LICENCE REFERENCE No.	RISK ASSESSMENT METHODOLOGY STAGE & STEP	REPORT VERSION
P0027-04	Stage 1	**Final**

2023 Groundwater Monitoring Report for submission to the Environmental Protection Agency

(April 2024)

(P0027-04)

Project Title:	Annual Groundwater Monitoring Report 2023
Licence No.	P0027-04
Project No:	IE1232-47
Report Ref:	IE1232-47-6045
Status:	FINAL
Client:	Medite Europe DAC.
Client Details:	c/o Andrew O' Meara, Environmental Manager Redmondstown, Clonmel, Co. Tipperary.
Issued By:	IE Consulting, Campus Innovation Centre, Green Road, Carlow. R93 W248

Document Production / Approval Record

	Name	Signature	Date	Position	% Input
Prepared by (consultant)	John Mc Gorian		22/01/24	Project Engineer	40%
Prepared by (consultant)	Joanne Mackey		09/04/24	Project Geologist	40%
Approved by (consultant)	Jer Keohane		09/04/24	Technical Director	19%
Site Approval by	Andrew O' Meara	Andrew O' Meara	12/04/24	Environmental Manager	1%

LIMITATION

No significant deviation occurred from the original proposed scope of works in the undertaking of this groundwater monitoring report for the Medite Europe DAC site in Redmondstown, Clonmel, Co. Tipperary.

This report has been prepared by IE Consulting with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with Medite Europe DAC. The scope of this assessment was based on a review of the existing information for the site, including site investigation data and historical groundwater monitoring data. IE Consulting have assumed that all work previously reported to the Agency by other parties is in good standing and the data holds through.

This report is for the exclusive use of Medite Europe DAC for submission to the EPA; no warranties or guarantees are expressed or should be inferred by any third parties.

TABLE OF CONTENTS

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Background

Medite Europe DAC was first granted an Integrated Pollution Prevention Control (IPPC) licence by the Environmental Protection Agency (EPA) on 16th April 1996 (Reg. No. P0027-01) for the "manufacturing of fibreboard installations, with a production capacity equal to, or exceeding, 25,000 tonnes of product per year". The licence was reviewed on the 30th of November 2001 (Reg. No. P0027-02). The facility was developed on a green field site previously in agricultural use.

Since the commencement of operations in 1983, some materials were deposited in a landfill to the north-west of the plant, adjacent to the log storage area. The landfill was built on existing ground, sloping to the east, and comprises an area of approximately 1 ha.

The Contaminants of Potential Concern (COPC's) and the parameters that are considered to pose a risk to the groundwater beneath the site are as follows: phenols, ammonium, formaldehyde, TPH, heavy metals, elevated pH, sodium, chloride and orthophosphate.

Groundwater Monitoring Network

A total of six monitoring boreholes (AGW1-AGW6) were installed as part of a groundwater monitoring network between 1995 and 1997 to provide information on the state of the groundwater environment beneath the site. Two further monitoring boreholes (AGW7 and AGW8) were installed in January 2016 (*IE Consulting IE1116-1590, February 2016*) in order to improve the conceptual understanding of the site and determine the groundwater flow direction beneath the site with a sufficient degree of certainty. Two additional monitoring boreholes (AGW9 and AGW10) were installed in October 2017 (*IE Consulting IE1232-30-2400, October 2017*) in order to improve the conceptual understanding of the site and determine the groundwater flow direction beneath the site with a sufficient degree of certainty. AGW9 was installed downgradient of AGW7 and the boiler condensate pipeline and along the southern site boundary. AGW10 was installed immediately downgradient of the chemical storage area.

Old Monitoring Borehole Names	New Monitoring Borehole Names
MW1	**AGW3**
MW2	**AGW4**
MW3	**AGW5**
MW4	**AGW6**
LF1	**AGW1**
LF2	**AGW2**

The landfill on site is monitored for carbon dioxide, methane, oxygen and barometric pressure biannually. Leachate levels are also monitored. There are four shallow gas monitoring wells located throughout the landfill.

Groundwater Levels – 2023

The reduced groundwater levels from March 2023 show a similar pattern to that of 2022. There is no evidence of significant groundwater mounding as was the case in 2016. The reduced levels indicate a regional groundwater flow direction from the **North West to the South East** – towards the River Anner/River Suir. This is consistent with the GWB description, whereby groundwater flows towards rivers.

Groundwater Quality – 2023

AGW1 and **AGW2** are located downgradient of the landfill. These monitoring points continue to show compromised groundwater quality.

AGW3 shows elevated concentrations of ammonia and nitrate even though it is notionally upgradient of the site. Nitrate here is likely from off-site and ammonia is only slightly above the threshold.

AGW4, AGW5 and **AGW6** reported good groundwater quality throughout 2023.

AGW7 continues to report compromised groundwater quality, as a result of the historical leak from the condensate pipeline in 2016. The isolated peaks in concentrations of salts and nitrogen are attributed to when groundwater levels are seasonally higher in AGW7. This is linked to residual contamination trapped within the subsoil's at the plume core. The residual contamination will subside, with progressive flushing via rainfall recharge over time.

A hydrogeological assessment of the plume originating at **AGW7** by IE Consulting in 2021 (IE1232-42-4960) determined that the risk to the main receptors (Regionally Important Aquifer and the River Suir) is low and that monitored natural attenuation is the best way forward to protect the groundwater resource.

Key contaminants of concern such as chloride, sodium, potassium and electrical conductivity at **AGW7** are reported in 2023 to have decreasing trends. There was a spike in Q4-2023 in Chloride, sodium, and electrical conductivity. Ammonia has stabilised and fluctuates within a narrow range, while nitrate was the only parameter to show an increase in 2023 at AGW7.

Temperature measurements collected during purging at **AGW7** ranged from 15.7 – 17.0°C. The elevated temperature reported at AGW7 is considered to be associated with the heat from the condensate pipeline located within 4m from the borehole.

AGW8 reported good water quality in 2023, with slightly elevated concentrations of chloride.

AGW9 is located in the centre of the plume originating from the area around AGW7. Elevated concentrations of chloride, orthophosphate, nickel, potassium and electrical conductivity were reported at AGW9 in 2023.

AGW10 is located at the edge of the plume migrating from AGW7. Elevated concentrations of chloride, nitrate, orthophosphate, potassium and electrical conductivity were reported in 2023.

Formaldehyde, Hydrocarbons, BTEX, Phthalates, Phenols, PAHs, VOCs and SVOCs were reported at the laboratory limit of detection in all groundwater monitoring wells throughout 2023.

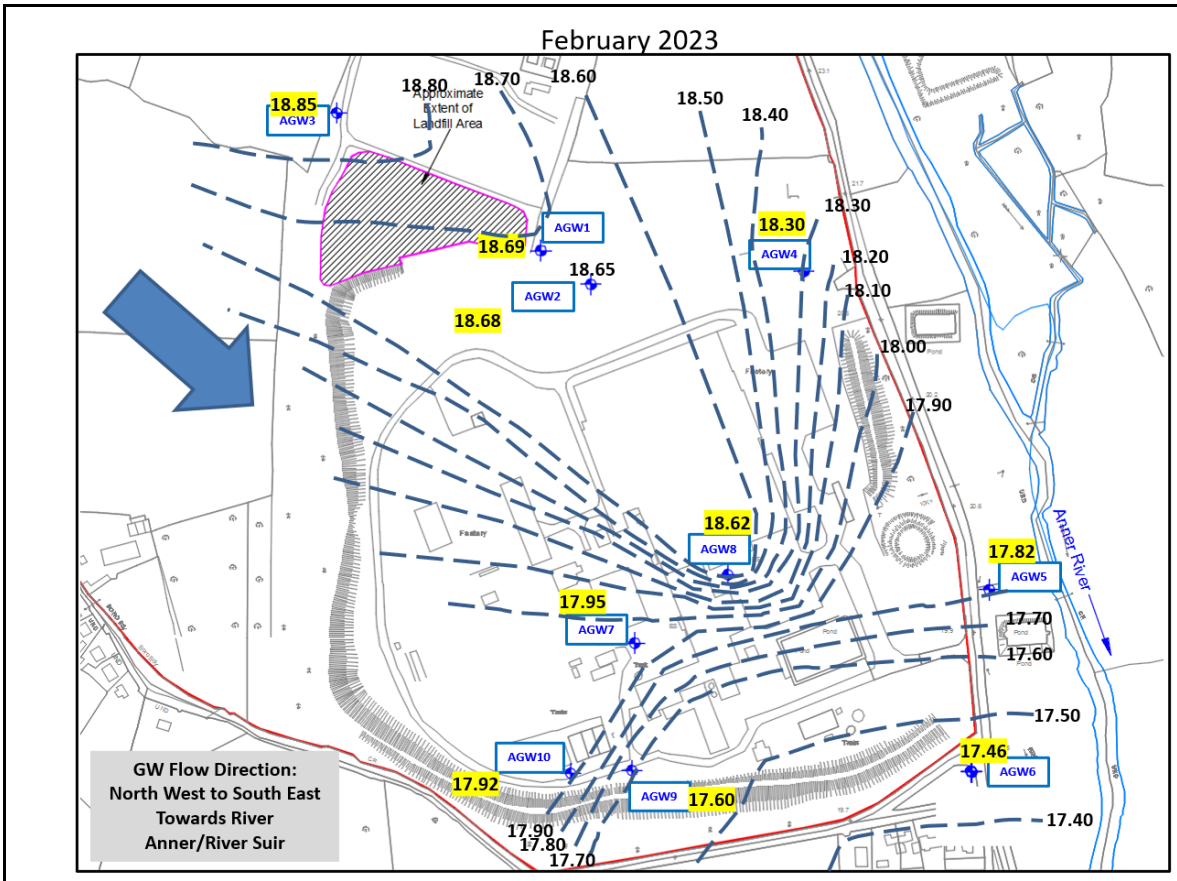
Landfill Gas Monitoring – 2023

Methane was not reported in the landfill for 2023.

All monitoring points reported carbon dioxide gas above the EPA trigger level of 1.5% v/v, in either or both of the bi-annual monitoring periods.

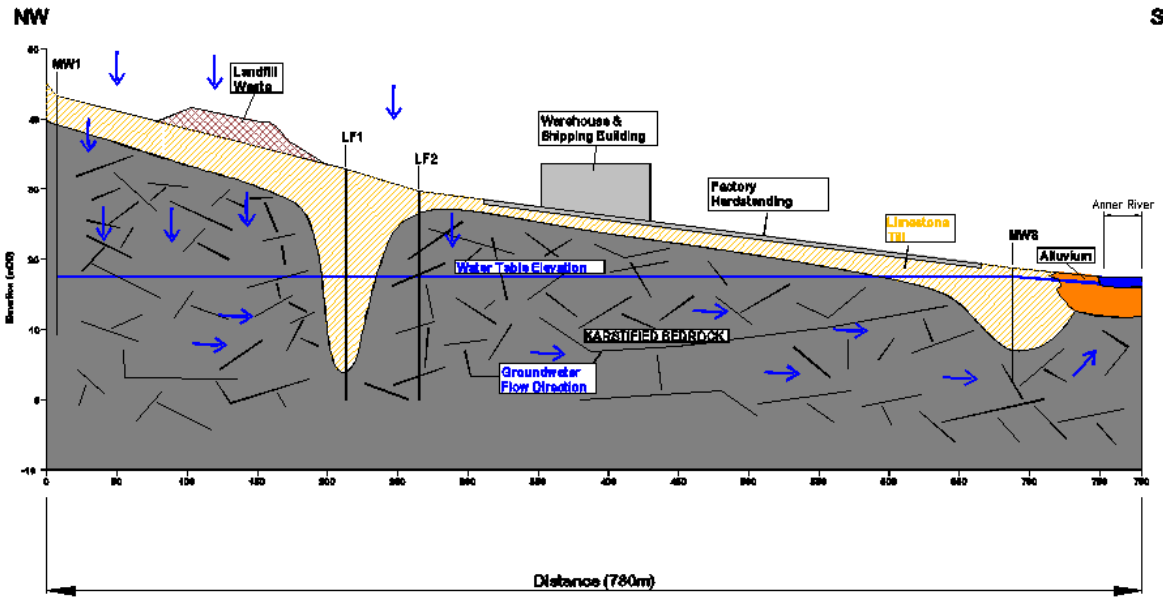
Recommendations for Future Monitoring

This report sets out several actions that are recommended to be implemented for 2024 and for the on-going monitoring of the site.



