



## Appendix 7.3: Ground Water Monitoring

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**APPENDIX 7.3**  
**GROUNDWATER MONITORING ASSESSMENT REPORT**  
**RSK IRELAND LIMITED, 2018**

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Hewlett Packard

# Groundwater Monitoring Assessment

Hewlett Packard, Liffey Park, Leixlip, Co. Kildare

602128– R2 (00)

JUNE 2018





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## RSK GENERAL NOTES

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**Project No.:** 602128- R2 (00)

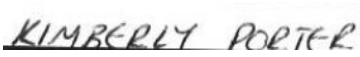
**Title:** Groundwater Monitoring Assessment: Hewlett Packard, Liffey Park, Leixlip, Co. Kildare

**Client:** EFIV IRISH PROPERTY ICAV

**Date:** June 2018

**Office:** Dublin

**Status:** DRAFT

<b>Author</b>	<u>Kimberly Porter</u>	<b>Technical reviewer</b>	<u>Peter Rodgers</u>
			
Signature:	_____	Signature:	_____
Date:	<u>June 2018</u>	Date:	<u>June 2018</u>

RSK Ireland Limited (RSK) has prepared this report for the sole use of the client, showing reasonable skill and care, for the intended purposes as stated in the agreement under which this work was completed. The report may not be relied upon by any other party without the express agreement of the client and RSK. No other warranty, expressed or implied, is made as to the professional advice included in this report.

Where any data supplied by the client or from other sources have been used, it has been assumed that the information is correct. No responsibility can be accepted by RSK for inaccuracies in the data supplied by any other party. The conclusions and recommendations in this report are based on the assumption that all relevant information has been supplied by those bodies from whom it was requested.

No part of this report may be copied or duplicated without the express permission of RSK and the party for whom it was prepared.

Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Ireland Ltd.

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# 1 INTRODUCTION

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RSK Ireland Limited (RSK) was commissioned by EFIV Irish Property ICAV to undertake a groundwater monitoring programme at Hewlett Packard Campus, Liffey Park, Leixlip, Co. Kildare.

This report is subject to the RSK service constraints given in Appendix A.

## 1.1 Aim

The aim of this study was to establish the potential sources of environmental risk and liabilities associated with any groundwater contamination at the site.

## 1.2 Objective

The purpose of the ground monitoring programme is to:

- Define the baseline water quality and physical conditions in the monitoring wells;
- Identify all vulnerable receptors and help identify potential pathways; and,
- Provide an early warning of adverse environmental impacts.

## 1.3 Scope

In the absence of specific guidance for the Republic of Ireland the scope of the investigation and layout of this report has been designed in accordance with industry acknowledged best practice presented in CLR11, Model Procedures for the Management of Land Contamination. The scope of works for the assessment included:

- Groundwater monitoring undertaken at the six (BH3, BH4, BH6, BH9/07, BH12/07 & BH13/08) previously installed monitoring locations;
- Review of groundwater monitoring data and subsequent laboratory results; and,
- A factual and interpretative report with recommendations for further works (if required).

## 1.4 Existing reports

This report should be read in conjunction with the following document:

- RSK. Preliminary Environmental Site Assessment: 'Hewlett Packard, Liffey Park, Leixlip, Co. Kildare' Ref: 602128-R01 dated March 2018.

## 1.5 Limitations

The options and recommendations expressed in this report are based on the ground conditions encountered during the site works, the results of field and laboratory testing and the interpretation between explanatory holes. The material encountered and samples obtained represents only a small proportion of the material present on-site,



therefore, other conditions may prevail at the site, which have not been revealed by this investigation.

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## 2 THE SITE

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### 2.1 Site location and description

The site is located on the Celbridge Road, Leixlip, County Kildare located approximately 4km south of Leixlip town and approximately 21km west of Dublin city centre. The site is centred at Irish Grid reference N 99080 34746 at an altitude of approximately 51m. The site operates as an inkjet cartridge manufacturing plant and construction of the site was completed in 1996. The topography of the site slopes gently down towards the south east, which is consistent with the surrounding area.

The 194.5 acres site comprises of 10 buildings with approximately 1,600 car spaces and associated green spaces. The site includes a two storey office building, two manufacturing facilities, warehousing and lab spaces, a main canteen building and two energycentre buildings which house heating boilers and associated ancillary equipment. The site is accessible by via the Celbridge Road and a private road located near the M4 motorway slipway (Junction 6).

The site is bordered to the north by the M4 motorway, to the south Barnhall Rugby and football club with residential dwellings and the river Liffey beyond, to the west agricultural land with Celbridge town beyond and to the east is agricultural land with Weston Airport beyond. The land use in the surrounding area predominantly comprises of agricultural land with a few scattered residential dwellings.

A site location plan is presented in Figure 1.



## 3 Monitoring Plan

### 3.1 Groundwater Monitoring Plan

A groundwater monitoring plan was utilised to assess the groundwater quality within the previously installed monitoring wells on the subject site.

Groundwater levels were recorded during the groundwater monitoring round, which was undertaken by a third party contractor TRC Companies Inc. on 10<sup>th</sup> May 2018 as detailed in Table 1 below.

**Table 1: Groundwater levels during groundwater monitoring round (10<sup>th</sup> May, 2018)**

Monitoring Well	Screened Strata	Level (mbgl)
BH3	Unknown *	4.117
BH4	Unknown	4.383
BH6	Unknown	3.731
BH9/07	Unknown	3.909
BH12/07	Unknown	2.791
BH13/08	Unknown	2.474
Notes: *Borehole logs not provided at the time of reporting.		

Light non-aqueous phase liquid (LNAPL) was not identified in any monitoring well during well development and sampling.

As shown in Table 1, groundwater was recorded at depths ranging from 2.474 to 4.383mbgl. Groundwater at the site is considered to flow in an east-south-east direction towards the River Liffey.

#### 3.1.1 Groundwater developing, sampling and analysis

Groundwater samples were retrieved using a United States Environment Protection Agency (USEPA) approved low-flow purging and sampling methodology. The low-flow method relies on moving groundwater through the well screen at approximately the same rate as it flows through the geological formation. This results in a significant reduction in the volume of water extracted before sampling and significantly reduces the amount of disturbance of the water in the monitoring well during purging and sampling. Drawdown levels in the monitoring well and water quality indicator parameters (pH, temperature, electrical conductivity, redox potential and dissolved oxygen) are monitored during low-flow purging and sampling, with stabilisation indicating that purging is complete and sampling can begin. As the flow rate used for purging, in most cases, is the same or only slightly higher than the flow rate used for sampling, and

because purging and sampling are conducted as one continuous operation in the field, the process is referred to as low-flow purging and sampling.

In situ water quality measurements undertaken during the low-flow sampling process can be provided upon request.

Groundwater analytical results are presented within Appendix B.

### **3.1.2 Visual/olfactory evidence of groundwater contamination**

No olfactory or visual evidence of contamination was detected in any monitoring well during the groundwater monitoring.

In addition, no LNAPL was detected within the groundwater during the sampling process.

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## 4 GROUND WATER QUALITY DATA

The results of the laboratory analysis of the groundwater samples retrieved from BH3, BH4, BH6, BH9/07, BH12/07, and BH13/08 are presented in Tables 2 to 4 below. The GAC for a sandy loam soil type with groundwater at 2.50mbgl, most representatives of on-site conditions has been used. The laboratory report is presented in Appendix D.

**Table 2: TPH, BTEX and MTBE Groundwater Analytical Results**

Contaminant of Concern	Max Concentration (µg/L)	GAC Human Health – Commercial (µg/L)	GAC – Protection of Water Environment (µg/L)
Aliphatics EC5-EC6	<10	35,900	**
Aliphatics EC6-EC8	<10	5,370	**
Aliphatics EC8-EC10	<10	427	**
Aliphatics EC10-EC12	<10	33.9	**
Aliphatics EC12-EC16	<10	0.759	**
Aliphatics EC16-EC21	<10	-	**
Aliphatics EC21-EC35	<10	-	**
Aromatics EC5-EC7	<10	-	**
Aromatics EC7-EC8	<10	-	**
Aromatics EC8-EC9	<10	-	**
Aromatics EC9-EC10	<10	64,600	**
Aromatics EC10-EC12	<10	24,500	**
Aromatics EC12-EC16	<10	5,750	**
Aromatics EC16-EC21	<10	-	**
Aromatics EC21-EC35	<10	-	**
Total TPH	<10	-	7.5 <sup>(1)*</sup>
Benzene	<7	30,740	0.75 <sup>(1)*</sup>
Toluene	<4	590,000	525 <sup>(1)</sup>
Ethylbenzene	<5	180,000	10 <sup>(2)</sup>
Xylene	<11	173,000	10 <sup>(2)*</sup>
MTBE	<28	2,065,395,0	10 <sup>(1)</sup>

Where values are in **bold** they have exceeded the GAC for Human Health

Where values are underlined the have exceeded the GAC for Environmental Waters

(1) S.I. 366 European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016

(2) EPA Interim Report Towards Setting Guideline values for the Protection of Groundwater in Ireland 2003

- GAC not calculated owing to low volatility of substance and therefore no pathway, or an absence of toxicological data

\* GAC is set below the LMDL .Where the analysis indicates concentrations below the LMDL a non-exceedence of the criteria will be inferred. \*\* No GAC available in legislation or guidance

**Table 3: Polycyclic Aromatic Hydrocarbons and Volatile Organic Compounds Groundwater Analytical Results**

Contaminant of Concern	Max. Reported Concentration (µg/l)	GAC Human Health – Commercial * (µg/l)	GAC – Protection of Water Environment (µg/L)
Naphthalene	0.0141	19,000	1.0 <sup>(2)</sup>
Acenaphthylene	<0.005	7,950	**
Acenaphthene	<0.005	4,100	**
Trichloroethane	<1	130	*
Tetrachloroethane	<1	810	*
1,1,1-Trichloroethane	<1	71,450	*
1,1,1,2 Tetrachloroethane	<1	5,330	*
1,1,2,2 -Tetrachloroethane	<1	27,650	*
Carbon Tetrachloride	<1	120	*
1,2-Dichloroethane	<1	170	*
Vinyl Chloride	<1	12	*
1,2,4-Trimethylbenzene	<1	9,850	*

As shown in Table 2 & 3 above, all samples returned concentrations below the RSK derived GAC for commercial end use and GrAC for protection of water environment for petroleum hydrocarbons and polycyclic aromatic hydrocarbons in groundwater.

In addition, a groundwater sample retrieved from all sampling locations was analysed for concentrations of Volatile Organic Compounds (VOCs) and all compounds were below the laboratory detection of limit and therefore poses a low risk to the site.

**Table 4: Dissolved Metal Groundwater Analytical Results**

Contaminant of Concern	Max Concentration (µg/L)	GAC Human Health – Commercial (µg/L)	GAC – Protection of Water Environment (µg/L)
Arsenic	0.733	-	7.5
Cadmium	<0.08	-	**
Chromium VI	<0.03	-	7.5
Copper	0.545	-	30
Lead	<0.2	-	7.5
Mercury	<0.01	51,110	0.75
Nickel	0.646	-	20
Selenium	1.56	-	**
Zinc	3.02	-	75

Where values are in **bold** they have exceeded the GAC for Human Health  
 Where values are underlined the have exceeded the GAC for Environmental Waters  
 (1) S.I. 366 European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016  
 (2) EPA Interim Report Towards Setting Guideline values for the Protection of Groundwater in Ireland 2003  
 - GAC not calculated owing to low volatility of substance and therefore no pathway, or an absence of toxicological data  
 \* GAC is set below the LMDL .Where the analysis indicates concentrations below the LMDL a non-exceedence of the criteria will be inferred.      \*\* No GAC available in legislation or guidance

As shown in Table 4 above, all groundwater samples returned concentrations below the RSK derived GrAC metallic compounds and protection of water environment.

Given the above, it is concluded that the site does not pose an unacceptable risk to controlled water receptors.

The screening values for human health and their derivation are included in Appendix C & D.

## 5 CONCLUSIONS

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Following the completion of the environmental site assessment works and receipt of laboratory analytical results, a groundwater assessment was completed to assess risks to human health and controlled waters at the site.

The groundwater GACs for protection of human health with regards to commercial end use were not exceeded in the shallow groundwater underlying the site.

The groundwater GACs for the protection of environmental waters did not exceed in the shallow groundwater underlying the site.

**Given the above findings, it is considered that the site does not pose an unacceptable risk to human health and controlled water receptors from the groundwater.**



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# FIGURES

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<b>Date:</b> □□ne □□□□

# APPENDIX A

## SERVICE CONSTRAINTS

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### RSK ENVIRONMENT LIMITED SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Ireland Limited (RSK) for EFIV Irish Property ICAV (the "client") in accordance with the terms of a contract between RSK and the "client", dated May 2018. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.
2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date hereof, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.
8. The phase II or intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.



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# APPENDIX B LABORATORY CERTIFICATES FOR GROUNDWATER ANALYSIS

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Tel: (01244) 528700

Fax: (01244) 528701

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Website: [www.alsenvironmental.co.uk](http://www.alsenvironmental.co.uk)

RSK Group Plc  
Unit B  
Bluebell Business Centre  
Old Naas Road  
Dublin  
Dublin 12

**Attention:** Paul Feely

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## CERTIFICATE OF ANALYSIS

**Date:** 25 May 2018  
**Customer:** D\_RSK\_DUB  
**Sample Delivery Group (SDG):** 180512-41  
**Your Reference:** 602128  
**Location:** HP  
**Report No:** 457687

**This report has been revised and directly supersedes 457479 in its entirety.**

We received 6 samples on Friday May 11, 2018 and 6 of these samples were scheduled for analysis which was completed on Friday May 25, 2018. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).

Approved By:

**Sonia McWhan**

Operations Manager



# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
17543971	BH3			10/05/2018
17543972	BH4			10/05/2018
17543973	BH6			10/05/2018
17543970	BH9/07			10/05/2018
17543974	BH12/07			10/05/2018
17543975	BH13/08			10/05/2018

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Maximum Sample/Coolbox Temperature (°C) : 11.4

ISO5667-3 Water quality - Sampling - Part3 -  
During Transportation samples shall be stored in a cooling device capable of maintaining a temperature of (5±3)°C.

ALS have data which show that a cool box with 4 frozen icepacks is capable of maintaining pre-chilled samples at a temperature of (5±3)°C for a period of up to 24hrs.

Only received samples which have had analysis scheduled will be shown on the following pages.



# CERTIFICATE OF ANALYSIS

Validated

**SDG:** 180512-41  
**Location:** HP

**Client Reference:** 602128  
**Order Number:** P2021483

**Report Number:** 457687  
**Superseded Report:** 457479

**Results Legend**

- X Test
- N No Determination Possible

**Sample Types -**

- S - Soil/Solid
- UNS - Unspecified Solid
- GW - Ground Water
- SW - Surface Water
- LE - Land Leachate
- PL - Prepared Leachate
- PR - Process Water
- SA - Saline Water
- TE - Trade Effluent
- TS - Treated Sewage
- US - Untreated Sewage
- RE - Recreational Water
- DW - Drinking Water Non-regulatory
- UNL - Unspecified Liquid
- SL - Sludge
- G - Gas
- OTH - Other

Analyte	Lab Sample No(s)	Customer Sample Reference	AGS Reference	Depth (m)	Container										Sample Type	
					0.5l glass bottle (ALE227)	500ml Plastic (ALE208)	H2SO4 (ALE244)	330ml Plastic bottle (ALE503)	Vial (ALE297)	250ml Amber Gl. PTFE/PE	NaOH (ALE245)	H2SO4 (ALE244)	500ml Plastic (ALE208)	0.5l glass bottle (ALE227)		
Ammoniacal Nitrogen	All	NDPs: 0 Tests: 6					X			X			X			UNL
Anions by Kone (w)	All	NDPs: 0 Tests: 6				X				X				X		UNL
Cyanide Comp/Free/Total/Thiocyanate	All	NDPs: 0 Tests: 6						X			X		X		X	UNL
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 6				X				X			X		X	UNL
EPH CWG (Aliphatic) Aqueous GC (W)	All	NDPs: 0 Tests: 6			X				X				X		X	UNL
EPH CWG (Aromatic) Aqueous GC (W)	All	NDPs: 0 Tests: 6			X				X				X		X	UNL
Fluoride	All	NDPs: 0 Tests: 6				X			X				X		X	UNL
GRO by GC-FID (W)	All	NDPs: 0 Tests: 6						X			X		X		X	UNL
Hexavalent Chromium (w)	All	NDPs: 0 Tests: 6				X			X				X		X	UNL
Mercury Dissolved	All	NDPs: 0 Tests: 6				X			X				X		X	UNL
PAH Spec MS - Aqueous (W)	All	NDPs: 0 Tests: 6			X				X				X		X	UNL
pH Value	All	NDPs: 0 Tests: 6				X			X				X		X	UNL
Phenols by HPLC (W)	All	NDPs: 0 Tests: 6					X		X				X		X	UNL
Sulphide	All	NDPs: 0 Tests: 6				X			X				X		X	UNL
TPH CWG (W)	All	NDPs: 0 Tests: 6			X				X				X		X	UNL

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17543975	BH13/08				
		Vial (ALE297)	UNL	UNL	
17543974	BH12/07	H2SO4 (ALE244)	UNL	UNL	
		330ml plastic bottle (ALE503)	UNL	UNL	
		250ml Amber Gl. PTFE/PE Vial (ALE297)	UNL	UNL	
		H2SO4 (ALE244)	UNL	UNL	
			X		
				X	
			X		
			X		
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			X		





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17543975	BH13/08			Via (ALE297)	UNL		X
				H2SO4 (ALE244)	UNL		
				330ml plastic bottle (ALE503)	UNL		
				250ml Amber Glass PTFE/PE	UNL		
17543974	BH12/07			Via (ALE297)	UNL		X
				H2SO4 (ALE244)	UNL		



