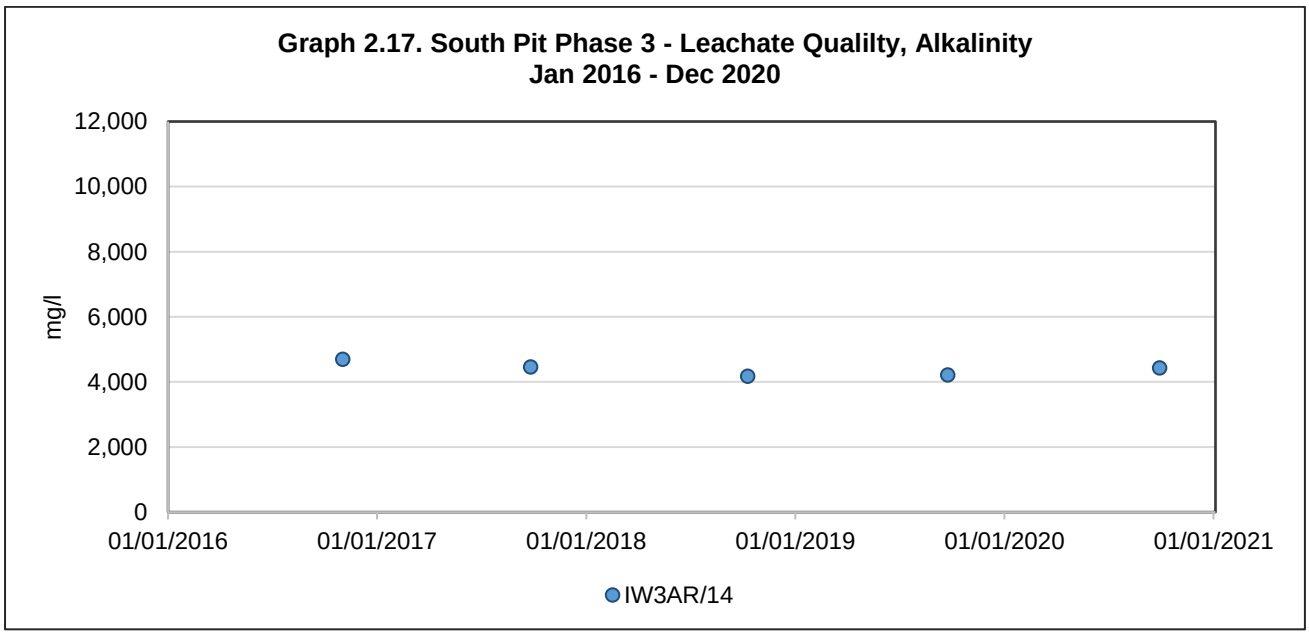
Ammoniacal-nitrogen – Graph 2.15 presents ammoniacal-nitrogen concentrations in leachate from 2016 to 2020. Ammoniacal-nitrogen concentrations from 2016 to 2018 were consistent and in the range 50mg/l to 60mg/l; the 2019 result was significantly lower at 7.8mg/l. In 2020, the ammoniacal-nitrogen concentration at **IW3AR/14** was elevated again at 39.4mg/l.



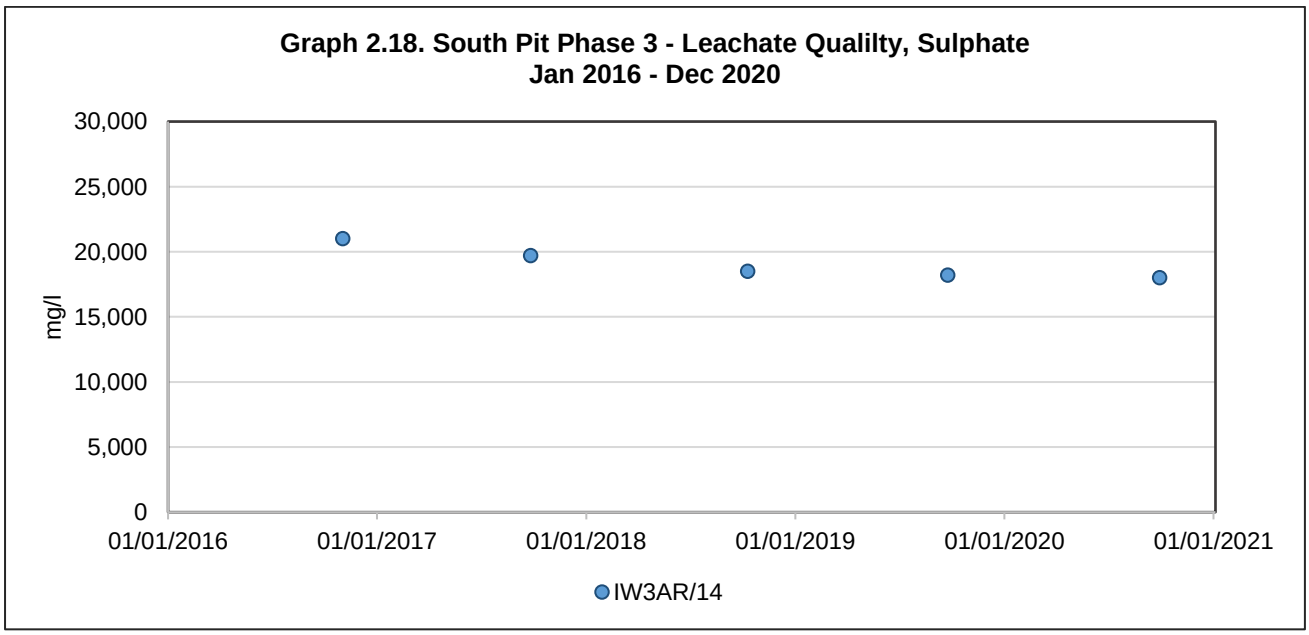
Chloride – Graph 2.16 presents chloride concentrations in leachate from 2016 to 2020 and confirms consistent, elevated concentrations at **IW1AR/14** characteristic of CKD leachate. A value of 3300mg/l was recorded in 2020.



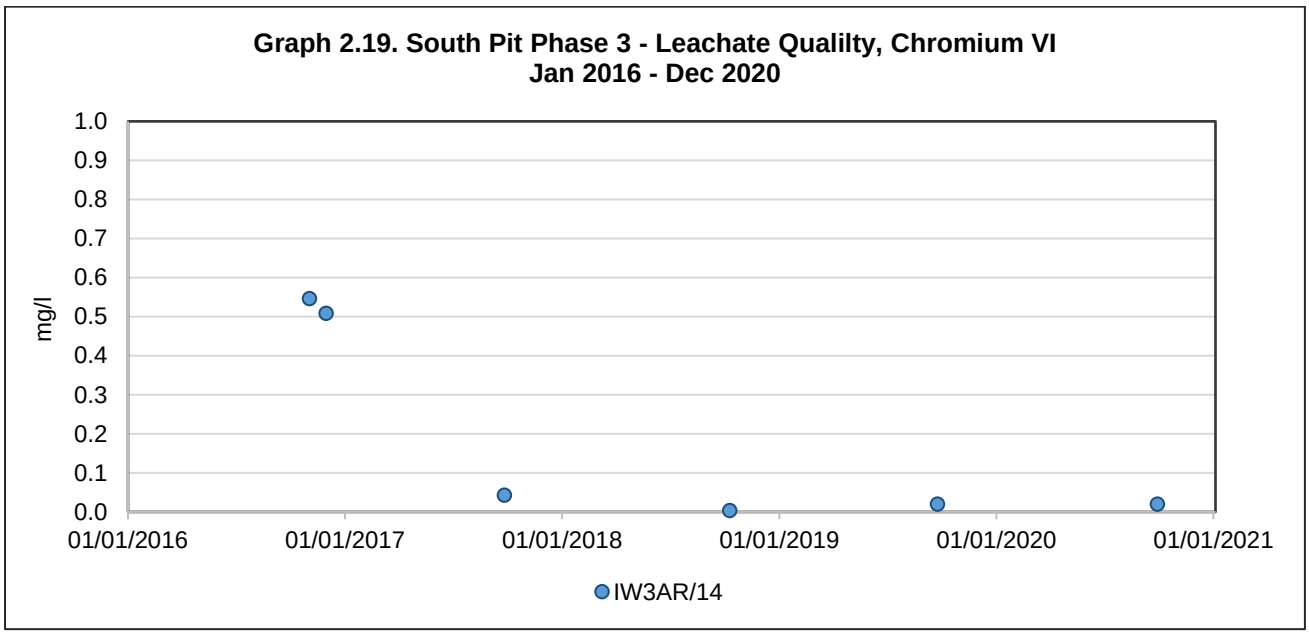
Alkalinity – Graph 2.17 presents the alkalinity of leachate samples from 2016 to 2020, and confirms elevated, consistent results, in the range 4100mg/l to 4700mg/l, with a 2020 result of 4430mg/l.



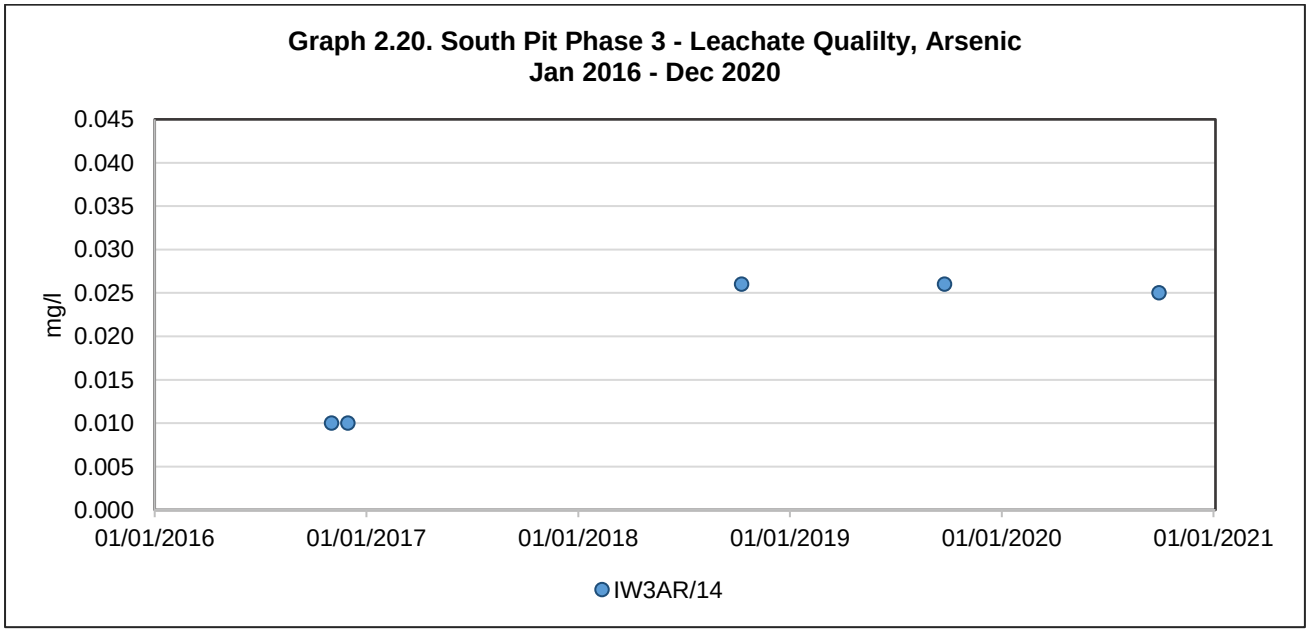
Sulphate – Graph 2.18 presents sulphate concentrations in leachate; CKD leachate is characterised by elevated sulphate. Although Phase 3 leachate has displayed a slight declining trend in sulphate levels since 2016, based on limited annual monitoring data only, the concentration recorded in 2020 remained elevated at 18,000mg/l.