2023 Groundwater Contour Maping – Above (Feburary 2023 data)

Conceptual Model - Below



Scale
Horizontal Scale: 1/500
Vertical Scale: 1/100

EPA Contaminated Land & Groundwater Risk Assessment Methodology		Report Reference	Report Date	Status
STAGE 1: SITE CHARACTERISATION & ASSESSMENT				
1.1	**PRELIMINARY SITE ASSESSMENT**	GES Report No.E95-05-01	1995	Final
1.2	**DETAILED SITE ASSESSMENT**	GES Report No. 98/29/01	1998	Final
1.3	**QUANTITATIVE RISK ASSESSMENT**			
STAGE 2: CORRECTIVE ACTION FEASIBILITY & DESIGN				
2.1	**OUTLINE CORRECTIVE ACTION STRATEGY**			
2.2	**FEASIBILITY STUDY & OUTLINE DESIGN**			
2.3	**DETAILED DESIGN**			
2.4	**FINAL STRATEGY & IMPLEMENTATION PLAN**			
STAGE 3: CORRECTIVE ACTION IMPLEMENTATION & AFTERCARE				
3.1	**ENABLING WORKS**			
3.2	**CORRECTIVE ACTION IMPLEMENTATION &VERIFICATION**			
3.3	**AFTERCARE**			

1.0 INTRODUCTION

1.1 PROJECT CONTRACTUAL BASIS AND PERSONNEL INVOLVED

IE Consulting were engaged by Medite Europe DAC to undertake an assessment of the 2023 groundwater monitoring data for the facility at Redmondstown, Clonmel, Co. Tipperary (*Figure 1*) as per our proposal dated 9th February 2023 (Reference IE090/JMC/6042).

The consultants involved in the project are listed below:

John McGorian

Civil Engineer, BEng (Hons), MIEI with 7 years experience in Civil/Water Resource Engineering.

Joanne Mackey

BSc (Hons), MSc – with 4 years' experience in Environmental Consultancy.

Jer Keohane

BSc. Geology, MSc. FCIWEM, MIEI - with 39 years' experience – technical direction, review and oversight.

2.0 BACKGROUND INFORMATION

2.1 SITE OVERVIEW

Medite Europe DAC was first granted an Integrated Pollution Prevention Control (IPPC) licence by the Environmental Protection Agency (EPA) on the 16th April 1996 (Reg. No. P0027-01) for the "manufacturing of fibreboard installations, with a production capacity equal to, or exceeding, 25,000 tonnes of product per year". The licence was subsequently reviewed on two occasions (Reg. No. P0027-02 and P0027-03). The most recent licence review (Reg. No. P0027-04) concluded in March 2017.

The entire site layout within the EPA licence boundary is presented on *Figure 2* and a closer map showing the layout of the plant is presented in *Figure 3*.

2.2 GROUNDWATER MONITORING NETWORK

In May 1995, as part of the original application to the EPA for an IPPC licence, GES (an associate company of IE Consulting) was requested by Medite Europe DAC to assist in developing a groundwater monitoring network (Report No. E95-05-01).

A total of four groundwater monitoring boreholes MW1, MW2, MW3 and MW4 were installed as part of the network (*Figure 4*) to provide information on the state of the groundwater environment beneath the site. (These boreholes were subsequently renamed AGW3, AGW4, AGW5 and AGW6 in 2015 following updated EPA licensing nomenclature). The boreholes were located so as to be spatially representative of the site and to intercept groundwater flow upgradient and downgradient of the site.

Two additional monitoring boreholes (AGW7 and AGW8) were installed at the site, in locations agreed with the agency in January 2016 (*IE Consulting IE1166-1590, February 2016*). During 2016

four rounds of groundwater levels were taken from the new boreholes and all existing boreholes and used to prepare groundwater contour maps.

Following a review of the existing groundwater monitoring network (IE Consulting, March 2017) the requirement for additional monitoring boreholes was identified. Proposals to drill two monitoring boreholes (AGW9 and AGW10) were submitted to the Environmental Protection Agency and approved. The monitoring boreholes were installed in late September/early October 2017.

A summary table of the target site activities for each of the new boreholes is presented below:

Borehole ID	Upgradient Target Activities
AGW9	AGW7 and the boiler condensate pipeline. To investigate the extent of the contaminant plume found at AGW7, and to investigate COPCs concentrations at the downgradient site boundary.
AGW10	The chemical storage area

Table 1. Target Activities for New Additional Monitoring Boreholes (AGW9 and AGW10)

2.3 LANDFILL MONITORING

Since the commencement of operations in 1983, some materials have been deposited in an unlined landfill to the north-west of the plant, adjacent to the log storage area (*Figure 4*). The landfill was built on existing ground, sloping to the east, and comprises an area of approximately 1 ha.

The materials deposited at the landfill are described as being mainly wood based i.e. fibre, sander dust (containing ~ 6-8% ammonium polyphosphate) and reject board (unsuitable for recycling).

Since 1986, settled sludge from the surface water settlement lagoons was also landfilled (containing ~1% ammonium polyphosphate and small quantities of urea formaldehyde resin).

In addition, considerable quantities of excavated clean soil were deposited in the landfill in 1994 during site construction works.

In late 1995-1997, GES were retained by Medite Europe DAC to evaluate the impact of the site landfill on the environment. This involved the drilling of a borehole (LF1 - now renamed AGW1) east of the site landfill to monitor groundwater downgradient of it. In addition, four shallow gas monitoring points (TP1-TP4) were installed within the landfill to monitor gas emissions from the landfill (*Figure 6*).

In late 1997, GES were requested to locate a suitable position for an additional groundwater monitoring borehole (LF2 – now renamed AGW2) downgradient of the landfill to further investigate the findings of the monitoring results from the first borehole (LF1/AGW1).

A report prepared by GES on 16/07/98 (Report No. 98/29/01) detailed a qualitative risk assessment and impact appraisal of the on-site landfill. The investigation indicated elevated concentrations of ammonia downgradient of the landfill. However, a water balance assessment, together with an assessment of monitoring data, indicated adequate available dilution and attenuation downgradient

of the landfill, which resulted in no significant off-site movement of contaminants.

It was recommended in GES Report No. 98/29/01 that the boreholes be sampled on a monthly basis for at least twelve months to establish a groundwater quality database. Regular monitoring has been undertaken on a quarterly basis since June 1999, with the most recent analysis results from 2023 being discussed as part of this report.

A summary of the information available for the original six groundwater monitoring boreholes and the four newly installed ones (AGW7 – AGW10) is presented in *Table 2* below. The logs for the boreholes are presented in *Appendix A*.

Table 2. Summary Details for Groundwater Monitoring Boreholes

Well Details	AGW1 (formerly LF1)	AGW2 (formerly LF2)	AGW3 (formerly MW1)	AGW4 (formerly MW2)	AGW5 (formerly MW3)	AGW6 (formerly MW4)	AGW7	AGW8	AGW9	AGW10
Year of Installation	1997	1997	1995	1995	1995	1995	2016	2016	2017	2017
National Grid Coordinates	E223939 N124326	E223951 N124298	E223766 N124442	E224160 N124298	E224317 N124040	E224301 N123887	E623963 N624045	E624038 N624103	E623952 N623938	E623912 N623932
Drilled Well Depth (m)	37	25	34	18	16.5	20	15.4	15.7	17.0	17.0
Internal diameter (m)	0.14	0.125	0.15	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Screened Interval (m)	30 – 37	12 – 25	4 - 34 (open hole)	3 – 18	1 - 16.5	1 – 20	4 - 15.4	3.5 - 15.7	5.5 – 17.0	3.5 – 17.0
Depth to Bedrock (m)	27	4	4	10	12	18	3.5	2.7	5.0	3.0

Well Details	AGW1 (formerly LF1)	AGW2 (formerly LF2)	AGW3 (formerly MW1)	AGW4 (formerly MW2)	AGW5 (formerly MW3)	AGW6 (formerly MW4)	AGW7	AGW8	AGW9	AGW10
Drilling Log Summary	0-6 m: CLAY and STONES 6-18m: Brown, silty CLAY 18-24 m: Brown, silty SAND and GRAVEL 24-27 m: Red, hard, consolidated CLAY 27-30 m: Weathered DOLOMITE and CLAY 30-33 m: Weathered DOLOMITE 33-37 m: Pale grey DOLOMITE	0-2 m: CLAY and STONES 4-14 m: Pale coloured, hard DOLOMITE 16-25 m: Red coloured, weathered, DOLOMITE and silty veins.	0-4 m: Gravelly CLAY 4-34 m: LIMESTONE with DOLOMITE bands	0-6 m: Loose, very clayey/silty, fine SAND 8-10 m: GRAVEL 10-18 m: LIMESTONE	0-12 m: Loose, very sandy CLAY, with silty fine SAND 12-16.5 m: LIMESTONE	0-16 m: Stiff, orange, sandy/gravelly CLAY 18-20 m: LIMESTONE	0-0.1 m Fill 0.1-0.35 m MADE GROUND 0.35-0.6 m Grey brown firm CLAY 0.6-1.5 m Orange brown sandy CLAY 1.5 -3.5 m Light brown SAND with fine gravel 3.5-15.4 m Varying weathered/ competent DOLOMITE (See log *Appendix A* for full details)	0-0.1 m Fill 0.1-0.35 m MADE GROUND 0.35-0.6 m Sandy gravelly CLAY 0.6-2.7 m Gravelly SAND 2.7 -7.0 m LIMESTONE 7.0 – 8.7 m DOLOMITE 8.7 – 15.7 m LIMESTONE	0-0.2 m Concrete 0.2-1.0 m FILL 1.0-4.2 m Sandy GRAVEL 4.2-5.0 m Gravelly SAND 5.0 -6.0 m Weathered DOLOMITE 6.0 – 10.0 m Competent DOLOMITE 10.0 – 10.5 m Highly Fractured DOLOMITE 10.5 – 17.0 m Competent DOLOMITE	0-0.15 m Concrete 0.15-0.50 m FILL 0.5-2.0 m Gravelly SAND 2.0-3.0 m Gravelly CLAY 3.0 -3.3 m Weathered DOLOMITE 3.3 – 17.0 m Competent DOLOMITE. Some fracturing 8.5-8.7 and 9.0-10.0.
Measured Well Depth (m) 2017	40.0	31.4	34.0	18.0	16.5	20.0	15.4	15.7	17.0	17.0

2.4 SITE DEVELOPMENT HISTORY

The facility was developed on a green field site previously set aside for agricultural purposes. An overview of the site development and planning history, as noted on historical maps, aerial photography and planning files, is presented in *Tables 3* and *4* below.