# CERTIFICATE OF ANALYSIS

Validated

**SDG:** 180512-41  
**Location:** HP

**Client Reference:** 602128  
**Order Number:** P2021483

**Report Number:** 457687  
**Superseded Report:** 457479

Results Legend			Customer Sample Ref.		BH3	BH4	BH6	BH9/07	BH12/07	BH13/08
# ISO17025 accredited. M mCERTS accredited. aq Aqueous / settled sample. diss.filt Dissolved / filtered sample. tot.unfilt Total / unfiltered sample. * Subcontracted test. ** % recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery (F) Trigger breach confirmed 1-5&*\$@ Sample deviation (see appendix)			Depth (m)		Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)
			Sample Type		10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018
			Date Sampled		11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018
			Sampled Time		180512-41	180512-41	180512-41	180512-41	180512-41	180512-41
			Date Received		17543971	17543972	17543973	17543970	17543974	17543975
			SDG Ref							
			Lab Sample No.(s)							
			AGS Reference							
Component	LOD/Units	Method								
Ammoniacal Nitrogen as N	<0.2 mg/l	TM099	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ammoniacal Nitrogen as NH4	<0.3 mg/l	TM099	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Sulphide	<0.01 mg/l	TM101	<0.01	<0.01	<0.01	<0.01	0.0237	0.0542	<0.01	<0.01
Fluoride	<0.5 mg/l	TM104	1.33	<0.5	<0.5	<0.5	<0.5	1.01	<0.5	<0.5
Arsenic (diss.filt)	<0.5 µg/l	TM152	0.733	0.588	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium (diss.filt)	<0.08 µg/l	TM152	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Chromium (diss.filt)	<1 µg/l	TM152	<1	2.88	<1	<1	<1	<1	<1	<1
Copper (diss.filt)	<0.3 µg/l	TM152	<0.3	0.545	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Lead (diss.filt)	<0.2 µg/l	TM152	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel (diss.filt)	<0.4 µg/l	TM152	<0.4	3	0.584	<0.4	<0.4	<0.4	<0.4	0.646
Selenium (diss.filt)	<1 µg/l	TM152	<1	1.08	<1	<1	<1	<1	<1	1.56
Zinc (diss.filt)	<1 µg/l	TM152	1.34	3.02	1.52	<1	<1	<1	<1	<1
Mercury (diss.filt)	<0.01 µg/l	TM183	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chloride	<2 mg/l	TM184	32.9	18	15.8	17.2	24.7	22		
Cyanide, Total	<0.05 mg/l	TM227	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium, Hexavalent	<0.03 mg/l	TM241	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
pH	<1 pH Units	TM256	7.86	7.37	7.88	7.65	7.85	7.69		
Phenol	<0.002 mg/l	TM259	<0.002	0.03	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cresols	<0.006 mg/l	TM259	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Xylenols	<0.008 mg/l	TM259	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Phenols, Total Detected monohydric	<0.016 mg/l	TM259	<0.016	0.03	<0.016	<0.016	<0.016	<0.016	<0.016	<0.016

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# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## PAH Spec MS - Aqueous (W)

Results Legend			Customer Sample Ref.	BH3	BH4	BH6	BH9/07	BH12/07	BH13/08	
#	ISO17025 accredited.		Depth (m) Sample Type Date Sampled Sampled Time Date Received SDG Ref Lab Sample No.(s) AGS Reference	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	
M	mCERTS accredited.			10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018
aq	Aqueous / settled sample.			11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018
diss.filt	Dissolved / filtered sample.			180512-41	180512-41	180512-41	180512-41	180512-41	180512-41	180512-41
tot.unfilt	Total / unfiltered sample.			17543971	17543972	17543973	17543970	17543974	17543975	17543975
*	Subcontracted test.									
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery									
(F)	Trigger breach confirmed									
1-5&*\$@	Sample deviation (see appendix)									
Component	LOD/Units	Method								
Naphthalene (aq)	<0.01 µg/l	TM178		0.0105	<0.01	0.0117	0.0143	0.0141	0.0123	
Acenaphthene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Acenaphthylene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Fluoranthene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	0.0059	<0.005	
Anthracene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Phenanthrene (aq)	<0.005 µg/l	TM178		0.0057	0.00551	0.00775	0.00757	0.0114	0.00901	
Fluorene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Chrysene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Pyrene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	0.00789	<0.005	
Benzo(a)anthracene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Benzo(b)fluoranthene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Benzo(k)fluoranthene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Benzo(a)pyrene (aq)	<0.002 µg/l	TM178		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
Dibenzo(a,h)anthracene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Benzo(g,h,i)perylene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Indeno(1,2,3-cd)pyrene (aq)	<0.005 µg/l	TM178		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
PAH, Total Detected USEPA 16 (aq)	<0.082 µg/l	TM178		<0.082	<0.082	<0.082	<0.082	<0.082	<0.082	

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# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## TPH CWG (W)

Results Legend			Customer Sample Ref.	BH3	BH4	BH6	BH9/07	BH12/07	BH13/08
#	ISO17025 accredited.								
M	mCERTS accredited.								
aq	Aqueous / settled sample.								
diss.filt	Dissolved / filtered sample.								
tot.unfilt	Total / unfiltered sample.								
*	Subcontracted test.								
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery								
(F)	Trigger breach confirmed								
1-5&*\$@	Sample deviation (see appendix)								
Component	LOD/Units	Method	Depth (m)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)
GRO Surrogate % recovery**	%	TM245	10/05/2018	98	99	91	91	101	100
GRO >C5-C12	<50 µg/l	TM245	11/05/2018	<50	<50	<50	<50	<50	<50
Methyl tertiary butyl ether (MTBE)	<3 µg/l	TM245	180512-41	<3	<3	<3	<3	<3	<3
Benzene	<7 µg/l	TM245	17543971	<7	<7	<7	<7	<7	<7
Toluene	<4 µg/l	TM245	180512-41	<4	<4	<4	<4	<4	<4
Ethylbenzene	<5 µg/l	TM245	17543972	<5	<5	<5	<5	<5	<5
m,p-Xylene	<8 µg/l	TM245		<8	<8	<8	<8	<8	<8
o-Xylene	<3 µg/l	TM245		<3	<3	<3	<3	<3	<3
Sum of detected Xylenes	<11 µg/l	TM245		<11	<11	<11	<11	<11	<11
Sum of detected BTEX	<28 µg/l	TM245		<28	<28	<28	<28	<28	<28
Aliphatics >C5-C6	<10 µg/l	TM245		<10	<10	<10	<10	<10	<10
Aliphatics >C6-C8	<10 µg/l	TM245		<10	<10	<10	<10	<10	<10
Aliphatics >C8-C10	<10 µg/l	TM245		<10	<10	<10	<10	<10	<10
Aliphatics >C10-C12	<10 µg/l	TM245		<10	<10	<10	<10	<10	<10
Aliphatics >C12-C16 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Aliphatics >C16-C21 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Aliphatics >C21-C35 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Total Aliphatics >C12-C35 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Aromatics >EC5-EC7	<10 µg/l	TM245		<10	<10	<10	<10	<10	<10
Aromatics >EC7-EC8	<10 µg/l	TM245		<10	<10	<10	<10	<10	<10
Aromatics >EC8-EC10	<10 µg/l	TM245		<10	<10	<10	<10	<10	<10
Aromatics >EC10-EC12	<10 µg/l	TM245		<10	<10	<10	<10	<10	<10
Aromatics >EC12-EC16 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Aromatics >EC16-EC21 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Aromatics >EC21-EC35 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Total Aromatics >EC12-EC35 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Total Aliphatics & Aromatics >C5-35 (aq)	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10
Aliphatics >C16-C35 Aqueous	<10 µg/l	TM174		<10	<10	<10	<10	<10	<10



# CERTIFICATE OF ANALYSIS

Validated

**SDG:** 180512-41  
**Location:** HP

**Client Reference:** 602128  
**Order Number:** P2021483

**Report Number:** 457687  
**Superseded Report:** 457479

**VOC MS (W)**

Results Legend			Customer Sample Ref.		BH3	BH4	BH6	BH9/07	BH12/07	BH13/08
# ISO17025 accredited. M mCERTS accredited. aq Aqueous / settled sample. diss.filt Dissolved / filtered sample. tot.unfilt Total / unfiltered sample. * Subcontracted test. ** % recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery (F) Trigger breach confirmed 1-5&*\$@ Sample deviation (see appendix)	Depth (m)	Sample Type	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)
	Date Sampled	Date Sampled	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018
	Date Received	Date Received	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018
	SDG Ref	SDG Ref	180512-41	180512-41	180512-41	180512-41	180512-41	180512-41	180512-41	180512-41
	Lab Sample No.(s)	Lab Sample No.(s)	17543971	17543972	17543973	17543970	17543974	17543974	17543975	17543975
	AGS Reference	AGS Reference								
Component	LOD/Units	Method								
Dibromofluoromethane**	%	TM208	108	119	114	107	110	109		
Toluene-d8**	%	TM208	96.8	94.2	94.8	97.7	96.9	97.1		
4-Bromofluorobenzene**	%	TM208	94.9	93.7	97.7	96.4	96.1	94.7		
Dichlorodifluoromethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Chloromethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Vinyl chloride	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Bromomethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Chloroethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Trichlorofluoromethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
1,1-Dichloroethene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Carbon disulphide	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Dichloromethane	<3 µg/l	TM208	<3	<3	<3	<3	<3	<3		
Methyl tertiary butyl ether (MTBE)	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
trans-1,2-Dichloroethene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
1,1-Dichloroethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
cis-1,2-Dichloroethene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
2,2-Dichloropropane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Bromochloromethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Chloroform	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
1,1,1-Trichloroethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
1,1-Dichloropropene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Carbontetrachloride	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
1,2-Dichloroethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Benzene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Trichloroethene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
1,2-Dichloropropane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Dibromomethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Bromodichloromethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
cis-1,3-Dichloropropene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
Toluene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
trans-1,3-Dichloropropene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		
1,1,2-Trichloroethane	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1		

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# CERTIFICATE OF ANALYSIS

Validated

**SDG:** 180512-41  
**Location:** HP

**Client Reference:** 602128  
**Order Number:** P2021483

**Report Number:** 457687  
**Superseded Report:** 457479

**VOC MS (W)**

Results Legend			Customer Sample Ref.	BH3	BH4	BH6	BH9/07	BH12/07	BH13/08	
#	ISO17025 accredited.		Depth (m) Sample Type Date Sampled Sampled Time Date Received SDG Ref Lab Sample No.(s) AGS Reference	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	
M	mCERTS accredited.			10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018
aq	Aqueous / settled sample.			11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018
diss.filt	Dissolved / filtered sample.			180512-41	180512-41	180512-41	180512-41	180512-41	180512-41	180512-41
tot.unfilt	Total / unfiltered sample.			17543971	17543972	17543973	17543970	17543970	17543974	17543975
*	Subcontracted test.									
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery									
(F)	Trigger breach confirmed									
1-5&*\$@	Sample deviation (see appendix)									
Component	LOD/Units	Method								
1,3-Dichloropropane	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Tetrachloroethene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Dibromochloromethane	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,2-Dibromoethane	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Chlorobenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,1,1,2-Tetrachloroethane	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Ethylbenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
m,p-Xylene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
o-Xylene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Styrene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Bromoform	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Isopropylbenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,1,2,2-Tetrachloroethane	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,2,3-Trichloropropane	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Bromobenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Propylbenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
2-Chlorotoluene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,3,5-Trimethylbenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
4-Chlorotoluene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
tert-Butylbenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,2,4-Trimethylbenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
sec-Butylbenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
4-iso-Propyltoluene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,3-Dichlorobenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,4-Dichlorobenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
n-Butylbenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,2-Dichlorobenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,2-Dibromo-3-chloropropane	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
1,2,4-Trichlorobenzene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Hexachlorobutadiene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
tert-Amyl methyl ether (TAME)	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	
Naphthalene	<1 µg/l	TM208		<1	<1	<1	<1	<1	<1	

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# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41 Client Reference: 602128 Report Number: 457687  
Location: HP Order Number: P2021483 Superseded Report: 457479

### VOC MS (W)

Results Legend			Customer Sample Ref.	BH3	BH4	BH6	BH9/07	BH12/07	BH13/08
#	ISO17025 accredited.		Customer Sample Ref.  Depth (m) Sample Type Date Sampled Sampled Time Date Received SDG Ref Lab Sample No.(s) AGS Reference						
M	mCERTS accredited.			Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)
aq	Aqueous / settled sample.			10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018	10/05/2018
diss.filt	Dissolved / filtered sample.								
tot.unfilt	Total / unfiltered sample.			11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018	11/05/2018
*	Subcontracted test.			180512-41	180512-41	180512-41	180512-41	180512-41	180512-41
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery			17543971	17543972	17543973	17543970	17543974	17543975
(F)	Trigger breach confirmed								
1-5&*\$@	Sample deviation (see appendix)								
Component	LOD/Units	Method							
1,2,3-Trichlorobenzene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1	
1,3,5-Trichlorobenzene	<1 µg/l	TM208	<1	<1	<1	<1	<1	<1	

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# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Table of Results - Appendix

Method No	Reference	Description
TM061	Method for the Determination of EPH, Massachusetts Dept. of EP, 1998	Determination of Extractable Petroleum Hydrocarbons by GC-FID (C10-C40)
TM099	BS 2690: Part 7:1968 / BS 6068: Part 2.11:1984	Determination of Ammonium in Water Samples using the Kone Analyser
TM101	Method 4500B & C, AWWA/APHA, 20th Ed., 1999	Determination of Sulphide in soil and water samples using the Kone Analyser
TM104	Method 4500F, AWWA/APHA, 20th Ed., 1999	Determination of Fluoride using the Kone Analyser
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS
TM174	Analysis of Petroleum Hydrocarbons in Environmental Media – Total Petroleum Hydrocarbon Criteria	Determination of Speciated Extractable Petroleum Hydrocarbons in Waters by GC-FID
TM178	Modified: US EPA Method 8100	Determination of Polynuclear Aromatic Hydrocarbons (PAH) by GC-MS in Waters
TM183	BS EN 23506:2002, (BS 6068-2.74:2002) ISBN 0 580 38924 3	Determination of Trace Level Mercury in Waters and Leachates by PSA Cold Vapour Atomic Fluorescence Spectrometry
TM184	EPA Methods 325.1 & 325.2,	The Determination of Anions in Aqueous Matrices using the Kone Spectrophotometric Analysers
TM208	Modified: US EPA Method 8260b & 624	Determination of Volatile Organic Compounds by Headspace / GC-MS in Waters
TM227	Standard methods for the examination of waters and wastewaters 20th Edition, AWWA/APHA Method 4500.	Determination of Total Cyanide, Free (Easily Liberatable) Cyanide and Thiocyanate
TM241	Methods for the Examination of Waters and Associated Materials; Chromium in Raw and Potable Waters and Sewage Effluents 1980.	The Determination of Hexavalent Chromium in Waters and Leachates using the Kone Analyser
TM245	By GC-FID	Determination of GRO by Headspace in waters
TM256	The measurement of Electrical Conductivity and the Laboratory determination of pH Value of Natural, Treated and Wastewaters. HMSO, 1978. ISBN 011 751428 4.	Determination of pH in Water and Leachate using the GLpH pH Meter
TM259	by HPLC	Determination of Phenols in Waters and Leachates by HPLC

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NA = not applicable.

Chemical testing (unless subcontracted) performed at ALS Environmental Hawarden (Method codes TM) or ALS Environmental Aberdeen (Method codes S).



# CERTIFICATE OF ANALYSIS

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SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Test Completion Dates

Lab Sample No(s)	17543971	17543972	17543973	17543970	17543974	17543975
Customer Sample Ref.	BH3	BH4	BH6	BH9/07	BH12/07	BH13/08
AGS Ref.						
Depth						
Type	Unspecified Liq	Unspecified Liq	Unspecified Liq	Unspecified Liq	Unspecified Liq	Unspecified Liq

Ammoniacal Nitrogen	14-May-2018	15-May-2018	14-May-2018	14-May-2018	14-May-2018	14-May-2018
Anions by Kone (w)	25-May-2018	25-May-2018	25-May-2018	25-May-2018	25-May-2018	25-May-2018
Cyanide Comp/Free/Total/Thiocyanate	16-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018
Dissolved Metals by ICP-MS	16-May-2018	16-May-2018	15-May-2018	15-May-2018	16-May-2018	16-May-2018
EPH CWG (Aliphatic) Aqueous GC (W)	16-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018
EPH CWG (Aromatic) Aqueous GC (W)	16-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018
Fluoride	25-May-2018	25-May-2018	25-May-2018	25-May-2018	25-May-2018	25-May-2018
GRO by GC-FID (W)	15-May-2018	15-May-2018	15-May-2018	15-May-2018	15-May-2018	15-May-2018
Hexavalent Chromium (w)	14-May-2018	15-May-2018	14-May-2018	14-May-2018	14-May-2018	14-May-2018
Mercury Dissolved	15-May-2018	15-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018
PAH Spec MS - Aqueous (W)	15-May-2018	17-May-2018	15-May-2018	15-May-2018	15-May-2018	15-May-2018
pH Value	14-May-2018	14-May-2018	14-May-2018	14-May-2018	14-May-2018	14-May-2018
Phenols by HPLC (W)	14-May-2018	16-May-2018	15-May-2018	14-May-2018	16-May-2018	16-May-2018
Sulphide	16-May-2018	16-May-2018	14-May-2018	16-May-2018	16-May-2018	14-May-2018
TPH CWG (W)	16-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018	16-May-2018
VOC MS (W)	14-May-2018	14-May-2018	14-May-2018	14-May-2018	14-May-2018	14-May-2018

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# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W)