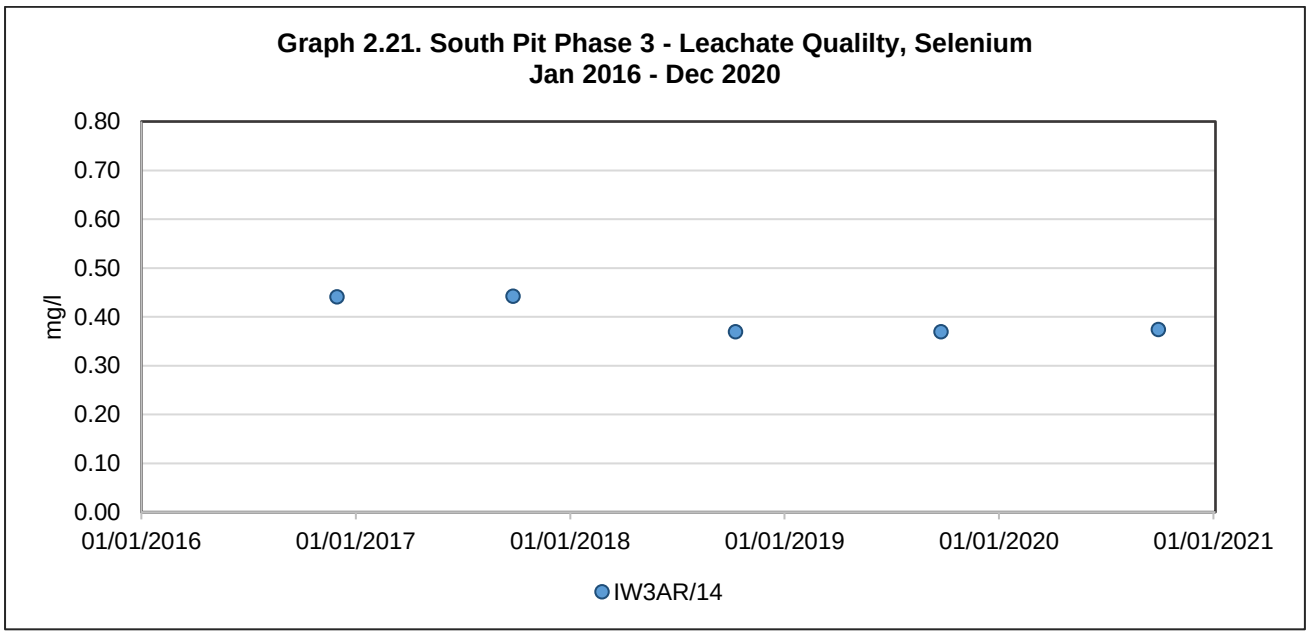
Chromium VI – Graph 2.19 presents hexavalent chromium concentrations in Phase 3 leachate from 2016 to 2020 and confirms that hexavalent chromium remained below the laboratory reporting limit (0.02mg/l) at **IW3AR/14** in 2020, as observed in 2018 and 2019.



Arsenic – Graph 2.20 presents arsenic concentrations in leachate from 2016 to 2020. Arsenic is a hazardous substance which has been occasionally detected at low concentrations above the 0.01mg/l LRL at **IW3AR/14**, with the 2020 result of 0.025mg/l comparable to recent results.



Selenium – Graph 2.21 presents selenium concentrations in Phase 3 leachate from 2016 to 2020. The data confirm relatively consistent results over the five year period; the concentration in 2020 was 0.374mg/l.



Hazardous Substances – a sample was taken from **IW3AR/14** for hazardous substance analysis on 29/09/2020 and only arsenic was detected above the relevant recommended laboratory reporting limit (10µg/l for volatiles and semi-volatiles and 1µg/l for mercury). The recorded concentration of arsenic (filtered) in 2020, of 0.025mg/l was comparable to 2018 and 2019 data.

4.3.3 Leachate Quality Summary

South Pit and Surge Pile: leachate quality is monitored quarterly when sufficient depth of leachate is present, with eleven samples analysed from the three monitoring points during 2020. However, the leachate quality statistics remain variable between the monitoring locations, with only the leachate samples obtained from **IW1AR/14** considered fully representative of the site leachate. Significantly lower concentrations at the other monitoring points (especially **IW1CR/14)** are indicative of groundwater seepage / dilution. The leachate quality at **IW1AR/14** remained characteristic of CKD leachate with elevated pH, chloride, sulphate and potassium but concentrations of many parameters in 2020 continued to follow the gradual declining trend observed in recent years.

South Pit Phase 3: leachate quality is monitored annually at South Pit Phase 3, with a single sample obtained in 2020 from **IW3AR/14**. The leachate remains characteristic of CKD leachate with concentrations of key indicator parameters comparable to previous years and reporting high alkalinity, high electrical conductivity and high concentrations of potassium, chloride and sulphate. Over a longer-term, five year review period, concentrations of indicator parameters generally remain consistent or are following a gradual declining trend. The 2020 leachate data remain within the concentration ranges assumed in the 2017 HRA Review for the priority contaminants: ammoniacal-nitrogen, chloride, sulphate, hexavalent chromium, phenol and selenium.

4.4 Surface Water Monitoring Data

4.4.1 Key Parameters

Surface water quality is monitored at the following locations around South Pit Landfills:

SSW1 – upstream of Phase 1 and Phase 3 within Swanscombe Main Drain

SSW2 – entrance to the Swanscombe Main Drain culvert, downstream of both sites

SSW3 – on the eastern (midstream) boundary of Phase 3, within the eastern marsh drain

SSW4 – upstream of Phase 3, within the eastern marsh drain

SSW5 – on the north-east (downstream) boundary of Phase 3, within the eastern marsh drain

SSW6 – downstream of Phase 1 (upstream of Phase 3), within Swanscombe Main Drain

SSW7 – within a site drainage ditch opposite (west of) SSW6 (downstream of Phase 1)

The Closure Report / EMP for **South Pit and Surge Pile** presents assessment and compliance limits for surface water quality at downstream compliance point **SSW6**, which were subject to review after 12 months (yet to be undertaken).

There are no surface water compliance limits for **South Pit Phase 3** and no compliance limits recommended in the 2017 HRA Review due to the difficulty in identifying impacts to surface water quality from Phase 3 in isolation from the other, adjacent CKD sources. However, the 2017 HRA Review recommended assessment limits for surface water at **SSW2**, to be used in conjunction with visual assessments of leachate seepages. **SSW2** assessment levels are to be fully implemented following the completion of the surface water drain clearance works which is due to be undertaken in 2021. The discussion below includes reference to **SSW2** assessment levels and provides information on the current situation.

Surface water graphs (**Graph 3.1 – 3.6**) presented below include data for all surface water monitoring points at South Pit Landfills (**SSW1** to **SSW7**) for the following priority leachate substances: pH, potassium, chloride, sulphate, ammoniacal-nitrogen and selenium. For the purposes of the graphs, values below the LRL are assumed to equal the LRL.

Due to low flow conditions, it was not possible to take samples at all the points on every monitoring occasion.

In addition to the assessment and compliance limits, surface water quality data have been reviewed against freshwater environmental quality standards (EQSs) as detailed in **Table 3.1** below.

Table 3.1 Surface Water Emission Limits and Environmental Quality Standards			
Parameter	**Assessment / Compliance Limits**	**Freshwater Environmental Quality Standard (EQS*)**	**Comment**
pH	SSW6: assessment: pH8.6; compliance: pH9.0	pH6 – pH9	UK Standards for protection of inland freshwaters
Electrical conductivity		2500µS/cm	UK Drinking Water Standard
Chloride	SSW2: 399mg/l (assessment limit) SSW6: assessment: 162mg/l; compliance: 250mg/l	250mg/l	Freshwater EQS (annual average)
Sulphate	SSW2: 883mg/l (assessment limit) SSW6: assessment: 296mg/l; compliance: 400mg/l	400mg/l	Freshwater EQS (annual average)
Arsenic	SSW6: compliance: 0.025mg/l	25 to 50µg/l	UK Standard for surface water quality and protection of aquatic life
Ammoniacal-nitrogen	SSW2: 1.29mg/l (assessment limit)	0.2mg/l – 2.5mg/l	EQS after Environment Agency H1 Environmental Risk Assessment, Annex D, A5 – Table 3
Phenol	SSW2: 7.7mg/l (assessment limit)	0.3mg/l	Freshwater EQS (maximum acceptable)
Selenium	SSW2: 0.01mg/l (assessment limit) SSW6: compliance: 0.03mg/l	0.01mg/l	UK Drinking Water Standard
Hexavalent Chromium	SSW2: 0.002mg/l (assessment limit)	-	-

Table note: Assessment limits for SSW2 after Phase 3 2017 HRA Review (no permit compliance limits exist)
Assessment and compliance limits for SSW6 after South Pit & Surge Pile Closure Report and are due review.
Water quality standards after EA Chemical Standards Database.

Table 3.2 presents surface water quality monitoring statistics for the general chemistry and leachate indicator parameters.

Table 3.2 – South Pit Landfills: 2020 Surface Water Quality Statistics

Monitoring Point: SSW1 (upstream)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	10	4.3	8.0	22.2
Sodium, total (mg/l)	10	24	28.6	36.3
pH (units)	10	7.9	8.2	9.3
Electrical Conductivity (µS/cm)	10	626	725	936
Alkalinity as CaCO3 (mg/l)	10	130	176.2	227
Ammoniacal-Nitrogen as N (mg/l)	10	<0.05	-	0.171
Chloride (mg/l)	10	37	51	63
Sulphate as SO4 (mg/l)	10	69	121	284
Selenium (total) (mg/l)	10	<0.005	-	0.007
Hexavalent Chromium (mg/l)	10	<0.002	-	0.006
Arsenic (total) (mg/l)	10	<0.005	<0.005	<0.005
Phenols (mono) (mg/l)	10	<0.01	-	0.018
Monitoring Point: SSW2 (downstream)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	12	16.6	60.0	124
Sodium, total (mg/l)	12	38.3	68.2	93.5
pH (units)	12	7.7	8.0	8.4
Electrical Conductivity (µS/cm)	12	822	1077	1350
Alkalinity as CaCO3 (mg/l)	12	200	238	270
Ammoniacal-Nitrogen as N (mg/l)	12	<0.05	-	0.746
Chloride (mg/l)	12	74	124	200
Sulphate as SO4 (mg/l)	12	81	136	172
Selenium (total) (mg/l)	12	<0.005	<0.005	<0.005
Hexavalent Chromium (mg/l)	12	<0.002	-	0.006
Arsenic (total) (mg/l)	12	<0.005	-	0.011
Phenols (mono) (mg/l)	12	<0.01	-	0.017

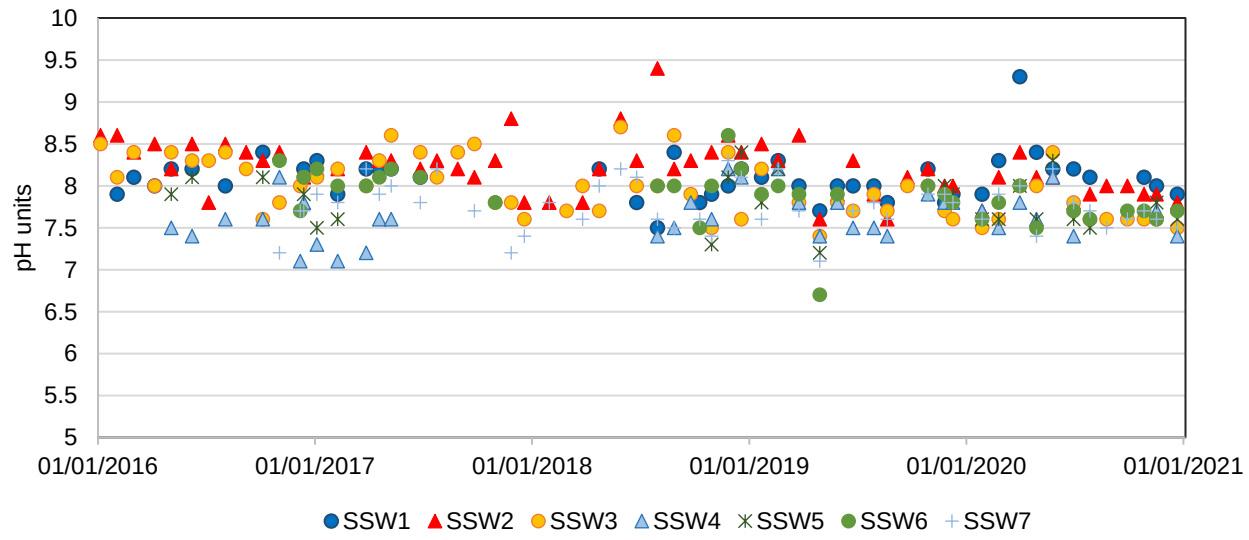
Monitoring Point: SSW3 (midstream)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	12	29.9	238	906
Sodium, total (mg/l)	12	56.2	140	357
pH (units)	12	7.5	7.7	8.4
Electrical Conductivity (µS/cm)	12	1020	2071	5650
Alkalinity as CaCO3 (mg/l)	12	265	341	495
Ammoniacal-Nitrogen as N (mg/l)	12	<0.05	-	1.56
Chloride (mg/l)	12	113	277	723
Sulphate as SO4 (mg/l)	12	90	298	836
Selenium (total) (mg/l)	12	<0.005	-	0.008
Hexavalent Chromium (mg/l)	12	<0.002	<0.002	<0.002
Arsenic (total) (mg/l)	12	<0.005	-	0.03
Phenols (mono) (mg/l)	12	<0.01	-	0.016
Monitoring Point: SSW4 (upstream)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	8	15	20	26.5
Sodium, total (mg/l)	8	40.2	65.2	87.1
pH (units)	8	7.4	7.7	8.1
Electrical Conductivity (µS/cm)	8	847	1094	2070
Alkalinity as CaCO3 (mg/l)	8	243	286	320
Ammoniacal-Nitrogen as N (mg/l)	8	<0.05	-	0.26
Chloride (mg/l)	8	86	112	136
Sulphate as SO4 (mg/l)	8	52	84	157
Selenium (total) (mg/l)	8	<0.005	<0.005	<0.005
Hexavalent Chromium (mg/l)	8	<0.002	<0.002	<0.002
Arsenic (total) (mg/l)	8	<0.005	-	0.011
Phenols (mono) (mg/l)	8	<0.01	<0.01	<0.01