Table 3. Review of Site Development from Historic Maps & Aerial Photographs

Year	Source	Record of Site Development
1887-1913	25-inch map www.osi.ie	Green field site
1928-1942	25-inch map www.osi.ie	Green field site
1995	Aerial photograph www.osi.ie	Facility comprised two large main buildings along with additional smaller structures, car park and storage areas
2000	Aerial photograph www.osi.ie	Additional structure near western boundary of site
2005	Aerial photograph www.osi.ie	Additional structure near eastern & southern boundary of site. Extension to structure directly south of eastern main factory building
2013	Aerial photograph www.bing.com/maps	No visible change

Table 4. Overview of Site Planning History

Planning File No.	Date of Grant of Planning Permission	Development Description
P37509	14/07/81	Manufacture of medium density fibreboard (MDF) from native Irish forest thinning.
P37801	06/10/81	Site development.
P37826	23/10/81	Site development works west of line for MDF plant.
P37963	04/01/82	Construction of warehouse.
P38217	13/08/82	Construction of medium density fibreboard plant.
P38500	15/10/82	Construction of a new 110 kV electrical sub-station.
P39948	08/10/85	Storage and utilisation of anhydrous ammonia.
P310884	14/02/87	Erection of two storey office and lab extension to plant.
P312141	15/03/89	Relocation of weighbridge, road re-alignment, chain link fence
P312748	28/01/90	Demolition of farm house.
95478	17/10/95	Replacement of existing fibre dryer.
11302	31/08/11	Installation of new plant structures within existing facility and construction of two extensions to this facility with a floor area of circa 360 m^2.
FS6911	21/02/12	Two extensions.
1292	07/05/12	Construction of a new chip storage area consisting of a store 450 m^2 and an external concrete apron.

The production lines at the Medite Europe DAC facility are used for the manufacturing of MDF boards. The two production lines operate in parallel. Both lines share the same chip processing facility and similar finishing facilities further downstream. A flow chart showing the manufacturing and wastewater processes, as developed by Medite Europe DAC, is presented in *Appendix B*.

A summary of the MDF manufacturing process is presented in *Table 5* below.

Table 5. Site Manufacturing Process Overview

Process	Process/Activity	Product/By-product	Use
Log and chip handling	*Wood debarking *Log chipping	*Wood bark *Wood chip	*On-site fuel source *MDF product
Refining	*Pre-steaming of chips *High pressure steaming *Excess water removal *Refining by grinding chips to fibres *Addition of resin and additives solutions	*Excess water	*Wastewater treatment plant *MDF product
Dryers	*Direct/indirect heating of fibres by boiler flue gases and steam	*Dried fibre	
Forming and Pressing	*Fibres are passed through forming head and compressed to required thickness, cut and cooled	*Wood fibre mats	
Finishing	*Sanding and grading of boards	*Final products *Sander dust and board cut-offs	*Distribution/shipment *On-site fuel source

The site manufacturing processes are supported by the following activities and service:

- On-site wastewater treatment plant – treats sanitary effluent and process effluent (mainly wood chip squeezing water);
- Two on-site septic tanks and percolation areas;
- Surface water interceptor settling ponds;
- Maintenance area;
- Bulk and drum chemical storage;

- Laboratory facilities;
- Administration offices;
- Engineering services;
- Fire water storage ponds.

The energy requirements are provided by the following:

- Recovery of waste wood biomass in two boilers and the on-site Energy Plant;
- Electricity;
- Natural gas;
- Liquified Petroleum Gas (LPG);
- Diesel fuel.

A summary of the potential contaminant sources relating to site processes and service activities is presented in *Table 6* below. The locations of these sources within the site boundary are shown on *Figure 3*.

Table 6. Summary of Potential Contamination Sources

Raw materials	Resin for adhesion (Urea Formaldehyde, Melamine Urea Formaldehyde)
	Waxes (Paraffin and Montan)
	Urea
	Fire retardants(e.g. Ammonium Polyphosphate)
	Colorants (water based)
Fuels / Heating	Wood biomass
	Liquified Petroleum Gas (LPG)
	Thermal fluid for heat transfer
	Gas Oil (Diesel Oil)
Utilities	Hydrochloric Acid
	Sodium Hydroxide
	Sodium Chloride (salt)
	"Betz" products (Biocides, Corrosion Inhibitors, Scale)
Wastewater Treatment Chemicals	Aluminium chloride (flocculant)
	Polymers (for sludge Dewatering)
	Polymers (coagulant)
	Anti Foams
	Nutrifeed (nutrient)
	Sodium Hypochlorite 15%
	Hydrated Lime
Maintenance Materials	Oils (lubricating, hydraulic)
	Degreaser
Laboratory Chemicals	Toluene, Acetone, COD reagent, Acids, Bases

2.5 CONTAMINANTS OF POTENTIAL CONCERN (COPCS)

Based on the above review of the site activities the Contaminants of Potential Concern (COPCs) and the parameters that would indicate an issue with the groundwater beneath the site are as follows:

- Phenols;
- Ammonium;
- Formaldehyde;
- Total Petroleum Hydrocarbons;
- Diesel range organics;
- Petrol range organics;
- Mineral oils;
- Heavy metals;
- Elevated pH;
- Sodium;
- Chloride;
- Orthophosphate.

2.6 ENVIRONMENTAL SETTING

An overview of the relevant information on rainfall, topography, land use, hydrology, and hydrogeology pertaining to the site is discussed below.

Topography (Figure 1)

Regionally, the topography is dominated by the Comeragh Mountains to the south and Slievenamon to the north-east. Locally, the land slopes from north-west to south-east towards the Anner River from a local high point elevation of 60 m OD west of the site. The ground elevation in the vicinity of the site is c. 25 m OD. The original land surface sloped from c. 45 m OD at the north-western corner of the site to approximately 22 m OD at the eastern side of the site. However, this original topography was modified to create a level site.

Hydrology (Figure 2)

The site is located in the River Suir Valley. The River Suir flows eastwards c. 1 km south of the site. The Anner River, a tributary of the River Suir, flows in a southerly direction, approximately 100 m east of the site. The confluence of the Anner River with the River Suir is approximately 1 km downstream of the site.

Topsoil

On the Teagasc soils map the site itself is classified as Made Ground, as the site has been shaped/levelled and developed. The soils surrounding the site are mainly mapped as deep well-

drained acidic mineral soils (AminDW), comprising Acid Brown Earths or Brown Podzolics with smaller areas of deep poorly drained mineral soil derived from mainly acidic parent materials (AminPD). Alluvial deposits (AlluvMIN) associated with the Anner River are mapped to the east of the site.

Subsoil (Map 1, Appendix C)

Teagasc subsoil mapping indicates the area of the site is classified as MADE GROUND as the site has been shaped/levelled and developed. The subsoil in the surrounding area are mapped as Till derived chiefly from Namurian Rocks (TNSSs) (shale and sandstone till). The GSI's recharge map classifies the till as being moderately permeable. Alluvial deposits (A) are mapped along the Anner River channel to the east of the site.

Site-specific information on the subsoil is available from drilling of the eight groundwater monitoring boreholes (see summary of borehole logs in *Table 2*). Subsoil encountered comprised mainly of sandy/gravelly CLAY. In AGW4 in the north-eastern area of the site the subsoil comprised of 10m of SAND/GRAVEL over bedrock. In AGW1, immediately east of the landfill, a thick band of SAND/GRAVEL was encountered from 18-24m. Small pockets of gravel such as this are common along the Anner River (GES Report 98/29/01).

In addition, subsoil information was available from a geotechnical investigation undertaken in 1981 to assess ground conditions for the plant foundations. The site investigation comprised 21 No. boreholes to depths ranging from 2.0-6.0 m bgl. The original report or logs were not available for review as part of this report, but the subsoil encountered were summarised as comprising mainly gravelly CLAY or SILT/CLAY overlying 2-3 m of dense, fine to medium grained GRAVEL transitioning into weathered bedrock (GES Report 98/29/01).

Depth to Bedrock

The depth to bedrock beneath the site is highly variable. Based on the information obtained from the borehole logs the depth to bedrock ranges from 2.7 m to 27 m below ground level, probably due to the underlying karst bedrock surface described below.

Groundwater Vulnerability (Map 2, Appendix C)

The groundwater beneath the main factory site is mapped as Moderate (M) vulnerability with areas of High (H) vulnerability extending to the west. An area of Extreme (E/X) vulnerability coincides with the mapped topographic high west of the site.

Bedrock & Structural Geology (Map 3 and Map 4, Appendix C)

The site is mapped as underlain by the Waulsortian Limestones, described as massive un-bedded lime-mudstones containing original cavities filled with calcareous cement. This bedrock is characterised by zones of intense fracture cleavage. Typically, the upper 2-3m is loose and weathered. The closest regional fault is mapped at approximately 1,350m east of the site. The regional faults trend predominantly in a north-south direction and also an east-west direction. In a regional geological context, the site is mapped within a heavily faulted east-west aligned structure, namely the Carrick-on-Suir Syncline.

Although the bedrock underlying the site is not mapped as WAdo (Waulsortian dolomitised) site specific drilling records indicate the site is underlain by dolomitised limestones (AGW1, AGW2,

AGW3, AGW7 & AGW8). Dolomitisation has the effect of increasing the porosity and thus permeability of limestone. The variable depth to bedrock recorded is indicative of a mature karst bedrock landscape.

Aquifer Classification (Map 5, Appendix C)

The bedrock formation is classified as a Regionally Important Aquifer dominated by diffuse flow (Rk_d). Groundwater flow is through karstified conduits, developed as a result of solutional widening of calcite-filled cleavage planes, original cavities, fissures and fractures, especially fault zones.

Groundwater Body (Map 5, Appendix C)

The site is located in the Clonmel groundwater body (GWB), the key characteristics of which have been identified by the Geological Survey of Ireland (GSI) as follows:

- Transmissivity values for the Carrick-on-Suir Syncline limestones are given as 100 - 2,000 m^2/d;
- Most recharge takes place through the till subsoil deposits and may receive indirect recharge from the north and south from the Lower Palaeozoic mountains;
- Most of the groundwater moves relatively rapidly along short flow paths and discharges into the streams which cross the aquifers;
- Hydraulic gradients in the Waulsortian Limestone are typically low (0.003 – 0.007);
- Flow in the karstified systems tends to be conduit flow along the fault zones. There are considerable variations in the hydrogeological conditions in this aquifer unit, owing to the wide range in elevation of the outcrop areas and its karstic nature;
- Conditions in the main limestone aquifers are predominantly unconfined, as the water table is generally less than 10m from the surface;
- The annual water table fluctuation is probably less than 5m in the better aquifers.

The groundwater body is categorised as having “good” status for the 2016-2021 monitoring period, and is ‘’At Risk’’ with regard to meeting the Water Framework Directive (WFD) objectives.