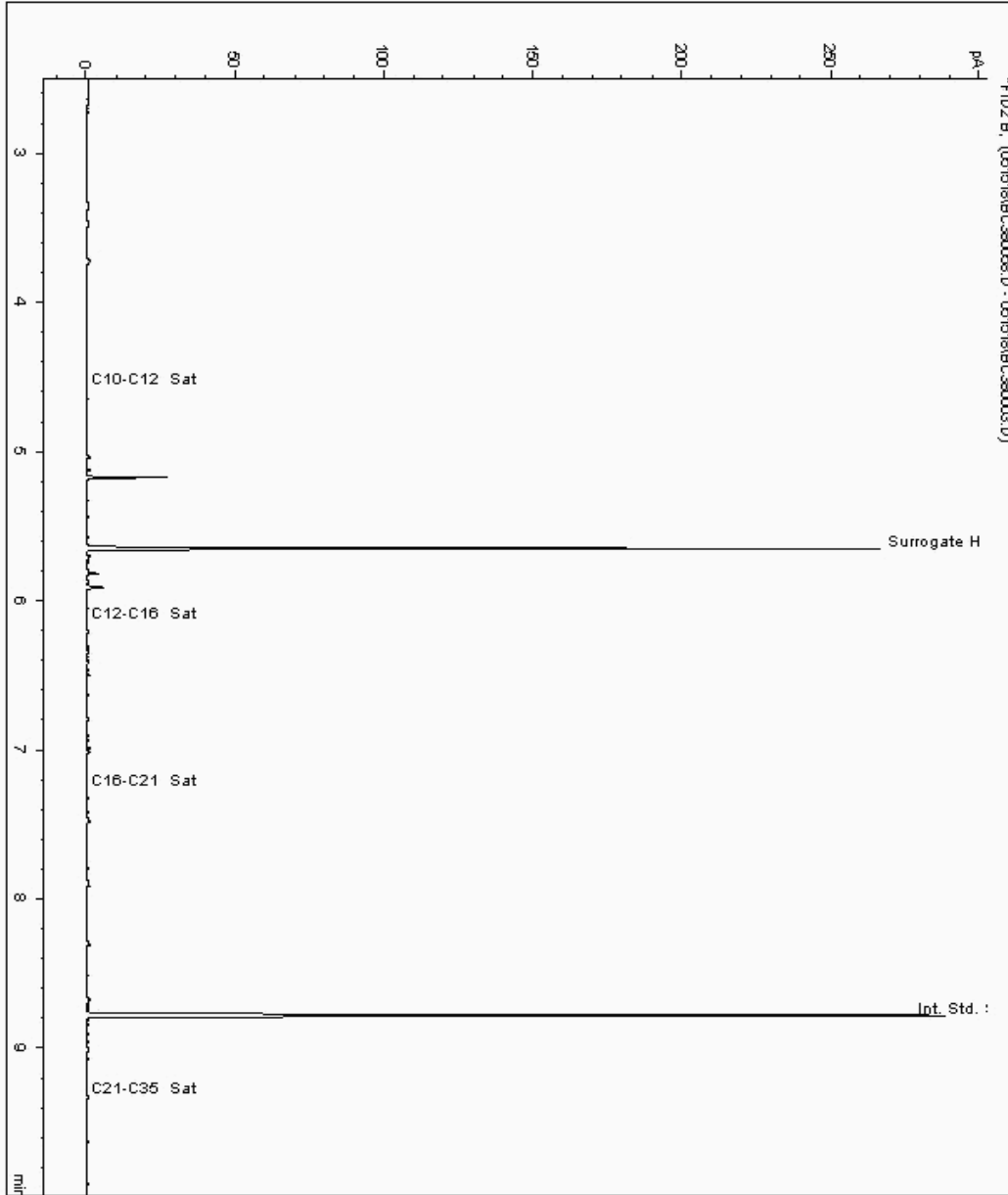
Sample No : 17545765  
Sample ID : BH4

Depth :

RECEIVED: 18/07/2023

Speciated TPH - SATS ( C12 - C40 )

Sample Identity: 16482955-  
Date Acquired : 16/05/18 09:47:07 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG:	180512-41	Client Reference:	602128	Report Number:	457687
Location:	HP	Order Number:	P2021483	Superseded Report:	457479

## Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W)

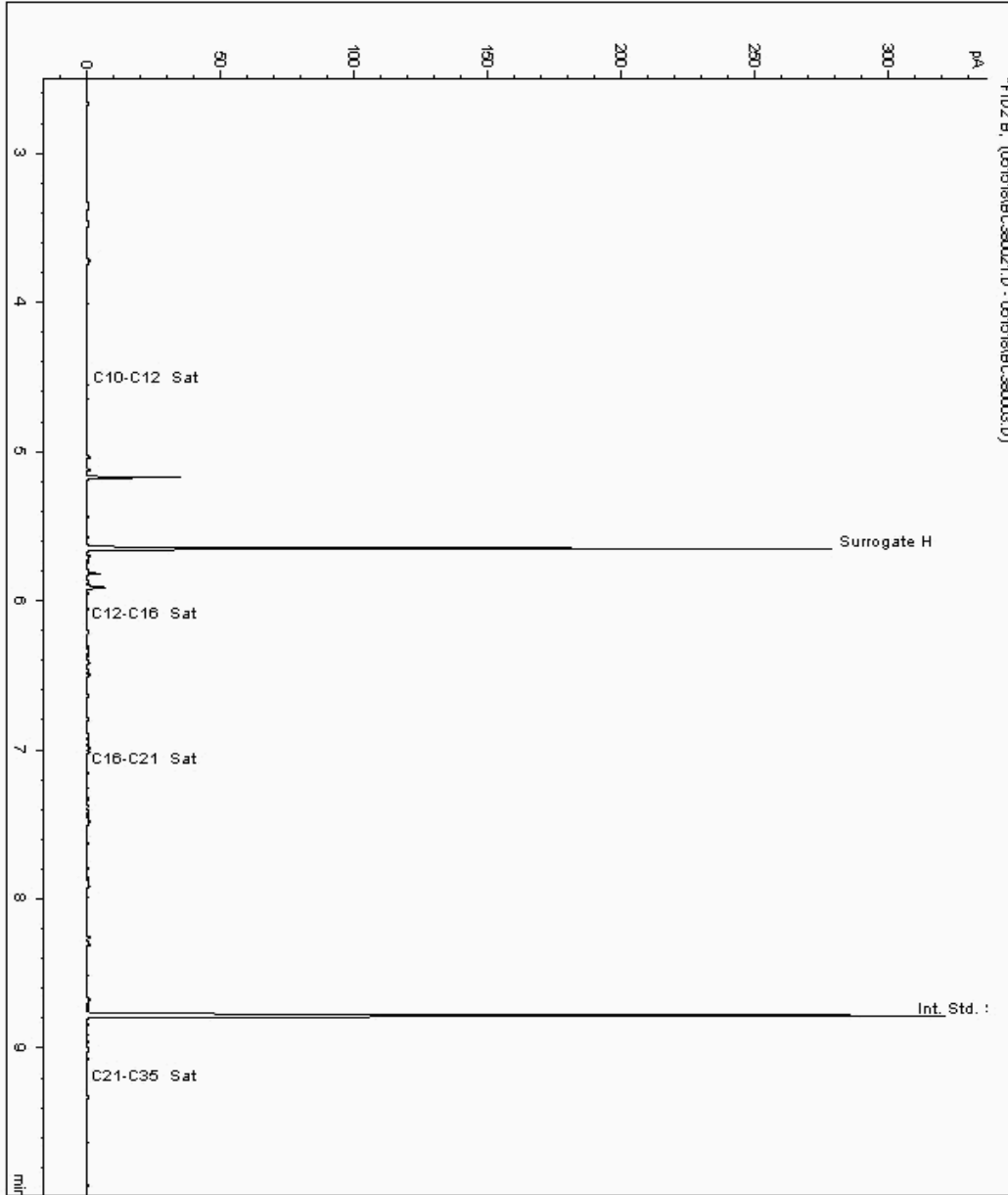
Sample No : 17545770  
Sample ID : BH3

Depth :

RECEIVED: 18/07/2023

Speciated TPH - SATS ( C12 - C40 )

Sample Identity: 16482940-  
 Date Acquired : 15/05/18 21:27:18 PM  
 Units : ppb  
 Dilution :  
 CF : 1  
 Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W)

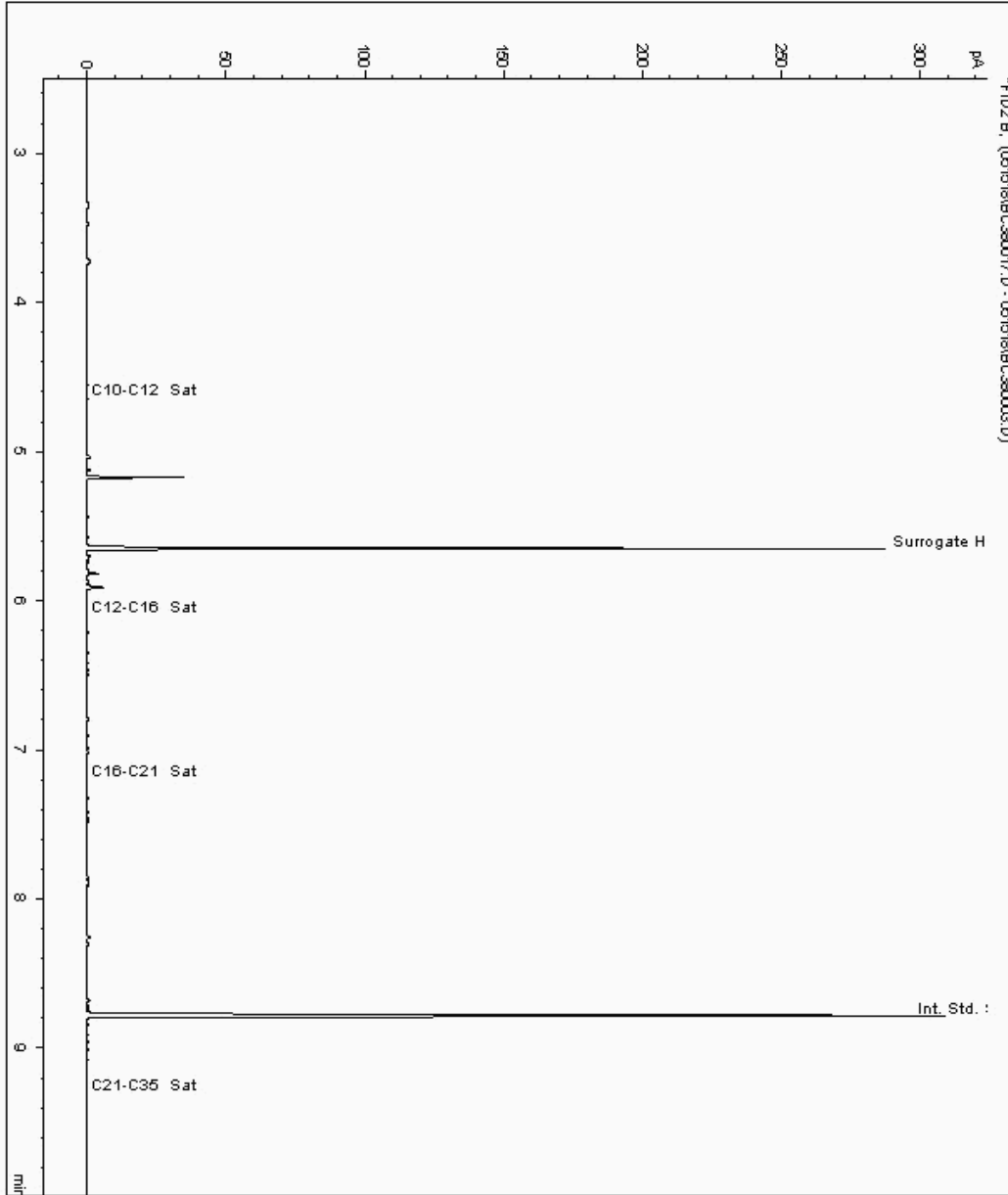
Sample No : 17545773  
Sample ID : BH12/07

Depth :

RECEIVED: 18/07/2023

Speciated TPH - SATS ( C12 - C40 )

Sample Identity: 16482985-  
Date Acquired : 15/05/18 19:54:49 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W)

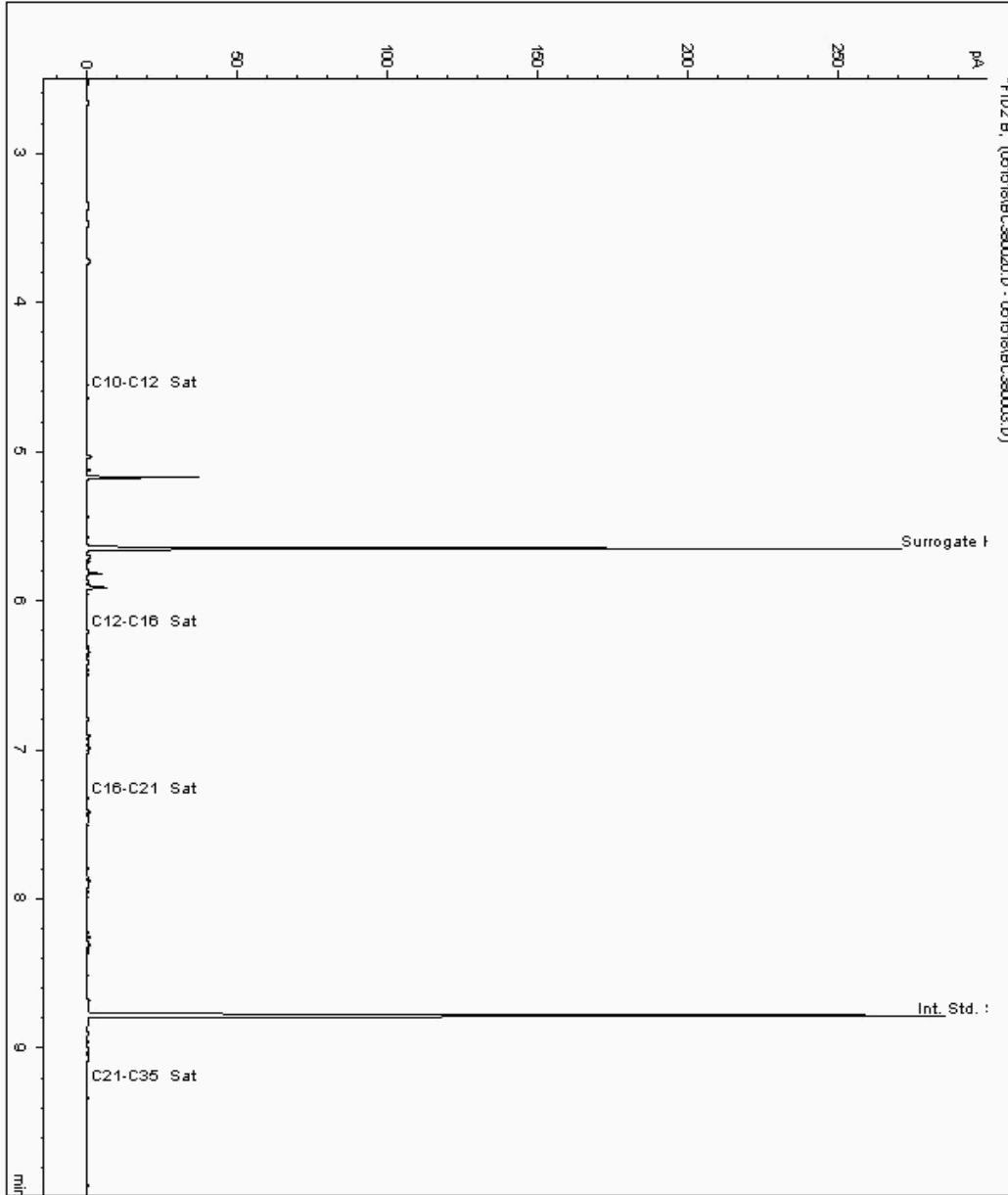
Sample No : 17545776  
Sample ID : BH6

Depth :

RECEIVED: 18/07/2023

Speciated TPH - SATS ( C12 - C40 )

Sample Identity: 16482970-  
Date Acquired : 15/05/18 21:04:02 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W)

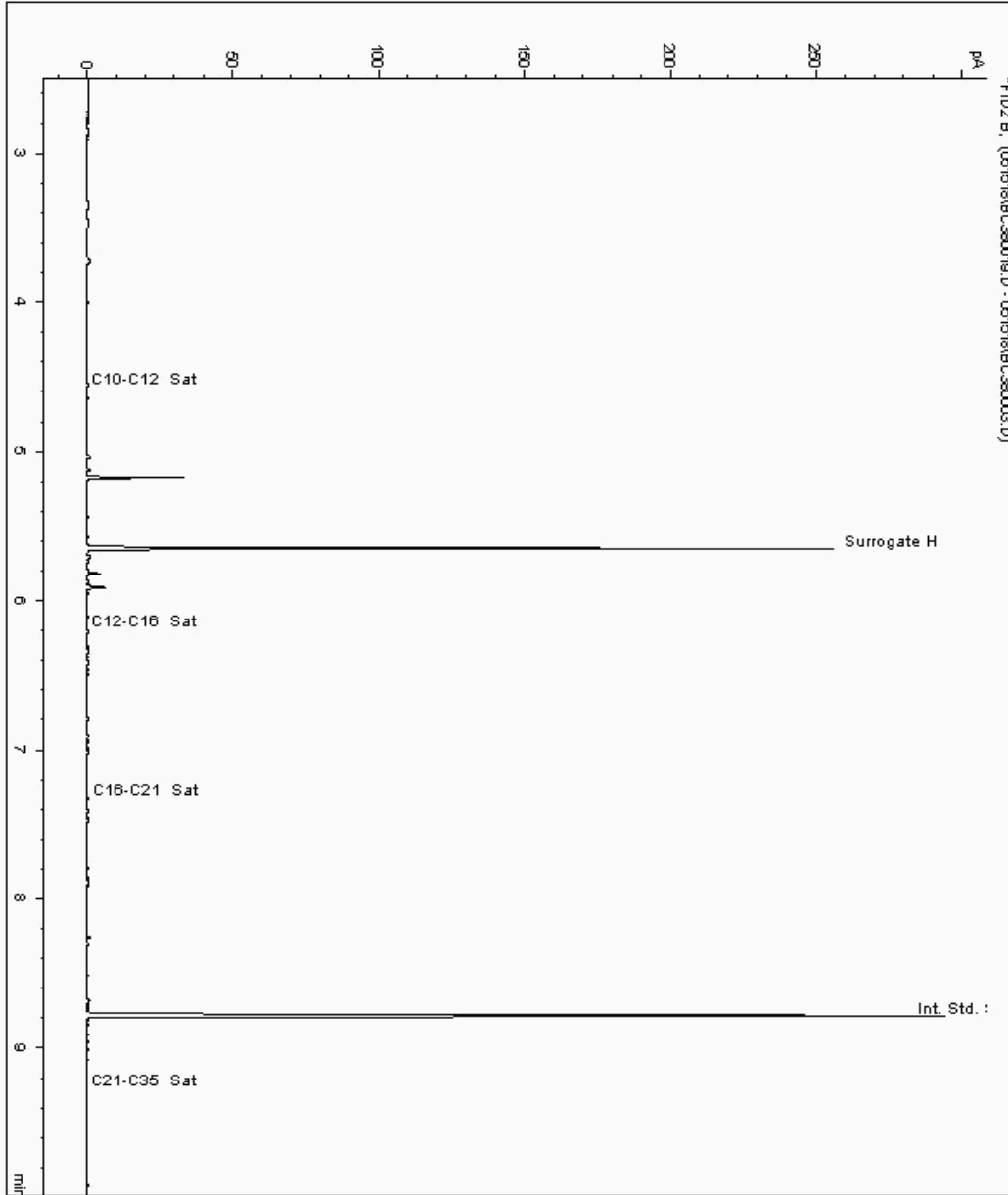
Sample No : 17545778  
Sample ID : BH9/07