Monitoring Point: SSW5 (downstream)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	9	51.3	220	358
Sodium, total (mg/l)	9	56.6	179	417
pH (units)	9	7.5	7.7	8.3
Electrical Conductivity (µS/cm)	9	977	2385	5290
Alkalinity as CaCO3 (mg/l)	9	260	330	420
Ammoniacal-Nitrogen as N (mg/l)	9	<0.05	-	0.424
Chloride (mg/l)	9	108	386	999
Sulphate as SO4 (mg/l)	9	108	329	712
Selenium (total) (mg/l)	9	<0.005	<0.005	<0.005
Hexavalent Chromium (mg/l)	9	<0.002	-	0.004
Arsenic (total) (mg/l)	9	<0.005	-	0.011
Phenols (mono) (mg/l)	9	<0.01	<0.01	<0.01
Monitoring Point: SSW6 (downstream)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	10	7.2	18.3	24.4
Sodium, total (mg/l)	10	32.8	53.3	77.1
pH (units)	10	7.5	7.7	8.0
Electrical Conductivity (µS/cm)	10	683	881	957
Alkalinity as CaCO3 (mg/l)	10	195	244	280
Ammoniacal-Nitrogen as N (mg/l)	10	<0.05	-	0.269
Chloride (mg/l)	10	60	90	116
Sulphate as SO4 (mg/l)	10	66	90	131
Selenium (total) (mg/l)	10	<0.005	<0.005	<0.005
Hexavalent Chromium (mg/l)	10	<0.002	-	0.006
Arsenic (total) (mg/l)	10	<0.005	-	0.005
Phenols (mono) (mg/l)	10	<0.01	<0.01	<0.01

Monitoring Point: SSW7 (downstream)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	12	20.8	170	512
Sodium, total (mg/l)	12	34.6	81.9	179
pH (units)	12	7.4	7.7	8.2
Electrical Conductivity (µS/cm)	12	734	1433	2980
Alkalinity as CaCO3 (mg/l)	12	145	236	330
Ammoniacal-Nitrogen as N (mg/l)	12	<0.05	-	0.699
Chloride (mg/l)	12	63	172	410
Sulphate as SO4 (mg/l)	12	87	215	535
Selenium (total) (mg/l)	12	<0.005	<0.005	<0.005
Hexavalent Chromium (mg/l)	12	<0.002	-	0.005
Arsenic (total) (mg/l)	12	<0.005	-	0.011
Phenols (mono) (mg/l)	12	<0.01	-	0.013

pH – Graph 3.1 presents the pH of surface water from 2016 to 2020. In 2020 the upstream pH, as monitored at **SSW1** and **SSW4**, ranged between pH7.4 and pH8.4 (excluding a single outlying value of pH9.3 at **SSW1** in April 2020). South Pit CKD leachate is characterised by high alkalinity with pH in the range pH11 to pH13. In 2020, the pH of water samples at all midstream and downstream monitoring points remained within the range observed at the upstream monitoring points. Excluding the **SSW1** outlier, all 2020 data remained within the UK freshwater quality standard range of pH6 -pH9 and there were no exceedances of the **SSW6** assessment limit (pH8.6) or compliance limit (pH9).

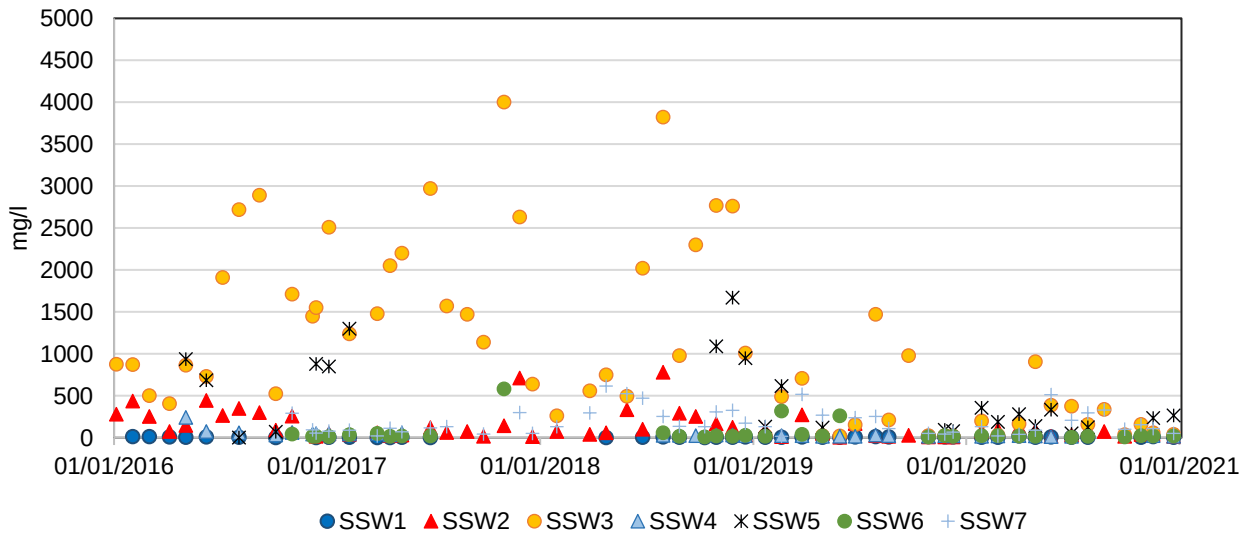
Graph 3.1 Surface Water Quality, pH Jan 2016 - Dec 2020



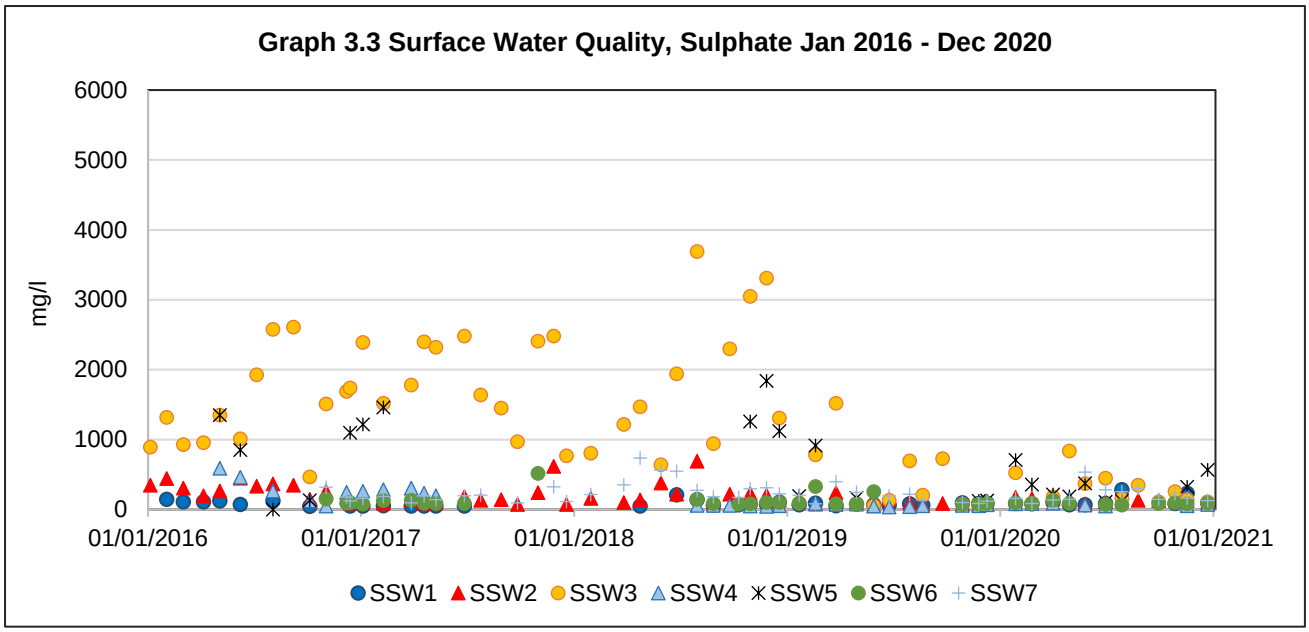
Potassium – Graph 3.2 presents potassium concentrations in surface water from 2015 to 2020. In 2020, the highest potassium concentrations are recorded at **SSW3**, as in previous years. However, the declining trend in concentrations at **SSW3** continued into 2020, with an average potassium concentration of 238mg/l, compared to a 2019 average of 347 and a 2018 average of 1611mg/l. Historically, elevated potassium concentrations at this location have been attributed to leachate outbreaks reaching the eastern marsh drain. Construction of the leachate collection system in 2014/15 aimed to reduce the incidence of leachate seepages from South Pit Phase 3. The five year data record shows a seasonal fluctuation in concentrations, with lower concentrations observed in winter months presumably due to higher surface water flow conditions affording greater dilution. There are no assessment or compliance limits for potassium.

It is noted that the potassium analysis is for 'total' potassium and could be influenced by the inclusion of sediment in low flow conditions. Analysis of 'dissolved' potassium, alongside 'total' potassium, commenced during 2019. Review of the results indicates that at lower potassium concentrations (typically <500mg/l) 'dissolved' and 'total' concentrations are comparable, but during periods of elevated total potassium (notably >1000mg/l), the 'dissolved' concentration is up to 50% lower than the reported 'total' concentration.

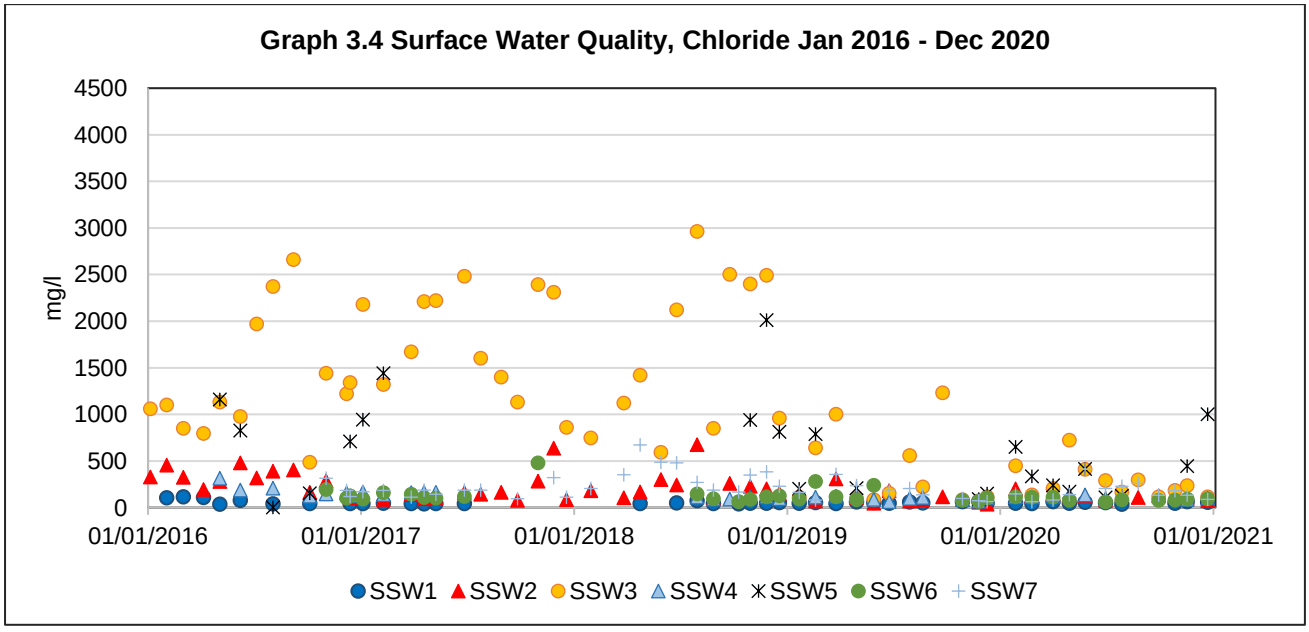
Graph 3.2 Surface Water Quality, Potassium (total) Jan 2016 - Dec 2020



Sulphate – Graph 3.3 presents sulphate concentrations in surface water from 2016 to 2020. The 2020 data follow similar trends as observed for potassium, with the highest concentrations generally recorded at midstream **SSW3.** As for potassium, concentrations of sulphate at **SSW3** have continued to follow a declining trend into 2020 (2018 average: 1880mg/l; 2019 average: 377mg/l; 2020 average: 298mg/l). 2020 concentrations at the downstream compliance points remained below the **SSW2** assessment limit (883mg/l) and below the **SSW6** compliance limit (400mg/l).