Groundwater Recharge (Map 6, Appendix C)

According to www.gsi.ie, the average recharge beneath the site is 136 mm/yr, probably due to the developed nature of the site. The average recharge in the area surrounding the site is 407 mm/yr, based on the hydrogeological setting (Rk_d aquifer; moderate groundwater vulnerability, moderate permeability subsoil and overlain by well-drained soil). The recharge coefficient for the surrounding area is taken as 60 % of the effective rainfall (679 mm/yr).

3.0 PROJECT OBJECTIVES

The objectives for the 2023 groundwater monitoring report are as follows:

- To review the groundwater quality for the 2023 period;
- To identify any increasing or decreasing trends in Contaminants of Potential Concern (COPC) and contamination indicator parameters;
- To assess the overall groundwater quality in the context of the Conceptual Site Model (CSM);
- To provide up-to-date groundwater contour maps of the site based on water level measurements etc.;
- To assess the suitability of the current groundwater monitoring network to adequately define the groundwater conditions beneath the site;
- An assessment of whether monitoring boreholes that are screened across multiple horizons adequately represent the groundwater flow of the site;
- Assess whether new boreholes are required in the monitoring network to provide a better understanding of groundwater flow.

4.0 SCOPE OF WORKS

4.1 RATIONALE & STRATEGY

Groundwater Monitoring

The sampling locations for the 2023 groundwater monitoring are presented in *Figure 4*. The rationale for the chosen monitoring point locations was discussed in *Section 2.2* and is summarised in *Table 7* below.

Table 7. Locations & Rationale for Site Groundwater Monitoring Points

Monitoring Point	Location Description /Rationale
AGW3 (MW1)	Overall upgradient monitoring point for the site
AGW4 (MW2)	Downgradient of landfill close the Anner River/Upgradient of factory
AGW1 (LF1)	Downgradient of landfill
AGW2 (LF2)	Downgradient of landfill (to confirm monitoring results in AGW1 (LF1))
AGW5 (MW3)	Overall downgradient of northern section of facility

Monitoring Point	Location Description /Rationale
AGW6 (MW4)	Overall downgradient of southern section of facility
AGW7	Downgradient of the fuel, chemical and raw material storage areas, chip yard, boiler house.
AGW8	Downgradient of the energy plant, warehouse and shipping, septic tank and percolation area, raw material storage area.
AGW9	Downgradient of AGW7. Investigate the extent of the contaminant plume found at AGW7, to investigate COPCs concentrations at the downgradient site boundary and to act as a compliance monitoring borehole.
AGW10	Immediately downgradient of the chemical storage area. Its purpose is to allow monitoring and assessment of groundwater quality downgradient of this area

AGW3 (MW1) was installed to provide information on overall background water quality. The monitoring boreholes AGW1 (LF1) and AGW2 (LF2) were specifically installed to target the impact on groundwater from the landfill. The monitoring boreholes, AGW4 (MW2), AGW5 (MW3) and AGW6 (MW4), were installed to monitor the groundwater at the edge of the site flowing towards the Anner River from the main site. AGW7 and AGW8 were installed to obtain a more accurate understanding of groundwater flow direction beneath the site and to target any impact from the fuel, chemical and raw material storage areas, energy plant, warehouse and shipping and septic tank percolation area. AGW9 was installed to investigate the extent of the contaminant plume at AGW7, to investigate COPCs concentrations at the downgradient site boundary and to act as a compliance monitoring borehole. AGW10 was installed to assess the groundwater quality downgradient of the chemical store area.

The parameters included in the groundwater monitoring programme are those set out in Schedule 4(ii) of the EPA IPPC licence. These parameters are:

- pH;
- Trace organics (as per USEPA Method 524.4);
- Major anions;
- Major cations;
- Individual heavy metals;
- Ammonia.

Gas Monitoring

The locations of all four gas monitoring points (TP1, TP2, TP3 and TP4) are shown on *Figures 6 and 7*. Monitoring was undertaken in March and November of 2023.

The concentrations of landfill gas component gases, Methane (CH_4), Carbon Dioxide (CO_2), and

Oxygen (O_2), were measured in addition to barometric pressure.

5.0 GROUNDWATER SAMPLING AND MONITORING

5.1 WATER LEVEL MONITORING

The static groundwater levels in each borehole are recorded by IE Consulting personnel as part of the quarterly groundwater monitoring programme (as per Schedule 4(ii) of the IPPC licence).

The water levels are recorded prior to purging and sample collection. Static water levels are also recorded quarterly by IE Consulting. The top of the steel casing is used as a reference point for measurements in all boreholes. During 2023 four rounds of water level measurements were taken from all boreholes. The water levels were reduced to Ordnance Datum (Malin). The groundwater levels recorded in 2023 are presented in *Table 8* below.

Table 8. Reduced Groundwater Levels 2023

BH ID	Reduced Water Level (m OD) Feb '23	Reduced Water Level (m OD) May '23	Reduced Water Level (m OD) Sep'23	Reduced Water Level (m OD) Nov '23
AGW1	18.694	18.094	17.544	19.394
AGW2	18.689	18.089	17.559	19.419
AGW3	18.847	18.187	17.647	19.597
AGW4	18.301	17.831	17.401	18.841
AGW5	17.819	17.169	16.859	18.539
AGW6	17.455	16.985	16.655	18.125
AGW7	17.954	17.294	16.794	18.714
AGW8	18.615	18.025	17.525	19.295
AGW9	17.595	16.975	16.525	18.295
AGW10	17.921	17.261	16.781	18.681

The water level data presented above indicates that the depth to the water table is variable. The groundwater level fluctuation data for the 2006 to 2023 period, as shown in *Table 9* below, indicates that the water level fluctuations in the site boreholes is approximately 2.50 m, for all years except 2018. The wider range in water levels noted in 2018, is attributed to 2018 being one of the warmest and direst summers on record in Ireland (Met Eireann, 2019). This coincides well with the expected characteristics of the groundwater body, as discussed in *Section 2.6* above.

Table 9. Groundwater Level Fluctuations 2023

Borehole	Fluctuation* (m)																	
	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006
MW1 (AGW3)	1.95	3.22	2.02	1.82	0.82	7.3	1.2	3.3	1.1	1.7	1.8	2.3	2.4	2.0	1.3	1.9	5.8	2.1
MW2 (AGW4)	1.44	2.43	2.03	1.79	0.96	3.7	1.0	3.4	1.3	1.2	1.5	2.3	1.6	1.7	0.4	1.2	1.6	2.2
MW3 (AGW5)	1.68	*Overflowing in November	2.15	1.71	1.52	2.7	1.2	3.7	1.4	2.5	2.7	1.3	2.1	2.2	1.6	1.8	2.5	2.0
MW4 (AGW6)	1.47	*Overflowing in November	1.63	1.28	1.73	2.4	1.13	2.41	0.8	1.9	2.2	2	1.9	1.5	1.5	1.8	1.5	1.5
LF1 (AGW1)	1.85	3.02	1.79	1.70	0.89	2.7	1.80	*Overflowing in January	1.0	1.5	2.6	1.8	1.9	2.0	2.5	1.9	2.8	2.7
LF2 (AGW2)	1.86	3.16	1.54	1.55	0.83	2.3	1.81	*Overflowing in January	2.1	2.2	2.2	1	1.8	2.5	2.4	1.5	2.7	3.1
AGW7	1.92	3.12	2.02	1.81	1.37	2.6	1.70	3.4	-	-	-	-	-	-	-	-	-	-
AGW8	1.77	2.93	1.96	1.66	0.90	2.6	1.66	2.35	-	-	-	-	-	-	-	-	-	-
AGW9	1.77	2.97	1.86	1.74	1.63	2.7	0.12	-	-	-	-	-	-	-	-	-	-	-
AGW10	1.90	3.14	1.79	1.82	1.40	2.2	0.08	-	-	-	-	-	-	-	-	-	-	-

*This table shows the difference between the maximum and minimum groundwater levels measured at each borehole throughout each year.

5.2 COLLECTION OF WELLHEAD PARAMETERS

Unstable hydrochemical parameters are currently recorded during purging and sampling (*Appendix I*). These include temperature, pH and electrical conductivity.

Physical observations of the sampled water (colour, odour, sheen, turbidity and other observations) are also recorded and are contained in *Appendix J*.

5.3 SAMPLING TECHNIQUES AND PROTOCOLS

Sampling of the ten boreholes was carried out by IE consulting personnel for Q1 – Q4 2023. The sampling was based on the sampling protocol provided in an internal Medite document '*Groundwater Monitoring Procedure ENSOP0374 Rev 2'* dated 05/01/2014. A copy of the document is reproduced in *Appendix H*.

For AGW1 – AGW6, a surface PP1 powerpack pump, dedicated tubing and a footvalve is used for purging and sampling. For AGW7 – AGW10, an inertial pump and reel is used for purging and sampling. The pump is decontaminated with Decon 90 and rinsed with clean water prior to the commencement of sampling and between boreholes in order to prevent cross-contamination. The following steps are carried out for sampling:

- Pump Decontamination;
- Record water level and well depth;
- Well volume calculation;
- Remove three well volumes;
- Collect sample.

5.4 SAMPLE CONTAINERS/BOTTLES

The 2023 samples were analysed by Element Materials Technology Laboratory, Deeside in the United Kingdom. Element Materials Technology is a UKAS accredited laboratory. The following sampling containers were used for the collected samples:

- Plastic HDPE (high density polyethylene) containers;
- Glass bottles for Phenols and TPH-CWG;
- Glass vials for semi-volatile and volatile parameters and TOC;
- Plastic HDPE bottle – one with sulphuric acid to preserve ammonia;
- Plastic HDPE bottle – one with nitric acid to preserve metals (water is filtered prior to filling to the bottle).

5.5 SAMPLING EVENTS:

A total of 4 No. quarterly groundwater samples were taken from each of the on-site monitoring boreholes on the dates set out in *Table 8* above.

5.6 SAMPLE HANDLING PROTOCOLS

Samples were stored in clean, secure cooler boxes with ice packs and brought back to the IE Consulting office in Carlow at the end of each day of sampling. The cooler boxes were packed with fresh ice packs that evening and the following morning. The samples were transported by DHL Courier to the Element Materials Technology Laboratory in the UK.

5.7 LABORATORY ANALYSES

The 2023 samples were analysed by Element Materials Technology Laboratory. No parameters were subcontracted in 2023.

In January 2020 a review of the limits of detection was completed by IE Consulting and Element Materials Technology was consulted. New, more stringent limits of detection have been applied for both total and dissolved metals, ammoniacal nitrogen and orthophosphate by the laboratory from Q1-2020 onwards.

The certificates of analysis for the 2023 data are presented in *Appendix D*. The parameter groups for the samples analysed are presented in *Section 4.1* above. All tabulated results from the 2023 groundwater analyses are presented in *Appendix E.* The graphs of parameter exceedances are presented in *Appendix F*.

The analysis results were compared with the following legislation and guidance sources:

- S.I. No. 9/2010 - European Communities Environmental Objectives (Groundwater) Regulations 2010.
- S.I. No. 366/2016 - European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016.
- Environmental Protection Agency (EPA) Interim Guideline Values (IGVs) (2003).

Where a result exceeded more than one standard/guideline, then the result was highlighted against the lower (more stringent) standard.

5.8 GAS MONITORING

The concentrations of landfill gas component gases, Methane (CH_4), Carbon Dioxide (CO_2), and Oxygen (O_2), were measured in addition to barometric pressure. The gas monitoring was completed with a GA2000 gas monitor.