Depth :

RECEIVED: 18/07/2023

Speciated TPH - SATS ( C12 - C40 )

Sample Identity: 16482925-  
Date Acquired : 15/05/18 20:40:44 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aliphatic) Aqueous GC (W)

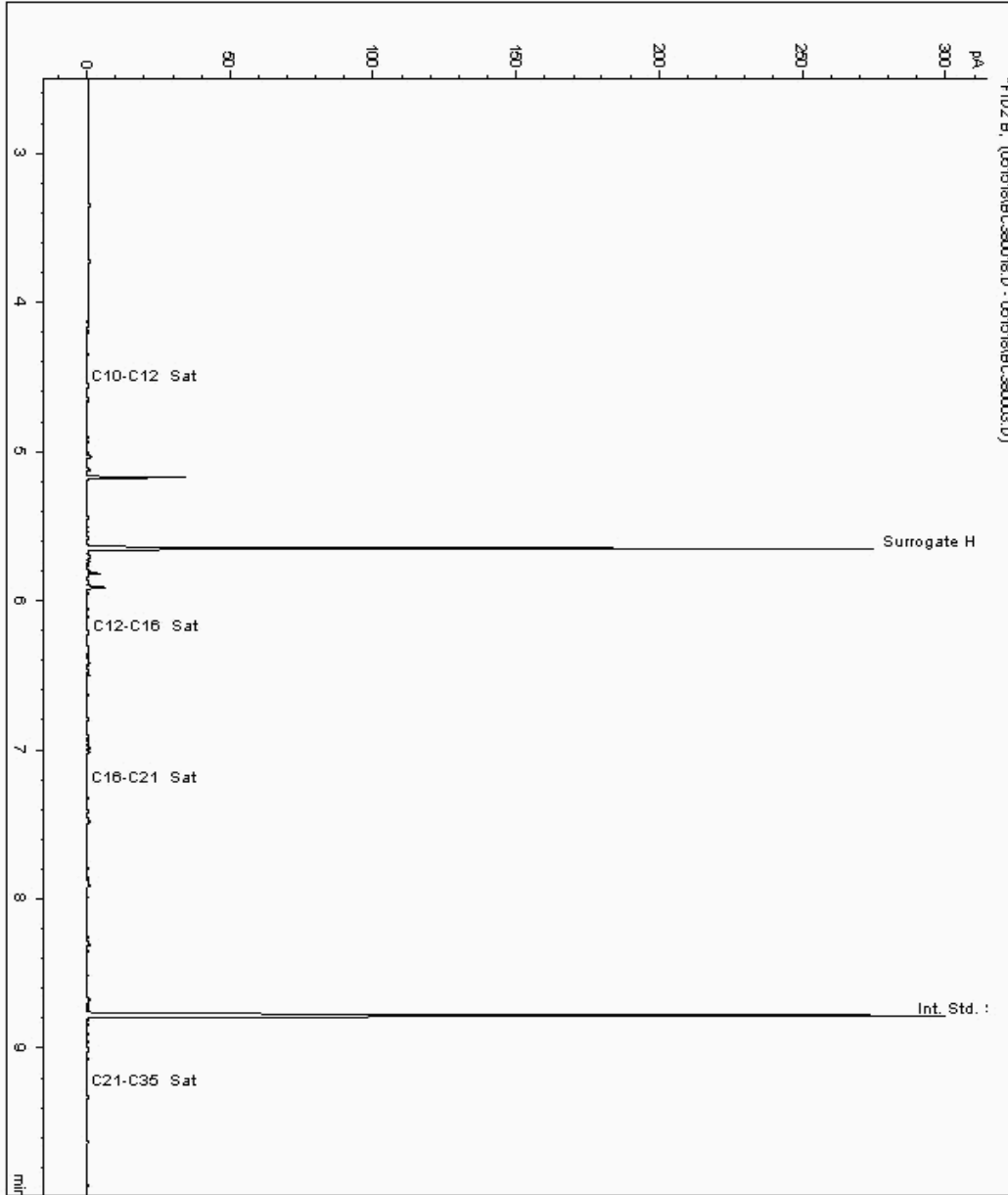
Sample No : 17545793  
Sample ID : BH13/08

Depth :

RECEIVED: 18/07/2023

Speciated TPH - SATS ( C12 - C40 )

Sample Identity: 16483000-  
Date Acquired : 15/05/18 20:17:42 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025







# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W)

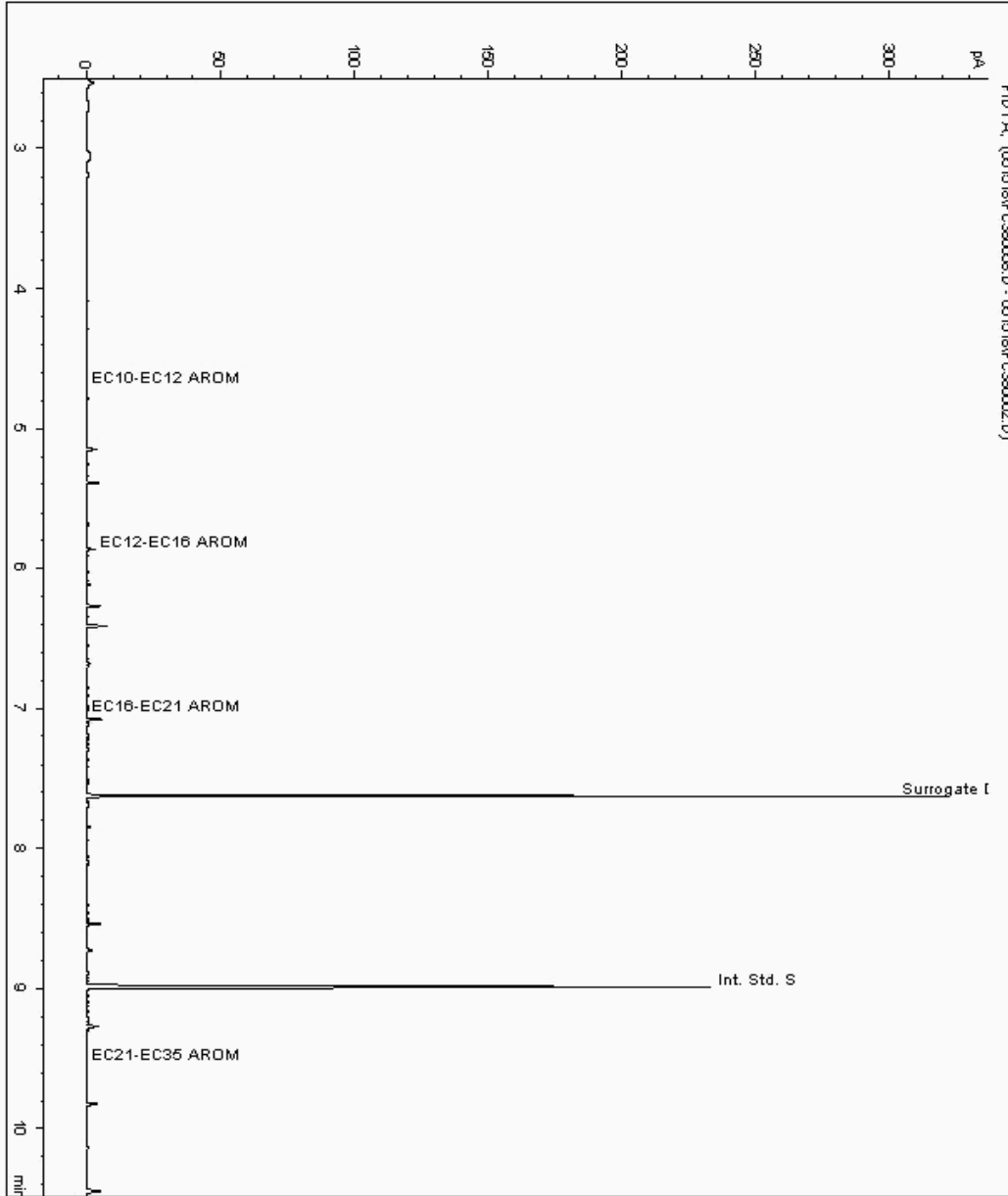
Sample No : 17545765  
Sample ID : BH4

Depth :

RECEIVED: 18/07/2023

Speciated TPH - AROM ( C12 - C40 )

Sample Identity: 16482956-  
Date Acquired : 16/05/18 09:47:07 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W)

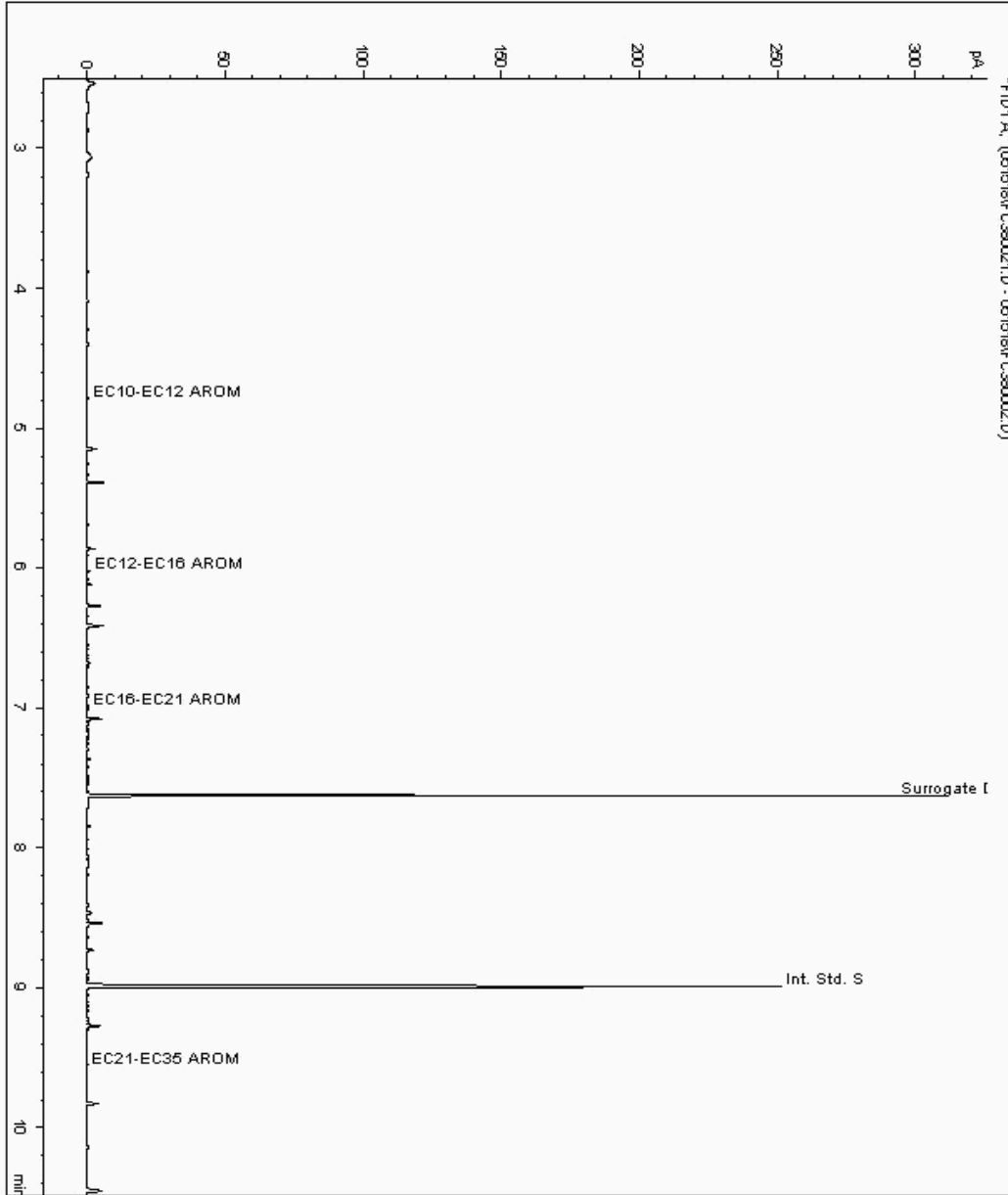
Sample No : 17545770  
Sample ID : BH3

Depth :

RECEIVED: 18/07/2023

Speciated TPH - AROM ( C12 - C40 )

Sample Identity: 16482941-  
Date Acquired : 15/05/18 21:27:18 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W)

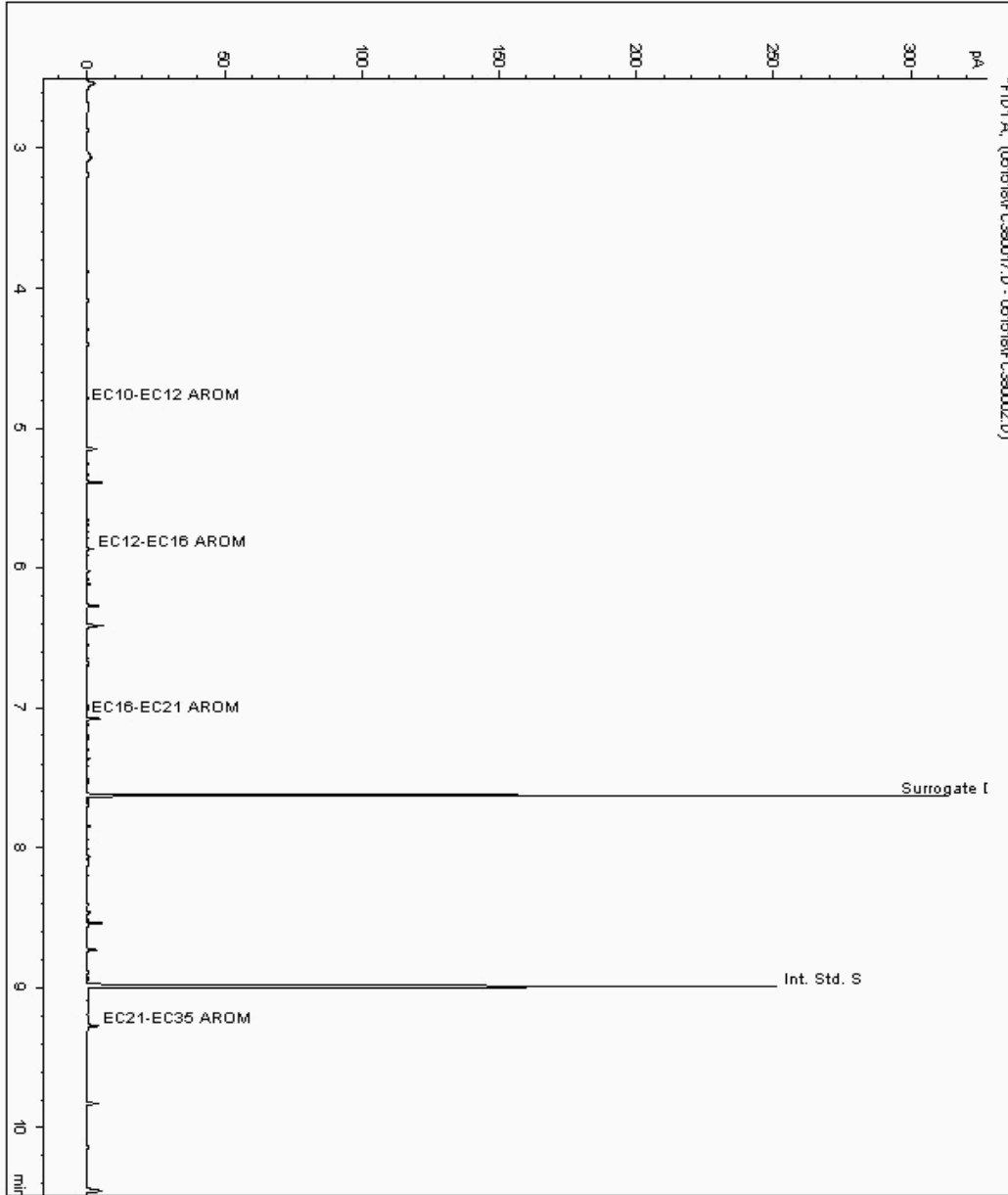
Sample No : 17545773  
Sample ID : BH12/07

Depth :

RECEIVED: 18/07/2023

Speciated TPH - AROM ( C12 - C40 )

Sample Identity: 16482986-  
Date Acquired : 15/05/18 19:54:49 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W)