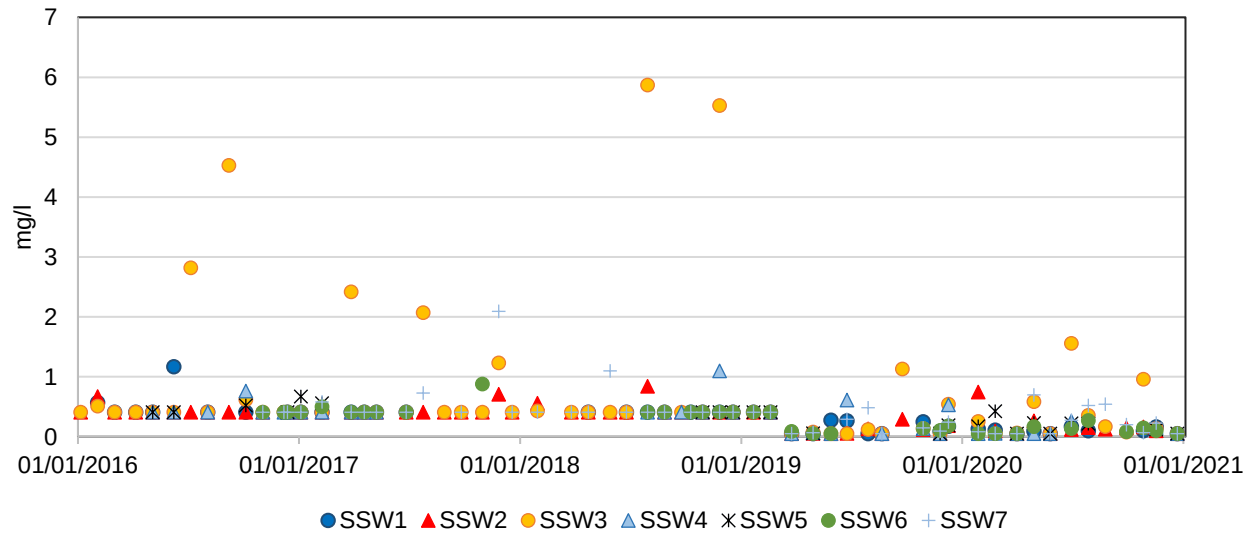
Chloride – Graph 3.4 presents chloride concentrations in surface water from 2016 to 2020; these follow comparable trends to sulphate and potassium. The highest concentrations in 2020 were generally observed at mid-stream **SSW3**, although, as for other parameters, chloride concentrations were significantly lower than in previous years (2018 average: 1651mg/l; 2019 average: 363mg/l; 2020 average: 277mg/l). Upstream concentrations at **SSW1** and **SSW4** remained relatively low in 2020 at <150mg/l. The maximum recorded concentration of chloride at compliance point **SSW6** in 2020 was 116mg/l, significantly below the compliance limit of 250mg/l, and below the assessment limit of 162mg/l. The **SSW2** assessment limit of 399mg/l was not exceeded in 2020, with a maximum concentration of 200mg/l.



Ammoniacal-Nitrogen - Graph 3.5 presents ammoniacal-nitrogen concentrations in surface water from 2016 to 2020. The laboratory transition from ALS to DETS in March 2019 resulted in a reduction in the ammoniacal-nitrogen LRL from 0.41mg/l to 0.05mg/l. The majority of results in 2020 remained below the LRL of 0.05mg/l, although ammoniacal-nitrogen was recorded at low concentrations in surface water at all monitoring points on at least one occasion in 2020. The highest concentrations were generally recorded at mid-stream **SSW3**

(maximum:1.56mg/l) and downstream **SSW7** (maximum: 0.699mg/l) although these concentrations remain below the maximum freshwater quality standard of 2.5mg/l. The **SSW2** assessment limit of 1.29mg/l was not exceeded in 2020 (maximum: 0.746mg/l).

Graph 3.5 Surface Water Quality, Ammoniacal-Nitrogen Jan 2016 - Dec 2020



Selenium – Graph 3.6 presents selenium concentrations in surface water from 2016 to 2020. The LRL for selenium was revised to 0.005mg/l in 2019 as a result of the laboratory transition and virtually all 2020 results were reported as below the LRL. Single detections of selenium were recorded at **SSW3** (0.008mg/l) and **SSW1** (0.007mg/l) in 2020. All concentrations at **SSW2** and **SSW6** remained below the LRL and therefore below the relevant assessment and compliance limits. The UK Drinking Water Standard of 0.01mg/l was not exceeded in 2020.

Graph 3.6 Surface Water Quality, Selenium (total) Jan 2016 - Dec 2020

Arsenic – arsenic (filtered) is a compliance parameter for **SSW6** with a compliance limit value 0.025mg/l. Historic surface water monitoring has been for total arsenic, rather than filtered content, with filtered analysis

commencing in 2019. The 2020 results at **SSW6** ranged from <0.005mg/l to 0.006mg/l, significantly below the compliance limit. In 2020 arsenic (filtered) was detected above the LRL at the majority of monitoring points on at least one occasion, as observed in 2019, with the highest concentrations recorded at **SSW3** (maximum: 0.032mg/l). This maximum concentration marginally exceeded the most stringent UK standard for surface water quality of 0.025mg/l.

Phenol – the 2017 Phase 3 HRA Review recommended a preliminary assessment limit for phenol of 7.7mg/l at **SSW2**, to be reviewed after additional upstream monitoring data became available. In 2020, phenol concentrations generally remained below the LRL of 0.01mg/l at all monitoring points, as previously observed. The highest concentration was recorded at upstream **SSW1** (maximum 0.018mg/l).

Chromium (VI) – the 2017 Phase 3 HRA Review recommended an assessment limit for hexavalent chromium of 0.002mg/l at **SSW2.** In 2020, sample results for all monitoring points remained close to, or below the LRL of 0.002mg/l, with low levels detected upstream and downstream of the site (maximum: 0.006mg/l at **SSW1, SSW2** and **SSW6**). The **SSW2** assessment limit of 0.002mg/l was exceeded on one occasion (0.006mg/l).

4.4.1 Surface Water Summary

Surface water quality in the perimeter drains at South Pit landfills is affected by very poor flow conditions and the historic land use of Swanscombe Peninsula. Lateral seepage and surface flow of CKD leachate can potentially impact surface water quality, and this is particularly evident at **SSW3**. Any visual evidence of leachate seepages is recorded during monitoring visits. 2020 monitoring data are generally comparable to previous years although peak concentrations at **SSW3** remained lower (as in 2019) than previously, possibly due to enhanced perimeter leachate collection within the Phase 3 leachate management system. The monitoring undertaken in accordance with the landfill Permit and CR/EMP is focussed on CKD leachate parameters, but it is not possible to attribute individual incidents of elevated concentrations to a specific (regulated or pre-regulation) CKD disposal area. Recently introduced compliance and assessment limits are used to provide an indication of increasing concentrations above the background and initiate a response. The limits remain under review and will be fully implemented once works to improve the ditch network are completed; this work is due in 2021. There were no exceedances of the **SSW6** compliance limits and a single marginal exceedance of the **SSW2** assessment limit for hexavalent chromium in 2020.

Low rainfall and low flow conditions prevented samples being taken from some monitoring points during periods of prolonged dry weather, as in previous years, and some samples are concluded to be non-representative with little or no flow. It is recommended that all metals (and certainly compliance parameters) continue to be analysed for dissolved content rather than (or as well as) total content to minimise the impact of any sediment collected during low flow conditions.

4.5 Groundwater

4.5.1 Elevation

South Pit and Surge Pile – groundwater levels are monitored quarterly at boreholes **EW4/12, EW5R/14**, **EW6/14** and **G13**. Groundwater levels from 2016 to 2020 are presented on **Graph 4.1**, with 2020 data summarised in **Table 4.1.**

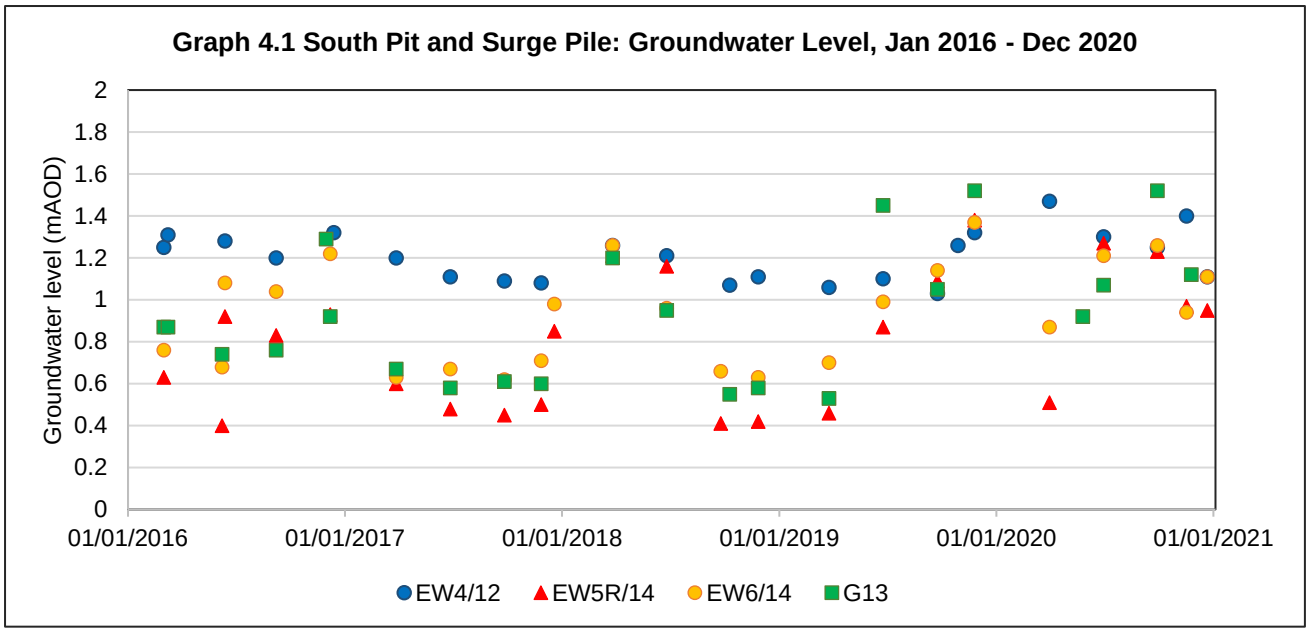


Table 4.1 – South Pit and Surge Pile: 2020 Groundwater Level Statistics (Quarterly Monitoring)

Monitoring Point	2020 Groundwater Level Statistics (mAOD)			
	Count	Minimum	Mean	Maximum
EW4/12	5	1.11	1.31	1.47
EW5R/14	5	0.51	0.99	1.27
EW6/14	5	0.87	1.08	1.26
G13	4	0.92	1.16	1.52

Groundwater levels in 2020 remained low, in the range 0.51mAOD to 1.52mAOD, with mid and down-gradient boreholes influenced by the adjacent tidal River Thames. **EW4/12** is up-gradient of the site, beyond the limit of tidal influence of the river and records the most consistent groundwater levels. The 2020 groundwater level data are generally comparable to previous years.

South Pit Phase 3 – groundwater levels are monitored monthly at down-gradient boreholes **G11** and **EW7/14** and quarterly at up-gradient boreholes **G13** and **SA5944.** The monthly results at **G11** and **EW7/14** are used to calculate an average groundwater level for leachate level compliance assessment. Groundwater levels from 2016 to 2020 are presented on **Graph 4.2**, with 2020 data summarised in **Table 4.2**. Previous studies have confirmed that groundwater levels at the down-gradient Phase 3 monitoring boreholes are tidally influenced by the River Thames. The monitoring aims to sample groundwater quality and record water levels within two hours after low tide to represent an outward groundwater flow direction from the site towards the river. However, this is not always possible due to tide times and sample collection logistics.

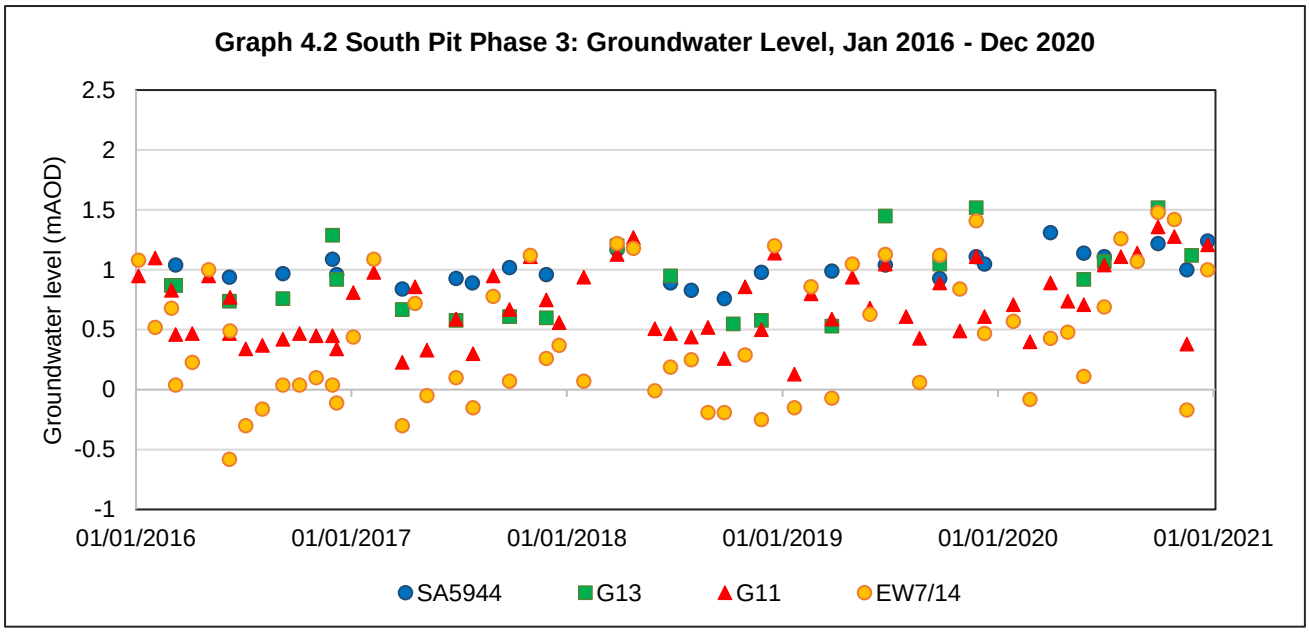


Table 4.2 – South Pit Phase 3: 2020 Groundwater Level Statistics

Monitoring Point	2020 Groundwater Level Statistics (mAOD)			
	Count	Minimum	Mean	Maximum
G13	4	0.92	1.16	1.52
SA5944	6	1.00	1.17	1.31
G11	12	0.38	0.91	1.36
EW7/14	12	-0.17	0.69	1.48

In 2020, as in previous years, borehole **EW7/14** shows the greatest variability in groundwater levels due to tidal influence, with the 2020 range reported as -0.17mAOD to 1.48mAOD. Groundwater levels are comparable with previous years and indicate a generally northerly flow direction towards the River Thames, with tidal influence beneath the northern part of the site.