6.0 RESULTS AND DISCUSSION OF MONITORING PROGRAMME

6.1 SITE HYDROGEOLOGY AND GROUNDWATER FLOW

Beneath the site, groundwater flow is in the Waulsortian Limestones, described as massive, un-bedded lime-mudstones containing cavities filled with calcareous cement and dolomitised limestone.

The bedrock is classified as a regionally important aquifer (Rk_d), which indicates that groundwater flows through karstified conduits. The presence of dolomitised limestone beneath the site is evident from the LF1 borehole in which the bedrock was described as completely dolomitised (and also new monitoring borehole logs, see *Table 2*).

The underlying bedrock forms part of the Clonmel Groundwater Body (GWB).

The groundwater flow paths are considered to be horizontal beneath the site. However, vertical flow paths are likely to exist closer to the Anner River, where groundwater discharges to the river.

An updated groundwater contour map has been prepared for the site for 2023 using groundwater level data from February 2023 (*Figure 5*). The measurements are provided in *Table 8* above.

The reduced groundwater levels from February 2023 show no evidence of groundwater mounding. The reduced levels indicate a regional groundwater flow direction from the North West to the South East – towards the River Anner/River Suir. This is consistent with the GWB description, whereby groundwater flows towards rivers.

The 2023 groundwater flow map is also consistent with the topography of the site – whereby the landfill is on high ground, and the landscape gently falls south east towards the River Anner/River Suir.

Historically, the groundwater contour maps have indicated groundwater mounding in the vicinity of the AGW1, AGW2 and AGW8 monitoring wells.

IE Consulting prepared a report presenting 2016 contour maps and interpreted groundwater flow direction along, with an assessment of the suitability/representativeness of the expanded monitoring network in light of the refined groundwater flow direction in 2016 (*IE Consulting 1116-1590, February 2016*). As in 2017, each contour map depicted groundwater mounding beneath the site. The reason for this was not clear. The report suggested several reasons that could cause mounding including discharges (e.g. stormwater soakaways, leaking pipes/tanks) and hydraulic head differences between percolating leachate causing groundwater mounding beneath the uncapped landfill. It also discussed the possibility that the mounding beneath the site may be due to rainfall infiltrating through the permeable infill of the old landfill, with the resulting percolating leachate causing mounding of groundwater beneath and downgradient of the landfill.

It is also plausible to suggest, the mounding may be related to production wells drilled on neighbouring industrial sites. The cone of depression of such production wells may extend onto the Medite site.

There are four gas/leachate monitoring points in the landfill and in a 2016 letter report by IE Consulting (*IE Consulting, 16/08/2016*) it was recommended that monitoring of leachate levels in these monitoring points be undertaken. The first round of leachate level monitoring was undertaken on 26/10/16 and was continued in 2023. The 2023 data is included in *Table 10* below. Leachate was encountered in all monitoring points. Leachate levels are above the surrounding bedrock groundwater level.

Table 10 – Leachate Level Monitoring 2023

Monitoring Point	Total Depth (m) (measured 26/10/16)	Description Leachate Level Datum	Elevation Leachate Level Datum (m OD)	24 March 2023		03 November 2023	
				Leachate Level (m below datum)	Reduced Leachate Level (m OD)	Leachate Level (m below datum)	Reduced Leachate Level (m OD)
TP1	2.22	Top PVC standpipe	**39.751**	2.55	37.201	2.55	37.201
TP2	2.50	Top PVC standpipe	**39.092**	1.40	37.692	1.34	37.752
TP3	1.83	Top PVC standpipe	**31.786**	2.46	29.326	2.38	29.406
TP4	1.87	Top PVC standpipe	**34.146**	2.27	31.876	2.26	31.886

6.2 GROUNDWATER RESULTS

A total of 4 No. samples were taken from each of the 10 No. on-site monitoring wells (AGW1 – AGW10) during the 2023 monitoring period (see *Appendix E*). The groundwater monitoring trends for key parameters are discussed below (see *Appendix F*).

In relation to the concentrations of the analyses reported by the laboratory (*Appendix D)*, the following should be noted:

- **Ammonia/ammonium**

  The parameter was analysed and reported as mg/l NH_3-N for all 2013 sampling rounds and for the Q1 and Q2 sampling rounds in 2014 and, as such, could not be compared to the legislation and guidelines, although a comparison was made between 2013 and 2014 results. Results for the Q3 and Q4 sampling rounds in 2014 and 2015, 2016 and 2017 were analysed and reported as the concentration of ammonium (mg/l NH_4^+), which can be compared to the EPA IGV for ammonium. These results were converted to concentrations of ammonium as N (mg/l NH_4-N) so that they could be compared to results from 2000 to 2012 and to the Groundwater Regulations TV. In 2018, the samples were analysed for Ammoniacal Nitrogen as N and so cannot be compared to pre-2018 readings. In 2019 the samples were analysed for Ammoniacal Nitrogen as NH4 (mg/l NH_4^+). In 2020, 2021, 2022 and 2023 the samples were analysed for both Ammonical Nitrogen as N and Ammonical Nitrogen as NH_4 to ensure consistency in the comparison to historical data/regulations.

- **Total metals/dissolved metals**

  Heavy metals were analysed and reported as concentrations of total metal only in Q1 of 2014. Subsequent sampling rounds in 2014 (Q2, Q3 and Q4) were analysed for both total metal and concentrations of dissolved metal. All sampling rounds from 2015 onwards were analysed for both total metal and concentrations of dissolved metal. In 2023 both the total and dissolved metals were analysed.

The groundwater results are discussed below in terms of the exceedances of the Groundwater Threshold Values (GTVs) (SI No. 366 of 2016) and the EPA IGV (2003), in the overall context of the confirmed site groundwater flow direction (*Figure 5*):

- Upgradient of site – AGW3 (MW1)/AGW4 (MW2). Note: AGW4 is downgradient of landfill
- Downgradient of site – AGW5 (MW3) and AGW6 (MW4).
- Downgradient of landfill – AGW1 (LF1) and AGW2 (LF2).
- Downgradient of condensate pipeline – AGW7
- Downgradient of main factory – AGW8
- Downgradient of condensate pipeline close to site boundary – AGW9
- Downgradient of chemical store – AGW10

It should be noted that S.I. No. 366 of 2016 of the European Communities Environmental Objectives (Groundwater) Regulations 2010 removed GTVs for several parameters relevant to this site. These are listed below:

- Cadmium, copper, nickel and sodium.

Note: *The upgradient/downgradient hydraulic position assigned to each groundwater monitoring well above, should be interpreted with the 2023 groundwater level data/groundwater contour map.*

The spatial concentrations of general indicator parameters and of heavy metals are presented in *Figure 6* and *Figure 7*, respectively.

AGW3 (formerly known as MW1)

AGW3 was considered to be the upgradient borehole for the site and the landfill. When groundwater mounding was identified in the middle of the site in previous years, there may have been an element of groundwater flow towards AGW3 at times.

Chloride concentrations ranged from 21.8 – 23.0 mg/l throughout 2023. All results were reported below the EPA IGV of 30 mg/l. The general background chloride concentration for Irish aquifers ranges from 20 – 30 mg/l, and the analysis from 2023 shows that chloride at AGW3 is at background levels. Overall, chloride fluctuates at AGW3 but has begun decreasing in recent years.

Calcium concentrations ranged from 156.0 mg/l to 169.4 mg/l and did not exceed the 2003 EPA IGV of 200 mg/l in 2023. However, high calcium concentrations are characteristic of the limestone bedrock beneath the site and surrounding area.

Nitrate as NO_3 was reported in the range of 28.7 – 30.6 mg/l throughout 2023. These concentrations are below the SI366/2016 TV of 37.5 mg/l, but slightly above the EPA IGV of 25 mg/l. The long term dataset shows a slight upward trend for nitrate as NO_3. This nitrate is likely from off-site.

Ammonia was reported below the SI366/2016 TV of 0.065 mg/l for Q1, Q3 & Q4-2023. Ammonia was reported just above the SI366/2016 TV of 0.065 mg/l for Q2-2023 at 0.19 mg/l.

Electrical Conductivity concentrations were reported above the lower GTV of 800 uS/cm in) in all of 2023, ranging from 833 - 870 uS/cm.

Total Nickel was reported ranging from 9.9-16.5 ug/l in 2023. This a decrease from 2022 of 19.7 –

34.3 ug/l and lower than the spike reported in Q3-2022 of 444.4 ug/l. Nickel is displaying a long-term fluctuating trend.

Chromium was reported ranging from 1.9-9.1 ug/l in 2023, a reduction from 2022 of 10.3 – 14.4 ug/l.

Copper was reported ranging from 3-10 ug/l in 2023, a reduction from 2022 of 13 – 23 ug/l and lower than the spike of 277 ug/l in Q3-2022.

Phthalates were all reported below the limit of detection and below the Groundwater Regulations S.I. No 366 of 2016 of 6 ug/l.

AGW1 (formerly known as LF1)

AGW1 is situated downgradient of the on-site landfill. AGW1 is screened from 12 mbgl – 25 mbgl. Groundwater quality is compromised at this location, although no hazardous substances were identified during monitoring in 2023.

Chloride concentrations exceeded the lower groundwater GTV during all monitoring rounds and the EPA IGV of 30 mg/l in 2023 ranging from 34.2 – 36.7 mg/l. These concentrations are above the background concentration of 23.0 mg/l at AGW3. However, the exceedances are not significant. Chloride is showing a long term, steady upward trend at AGW1.

Ammonia was reported between 0.05 mg/l and 0.12 mg/l throughout 2023, exceeding the GTV of 0.065 mg/l, but a decrease from 2022. Ammonia is displaying a downward trend since Q1-2016.

Conductivity was reported in the range of 1146 – 1245 uS/cm throughout 2023, in excesses of the lower GTV (800 uS/cm), but below the upper GTV (1875 uS/cm).

Dissolved Calcium concentrations ranged between 196.0 mg/l and 285.6 mg/l throughout 2023, which are elevated; with Q3-2023 the only quarter not to exceed the EPA IGV of 200 mg/l. The elevated calcium is attributed to the underlying carbonate bedrock geology.

Dissolved Potassium concentrations exceeded the EPA IGV of 5 mg/l in all quarters, ranging from 7 – 8.1 mg/l throughout 2023. Background potassium concentrations in Irish aquifers are generally in the range of 0.5 – 2 mg/l.

Total Organic Carbon showed some variability in 2023, reported at between 4 mg/l – 17 mg/l.

AGW2 (formerly known as LF2)

AGW2 is situated further downgradient from the landfill; located approximately 70 m downgradient of AGW1 and closer to the factory. AGW2 is screened from 33 mbgl to 37 mbgl. Groundwater quality is also somewhat compromised at this location.

Chloride concentrations ranged from 35.6 mg/l to 52.3 mg/l throughout 2023 and exceeded the SI366 GTV of 24 mg/l. AGW3, which is up gradient of the landfill reported a background chloride concentration of 23.0 mg/ in 2023. Chloride peaked in Q1-2008 (74.5 mg/l) and decreased until Q3-2014 (19.1 mg/l). From Q3-2014 onwards chloride has displayed an upward trend.

Dissolved Potassium was reported between 21.3 mg/l and 31.2 mg/l throughout 2023 – which is in excess of the EPA IGV of 5 mg/l. Potassium was reported at 0.2– 0.3 mg/l in 2023 at AGW3 [background].