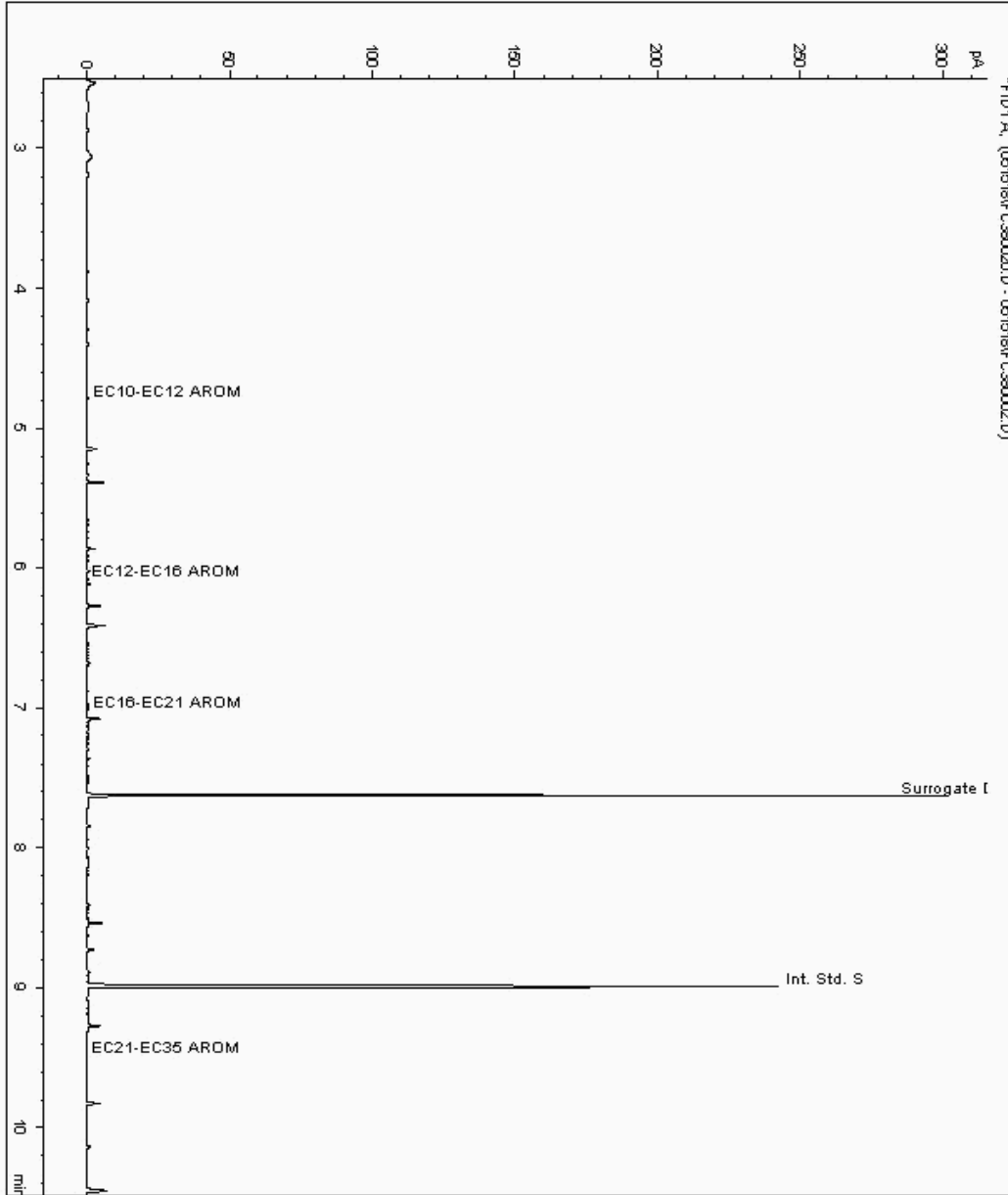
Sample No : 17545776  
Sample ID : BH6

Depth :

RECEIVED: 18/07/2023

Speciated TPH - AROM ( C12 - C40 )

Sample Identity: 16482971-  
Date Acquired : 15/05/18 21:04:02 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W)

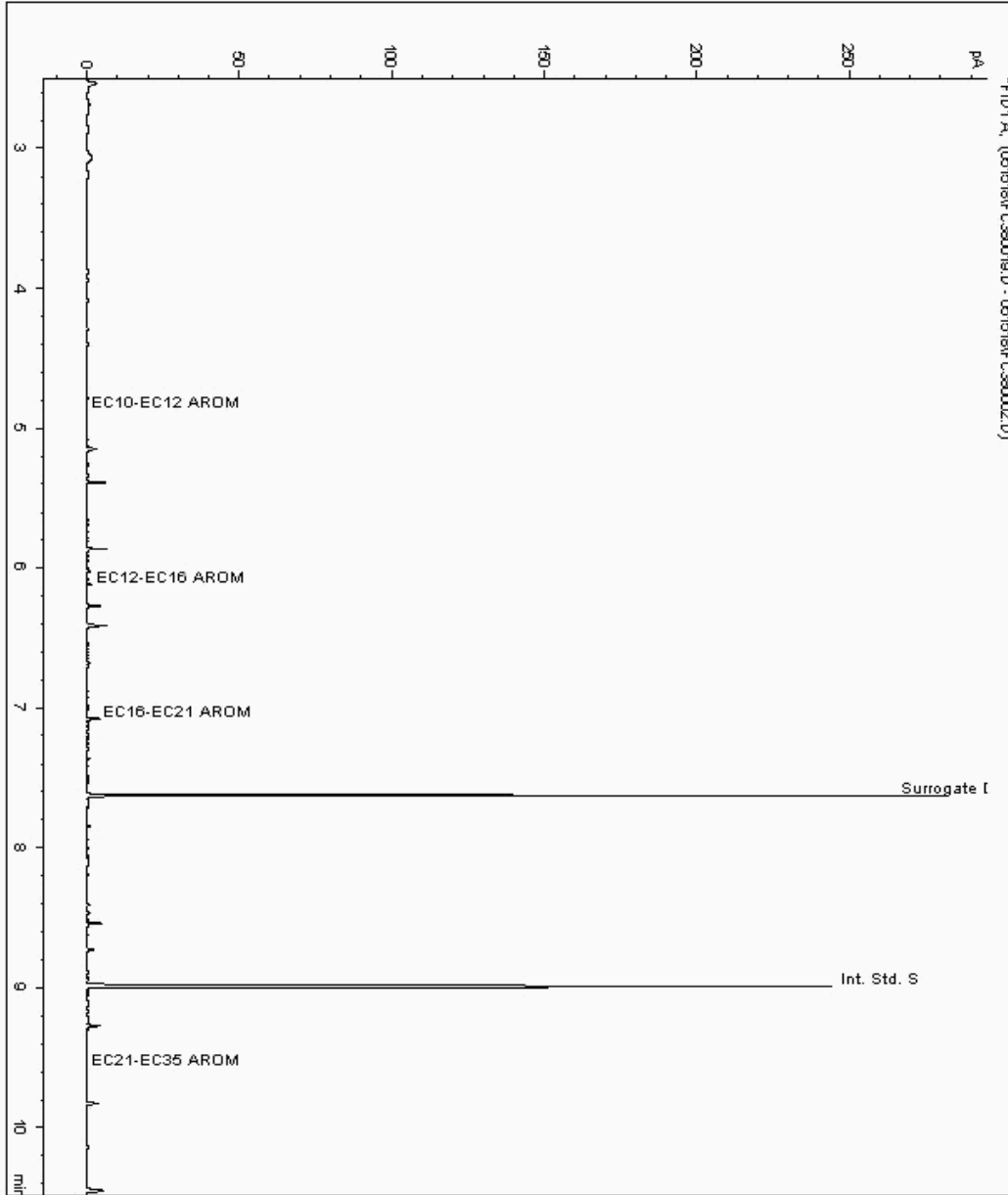
Sample No : 17545778  
Sample ID : BH9/07

Depth :

RECEIVED: 18/07/2023

Speciated TPH - AROM ( C12 - C40 )

Sample Identity: 16482926-  
Date Acquired : 15/05/18 20:40:44 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

## Chromatogram

Analysis: EPH CWG (Aromatic) Aqueous GC (W)

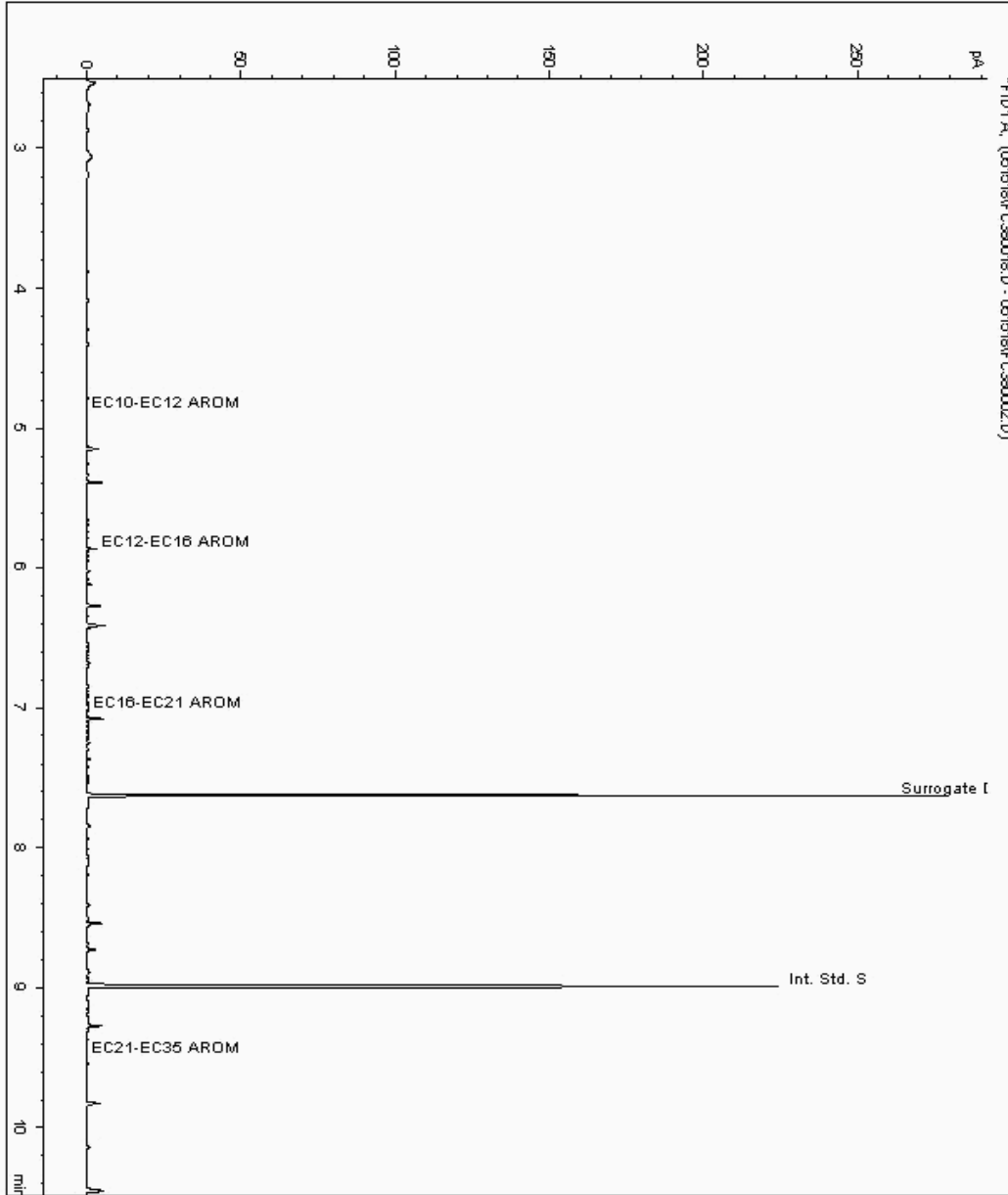
Sample No : 17545793  
Sample ID : BH13/08

Depth :

RECEIVED: 18/07/2023

Speciated TPH - AROM ( C12 - C40 )

Sample Identity: 16483001-  
Date Acquired : 15/05/18 20:17:42 PM  
Units : ppb  
Dilution :  
CF : 1  
Multiplier : 0.025





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

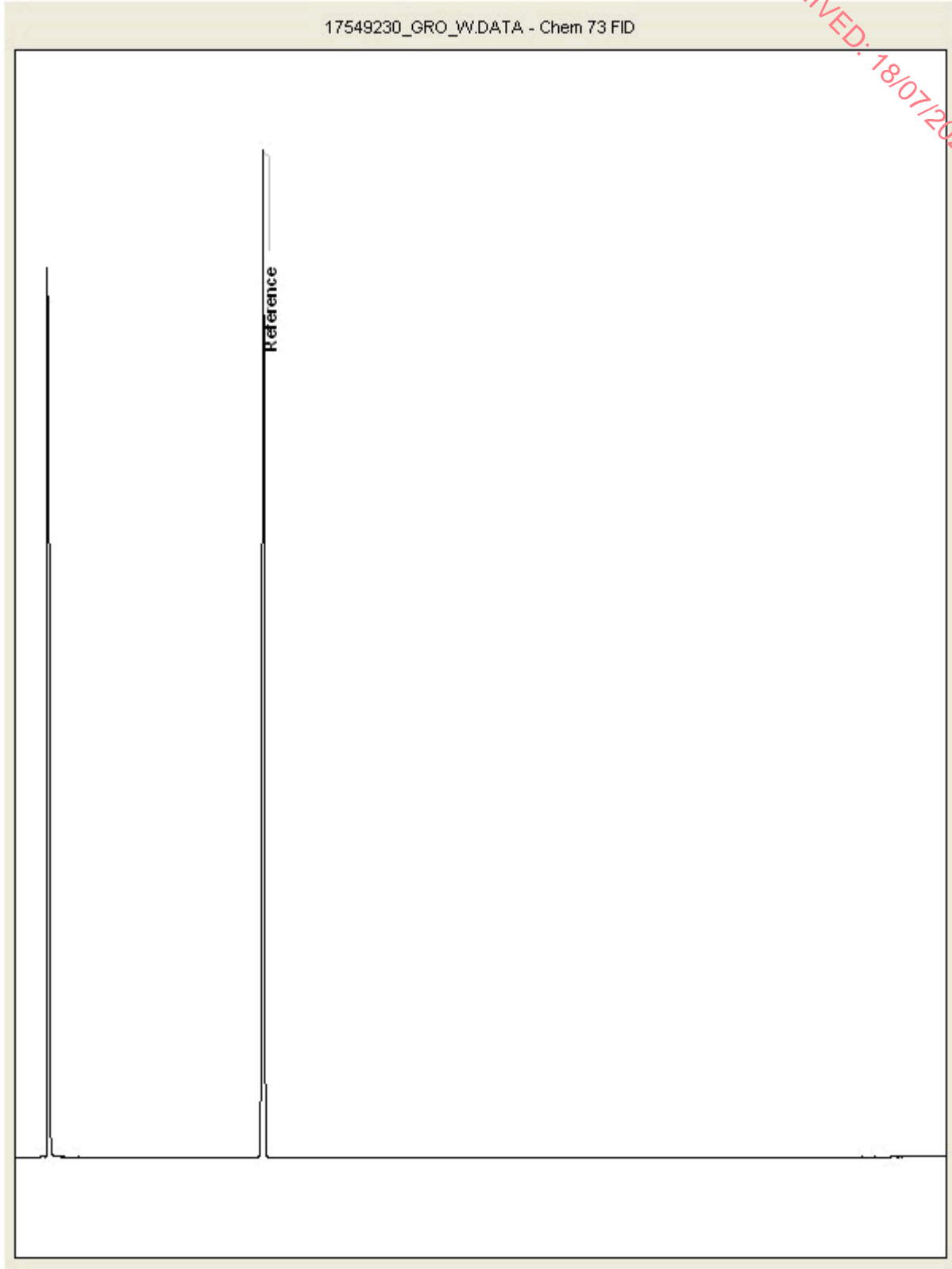
## Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 17549230  
Sample ID : BH4

Depth :

RECEIVED: 18/07/2023





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

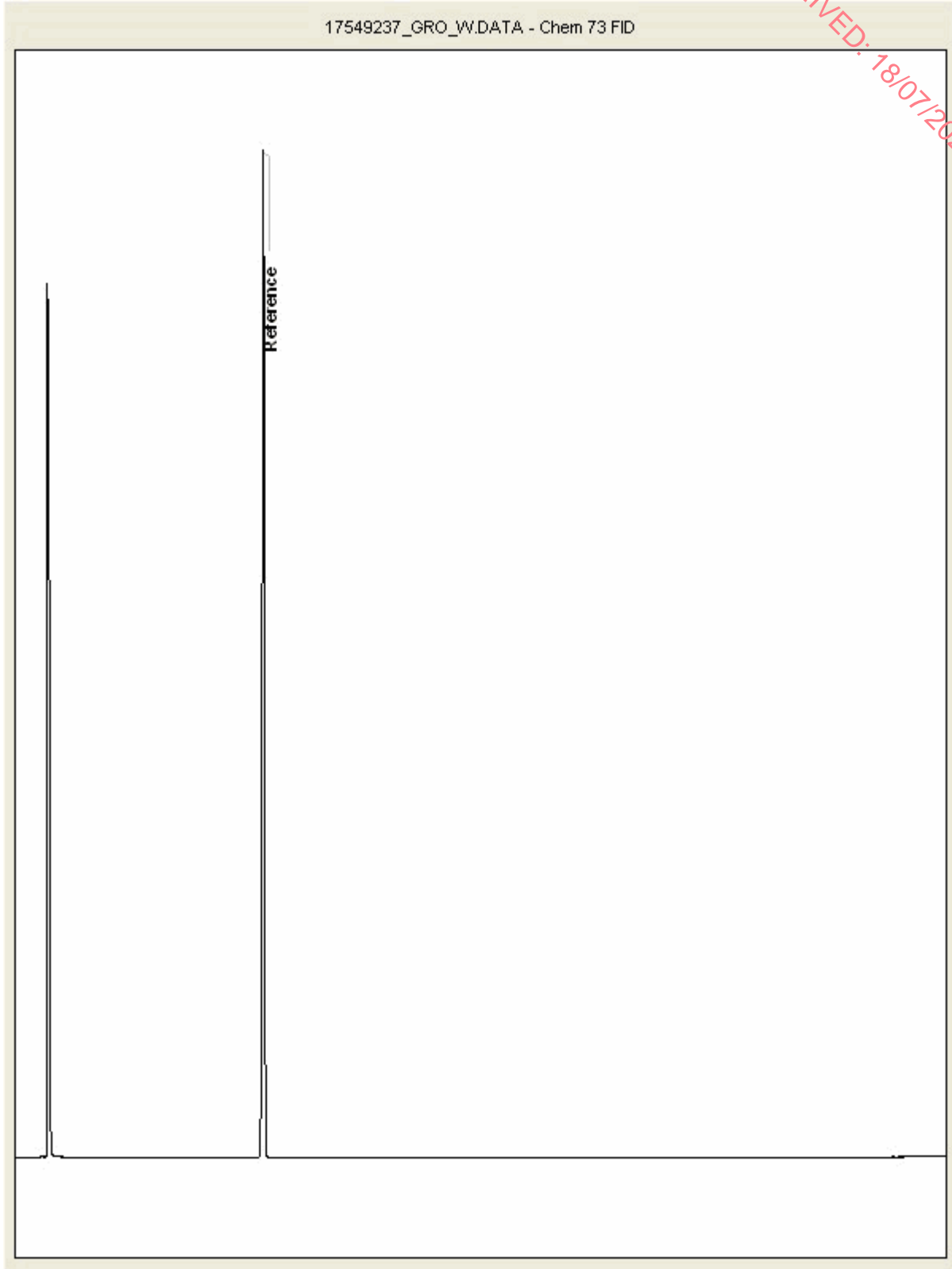
## Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 17549237  
Sample ID : BH12/07