4.5.2 Groundwater Quality - Key Parameters

South Pit & Surge Pile – Groundwater quality is monitored quarterly within the four perimeter boreholes (EW4/12 located up-gradient of the site, G13 located mid-gradient and EW5R/14 and EW6/14 located down-gradient of the site). 2020 statistics are presented in **Table 4.3** below.

Table 4.3 – South Pit & Surge Pile: 2020 Groundwater Quality Statistics

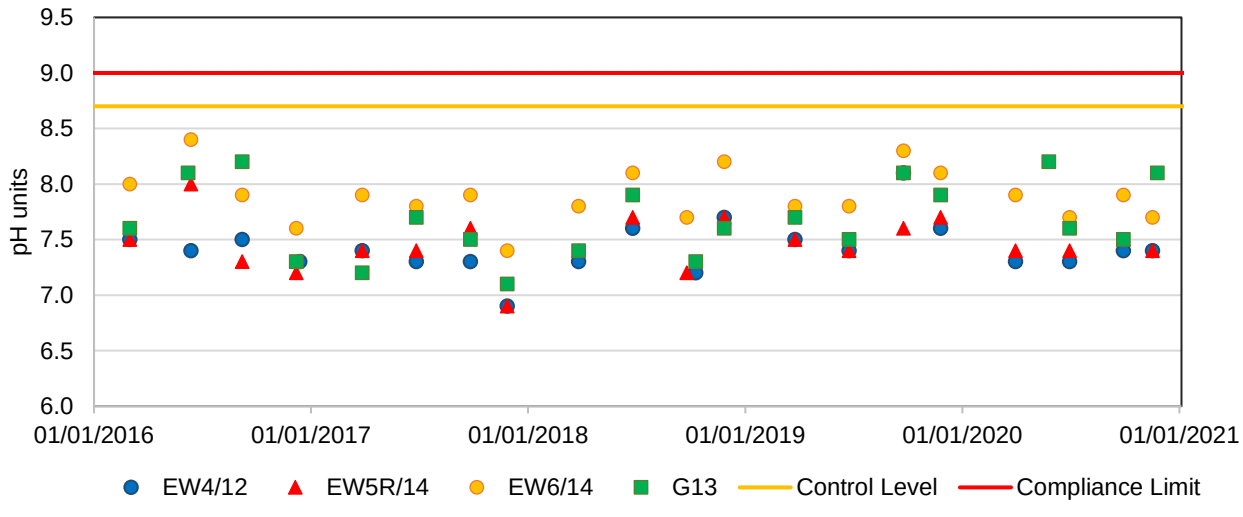
Monitoring Point: EW4/12 (up-gradient)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, filtered (mg/l)	4	34.4	38.0	43.9
Sodium, filtered (mg/l)	4	294	326	382
pH (units)	4	7.3	7.4	7.4
Electrical Conductivity (µS/cm)	4	2740	2983	3160
Alkalinity as CaCO3 (mg/l)	4	452	642	752
Ammoniacal-Nitrogen as N (mg/l)	4	1.74	2.21	2.43
Chloride (mg/l)	4	349	439	491
Sulphate as SO4 (mg/l)	4	213	348	407
Selenium, filtered (mg/l)	4	<0.005	<0.005	<0.005
Arsenic, filtered (mg/l)	4	<0.005	<0.005	<0.005
Monitoring Point: G13 (mid-gradient)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, filtered (mg/l)	4	54.3	70.3	99.7
Sodium, filtered (mg/l)	1	409	409	409
pH (units)	4	7.5	7.9	8.2
Electrical Conductivity (µS/cm)	4	2080	2728	3510
Alkalinity as CaCO3 (mg/l)	1	455	455	455
Ammoniacal-Nitrogen as N (mg/l)	4	<0.05	1.61	3.10
Chloride (mg/l)	4	316	629	931
Sulphate as SO4 (mg/l)	4	169	208	257
Selenium, filtered (mg/l)	4	<0.005	<0.005	<0.005
Arsenic, filtered (mg/l)	4	0.007	0.008	0.011
Monitoring Point: EW5R/14 (down-gradient)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, filtered (mg/l)	4	57.6	71.9	99.9
Sodium, filtered (mg/l)	4	777	975	1160
pH (units)	4	7.4	7.4	7.5
Electrical Conductivity (µS/cm)	4	4130	6563	8380
Alkalinity as CaCO3 (mg/l)	4	495	533	570
Ammoniacal-Nitrogen as N (mg/l)	4	4.19	4.82	5.15
Chloride (mg/l)	4	1680	1765	1830
Sulphate as SO4 (mg/l)	4	267	307	335
Selenium, filtered (mg/l)	4	<0.005	<0.005	<0.005
Arsenic, filtered (mg/l)	4	<0.005	<0.005	<0.005

Monitoring Point: EW6/14 (down-gradient)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, filtered (mg/l)	4	16.6	17.6	18.6
Sodium, filtered (mg/l)	4	188	214	272
pH (units)	4	7.7	7.8	7.9
Electrical Conductivity (µS/cm)	4	1800	1910	1970
Alkalinity as CaCO3 (mg/l)	4	360	385	405
Ammoniacal-Nitrogen as N (mg/l)	4	0.055	0.106	0.192
Chloride (mg/l)	4	277	307	340
Sulphate as SO4 (mg/l)	4	148	185	201
Selenium, filtered (mg/l)	4	<0.005	<0.005	<0.005
Arsenic, filtered (mg/l)	4	<0.005	<0.005	<0.005

Graphs 4.3 to 4.8 present concentrations in groundwater of the following key leachate indicator parameters: pH, electrical conductivity, potassium, sulphate, selenium (filtered), arsenic (filtered) and alkalinity. The **EMP/CR** introduced control levels and compliance limits for pH, potassium, selenium, arsenic and alkalinity at down-gradient boreholes **EW5R/14** and **EW6/14**. Borehole **EW4/12** is up-gradient of the site and representative of background groundwater quality. It is recognised that groundwater within the mid and down-gradient boreholes is strongly influenced by saline intrusion from the tidal River Thames. For the purposes of the graphs, values below the LRL are assumed to equal the LRL.

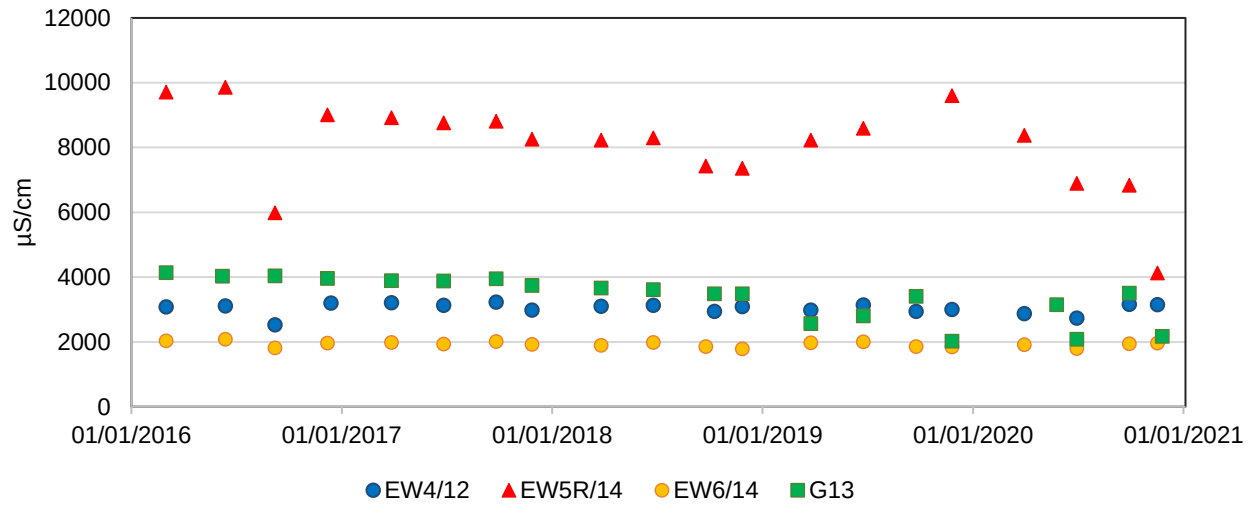
pH – Graph 4.3 presents the pH of groundwater samples from 2016 to 2020. In 2020 the pH of groundwater was slightly alkaline, ranging from pH7.3 to pH8.2, which is comparable to previous years. The highest pH values were recorded at mid-gradient borehole **G13** and down-gradient **EW6/14**. In 2020, as in previous years, the results at the compliance boreholes **EW5R/14** and **EW6/14** were consistently below the **EMP/CR** control level (pH8.7) and compliance limit (pH9.0).

Graph 4.3 South Pit and Surge Pile: Groundwater Quality, pH, Jan 2016 - Dec 2020



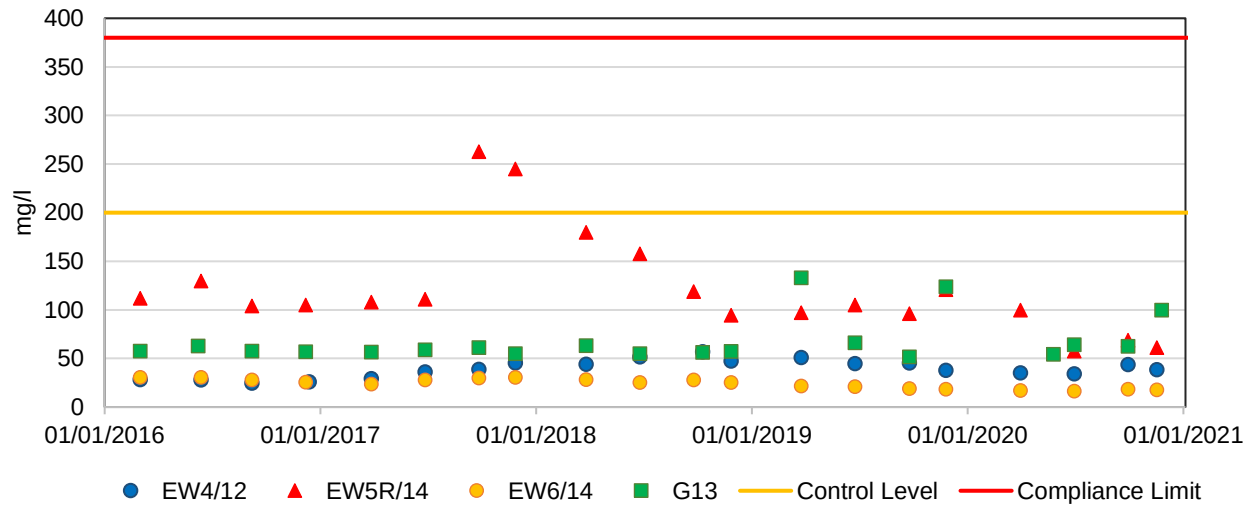
Electrical conductivity – Graph 4.4 presents the electrical conductivity of groundwater from 2016 to 2020. In 2020, as in previous years, electrical conductivity was consistently highest at **EW5R/14**, with a maximum of 8380µS/cm, although the results followed a steep declining trend through 2020. Electrical conductivity of groundwater at up-gradient **EW4/12** continued to be higher than the level recorded at down-gradient borehole **EW6/14,** indicating an off-site source. The electrical conductivity at down-gradient **EW6/14** remained consistent, with an average value of 1910µS/cm in 2020. Although there are no groundwater compliance limits for electrical conductivity, the conductivity of groundwater both up-gradient and down-gradient of the site frequently exceeded the UK Drinking Water Standard of 2500µS/cm in 2020.