Nitrate as NO_3 ranged between 3.7 – 46.0 mg/l throughout 2023 – mostly below the EPA IGV of 25 mg/l , with the exception of Q2-2023. The maximum nitrate reported at AGW2 was 186.5 mg/l in Q2-2020. Since this peak, nitrate has displayed a steady downward trend.

Nitrite as NO_2 was reported at <0.02mg/l in 2023 and did not exceed the EPA IGV of 0.1 mg/l.

Ammonia ranged between 1.14 - 2.84 mg/l and exceeded the GTV of 0.065 mg/l in all monitoring rounds in 2023. Ammonia has displayed an upward trend since Q4-2016.

Conductivity ranged from 1322 - 1654 uS/cm throughout 2023, exceeding the lower GTV of 800 uS/cm, but reported below the upper GTV of 1875 uS/cm.

Dissolved Nickel concentrations ranged between 49.2 – 78.6 ug/l throughout 2023 – in excess of the 20 ug/l EPA IGV. The long-term dataset shows that nickel fluctuates at AGW2 with an emerging increasing trend.

Magnesium was reported between 32.9 - 44.5 mg/l throughout 2023 at AGW2. These concentrations are below the EPA IGV of 50 mg/l.

Dissolved Calcium concentrations ranged from 233.4 – 296.2 mg/l throughout 2023 – in excess of the EPA IGV which is set at 200 mg/l. Calcium is displaying an upward trend at AGW2 and is attributed to the limestone bedrock geology of the wider area.

Cadmium (Total) ranged between 1.16 – 1.36 ug/l throughout 2023 – reported below the EPA IGV of 5 ug/l.

Total Organic Carbon ranged from 6 – 30 mg/l throughout 2023, with the concentrations reported at AGW2 higher than those detected at AGW1.

AGW4 (formerly known as MW2)

Based on the updated groundwater map, AGW4 is considered to be downgradient of the landfill and upgradient of the main processing site/factory area.

AGW4 is screened from 3 – 18 mbgl (refer to Table 2). Overall, the groundwater quality is good at AGW4.

Chloride was reported in the range of 20.1 – 21.2 mg/l throughout 2023. Overall, a slight natural fluctuation in chloride concentrations is evident in the long-term dataset.

Ammonia as N was reported below the limit of detection for 2023 (<0.03mg/l), this is below the Groundwater Regulations S.I. No 366 of 2016 of 0.065 mg/l.

AGW7

AGW7 was drilled in 2016 in front of the boiler house. The condensate pipeline, which runs from the boiler house to the lagoons, passes adjacent to AGW7. AGW7 was drilled with the aim of establishing the reasons for the groundwater mound and determining the groundwater flow direction.

Routine groundwater monitoring between 2016/2017 showed elevated concentrations of chloride, ammonia, nitrate and electrical conductivity (nitrogen/salts). The COPCs found in AGW7 were suggestive of salt compounds, similar to those used in the treatment of water in the boiler house. Analysis of the boiler water condensate confirmed this hypothesis.

A CCTV survey of the condensate pipeline in January 2017 indicated gaps in the pipe joints and all sections of the pipeline failed the hydrostatic test. Repair work, which consisted of relining the pipeline, was completed in February 2017. A follow up CCTV survey and hydrostatic test on the pipeline resulted in the pipeline passing the hydrostatic test. Medite continue to monitor the condensate pipeline, to ensure its integrity. Measures include:

- Hydrostatic testing of the condensate pipeline. The pipeline passed the routine hydrostatic testing in 2023.
- Routine groundwater analysis and reporting for all groundwater monitoring wells on site;
- Good housekeeping of all activities associated with the condensate pipeline.

The leaking condensate pipeline resulted in a plume migrating from the area around AGW7.

Groundwater levels collected in previous years have made establishing the groundwater flow direction difficult. A hydrogeological assessment completed by IE Consulting in 2021 included a review of groundwater quality and groundwater level data (IE1232-42-4960). The review determined that the plume is migrating southwards towards the River Suir.

AGW9 and AGW10 were drilled in 2017 and are positioned down gradient of AGW7 to monitor the plume and have shown elevated concentrations of salts and nitrogen.

AGW7 is located close to the source of the plume; AGW9 is located in the centre of the plume; while AGW10 is located at the outer edge of the plume. AGW8 has reported good groundwater quality since Q1-2018 and does not appear to be impacted by the plume (IE1232-42-4960).

The results of the hydrogeological assessment determined that the risk to the main receptors (Regionally Important Aquifer and the River Suir) is low and that monitored natural attenuation is the best way forward to protect the groundwater resource.

Medite have implemented the recommendations of the 2021 IE Consulting hydrogeological assessment. In addition, bromide and fluoride have been added to the groundwater monitoring programme to act as ''check parameters'' for future condensate pipeline leaks. Monitoring commenced in Q3-2021 for bromide and fluoride.

The findings of the 2023 monitoring are discussed below, for AGW7:

- Chloride ranged from 91.6 – 492.3 mg/l in 2023. The SI122/2014 drinking water concentration is 250 mg/l for chloride. The Q3-2022 chloride concentration of 63.5 mg/l was the lowest reported since monitoring commenced. Overall, since the peak of 1050 mg/l in February 2016, chloride has shown a steady downward trend with the exception of the significant spike in November 2023 (492.3 mg/l) which is the highest concentration since June 2016 at this location. This may be partially related to exceptional rainfall in October.
- Sodium ranged from 38.9 – 122.6 mg/l throughout 2023, an increase from 29.1 – 42.6 mg/l in 2022. Sodium is currently displaying a short term upward trend.
- Potassium concentrations ranged from 6.7 – 14.5 mg/l in 2023, all above the IGV of 5 mg/l.
- Ammonia as N – is reported between 4.19 – 6.38 mg/l. Overall, ammonia fluctuates within a range of c. 5 – 9 mg/l, following a decrease from a high in Q2-2017 (14.99 mg/l). 2023 reported above the Groundwater Regulations S.I. No. 9 of 2010 of 0.175 mg/.
- Nitrate as NO_3 – ranged from 68.4 – 91.3 mg/l in 2023, above the SI366/2016 TV of 37.5

mg/l. Overall, nitrate is showing an upward trend since Q2-2018.

- Electrical conductivity – ranged from 1186 - 2373 uS/cm throughout 2023, reported above the SI366/2016 Lower TV of 800 uS/cm, but for Q4 was reported above the SI366/2016 Upper TV of 1875 uS/cm. Conductivity is displaying a long term downward trend, which suggests the plume is dissipating.
- Calcium is elevated due to the underlying bedrock geology (141.8 – 365.1 mg/l for 2023).
- Fluoride was reported at the laboratory limit of detection in 2023.
- Bromide was <0.05 – 0.36mg/l in 2023.

Isolated peaks in concentrations of salts and nitrogen are evident, when groundwater levels are seasonally higher in AGW7. This is attributed to residual contamination trapped within the subsoil's at the plume core. The residual contamination will subside, with progressive flushing via rainfall recharge over time.

Concentrations of selected parameters in AGW7 for 2016 - 2023 are shown in Chart 1. The groundwater monitoring results are tabulated in Appendix E.

Temperature measurements taken at the time of sampling in 2023 ranged from 15.7 – 17.0°C.

AGW7 is located within 4m from the condensate pipeline, which transports liquid with a temperature of c. 80°C. Thus, the heat of the pipeline will have a direct impact on the groundwater temperature along the pipeline corridor. The elevated temperature reported in AGW7 is considered to be associated with the heat from the condensate pipeline. The potential for leaks have been ruled out, which is borne out in the groundwater monitoring data from 2023 and the annual hydrostatic testing on the pipeline.

Temperature data for AGW7 is shown in Chart 2.

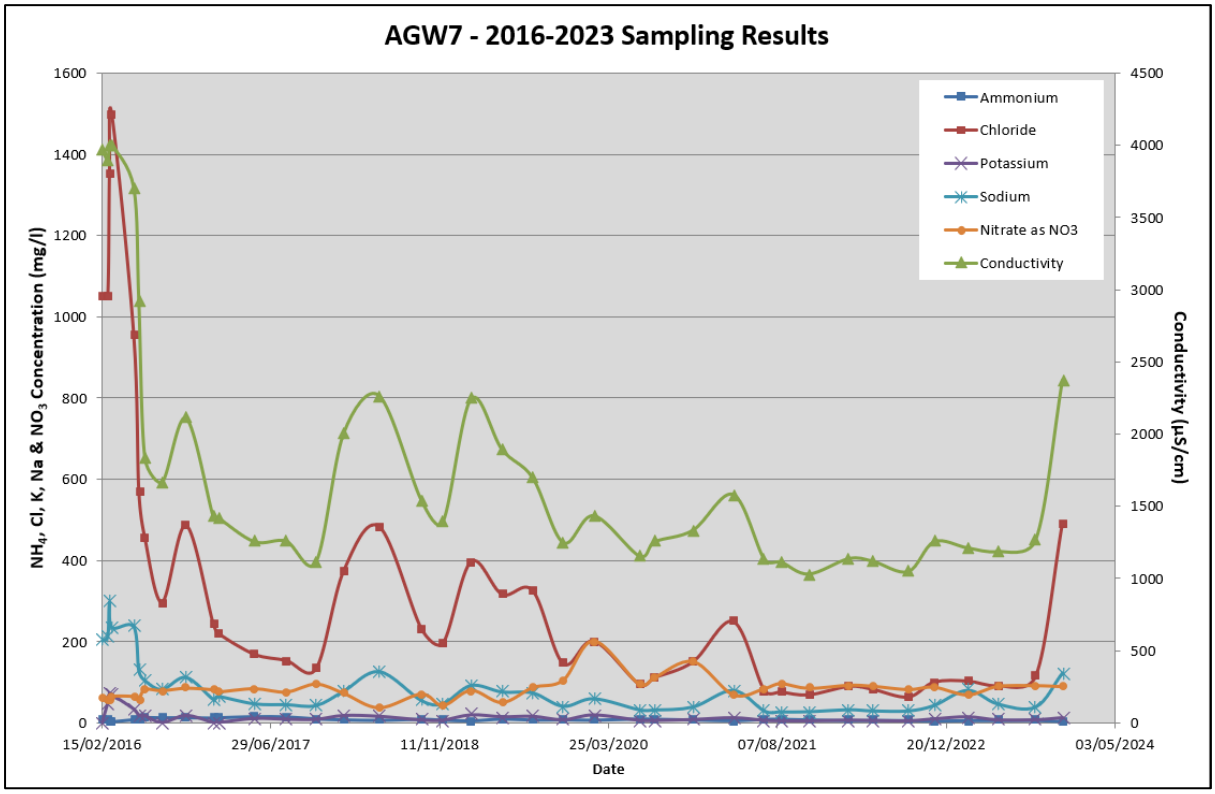


Chart 1. Trends for Selected COPCs in AGW7 (Feb. 2016 to Nov. 2023)