Depth :

RECEIVED: 18/07/2023







# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

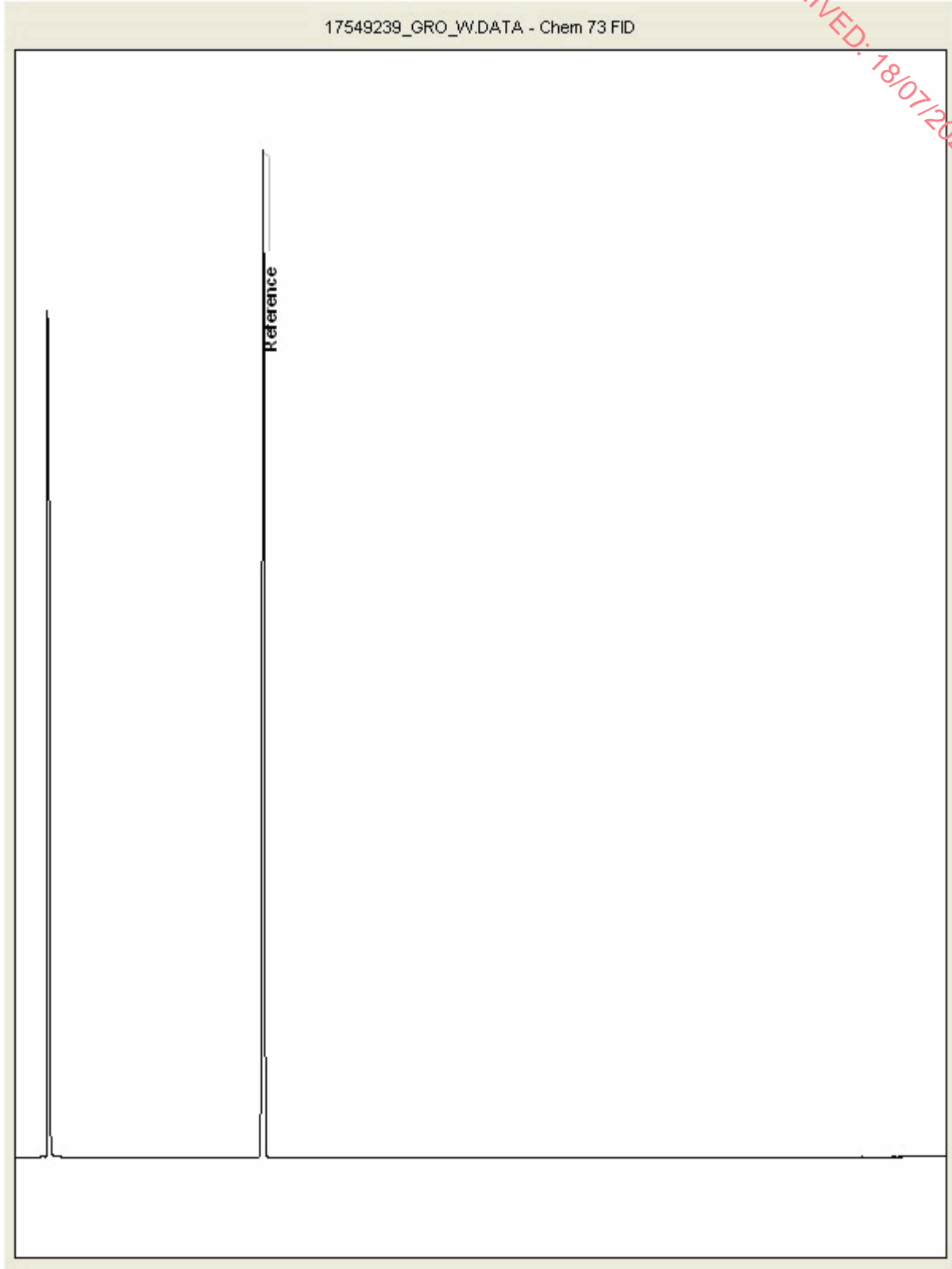
## Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 17549239  
Sample ID : BH13/08

Depth :

RECEIVED: 18/07/2023





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

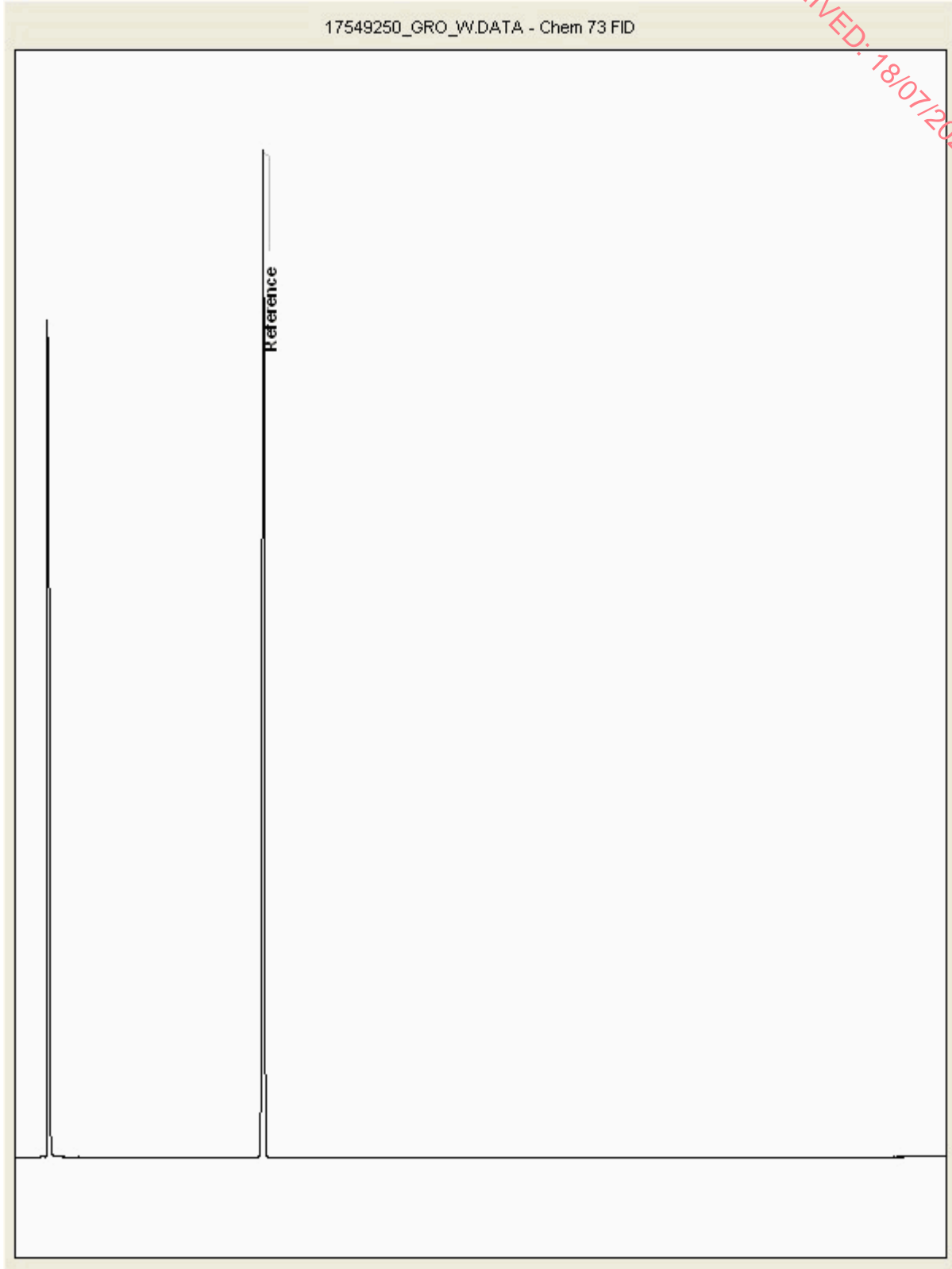
## Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 17549250  
Sample ID : BH3

Depth :

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# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

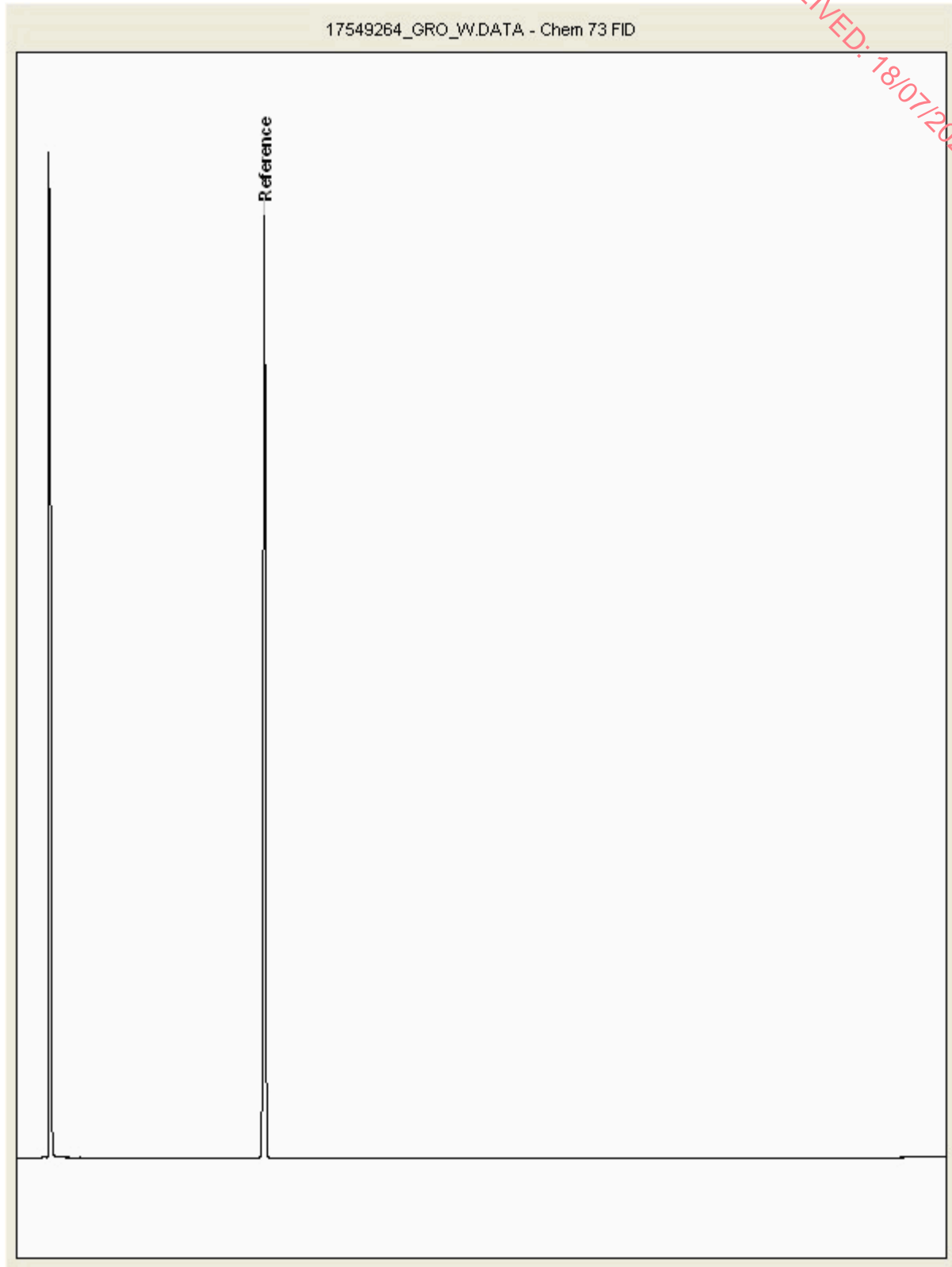
## Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 17549264  
Sample ID : BH9/07

Depth :

RECEIVED: 18/07/2023





# CERTIFICATE OF ANALYSIS

Validated

SDG: 180512-41  
Location: HP

Client Reference: 602128  
Order Number: P2021483

Report Number: 457687  
Superseded Report: 457479

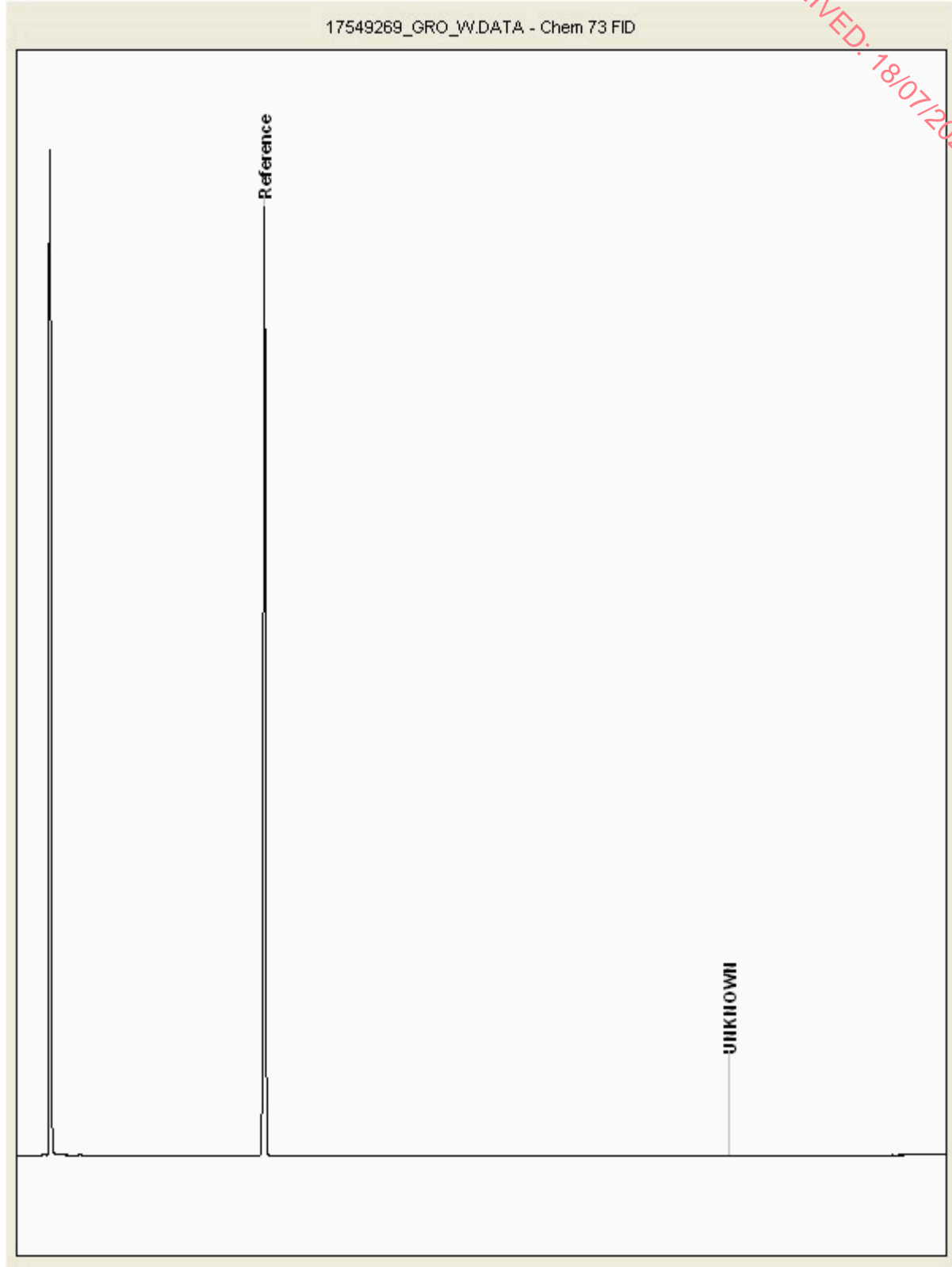
## Chromatogram

Analysis: GRO by GC-FID (W)

Sample No : 17549269  
Sample ID : BH6

Depth :

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# CERTIFICATE OF ANALYSIS

<b>SDG:</b> 180512-41	<b>Client Reference:</b> 602128	<b>Report Number:</b> 457687
<b>Location:</b> HP	<b>Order Number:</b> P2021483	<b>Superseded Report:</b> 457479

## Appendix

## General

1. Results are expressed on a dry weight basis (dried at 35°C) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP - No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals - total metals must be requested separately.

11. Results relate only to the items tested.

12. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%, they are generally wider for volatiles analysis, 50-150%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

14. **Product analyses** - Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethylphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

21. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

24. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as "mixed hydrocarbons". Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

## Sample Deviations

If a sample is classed as deviated then the associated results may be compromised.

1	Container with Headspace provided for volatiles analysis
2	Incorrect container received
3	Deviation from method
4	Holding time exceeded before sample received
5	Samples exceeded holding time before preservation was performed
§	Sampled on date not provided
◆	Sample holding time exceeded in laboratory
@	Sample holding time exceeded due to sampled on date
&	Sample Holding Time exceeded - Late arrival of instructions.