Graph 4.4 South Pit and Surge Pile: Groundwater Quality, Electrical Conductivity Jan 2016 - Dec 2020



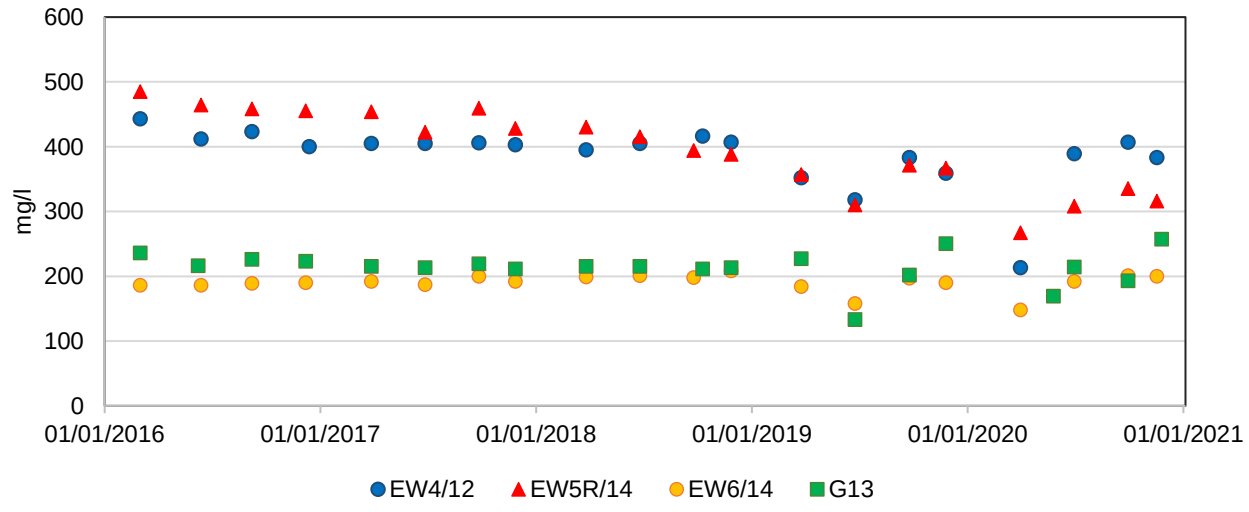
Potassium – Graph 4.5 presents the potassium concentrations in groundwater from 2016 to 2020. Potassium concentrations in 2020 at down-gradient **EW5R/14** were slightly lower than in previous years (maximum: 99.9mg/l) and comparable to the concentrations recorded at mid-gradient borehole **G13.** A potassium control level of 200mg/l and a compliance limit of 380mg/l have been imposed by the **EMP/CR** at **EW5R/14** and **EW6/14**. 380mg/l represents the typical concentration of potassium in seawater and therefore the background level for the tidally influenced boreholes. There was no exceedance of these assessment levels during 2020.

Graph 4.5 South Pit and Surge Pile: Groundwater Quality, Potassium (filtered) Jan 2016 - Dec 2020



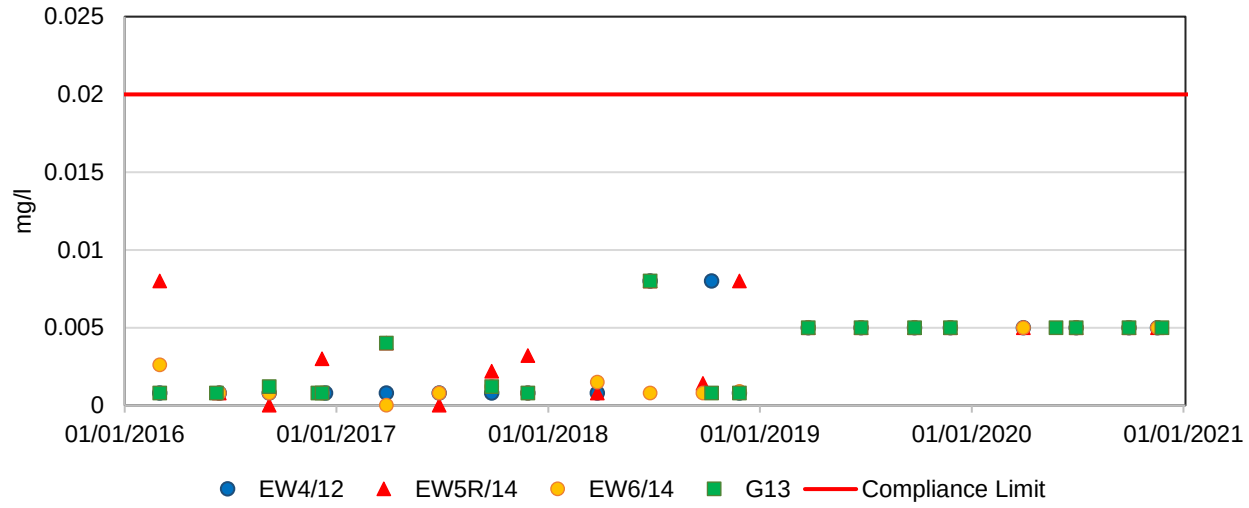
Sulphate – Graph 4.6 presents the sulphate concentrations in groundwater from 2016 to 2020. In 2020 the highest sulphate concentrations were recorded at upgradient **EW4/12** (maximum: 407mg/l) and down-gradient **EW5R/14** (maximum: 335mg/l), as in previous years, with concentrations at **EW5R/14** continuing a long-term declining trend. These concentrations remain close to, or below the freshwater EQS of 400mg/l. There are no assessment limits for sulphate in groundwater.

Graph 4.6 South Pit and Surge Pile: Groundwater Quality, Sulphate, Jan 2016 - Dec 2020



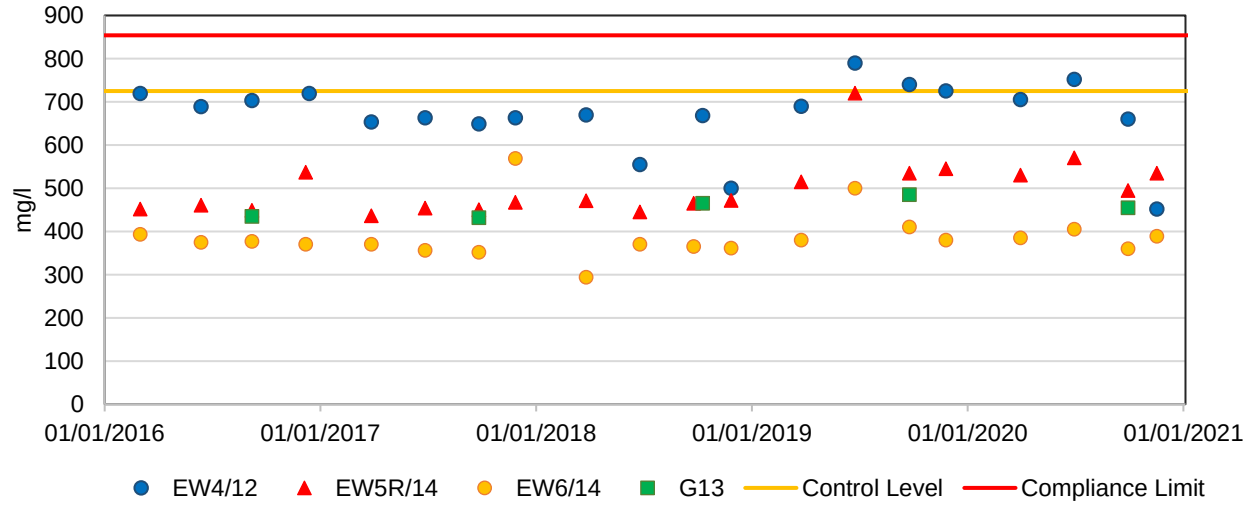
Selenium (filtered) – Graph 4.7 presents the selenium concentrations in groundwater from 2016 to 2020. The laboratory transition to DETS in 2019 resulted in a revision of the selenium LRL to 0.005mg/l. The 2020 data confirm that all selenium concentrations in groundwater remained below the LRL (<0.005mg/l), as in 2019, and therefore concentrations were below the compliance limit of 0.02mg/l at down-gradient boreholes **EW5R/14** and **EW6/14**.

Graph 4.7 South Pit and Surge Pile: Groundwater Quality, Selenium (filtered)
Jan 2016 - Dec 2020



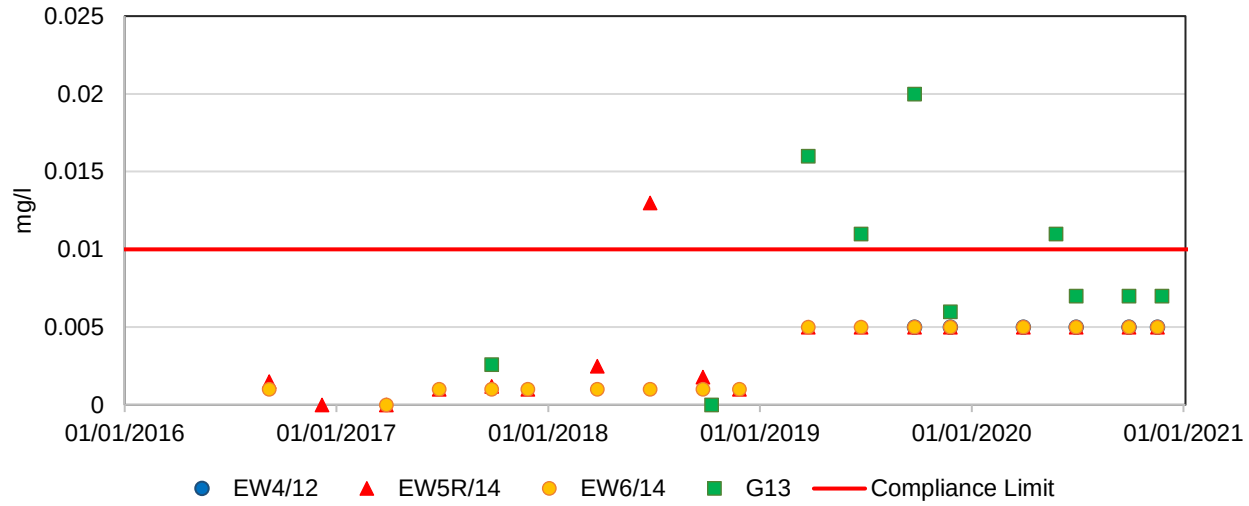
Alkalinity – Graph 4.8 presents the alkalinity of groundwater from 2016 to 2020 and confirms that 2020 data were generally comparable to recent years, with the highest alkalinity levels were recorded at up-gradient borehole **EW4/12** (maximum: 752mg/l). There was no exceedance of the groundwater control level (725mg/l) or compliance limit (854mg/l) at the down-gradient compliance boreholes in 2020. The maximum alkalinity recorded down-gradient of the site in 2020 was 570mg/l at **EW5R/14** in June 2020.

Graph 4.8 South Pit and Surge Pile: Groundwater Quality, Alkalinity
Jan 2016 - Dec 2020



Arsenic – Graph 4.9 presents the arsenic (filtered) concentrations in groundwater from 2016 to 2020. In 2020, as in 2019, all concentrations remained below the LRL of 0.05mg/l in all boreholes except mid-gradient **G13**. Concentrations at **G13** ranged from 0.007mg/l to 0.011mg/l in 2020, and were generally lower than observed in 2019. Arsenic was not detected at the down-gradient boreholes **EW5R/14** and **EW6/14**; therefore, there was no exceedance of the groundwater compliance limit of 0.01mg/l which is equivalent to the UK Drinking Water Standard.

Graph 4.9 South Pit and Surge Pile: Groundwater Quality, Arsenic (filtered) Jan 2016 - Dec 2020



Hazardous Substances – groundwater samples were collected for annual hazardous substance analysis on 29/09/2020 and the substances listed below were detected above the laboratory reporting limit. As in 2019, arsenic has only been detected in up-gradient borehole **G13** in 2020**.** The remaining hazardous substances detected at trace concentrations, only marginally above the LRL, are PAHs. These were generally in both up-gradient and down-gradient boreholes and therefore are not considered significant.

- Arsenic (filtered) **G13:** 0.007mg/l
- Arsenic (total) **G13:** 0.024mg/l
- Acenaphthene **G13:** 0.02µg/l
- Fluoranthene **EW5R/14:** 0.01µg/l; **G13:** 0.02µg/l
- Anthracene **EW5R/14:** 0.03µg/l
- Pyrene **EW5R/14:** 0.05µg/l; **G13:** 0.01µg/l
- Fluorene **EW5R/14:** 0.05µg/l;
- Phenanthrene **EW5R/14:** 0.03µg/l; **G13:** 0.01µg/l

South Pit Phase 3

Groundwater quality is monitored quarterly within the four perimeter boreholes (up-gradient: **G13** and **SA5944;** down-gradient: **G11** and **EW7/14**). Statistics are presented in **Table 4.4** below.