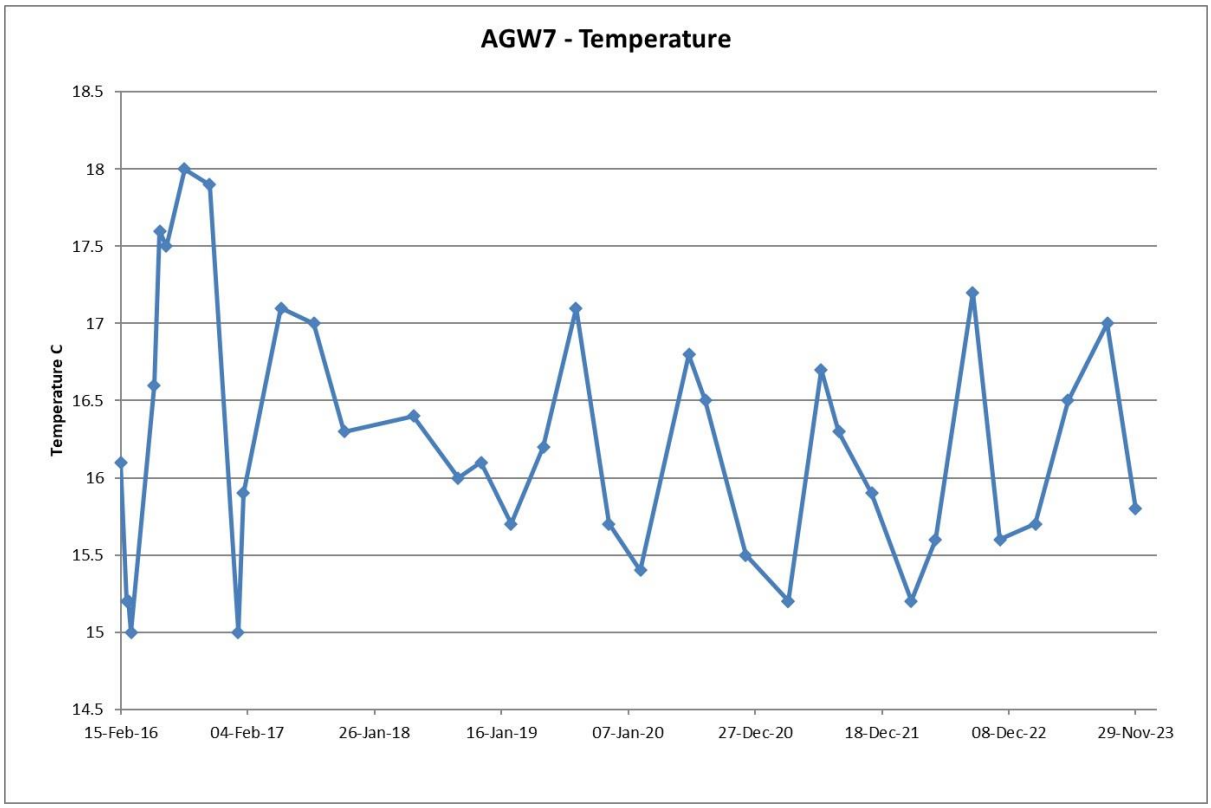


Chart 2 - AGW7 Temperature

AGW8

AGW8 is situated downgradient of the main factory building, and monitoring commenced in February 2016. Overall, AGW8 displays good water quality.

Chloride concentrations ranged from 18.4 – 51.5 mg/l throughout 2023. Chloride in Q2 & Q3 2023 exceeded the Groundwater Regulations S.I. No 366 of 2016 of 24 mg/l. Overall, the long term data set shows that chloride fluctuates with steep peaks and deep troughs, and there is no upward trend evident.

Temperature measurements ranged from 13.7 °C to 15.5°C during purging in 2023.

AGW9

AGW9 was drilled as a downgradient well from the condensate pipeline and AGW7. The findings of the 2021 hydrogeological assessment by IE Consulting (IE1232-43-4960) showed that AGW9 was located in the centre of the plume migrating from AGW7. AGW9 displays poor water quality.

Chloride concentrations ranged from 53.0 – 110.4 mg/l in 2023, an overall reduction from 89 – 136.6 mg/l reported in 2022. Chloride fluctuates with sharp peaks and deep troughs, which are attributed to the progressive flushing of residual contamination in the subsoil's via rainfall recharge over time.

Ammonia as N ranged from <0.03 – 0.04 mg/l in 2023 and does not exceed the SI366/2016 GTV in 2023. The ammonia concentrations reported at AGW9 are significantly lower than those detected at AGW7 (4.19 – 6.38 mg/l). Ammonia is displaying a semi stable trend.

Nitrate as NO_3 concentrations never exceeded the EPA IGV which is set at 25 mg/l. Concentrations ranged from 9.6 – 14.0 mg/l in 2023. Nitrate fluctuates at AGW9.

Orthophosphate as PO_4 ranged from 0.14 – 0.17 mg/l in 2023 and has exceeded the SI366/2016 TV of 0.107 mg/l.

Electrical Conductivity exceeded the 800 uS/cm for 2023 (812 - 994 uS/cm). Conductivity peaked in Q1-2019 (2018 uS/cm) and displayed a downward trend to Q1-2021, after which an upward trend emerged.

Dissolved Potassium concentrations ranged from 10.5 – 11.6 mg/l in 2023. They exceeded the EPA IGV of 5 mg/l in all four sampling events of 2023. Overall, potassium is showing a slight upward trend.

Dissolved Nickel concentrations ranged from 17.2 - 19 ug/l in 2023. This did not exceed the EPA IGV of 20 ug/l. Nickel fluctuates at AGW9 and has had a downward trend since Q4-2021.

Dissolved Sodium concentrations ranged from 27.7 – 49.7 mg/l in 2023 – below the 150 mg/l IGV. However, such concentrations are significantly elevated in comparison to the background values for Irish aquifers (10 – 15 mg/l). There is no discernible trend evident for sodium; further monitoring will enable the establishment of a trend pattern.

AGW10

AGW10 was installed as a well directly downgradient from the chemical store. AGW10 is located due west of AGW9. The findings of the 2021 hydrogeological assessment by IE Consulting (IE1232-43-4960) showed that AGW10 was at the edge of the plume migrating from AGW7.

Chloride concentrations was reported at 23 – 68.8 mg/l, exceeding the 30 mg/l IGV in Q2 & Q3. The SI366/2016 TV of 24 mg/l was also exceeded in Q2, Q3 & Q4. Chloride concentrations fluctuate at AGW10.

Electrical conductivity exceeded the SI366/2016 TV of 800 uS/cm in Q2-2023 (902 uS/cm) but was below in all other quarters. Overall, conductivity is showing a semi stable trend.

Ammonia as N was reported at <0.03 – 0.12 mg/l for 2023, which exceeds the EPA IGV of 0.12 mg/l for Q1-2023 only.

Orthophosphate as PO_4 was reported slightly above the SI366/2016 TV of 0.107 mg/l, at 0.12 – 0.14 mg/l for 2023.

Nitrate as NO_3 was reported at 15.6 – 29.9 mg/l in 2023, above the EPA IGV of 25 mg/l for Q1-2023 only.

Dissolved Sodium concentrations at AGW10 (12.3 – 30.3 mg/l) are lower than those reported at AGW9 (27.7 – 49.7 mg/l for 2023).

Dissolved Potassium concentrations ranged from 5.9 - 7.4 mg/l throughout 2023 – exceeding the EPA IGV of 5 mg/l. Potassium is showed a downward trend at AGW10 until Q2-2021 and it has since shown a slight upward trend.

AGW5 (formerly known as MW3)

AGW5 is situated between the factory and the Anner River, and is downgradient of the northern section of the factory site. Overall, the groundwater quality is good at AGW5.

Chloride concentrations ranged from 22.2 to 31.7 mg/l throughout 2023. Chloride slightly exceeded the EPA IGV of 30 mg/l in Q1 & Q4-2023. Overall, chloride is showing a very slight upward trend when the previous 20 years of data are analysed.

Nitrate as NO_3 concentrations range from 13.6 – 29.2 mg/l throughout 2023. Q1-2023 reported 29.2 g/l, which is below the SI366/2016 TV but slightly above the 25 mg/l EPA IGV. Overall, nitrate fluctuates at AGW5.

Orthophosphate as PO_4 was reported above the SI366/2016 TV of 0.107 mg/l in Q2-2023 (0.13 mg/l).

AGW6 (formerly known as MW4)

AGW6 is situated at the south-eastern corner of the site, south of AGW5. The groundwater contour map indicates that AGW6 (MW4) is downgradient of the southern section of the factory site.

Chloride was reported in the range of 18.7 – 19.7 mg/l, which is below the SI366/2016 GTV of 24 mg/l. Chloride is displaying a stable trend.

Overall, the groundwater quality continues to be reported as good at AGW6. There was no parameter reported in excess of the relevant GTVs/IGVs, however the limit of detection for a minor number of parameters was greater than the threshold of the GTVs/IGVs throughout 2023.

An overview of the trends (2000-2023) for historical key parameters is presented in *Table 11* below (see *Appendix F* for graphs).

Table 11. Trends for Historical Key Parameters (2000-2023)

Parameter	Upgradient of Site	Upgradient of Factory Area/ Downgradient of Landfill	Downgradient of Landfill		Downgradient main Factory Building	Downgradient of Chemical Store	Downgradient of Condensate Pipeline		Downgradient of Site by Anner River	
	AGW3	AGW4	AGW1	AGW2	AGW8	AGW10	AGW7	AGW9	AGW5	AGW6
Chloride	↑	↑	↑	↑	≈	≈	↓	↓	↑	↑
Sodium	N/A	N/A	N/A	N/A	N/A	-	↓	↓	N/A	N/A
Ammonia	↓	≈	≈	↑	-	≈	↓	↓	N/A	≈
Nitrate	↑	≈	~	↓	↓	N/A	↑	↓	↑	↓
Calcium	↑	≈	↑	↑	N/A	N/A	N/A	N/A	N/A	N/A
Orthophosphate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	↑	N/A	N/A
Cadmium	N/A	-	≈	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	↑	↑	≈	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note

↑ Increasing trend

↓ Decreasing trend

~ No discernible trend evident

- Stable

≈ Fluctuates

N/A Not graphed

Total Petroleum Hydrocarbons (TPH) and other Organic Compounds

Total Petroleum Hydrocarbons and mineral oil were reported at the limit of detection throughout 2023 for all monitoring wells.

Benzene, toluene, ethylbenzene and xylene were not detected in any wells throughout the 2023 monitoring rounds.

Phthalates, Phenols, PAHs, VOCs and SVOCs were reported at the limit of detection for all monitoring rounds throughout 2023 for all wells.

Formaldehyde

Formaldehyde is not currently regulated in the EPA IGV's or statutory groundwater regulations (SI366/2016). The laboratory limit of detection for formaldehyde is set at <0.05 mg/l. All monitoring rounds reported formaldehyde at the limit of detection for 2023.

pH

All groundwater monitoring wells reported pH within the range ≥ 6.5 and ≤ 9.5 as per the EPA IGV's for 2023.

6.3 LANDFILL RISK ASSESSMENT

The Preliminary Risk Assessment Review of Landfill COPCs (*IE Consulting, 16/08/2016*) is summarised as follows: COPC (Ammonium, cadmium and chloride) concentrations will likely mitigate over a period of 10s of years with residual Ammonium flushing from the historical landfill. Groundwater threshold values for Ammonium may not be achieved at AGW1 in the foreseeable future. The compliance points AGW4, AGW5, and AGW6 are the key drivers of risk for the assessment of bedrock groundwater quality off-site. The groundwater quality at these compliance points continued to be reported as good for 2023.