## Asbestos

### Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Astestost Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

### Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

**Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.**

**The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.**



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# APPENDIX C HUMAN HEALTH GENERIC ASSESSMENT CRITERIA

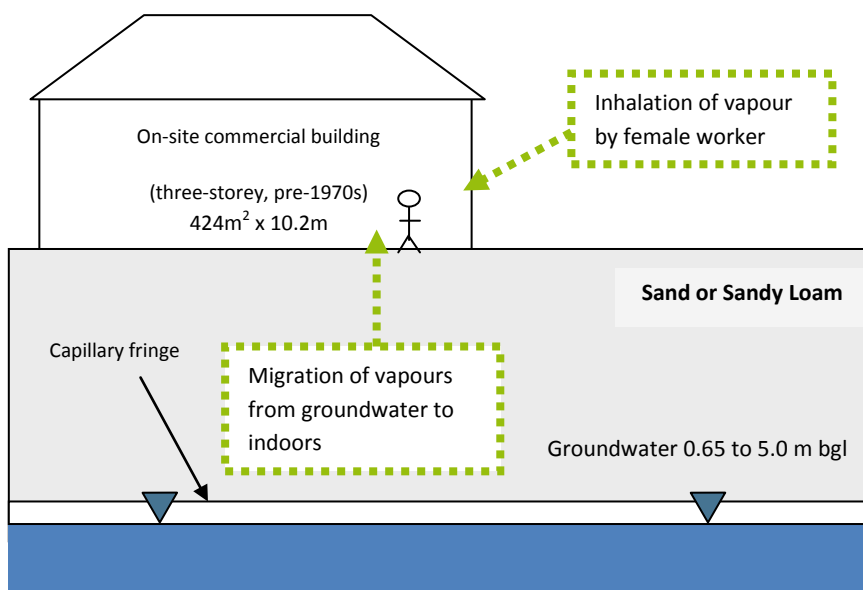
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# Generic groundwater assessment criteria (GrAC) for human health: commercial scenario (adult receptor)

## Background

Volatile organic compounds (VOC) in groundwater have the potential to pose risks to residential site end users via indoor and outdoor inhalation exposure. Due to significant dilution effects in outdoor air, inhalation risk is dominated by indoor exposure. The GrAC conceptual site model (CSM) is shown in Figure 1 (not to scale).

**Figure 1: GrAC conceptual model for a generic commercial scenario**



## RSK GrAC derivation

### Model selection

The Society for Brownfield Risk Assessment (SoBRA) published a set of generic assessment criteria for assessing vapour risk to human health from volatile contaminants in groundwater in February 2017<sup>(1)</sup>. The criteria were developed for a list of common VOC using the Environment Agency Contaminated Land Exposure Assessment (CLEA) tool<sup>(2)</sup> based on a sand soil type and a groundwater depth of 0.65 m below foundation base level. The CLEA tool is not designed to directly model VOC in groundwater and the SoBRA generic criteria are recognised as being conservative since calculations in CLEA are based on three-phase partitioning in the unsaturated zone between soil, soil vapour and soil moisture, with the latter taken by SoBRA as a groundwater equivalent. This method does not take account of the presence of a semi-saturated capillary fringe above the water table, which will serve to provide some mitigation to vertical soil vapour migration.

RSK GrAC are calculated using the RBCA Toolkit for Chemical Releases (version 2.6) with the Johnson and Ettinger model, based on the CSM in Figure 1 for a pre-1970 three storey office

building (as defined in SR3<sup>(3)</sup>, Table 4.21) and which allows consideration of a capillary fringe. The capillary fringe is the subsurface layer in which groundwater seeps up from a water table by capillary action to partially fill soil pores.

The RBCA model was used in preference to the Environment Agency Contaminated Land Exposure Assessment (CLEA) tool<sup>(2)</sup>, as the CLEA tool is not designed to directly model VOC in groundwater and does not take account of the presence of a semi-saturated capillary zone.

#### *Conceptual model*

In accordance with SR3<sup>(3)</sup>, the commercial scenario considers risks to an adult female worker who works from the age of 16 to 65 years. It should be noted that this end use is not suitable for a workplace nursery (where children will be present for an extended period of time) but may be appropriate for a sports centre or shopping centre where children are present but for limited periods of time.

The pollutant linkage considered in production of the GrAC is the volatilisation of compounds from groundwater and subsequent vapour inhalation by the identified receptor while indoors. Figure 1 illustrates this linkage. Although the outdoor air inhalation pathway is also valid, this contributes little to the overall risks owing to the dilution in outdoor air. RBCA does not take account of the presence of non-aqueous phase chemicals but highlights when the assessment criterion exceeds the solubility limit of the pure compound.

#### *Input selection – chemical and toxicological parameters*

Key parameters used in the RBCA model are listed and justified in Table 1. The most up-to-date published chemical and toxicological data was obtained from EA Report SC050021/SR7<sup>(2)</sup>, the EA TOX<sup>(5)</sup> reports, and published by Nathaniel et al.,<sup>(6)</sup> as appropriate. Toxicological and specific chemical parameters for aromatic hydrocarbon C8–C9 (styrene), 1,2,4-trimethylbenzene and methyl tertiary-butyl ether (MTBE) were obtained from the CL:AIRE Soil Generic Assessment Criteria report<sup>(7)</sup>.

The toxicological input parameters are associated with minimal risk, rather than low risk.

For petroleum hydrocarbon fractions, aromatic hydrocarbons C5–C8 were not modelled, as this range comprises benzene and toluene, which are modelled separately. The aromatic C8–C9 hydrocarbon fraction comprises ethylbenzene, xylenes and styrene. As ethylbenzene and xylenes are being modelled separately, the physical, chemical and toxicological data for aromatic C8–C9 have been taken from styrene.

For the Commercial GrAC, the Health Criteria Values (HCV) used in the modelling were derived using the toxicological data discussed above, amended as follows:

- An adult weighing 70kg and breathing 15.7m<sup>3</sup> air per day in accordance with the revised exposure parameters used in the SP1010 final project report for the Category 4 Screening Levels (C4SL) (Table 3.2<sup>(8)</sup>) and USEPA data<sup>(9)</sup>
- Background inhalation (mean daily intake(MDI)) for an adult (Age Class 17).

The amended HCV used in the derivation of the RSK GrAC are presented in Table 1.



**Table 1: Amended Health Criteria Values**

	Modified HCV (mg/m <sup>3</sup> )
VOC / SVOC	Adult (Commercial)
MTBE	3.2064
Benzene	0.0062
Toluene	6.2362
Ethylbenzene	0.3301
Xylenes	0.2609
Trimethylbenzenes	0.0085
TPH_Aliph EC5-EC6	11.1465
TPH_Aliph >EC6-EC8	11.1465
TPH_Aliph >EC8-EC10	0.6465
TPH_Aliph >EC10-EC12	0.6465
TPH_Aliph >EC12-EC16	0.6465
TPH_Arom >EC8-EC9 (styrene)	0.5350
TPH_Arom >EC9-EC10	0.1338
TPH_Arom >EC10-EC12	0.1338
TPH_Arom >EC12-EC16	0.1338
Acenaphthene	0.2675
Acenaphthylene	0.2675
Naphthalene	0.0037
Vinyl chloride	0.0013
Dichloroethane-1,2	0.0005
Tetrachloroethene	0.0363
Carbon tetrachloride	0.0114
Trichloroethane-1,1,1	2.6752
Trichloroethene	0.0025
Tetrachloroethane 1,1,2,2 & 1,1,1,2	0.0257
1,1,2-Trichloroethane	0.0216
1,1-dichloroethane	0.8915
1,1-dichloroethene	0.2541
Chloroethane	12.7374
Chloromethane	0.0115
cis-1,2-dichloroethene	0.0264
Dichloromethane	0.5765
trans-1,2-dichloroethene	0.0754
Trichloromethane (chloroform)	0.1752

*Note on Trimethylbenzenes*

For trimethylbenzenes the CL:AIRE report<sup>(7)</sup> based background inhalation from non-soil sources (MDI) on a Dutch study from 1985, which is reported to have identified an average daily dose of 1,2,4-trimethylbenzene of 86 ug d<sup>-1</sup> (1,3,5-trimethylbenzene was 20.5 ug d<sup>-1</sup>). This dose value was based on the upper end of the identified concentration range of 1,2,4-trimethylbenzene (2.46 – 5.66 ug m<sup>-3</sup>) and was used to calculate an a MDI of 1.23 ug kg<sup>-1</sup> bw d<sup>-1</sup> for a 70 kg adult breathing 20 m<sup>3</sup> of air daily.

The approach recommended in SR2<sup>(10)</sup>, and also adopted for the C4SLs<sup>(8)</sup> for non-carcinogenic (threshold) compounds such as trimethylbenzenes is to subtract the MDI from the tolerable daily intake (TDI) to obtain a tolerable daily intake from soil (TDSI) in units of  $\mu\text{g kg}^{-1} \text{bw d}^{-1}$ . For 1,2,4-trimethylbenzene, the adult MDI from the Dutch study used in the CL:AIRE report<sup>(7)</sup> ( $1.23 \mu\text{g kg}^{-1} \text{bw d}^{-1}$ ) is a significant proportion of the TDI ( $2.0 \mu\text{g kg}^{-1} \text{bw d}^{-1}$ ), resulting in a low TDSI ( $1.0 \mu\text{g kg}^{-1} \text{bw d}^{-1}$ ) when the 50% rule is applied (i.e.  $\text{TDSI} = \text{TDI} * 0.5$  when MDI is high relative to TDI). This TDSI equates to an Inhalation Reference Concentration (or modified Health Criteria Value) for adults of  $3.4 \mu\text{g m}^{-3}$  (70 kg adult breathing  $15.7 \text{ m}^3 \text{ d}^{-1}$ ).

By comparison the adult inhalation modified HCV for benzene is  $6.2 \mu\text{g m}^{-3}$ , which is proven human carcinogen (non-threshold compound).

The MDI for 1,2,4-trimethylbenzene is considered by RSK to be overly conservative for the following reasons:

- The Dutch 1985 study is dated and air quality has improved since this time
- The maximum value in the range ( $5.66 \mu\text{g m}^{-3}$ ) was used in calculating the MDI
- Experience has shown that trimethylbenzenes often appear to drive inhalation risks to a greater extent than benzene, even though the latter is carcinogenic and more volatile.

As an alternative to the 1985 Dutch study, RSK have obtained automated roadside air quality monitoring data for the UK from [www.uk-air.defra.gov.uk/](http://www.uk-air.defra.gov.uk/). The average concentration of 1,2,4-trimethylbenzene measured during 2015 at Eltham, south-east London (urban) was  $0.309 \mu\text{g m}^{-3}$ , significantly lower than that identified in the Dutch study and used by CL:AIRE<sup>(7)</sup> for calculation of a MDI. Whilst an average concentration of 1,2,4-trimethylbenzene in UK urban and rural areas is likely to be significantly below  $0.0.309 \mu\text{g m}^{-3}$ , this value is considered to be suitably conservative for the calculation of a modified HCV for trimethylbenzenes in the UK.

On this basis, the HCV for 1,2,4-trimethylbenzene for adults and children was calculated as  $8.5 \mu\text{g m}^{-3}$  ( $0.0085 \text{ mg m}^{-3}$ ) and  $2.6 \mu\text{g m}^{-3}$  ( $0.0026 \text{ mg m}^{-3}$ ), respectively (see Table 3). Due to the paucity of toxicological data for 1,2,3-trimethylbenzene and 1,3,5-trimethylbenzene the modified HCV for 1,2,4-trimethylbenzene is considered suitable for assessing total trimethylbenzenes.

#### *Note on aqueous solubility and the RSK GrAC*

Where the modelled assessment criteria, or the modelled assessment criteria with the correction factor applied to those contaminants specified below, exceeds the aqueous solubility limit the assessment criteria defaults to this concentration and consequently the GrAC is set at the limit of solubility. These assessment criteria are shaded in red in Table 3 at the end of this document.

The theoretical aqueous solubility is the maximum amount of a single chemical that will dissolve in pure water at a specified temperature. Above this concentration, the chemical will exist in the non-aqueous phase (i.e. in its natural physical form as a solid, liquid (NAPL) or gas). If the contaminant, based on its toxicity, is not considered to pose a risk to human health at the aqueous solubility concentration then the contaminant can be considered not to pose a risk to human health. Where the GrAC is set at the aqueous solubility limit (shaded in red on Table 3), this is not a risk based assessment criteria but is indicative of the maximum amount of chemical that would be found dissolved in the water. Therefore an exceedance of the RSK GrAC set at the aqueous solubility limit is not indicative that there may be potential risks to human health. It

should be noted that for certain contaminants (e.g. the lighter petroleum hydrocarbon fractions) the aqueous solubility is very low and may be at, or below, the laboratory method detection limit. It should also be noted that non-aqueous phase may exist where concentrations of individual compounds are well below their solubility limits where they are part of a mixture, in accordance with Raoult's Law.

*Input selection - physical parameters*

For the commercial scenario, the CLEA default pre-1970s three-storey office building was used. SR3<sup>(3)</sup> notes this commercial building type to be the most conservative in terms of risk from vapour intrusion. The building parameters used in the production of the RSK GrACs are the default CLEA v1.06 inputs presented in Table 3.3 of SR3<sup>(3)</sup>.

The RSK GrAC have been calculated for both Sand and Sandy Loam soils. The soil parameters used in the derivation of the RSK GrAC are those presented in Table 3.1 of SR3<sup>(3)</sup>.

The RSK GrAC have been derived for groundwater depths of 0.65 m, 1.5 m, 2.5 m and 5.0 m below ground level, incorporating a capillary fringe (see Table 2).

*Input selection - attenuation factors*

In line with recommendations provided in Environment Agency SR3<sup>(3)</sup> a sub-surface to indoor attenuation factor of 10 has been applied to certain RBCA derived 'site-specific target levels'. SR3<sup>(3)</sup> states that, as a general rule of thumb, it is recognised that estimating vapour phase concentrations from dissolved and sorbed phase petroleum hydrocarbons by using partition coefficients are at least a factor of ten higher than those likely to be measured on-site. This difference is likely to be due to a number of factors, however aerobic biodegradation in the unsaturated zone is believed to be largely responsible. RSK has therefore applied this attenuation factor to all volatile petroleum hydrocarbon fractions (including BTEX, trimethylbenzenes and the polycyclic aromatic hydrocarbons (PAH) naphthalene, acenaphthene and acenaphthylene). No such attenuation factors have been applied to other non-hydrocarbon chemical species, including chlorinated hydrocarbons or fuel oxygenates such as MtBE.

Convective (volumetric) air flow through foundation cracks ( $Q_{soil}$ ) is a sensitive parameter in the calculation of GrAC and has been calculated within RBCA on a soil-specific basis for Sand and Sandy Loam in a residential exposure scenario (see Table 2). This approach is less conservative than using the default  $Q_{soil}$  value recommended in SR3<sup>(3)</sup> for a Sandy Loam ( $150 \text{ cm}^3 \text{ s}^{-1}$ ) and used in the CLEA model (version 1.071) for Sandy Loam (and Sand) soils ( $150 \text{ cm}^3 \text{ s}^{-1}$ ) in a commercial scenario.

**Table 2: Commercial scenario – RBCA inputs**

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Parameter	Unit	Value	Justification
<b>Receptor – female child</b>			
Averaging time	Years	49	From Box 3.5, SR3 <sup>(3)</sup>
Receptor weight	kg	70	Female adult, Table 4.6, SR3 <sup>(3)</sup>
Exposure duration	Years	49	From Box 3.5, SR3 <sup>(3)</sup>
Exposure frequency	Days yr <sup>-1</sup>	86.25	Weighted using occupancy period of 9 hours per day for 230 days of the year ((9hours x 230 days)/24 hours)
<b>Soil type – sand</b>			
Total porosity	-	0.54	CLEA value for sand. Parameters for sand from Table 4.4, SR3 <sup>(3)</sup> Volumetric water content in the vadose zone is a highly sensitive parameter within the model and potentially highly variable in the field.
Volumetric water content – unsaturated (vadose) zone	-	0.24	
Volumetric air content - unsaturated (vadose) zone	-	0.30	
Dry bulk density	g cm <sup>-3</sup> or kg L <sup>-1</sup>	1.18	
Volumetric water content – capillary zone	-	0.35	Calculated using SR3 Equation 4.1. Value taken as the average moisture content calculated for suction heads (cm H <sub>2</sub> O); 0 (i.e. saturated), 10, 20, 30, 40, 50 (i.e. unsaturated soil at field capacity). This is a highly sensitive parameter within the model.
Volumetric air content - capillary zone	-	0.19	Calculated from total porosity and volumetric water content of capillary zone. This is a highly sensitive parameter within the model.
Vertical hydraulic conductivity	cm d <sup>-1</sup>	636	CLEA value for saturated conductivity of sandy loam, Table 4.4, SR3 <sup>(3)</sup> equivalent to 7.36 E-03 cm s <sup>-1</sup>
Vapour permeability	m <sup>2</sup>	5.83 E-12	Calculated for sandy loam using equations in Appendix 1, SR3 <sup>(3)</sup>
Capillary zone thickness	m	0.25	Taken from C W Fetter, Applied Hydrogeology 4 <sup>th</sup> Ed, 1994 <sup>(11)</sup> and R Heath, Basic groundwater hydrology 1992 <sup>(12)</sup> for a medium sand
Fraction organic carbon	%	0.0058	Equivalent to SOM = 1%. Note that GrAC are independent on FOC/SOM content since partitioning is assumed to be between aqueous and vapour phases only
<b>Soil type – sandy loam</b>			
Total porosity	-	0.53	CLEA value for sandy loam. Parameters for sandy loam from Table 4.4, SR3 <sup>(3)</sup> . Volumetric water content in the vadose zone is a highly sensitive parameter within the model and potentially highly variable in the field.
Volumetric water content – unsaturated (vadose) zone	-	0.33	
Volumetric air content - unsaturated (vadose) zone	-	0.20	
Dry bulk density	g cm <sup>-3</sup> or kg/L	1.21	
Volumetric water content – capillary zone	-	0.42	Calculated using SR3 Equation 4.1 <sup>(3)</sup> . Value taken as the average moisture content calculated for suction heads (cm H <sub>2</sub> O); 0 (i.e. saturated), 10, 20, 30, 40, 50 (i.e. unsaturated soil at field capacity). This is a highly sensitive parameter within the model.
Volumetric air content - capillary zone	-	0.11	Calculated from total porosity and volumetric water content of capillary zone. This is a highly sensitive parameter within the model.