Table 4.4 – South Pit Phase 3: 2020 Groundwater Quality Statistics

Monitoring Point: G13 (up-gradient)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	4	56.7	78.0	122
Sodium, total (mg/l)	1	405	405	405
pH (units)	4	7.5	7.9	8.2
Electrical Conductivity (µS/cm)	4	2080	2728	3510
Alkalinity as CaCO3 (mg/l)	1	455	455	455
Ammoniacal-Nitrogen as N (mg/l)	4	<0.050	-	3.10
Chloride (mg/l)	4	316	629	931
Sulphate as SO4 (mg/l)	4	169	208	257
Selenium, total (mg/l)	4	<0.005	<0.005	<0.005
Chromium, total (mg/l)	4	<0.005	-	0.008
Monitoring Point: SA5944 (up-gradient)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	5	44.6	56.0	65.8
Sodium, total (mg/l)	1	1380	1380	1380
pH (units)	5	7.3	7.5	8.0
Electrical Conductivity (µS/cm)	5	6310	11258	17700
Alkalinity as CaCO3 (mg/l)	1	335	335	335
Ammoniacal-Nitrogen as N (mg/l)	5	<0.05	-	0.590
Chloride (mg/l)	5	2520	3452	5680
Sulphate as SO4 (mg/l)	5	365	476	563
Selenium, total (mg/l)	5	<0.005	<0.005	<0.005
Chromium, total (mg/l)	5	<0.005	-	0.007

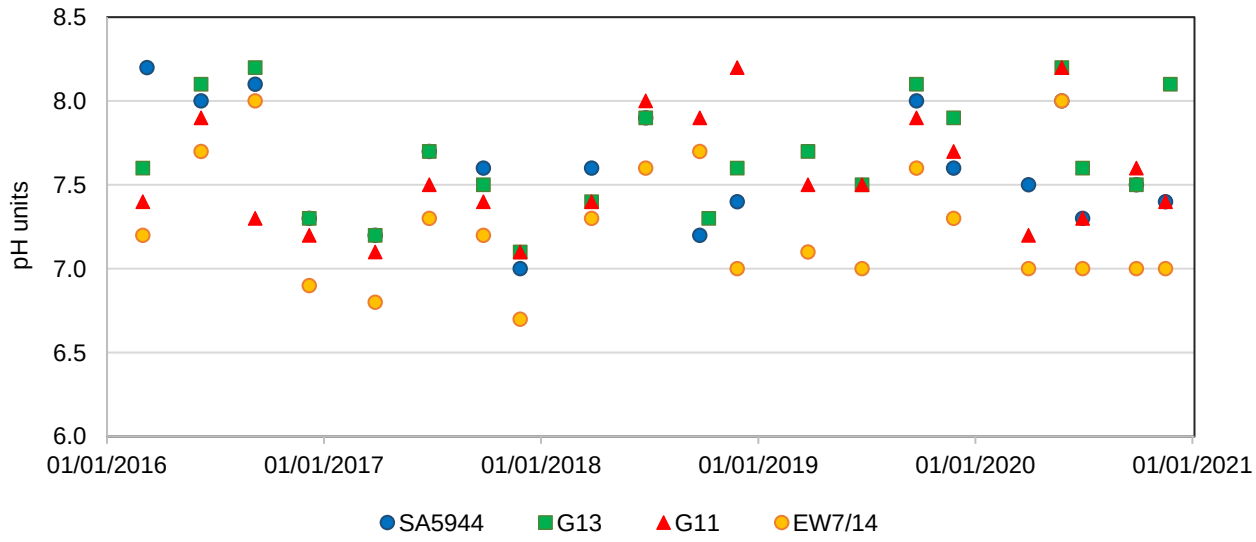
Monitoring Point: G11 (down-gradient)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	5	24.9	26.0	27.5
Sodium, total (mg/l)	1	1130	1130	1130
pH (units)	5	7.2	7.5	8.2
Electrical Conductivity (µS/cm)	5	3460	5356	6880
Alkalinity as CaCO3 (mg/l)	1	530	530	530
Ammoniacal-Nitrogen as N (mg/l)	4	3.14	4.52	6.07
Chloride (mg/l)	4	1300	1423	1530
Sulphate as SO4 (mg/l)	5	197	239	267
Selenium, total (mg/l)	5	<0.005	<0.005	<0.005
Chromium, total (mg/l)	5	<0.005	-	0.006

Monitoring Point: EW7/14 (down-gradient)				
Parameter	**Count**	**Minimum**	**Mean**	**Maximum**
Potassium, total (mg/l)	5	84.1	103	125
Sodium, total (mg/l)	1	2450	2450	2450
pH (units)	5	7.0	7.2	8.0
Electrical Conductivity (µS/cm)	5	5310	15542	22300
Alkalinity as CaCO3 (mg/l)	1	515	515	515
Ammoniacal-Nitrogen as N (mg/l)	5	3.46	8.97	11.10
Chloride (mg/l)	5	5740	6760	8570
Sulphate as SO4 (mg/l)	5	493	606	652
Selenium, total (mg/l)	5	<0.005	<0.005	<0.005
Chromium, total (mg/l)	5	<0.005	<0.005	<0.005

Graphs 4.9 to 4.14 present concentrations in groundwater of the following key leachate indicator parameters: pH, electrical conductivity, potassium (total), sulphate, selenium (total) and chromium (total). Monitoring boreholes **G13** and **SA5944** are up-gradient of the site and boreholes **G11** and **EW7/14** are the down-gradient compliance points with associated permit compliance limits. The influence of saline intrusion on groundwater quality increases with proximity to the River Thames. For the purposes of the graphs, values below the LRL are assumed to equal the LRL.

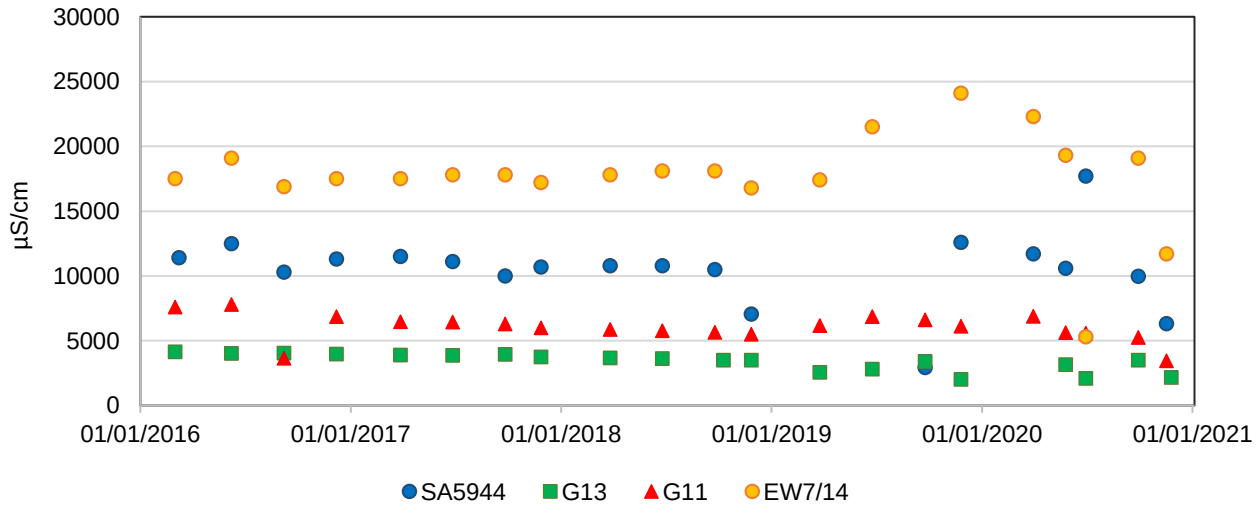
pH – Graph 4.10 presents the pH of groundwater from 2016 to 2020 and confirms that groundwater is near-neutral with pH ranging from pH 7.0 to pH 8.2 in 2020. This is comparable to previous years, with up-gradient and down-gradient boreholes displaying similar pH values with no evident impact of highly alkaline CKD leachate on down-gradient groundwater quality.

Graph 4.10 South Pit Phase 3: Groundwater Quality, pH, Jan 2016 - Dec 2020



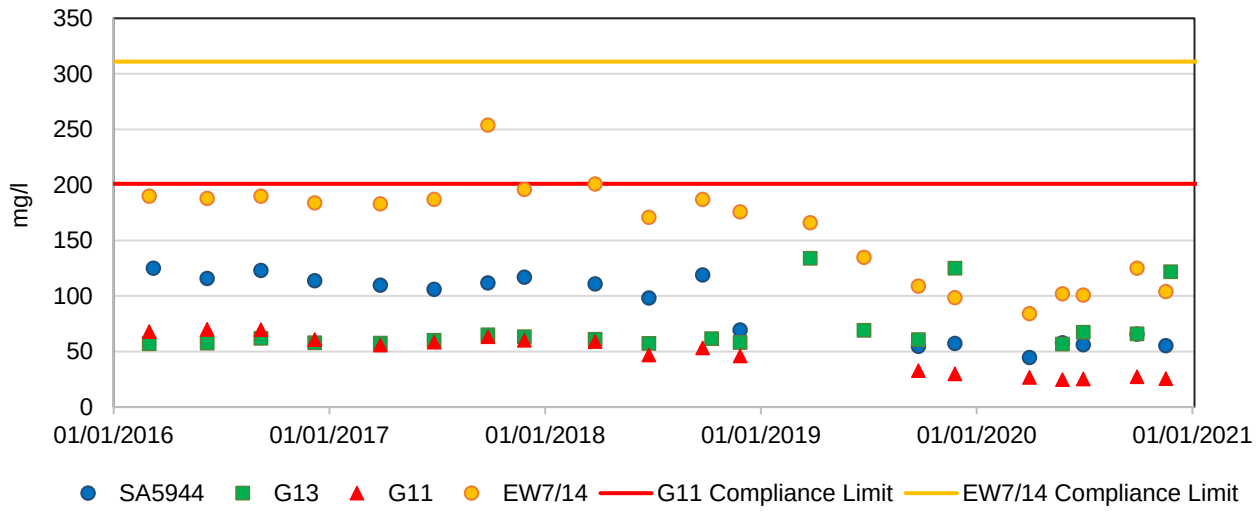
Electrical conductivity – Graph 4.11 presents the electrical conductivity of groundwater from 2016 to 2020. The electrical conductivity of groundwater was historically very consistent until 2019, when results displayed greater variation, notably increased conductivity at down-gradient **EW7/14** and reduced conductivity at up-gradient **SA5944**. In 2020, conductivity values returned close to pre-2019 levels. Groundwater quality at **EW7/14** is strongly influenced by saline intrusion and continued to record the highest conductivity values in 2020 (maximum 22300µS/cm). The lowest electrical conductivity values are consistently recorded at up-gradient borehole **G13**, although values here still frequently exceed the UK Drinking Water Standard of 2500µS/cm and ranged from 2080µS/cm to 3510µS/cm in 2020.

Graph 4.11 South Pit Phase 3: Groundwater Quality, Electrical Conductivity Jan 2016 - Dec 2020



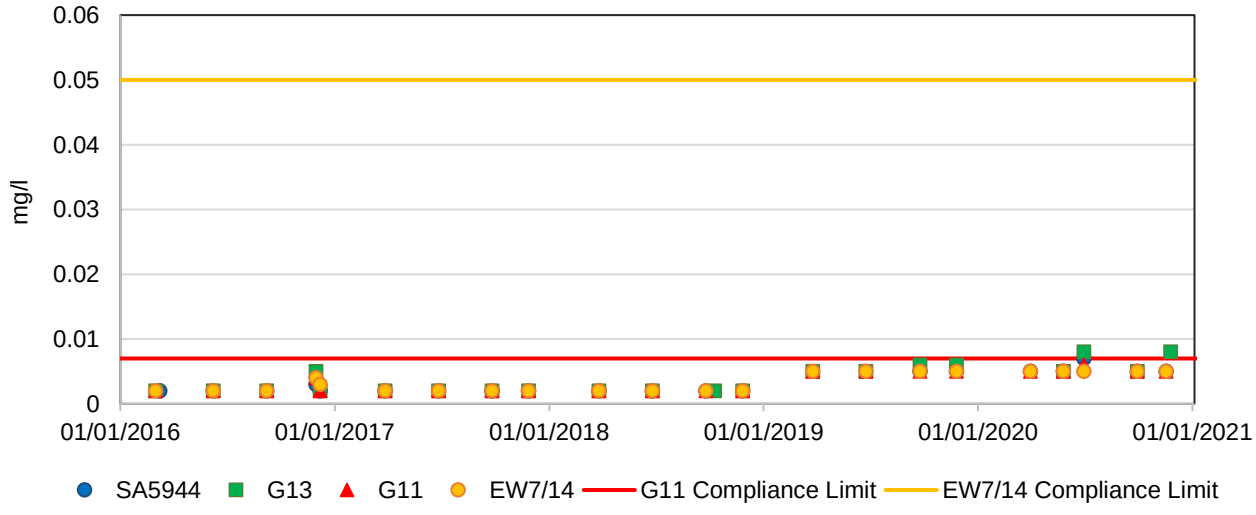
Potassium (total) – Graph 4.12 presents potassium concentrations in groundwater from 2016 to 2020. The 2020 potassium concentrations are generally lower than observed in recent years at all boreholes, except up-gradient G13. Concentrations at down-gradient borehole **G11** remained low (maximum: 27.5mg/l) and the highest concentrations were generally recorded at down-gradient (tidal) borehole **EW7/14**, although concentrations in 2020 were lower than previously observed, ranging from 84.1mg/l to 125mg/l. It is noted that seawater has a typical potassium concentration of 380mg/l. There was no exceedance of the permit compliance limits at boreholes **G11** and **EW7/14** in 2020.