In the context of the aquifer resource, it is considered that the on-going landfill monitored natural attenuation (MNA) programme is the most sensible solution for the management of the residual contamination and leachate generation within the waste body.

6.4 GAS MONITORING RESULTS

Gas monitoring was completed in March and November 2023 using a GA2000 gas monitor. All gas monitoring points are monitored for:

- Methane (CH_4)
- Carbon Dioxide (CO_2)
- Oxygen (O_2)
- Barometric Pressure

Gas concentrations are detailed in *Tables 1-4, Appendix G*.

TP-01

No methane was detected at TP-01 in 2023.

Carbon dioxide was reported at 0.6 % v/v in March 2023 and was reported at 2.8% v/v in November 2023. Novembers reading exceeded the EPA trigger level (1.5% v/v) for carbon dioxide.

Oxygen concentrations were reported at 20.3 % v/v in March 2023 and from 18.6 – 18.9 % v/v in November 2023.

TP-02

No methane was detected at TP-02 in 2023.

Carbon dioxide ranged between 1.1 – 3.7 % v/v in March 2023 and ranged between 0.1 – 11.7 % v/v in November 2023. The 2023 concentrations are in excess of the EPA trigger level (1.5% v/v) for carbon dioxide.

Oxygen concentrations ranged from 16.0 – 19.7 % v/v in March 2023 and from 8.9 – 20.5 % v/v in November 2023.

TP-03

No methane was detected at TP-03 in 2023.

Carbon dioxide was at 1.2 % v/v in March 2023 and ranged from 1.3 – 6.7 % v/v in November 2023. The March 2023 concentrations are not excess of the EPA trigger level (1.5% v/v) for carbon dioxide, however the November 2023 concentrations are.

Oxygen concentrations ranged from 20.1 – 20.2 % v/v in March 2023 and from 15.8 – 19.7 % v/v in November 2023.

TP-04

No methane was detected at TP-04 2023.

Carbon dioxide ranged from 5.5 – 7.4 % v/v in March 2023 and ranged from 0.7 – 1.1 % v/v in November 2023. The concentrations for March 2023 exceeded the EPA trigger level (1.5% v/v) for carbon dioxide.

Oxygen concentrations ranged from 12.9 – 13.9 % v/v in March 2023 and ranged from 20.4 – 20.7 % v/v in August 2022.

The historical monitoring results indicate fluctuating concentrations of carbon dioxide that often exceed the recommended trigger value. In 2023 concentrations continue this trend.

An analysis of gas monitoring data for 2023, in addition to comparisons with historical data for 2010 - 2023 (*Table 1- 4, Appendix G)*, is included in *Appendix G*. Peak and stabilised gas concentrations are compared to the Barometric Pressure recorded at the time of sampling.

8.0 POTENTIAL POLLUTANT LINKAGES

The primary potential pollution linkage identified based on a review of the 2023 groundwater monitoring results is summarised in *Table 12* below.

Table 12. Site Potential Pollution Linkage

Source	Pathway	Receptor
*Landfill Leachate *Residual contamination from leaking condensate pipeline in the soil	*Vertical infiltration through soil and subsoil. *Horizontal movement through the sand and gravel lenses on site *Horizontal movement through fractured bedrock aquifer.	*Regionally Important Bedrock aquifer *River Anner/River Suir

9.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn, based on the sampling, analysis and reporting of the 2023 groundwater monitoring and gas monitoring data:

1. The groundwater monitoring network consists of 10 monitoring wells, spatially distributed across the site to monitor groundwater quality. The monitoring network is monitored on a quarterly basis.

2. The main parameters which would indicate a potential issue of concern for groundwater beneath the site are: sodium, chloride, orthophosphate, ammonium, elevated pH, formaldehyde, heavy metals, phenols, and hydrocarbons.

3. Overall, there was no significant deterioration in groundwater quality in 2023, in comparison to 2022.

4. The integrity of the groundwater monitoring network was inspected quarterly, and found to be in good condition (no damage, vandalism, collisions from vehicles etc.). New locking bolts and pad locks [where applicable] have since been installed on the well casings for security purposes.

5. The reduced groundwater levels from Q1-2023 are consistent with 2022. The reduced levels indicate a regional groundwater flow direction from the North West to the South East – towards the River Anner/River Suir. This is consistent with the GWB description, whereby groundwater flows towards rivers.

6. **AGW1** is located immediately downgradient of the landfill – and reported elevated concentrations of chloride, ammonia and potassium. Electrical conductivity exceeded the lower GTV for all monitoring rounds.

7. **AGW2** is located c. 70 m downgradient of the landfill and continues to report a compromised groundwater quality. Elevated concentrations of chloride, nitrate, ammonia, nickel, potassium, calcium, and electrical conductivity were reported in 2023.

8. The preliminary Risk Assessment Review for the landfill (IE Consulting 1116-1590, February 2016) suggests that the risk from landfill leachate to the underlying groundwater and the River Anner is low. It considered that the on-going landfill monitored natural attenuation programme is the most sensible solution for the management of the residual contamination and leachate generation within the waste body.

9. **AGW3** reported elevated concentrations of Ammonia and nitrates, along with conductivity values in excess of the lower GTV in 2023. Nitrate here is likely from off-site and ammonia is only slightly above the threshold.

10. Groundwater quality was good at **AGW4** – with no exceedances in 2023.

11. **AGW5** reported good water quality, with chloride exceeding the GTV in Q1 and Q4-2023 and nitrate exceeding the GTV in Q1-2023 only. Orthophosphate was reported above the GTV in Q2-2023.

12. Monitoring demonstrated that **AGW6** had good water quality, with no parameters reported in excess of the TV's for 2023.

13. **AGW7** continues to report compromised groundwater quality, as a result of the leak from the condensate pipeline in 2016. The isolated peaks in concentrations of salts and nitrogen

are attributed to when groundwater levels are seasonally higher in AGW7. This is linked to residual contamination trapped within the subsoil's at the plume core. The residual contamination will subside, with progressive flushing via rainfall recharge over time.

14. The condensate pipeline passed hydrostatic testing in 2023 and the groundwater monitoring data shows no evidence of new leaks. Bromide and fluoride have been added to the groundwater monitoring analysis to act as check parameters for future potential leaks. Fluoride was reported at the laboratory limit of detection in 2023. Bromide was between <0.05 – 0.36 mg/l in 2023.

15. A hydrogeological assessment of the plume originating at **AGW7** by IE Consulting in 2021 (IE1232-42-4960) determined that the risk to the main receptors (Regionally Important Aquifer and the River Suir) is low and that monitored natural attenuation is the best way forward to protect the groundwater resource.

16. Key contaminants of concern such as chloride, sodium, potassium and electrical conductivity at **AGW7** reported in 2023 are all displaying downward trends. There was a spike in Q4-2023 in Chloride, sodium, and electrical conductivity. Ammonia has stabilised and fluctuates within a narrow range, while nitrate was the only parameter to show an increase in 2021 at AGW7.

17. Temperature measurements collected during purging at **AGW7** ranged from 15.7 to 17.0°C. The elevated temperature reported at AGW7 is considered to be associated with the heat from the condensate pipeline located within 4 m from the borehole.

18. **AGW8** reported good water quality in 2023, with some elevated concentrations of chloride.

19. **AGW9**, which is downgradient of AGW7 near the southern site boundary, reported poor water quality throughout 2023. AGW9 is located in the centre of the plume originating from the area around AGW7. Elevated concentrations of chloride, orthophosphate, nickel, potassium and electrical conductivity were reported at AGW9 in 2023.

20. **AGW10** is located at the edge of the plume migrating from AGW7. Elevated concentrations of chloride, nitrate, orthophosphate, potassium, and electrical conductivity were reported at AGW10.

21. **Formaldehyde, Hydrocarbons, BTEX, Phthalates, Phenols, PAHs, VOCs and SVOCs** were reported at the laboratory limit of detection in all groundwater monitoring wells throughout 2023.

22. **pH** was reported within the range of ≥ 6.5 and ≤ 9.5 as per the EPA IGV's for all groundwater monitoring wells in 2023.

23. The landfill leachate and gas monitoring network consist of four shallow wells which are monitored on a biannual frequency.

24. Methane was not reported in the landfill for 2023.

25. All monitoring points reported **carbon dioxide** gas above the EPA trigger level of 1.5% v/v, in either or both of the bi-annual monitoring periods.

9.1 COMMENT ON SUITABILITY OF MONITORING NETWORK.

It is considered that the monitoring network is fit for purpose, and no further boreholes are required at this stage.

Similarly, the screened intervals are appropriate in the context of the variable nature of the depth to bedrock, and intensity of dolomitisation.

9.2 RECOMMENDED WAY FORWARD

Based on this assessment, the following actions are recommendations:

1. Continue groundwater monitoring at all monitoring wells (AGW1 – AGW10) at a quarterly frequency throughout 2023.
2. The water levels in all monitoring wells should be continued to be measured on a quarterly basis using a dip meter, with an accuracy of +/-0.01m to confirm the direction/variability of groundwater flow beneath the main site.
3. Unstable hydrochemical parameters (pH, Electrical Conductivity, Temperature) should continue to be measured during the purging phase of groundwater sampling.
4. Continue to analyse for both total and dissolved metals heavy metals.
5. The analysis for both Ammonia as NH_4-N and Ammonia as N should continue for future sampling rounds to enable the comparison of data with the groundwater regulations and historical groundwater datasets.
6. The analysis for Total Petroleum Hydrocarbons, Mineral Oil and Diesel Range Organics should be scheduled as part of the routine quarterly monitoring. This will enable the assessment of any linkage to the potential source of TPH detected in the 2015, 2017 and 2020 (AGW7) monitoring rounds.
7. The laboratory limits of detection should be continuously reviewed, to ensure they are sufficient to ensure the comparison of monitoring results with the groundwater regulations.
8. Hydrostatic testing should continue annually for the condensate pipeline, and on a rolling three year period for all other pipelines.
9. The landfill gas and leachate level monitoring should continue on a biannual basis.

oo00oo

Respectfully submitted

On behalf of **IE Consulting**

Joanne Mackey	**Jerome Keohane**
	
Project Geologist	Technical Director
IE Consulting	IE Consulting

10. REFERENCES

EPA Landfill Manual, Landfill Monitoring, 2nd Edition, EPA, 2003.

EPA 2003. Interim Report: *'Towards Setting Guideline values for the Protection of Groundwater in Ireland'*. Environmental Protection Agency.

IE Consulting, 22nd February 2016. Assessment of Representativeness of Groundwater Monitoring Network (IE1116-1964).

IE Consulting, 16th August 2016, Preliminary Landfill Risk Assessment (IE1232-27/1803) submitted as a letter to the EPA.

IE Consulting, 5th August 2021, Hydrogeological Assessment for the Potential of the Plume at AGW7 to Migrate Offsite (IE1232-42-4960).

Met Eireann, 2019. Summer 2018 Analysis. Irish Meteorological Service. Department of Housing, Local Government and Heritage. Accessed 14/01/2020.

S.I. No. 366/2016 - European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016.

S.I. No. 9/2010 - European Communities Environmental Objectives (Groundwater) Regulations 2010.

Thompson, C.K., Nathanail, P.C., 2003. Chemical Analysis of Contaminated Land. Blackwell Publishing, Oxford, UK. ISBN 1–84127–334–1