Graph 4.12 South Pit Phase 3: Groundwater Quality, Potassium (total)
Jan 2016 - Dec 2020



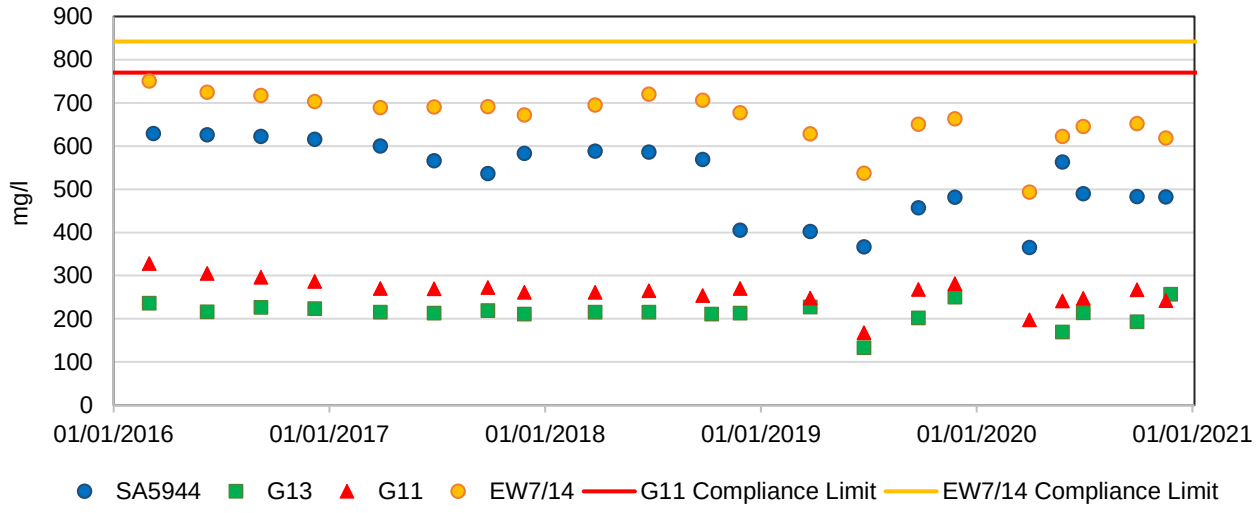
Chromium (total) – Graph 4.13 presents total chromium concentrations in groundwater from 2016 to 2020. In 2019, the LRL for chromium increased to 0.005mg/l as a result of the laboratory transition. All 2020 chromium concentrations in groundwater at the down-gradient boreholes remained below this LRL of 0.005mg/l; all results were therefore below the groundwater compliance limits of 0.007mg/l for borehole **G11** and 0.05mg/l for borehole **EW7/14**. In 2020 chromium was only detected at up-gradient boreholes **SA594** and **G13** at low concentrations (maximum: 0.08mg/l).

Graph 4.13 South Pit Phase 3: Groundwater Quality, Chromium (total)
Jan 2016 - Dec 2020



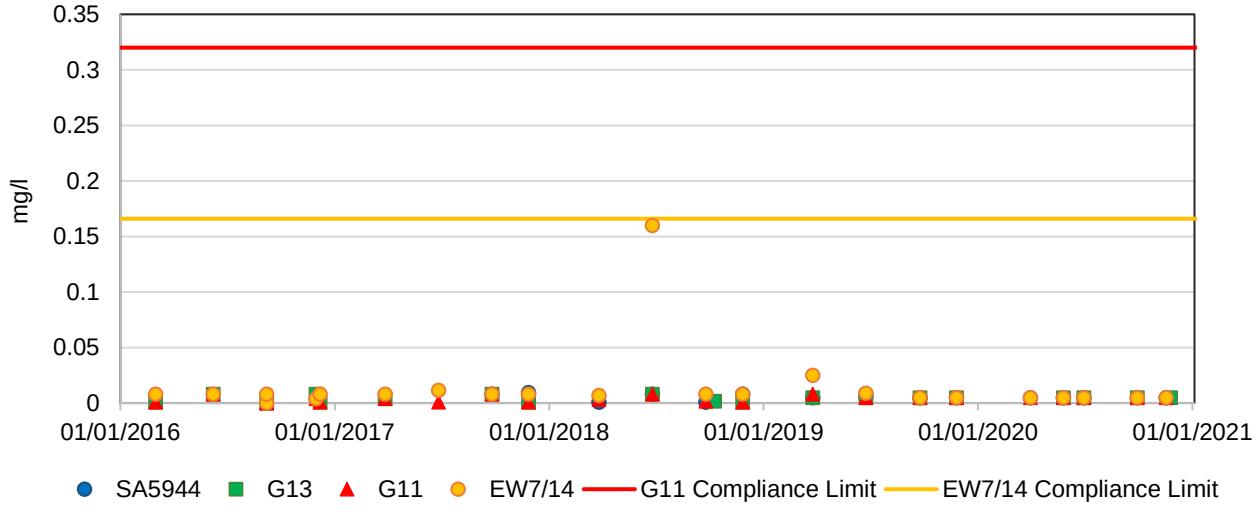
Sulphate – Graph 4.14 presents sulphate concentrations in groundwater from 2016 to 2020. Sulphate concentrations generally follow a similar trend to potassium and in 2020 all results remained below the groundwater compliance limits at **G11** and **EW7/14**. The highest sulphate concentrations are recorded at **EW7/14** (downgradient) and **SA5944** (up-gradient), as previously observed. The gradual long-term downward trend in concentrations continues at all boreholes.

Graph 4.14 South Pit Phase 3: Groundwater Quality, Sulphate, Jan 2016 - Dec 2020



Selenium (total) – Graph 4.15 presents total selenium concentrations in groundwater from 2016 to 2020. In 2020, all results were below the laboratory reporting limit of 0.005mg/l and consistent with previous years. Therefore, concentrations at **G11** and **EW7/14** were below the relevant groundwater compliance limits in 2020.

Graph 4.15 South Pit Phase 3: Groundwater Quality, Selenium (total) Jan 2016 - Dec 2020



Hazardous Substances - groundwater samples were collected for hazardous substance analysis from all monitoring boreholes on 29/09/2020. The substances listed below were detected in groundwater at concentrations above the laboratory reporting limit.

- Arsenic (filtered) **G11**: 0.007mg/l; **G13**: 0.007mg/l
- Arsenic (total) **G11**: 0.009mg/l; **G13**: 0.024mg/l
- Fluoranthene **G13**: 0.02µg/l
- Pyrene **G13**: 0.01µg/l
- Acenaphthene **G13:** 0.02µg/l
- Phenanthrene **G13:** 0.01µg/l

The arsenic concentrations are comparable to 2019 data, with the maximum concentration recorded at up-gradient **G13**. Concentrations of PAHs in groundwater at up-gradient **G13** are at or marginally above the LRL and therefore are not considered significant.

4.5.3 Groundwater Summary

South Pit and Surge Pile: Groundwater quality surrounding South Pit and Surge Pile landfill in 2020 remained generally comparable to previous years with evidence of impact from saline intrusion at down-gradient boreholes. Concentrations of many leachate indicator parameters at down-gradient borehole **EW5R/**14 continued to display a declining trend. There was no exceedance of the EMP/CR control levels and compliance limits at down-gradient boreholes **EW5R/14** and **EW6/14** in 2020.

South Pit Phase 3: Groundwater quality surrounding South Pit Phase 3 remained generally comparable to previous years, with down-gradient borehole **EW7/14** continuing a declining trend in concentrations for most leachate indicator parameters. There were no exceedances of permit compliance limits in 2020. Groundwater quality is influenced by saline intrusion from the adjacent tidal River Thames and, as previously reported groundwater is not considered a primary receptor for the site.

4.6 Restored Surface Monitoring

4.6.1 Settlement and stability

South Pit and Surge Pile – defects with the Site surface and slopes are Reported quarterly by exception and no issues were raised during the 2020 Reporting period. Survey of settlement pegs is carried out annually and comparison of levels shown below.

Forty pegs were installed and surveyed in 2010 and of these 17 have been lost. Survey levels were taken for the points noted as gone or remanence. These will be programmed for replacement and re-measure if they are no longer usable. The maximum height difference between 2019 and 2020 was -0.4m, **EMP/CR Table 22** has an assessment level +/-0.5m therefore no further action is required.

South Pit Phase 3 – with regards to survey and settlement assessment the **South Pit Phase 3** Permit contains the following conditions:

- **Condition 3.5.3(a)** of the Permit requires an annual topographic survey; reference 2008050 - Swanscombe Phase 3 – November 2020
- **Condition 4.2.2 (d)** requires the topographic survey to be included in the annual report. A copy has been included in the drawings section of this Report.
- **Condition 4.2.2 (e)** requires assessment of the void space used by waste deposit to be reported. This is not applicable for **South Pit Phase 3**.
- **Condition 4.2.2 (f)** requires assessment of settlement behaviour by comparison of levels between surveys. An Isopachyte drawing is included in this report, drawing reference 2008050 - Swanscombe Phase 3 – November 2020. This shows that very little change in levels is evident. The 2020 isopachyte drawing compared data from 2020 topographic survey with data from the 2019 topographic survey. Results are shown as contours linking areas of lower, increased or no change in level. The majority of the

site has remained at the same level and only minor changes (+/- 0.4m maximum) noted elsewhere. Settlement pegs are also installed and monitored annually. It should be noted that a number of the pegs have been damaged or lost during works on South Pit and the measurements results of the remaining pegs may have been compromised. A review of the use of pegs as a settlement monitoring techniques will be undertaken as part of the closure process. All results are below the nominal assessment level of -0.5m therefore settlement is not significant at **South Pit Phase 3**.

- **Condition 4.2.2 (g)** requires a calculation of remaining void space which is not applicable for **South Pit Phase 3** landfill.

5 Conclusions & Recommendations

5.1 Landfill Gas

Landfill gas is not an issue at either of the South Pit landfills and results of monitoring at in waste monitoring points continues to confirm that LFG production is inhibited by the high pH and low carbon content of the waste.

Continue monitoring in accordance with **Permit** and **EMP/CR** requirements.

5.2 Leachate

Leachate levels remained compliant throughout 2020 for both landfill units. Leachate quality is typical of a CKD waste leachate with elevated pH and high concentrations of potassium, chloride and sulphate. Leachate treatment is required for leachate collected in the perimeter drain at **South Pit Phase 3** and is fully commissioned, closing IC8 of Table S1.3.

Continue monitoring in accordance with **Permit** and **EMP/CR** requirements.

5.3 Surface Water

Surface water is monitored at locations on the Swanscombe Main Drain and the marsh ditch network when sufficient flow is available for sampling. CKD leachate has historically impacted locations where rainfall has washed localised leachate emissions into the water course. Improvements to the perimeter of **South Pit Phase 3** have been proposed within a Surface Water Action Plan; this has been accepted by the Environment Agency with a Flood Risk Activity Permit issued in July 2019 and is due to be implemented in 2021. Monitoring should continue in accordance with **EMP/CR** and **Permit** requirements and Hydrogeological Risk Assessment Review recommendations.

The limited data set for those compliance parameters introduced in the **EMP/CR** remain in place for another year before formal review. The limits remain under review and will be fully implemented once works to improve the ditch network are completed. Low rainfall and low flow conditions prevented samples being taken from some points on all monitoring occasions and some samples are concluded to be non-representative with little or no flow.

5.4 Groundwater

Groundwater is not a primary receptor due to the influence of saline intrusion and historic land usage.

Continue monitoring in accordance with **Permit and EMP/CR** requirements. The limited data set for those compliance parameters introduced in the EMP/CR remain in place for another year before formal review. The limits remain under review and will be fully implemented once works to improve the ditch network are completed.

5.5 Restored Surface

Restored surface monitoring involves a site inspection and survey results. Review of settlement peg monitoring for **South Pit and Surge Pile landfill** concludes that any change in measured levels is not significant (below the nominal assessment level of -0.5m). Settlement is assessed by isopachyte review of topographic

surveys for **South Pit Phase 3** and no significant levels of settlement were noted. Settlement monitoring to continue by use of settlement pegs only at this site.

Annual topographic surveys and isopachyte drawings will continue at **South Pit Phase 3** landfill and the use of settlement pegs postponed until site is formally closed.

Drawings

2008050 - Swanscombe 2020 - Sheet 1 – Survey

2008050 - Swanscombe 2020 - Sheet 2 – Isopachytes

2008050 - Swanscombe - EMMP1C - November 2020

Appendix 1 – Raw Data (Hazardous substances displayed as laboratory raw data in the excel spreadsheet)

Appendix 2 – Restored Surface

Appendix 3 – Trace Gas Analysis