Parameter	Unit	Value	Justification
Vertical hydraulic conductivity	cm d <sup>-1</sup>	308	CLEA value for saturated conductivity of sandy loam, Table 4.4, SR3 <sup>(3)</sup> equivalent to 3.56E-3 cm s <sup>-1</sup>
Vapour permeability	m <sup>2</sup>	2.96 E-12	Calculated for sandy loam using equations in Appendix 1, SR3 <sup>(3)</sup>
Capillary zone thickness	m	0.4	Taken from R Heath, Basic Groundwater Hydrology (1992) <sup>(12)</sup> for a fine sand. Note: C W Fetter, Applied Hydrogeology 4 <sup>th</sup> Ed, 1994 <sup>(11)</sup> value for fine sand is 0.5 m
Fraction organic carbon	%	0.0058	Equivalent to SOM = 1%. Note that GrAC are independent on FOC/SOM content since partitioning is assumed to be between aqueous and vapour phases only
<b>Building – pre-1970 three storey office</b>			
Building volume/area ratio	m	9.6	Table 3.10, SR3 <sup>(3)</sup>
Foundation area	m <sup>2</sup>	424	
Foundation perimeter	m	82.40	Based on square root of building area being 20.59m
Building air exchange rate	d <sup>-1</sup>	24	Table 3.10, SR3 <sup>(3)</sup> Building air exchange rate equivalent to 2.8 E-04 s <sup>-1</sup>
Depth to bottom of foundation slab	m	0.15	
Foundation thickness	m	0.15	
Foundation crack fraction	-	3.89E-04	Calculated from floor crack area of 0.165m <sup>2</sup> and building footprint of 424m <sup>2</sup> in Table 4.21, SR3 <sup>(3)</sup>
Volumetric water content of cracks	-	0.24 / 0.33	For sand / sandy loam, assumed equal to underlying soil type in assumption that cracks become filled with unsaturated zone soil over time. Parameters for sand and sandy loam from Table 4.4, SR3 <sup>(3)</sup>
Volumetric air content of cracks	-	0.30 / 0.20	
Indoor/outdoor differential pressure	Pa	4.4	From Table 3.3, SR3 <sup>(3)</sup> Equivalent to 44g/cm/s <sup>2</sup>
Convective air flow through cracks (Q <sub>soil</sub> ) - Sand	m <sup>3</sup> s <sup>-1</sup>	1.43E-04	Soil-specific calculated parameter in RBCA equivalent (and cross checked) with equations A1, A2, A3, A8, A9 in SR3 <sup>(3)</sup> . Equivalent to <b>142.6 cm<sup>3</sup> s<sup>-1</sup></b>
Convective air flow through cracks (Q <sub>soil</sub> ) – Sandy Loam	m <sup>3</sup> s <sup>-1</sup>	7.24E-05	Soil-specific calculated parameter in RBCA equivalent (and cross checked) with equations A1, A2, A3, A8, A9 in SR3 <sup>(3)</sup> . Equivalent to <b>72.4 cm<sup>3</sup> s<sup>-1</sup></b>

## RSK GrAC derivation outputs

The RSK GrACs are presented in Table 3.

Within the RSK GrAC the following should be noted:

- GrAC do not take account of outdoor inhalation exposure to VOC, which is considered to contribute minimally to overall inhalation exposure
- GrAC do not take account of other exposure routes potentially relevant to VOC in shallow groundwater such as direct contact or root uptake
- No biodegradation is assumed to occur in the unsaturated zone. Where aerobic conditions on site are known to exist the GrAC for hydrocarbons may therefore be conservative
- GrAC do not take account of preferential flow into buildings such as through unsealed service entries. In such circumstances GrAC may not be appropriate for use
- GrAC are based on a soil vapour intrusion CSM and are not appropriate for use when the foundation is in direct contact with contaminated groundwater

- GrAC assume that the capillary fringe is un-contaminated with VOC, which is unlikely, particularly where groundwater levels are variable
- GrAC set at the theoretical aqueous solubility limit are not considered to pose a risk to human health
- GrAC do not take into account the interaction between contaminants and the influence this may have on the theoretical aqueous solubility
- GrACs are only applicable to dissolved phase contaminants where the modelled assessment criteria is below the aqueous solubility limits

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12. Heath, R. (1992), *Basic Groundwater Hydrology*. U.S. Geological Survey, Water Supply Paper 2220.

		Table 3: RSK GrAC (ug/l)							
		COMMERCIAL							
		SAND				SANDY LOAM			
GW Depth (m)		0.65	1.5	2.5	5	0.65	1.5	2.5	5
<b>Metals</b>									
Elemental mercury		56	56	56	56	56	56	56	56
Methyl mercury		100000	100000	100000	100000	100000	100000	100000	100000
<b>Volatile Organic Compounds</b>									
Benzene		34730	44200	55330	83160	159690	194750	235990	339090
Toluene		59000	59000	59000	59000	59000	59000	59000	59000
Ethylbenzene		180000	180000	180000	180000	180000	180000	180000	180000
Xylene - m		20000	20000	20000	20000	20000	20000	20000	20000
Xylene - o		173000	173000	173000	173000	173000	173000	173000	173000
Xylene - p		200000	200000	200000	200000	200000	200000	200000	200000
Methyl tertiary-Butyl ether (MTBE)		13554980	17499620	22140360	33742220	48000000	48000000	48000000	48000000
Trichloroethene		930	1190	1510	2290	4440	5430	6580	9470
Tetrachloroethene		8290	10790	13720	21060	41420	50680	61580	88830
1,1,1-Trichloroethane		511410	659300	833290	1268260	1300000	1300000	1300000	1300000
1,1,1,2 Tetrachloroethane		39110	51080	65170	100390	181910	226070	278020	407900
1,1,2,2-Tetrachloroethane		258860	340390	436310	676110	851170	1138720	1477010	2322750
Carbon Tetrachloride		1350	1740	2200	3350	6640	8090	9800	14080
1,2-Dichloroethane		1460	1860	2340	3520	5900	7380	9110	13440
Vinyl Chloride		110	130	160	240	460	560	660	940
1,2,4-Trimethylbenzene		55900	55900	55900	55900	55900	55900	55900	55900
<b>Semi-Volatile Organic Compounds</b>									
Acenaphthene		4100	4100	4100	4100	4100	4100	4100	4100
Acenaphthylene		7950	7950	7950	7950	7950	7950	7950	7950
Naphthalene		19000	19000	19000	19000	19000	19000	19000	19000
<b>Petroleum Hydrocarbons</b>									
Aliphatic hydrocarbons EC5-EC6		35900	35900	35900	35900	35900	35900	35900	35900
Aliphatic hydrocarbons >EC6-EC8		5370	5370	5370	5370	5370	5370	5370	5370
Aliphatic hydrocarbons >EC8-EC10		427	427	427	427	427	427	427	427
Aliphatic hydrocarbons >EC10-EC12		33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9
Aliphatic hydrocarbons >EC12-EC16		0.759	0.759	0.759	0.759	0.759	0.759	0.759	0.759
Aromatic hydrocarbons >EC8-EC9 (styrene)		29000	29000	29000	29000	29000	29000	29000	29000
Aromatic hydrocarbons >EC9-EC10		64600	64600	64600	64600	64600	64600	64600	64600
Aromatic hydrocarbons >EC10-EC12		245000	245000	245000	245000	24500	24500	24500	24500
Aromatic hydrocarbons >EC12-EC16		5750	5750	5750	5750	5750	5750	5750	5750
Notes:									
Values less than 100 have not been rounded up; values greater than 10 have been rounded up to the nearest 10.									
Highlighted values exceed solubility limit for the pure compound in water (aqueous solubility); GrAC defaults to the limit of solubility. No vadose zone biodegradation considered									
Sub-surface to indoor air correction factor of 10 applied to all petroleum (non-chlorinated) hydrocarbons, the PAHs and trimethylbenzene									
All GrAC are for 1% SOM (0.0058 FOC)									





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# APPENDIX D GENERIC ASSESSMENT CRITERIA FOR CONTROLLED WATERS

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# GENERIC ASSESSMENT CRITERIA FOR CONTROLLED WATERS

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## Protection of the water environment

The water environment in the United Kingdom is protected under a number of regulatory regimes. The relevant environmental regulator is consulted where there may be a risk that pollution of 'controlled waters' may occur or may have occurred in the past.

The term 'controlled waters' refers to coastal waters, inland freshwaters and groundwater. The EU Water Framework Directive (WFD) (2000/60/EC) is implemented via domestic regulations and guidance, covering aspects of groundwater and surface water protection as well as drinking water supply policy. Domestic legislation and guidance will vary across the United Kingdom. Therefore, the relevant legislation for England, Wales, Northern Ireland and Scotland should be reviewed, alongside guidance provided by the Environment Agency (EA), Natural Resource Wales (NRW), the Scottish Environmental Protection Agency (SEPA) or the Northern Ireland Environment Agency (NIEA), as appropriate.

The main objectives of the protection and remediation of groundwater under threat from land contamination are set out within "The Environment Agency's approach to groundwater protection", version 1.0 (March 2017)<sup>(1)</sup> and the associated guidance "Land contamination groundwater compliance points: quantitative risk assessments (March 2017)<sup>(1a)</sup> that have replaced the previous guidance document "Groundwater Principles and Practice (GP3)". When assessing risks to groundwater, the following need to be considered:

- Where pollutants have not yet entered groundwater, all necessary and reasonable measures must be taken to:
  - **prevent** the input of **hazardous** substances into groundwater (see description of hazardous substances below)
  - **limit** the entry of other (non-hazardous) pollutants into groundwater to avoid pollution, deterioration in the status of groundwater bodies and to prevent sustained, upward trends in pollutant concentrations in groundwater.
- Where pollutants have already entered groundwater, the priority is to take all necessary and reasonable measures to:
  - **minimise** further entry of "contaminants" where there is a defined source
  - **limit the pollution** of groundwater or any effect on the status of the groundwater body from the future expansion of the 'plume', if necessary, by actively reducing its extent.

Within the context of groundwater risk assessments on sites affected by land contamination, "reasonable" means feasible without involving disproportionate costs. What costs are "disproportionate" depends on site-specific circumstances, which may include:

- Considerations of technical feasibility such as identified by the remedial options appraisal, this may be due to the distribution or nature of the contamination and the available remedial methods to treat the identified contamination;
- Sustainability considerations.

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## DEFINITIONS AND SUBSTANCE CLASSIFICATIONS

### Risks to surface waters:

**When assessing risks to surface waters, the following list of definitions should be understood:**

**Priority substances (PS)** are harmful substances originally identified under the Water Framework Directive (WFD) 2000/60/EC as substances ‘presenting a significant risk to or via the aquatic environment’ at a European level. Member States are required to incorporate the identified **PS** into their country-wide monitoring programmes. There are currently 33 **PS** defined within the Priority Substances Directive (2013/39/EU; Annex 1), with a further 12 additional substances due to come into force from 22 December 2018. Directive 2013/39/EU has been transposed into domestic legislation for England and Wales by The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Under the umbrella of **PS**, there is a sub-set of substances identified as being “hazardous”, and these are referred to as **Priority hazardous substances (PHS)**. The list of **PHS** is defined at EU level within the Priority Substances Directive (2013/39/EU). The WFD defines hazardous substances as ‘substances (or groups of substances) that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances that give rise to an equivalent level of concern.’ There are currently 15 **PHS**, with a further 6 additional substances due to come into force from 22 December 2018.

There is also another group of substances defined at EU level and which are referred to as **other pollutants (OP)** in Directive 2013/39/EU. These are additional substances which although not **priority substances**, have EQS which are identical to those laid down in the legislation which applied prior to 13 January 2009 (Directive 2008/105/EU). The **OP** are listed along with the **priority substance (PS)** within the Priority Substances Directive (2013/39/EU), and their associated EQS are also listed therein. There are 6 **OP** defined within the Priority Substances Directive (2013/39/EU).

In addition to the EU level substances, there are also a group of pollutants defined at a Member State level, referred to as **Specific pollutants (SP)**. These substances are pollutants which are released in significant quantities into water bodies in each of the individual European Member States. Under the WFD, Member States are required to set their own EQS for these substances. An indicative list of **SP** is given in Annex VIII of the WFD. Many of the substances categorised as **SP** in the UK were formerly List 2 substances under the old Groundwater Directive (80/68/EEC). The **SP** are defined within Part 2 (Table 1) of The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

### Risks to groundwater:

**When assessing risks to groundwater, the following definitions should be understood:**

Under the requirements of the Groundwater Daughter Directive (2006/118/EU), the UK has published a list of substances it considers to be **hazardous substances** with respect to groundwater. In their advisory capacity to the government, this list has been derived by the UK Joint Agencies Groundwater Directive Advisory Group (JAGDAG), of which the Environment Agency is a member. The JAGDAG list of **hazardous substances** was published in January 2017 and the Environment Agency will use the updated list of hazardous substances from this date for all new activities that may lead to the discharge of hazardous substances to groundwater. The list is extensive and can be found in full at:

<https://www.wfduk.org/stakeholders/jagdag>

### Selecting the appropriate assessment criteria

When assessing the risks to controlled waters, various assessment criteria apply, depending on the nature of the assessment and the conceptual site model.

Where a surface water body is involved, then Environmental Quality Standards (EQS) are the relevant assessment criteria as they are designed to be protective of surface water ecology.

Where a public water supply or a Principal aquifer is involved, then the standards defined in The Water Supply (Water Quality) Regulations<sup>(2)</sup> are the primary source of assessment criteria. The Private Water Supplies Regulations<sup>(3)</sup> may also be applicable in some cases. For instances where there are no UK assessment criteria, then the World Health Organisation (WHO) drinking water guidelines<sup>(4)</sup> may be used.

This appendix presents the generic assessment criteria (GAC) that RSK considers suitable for assessing risks to controlled waters for our most commonly encountered determinants. A full list of EQS for England and Wales are included in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

The RSK GAC for controlled waters are presented in **Table 1** and **Table 2**. In line with the Environment Agency's Remedial Targets Methodology, the GAC for controlled waters are termed 'target concentrations'.

The appropriate target concentrations should be selected with consideration to:

- the site conceptual model (i.e. the receptor at potential risk);
- whether the substance is already present in groundwater at the site;
- whether or not the substance is classified as a priority hazardous substance under the Priority Substances Directive (2013/39/EC) (see above), or as a hazardous substance according to the current list of JAGDAG determinations<sup>(5)</sup>; and
- background concentrations in the aquifer (if applicable).

It is important to remember that the WFD and Environment Agency guidance<sup>(1 & 1a)</sup> support a sustainable, risk-based approach be applied to groundwater contamination. Exceedance of any target concentration does not necessarily imply that an unacceptable risk exists or that remediation is inevitably required.

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Target concentrations shaded in green are <u>statutory values</u>	Target concentrations shaded in orange are <u>non-statutory values</u>
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**Note:** Units µg/l throughout (unless otherwise stated)

**Table 1: Target concentrations for controlled waters (excluding TPH CWG fractions)**

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<b>Metals &amp; other inorganics</b>						
<b>Hazardous substance</b>	Specific pollutant	Arsenic	-	10 <sup>(2)</sup>	50 <sup>(6a)</sup>	25 <sup>(6a)</sup>
Non-hazardous pollutant	Priority substance	Cadmium	0.1 <sup>(7)</sup>	5 <sup>(2)</sup>	≤0.08, 0.08, 0.09, 0.15, 0.25 <sup>(6b)</sup>	0.2 <sup>(6a)</sup>
<i>(Not determined)</i>	-	Chromium (total)	-	50 <sup>(2)</sup>	Sum values for chromium III and VI	
<i>(None)</i>	Specific pollutant	Chromium (III)	-	Use value for total chromium	4.7 <sup>(6a)</sup>	-
<b>Hazardous substance</b>	Specific pollutant	Chromium (VI)	-		3.4 <sup>(6a)</sup>	0.6 <sup>(6a)</sup>

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<i>(Not determined)</i>	Specific pollutant	Copper	-	2,000 <sup>(2)</sup>	1 bioavailable <sup>(6a)</sup>	3.76 dissolved, where DOC ≤1mg/l <sup>(6a)</sup>
						3.76µg/l + (2.677µg/l x ((DOC/2) – 0.5µg/l)) dissolved, where DOC >1mg/l <sup>(6a)</sup>
<b>Hazardous substance</b>	Priority substance	Lead	-	10 <sup>(2)</sup>	1.2 bioavailable <sup>(6a)</sup>	1.3 <sup>(6a)</sup>
<b>Hazardous substance</b>	<b>Priority hazardous substance</b>	Mercury	0.01 <sup>(7)</sup>	1 <sup>(2)</sup>	0.07 <sup>(6c)</sup>	0.07 <sup>(6c)</sup>
Non-hazardous pollutant	Priority substance	Nickel	-	20 <sup>(2)</sup>	4.0 bioavailable <sup>(6a)</sup>	8.6 <sup>(6a)</sup>
Non-hazardous pollutant	-	Selenium	-	10 <sup>(2)</sup>	-	-
Non-hazardous pollutant	Specific pollutant	Zinc	-	3,000 <sup>(8)</sup>	10.9 bioavailable <sup>(6a)</sup>	6.8 dissolved <sup>(6a)</sup>
<i>None</i>	Specific pollutant	Iron	-	200 <sup>(2)</sup>	1000 <sup>(6a)*1</sup>	1000 <sup>(6a)*1</sup>
<i>None</i>	Specific pollutant	Manganese	-	50 <sup>(2)</sup> (0.05mg/l)	123 bioavailable <sup>(6a)</sup> (0.123mg/l)	-
<i>(Not determined)</i>	-	Aluminium	-	200 <sup>(2)</sup>	-	-

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<b>Hazardous substance</b>	<b>Priority hazardous substance</b>	Tributyltin compounds (Tributyltin-cation)	0.001 <sup>(7)</sup>	-	0.0002 <sup>(6a)</sup>	0.0002 <sup>(6a)</sup>
<i>(Not determined)</i>	-	Sodium	-	200,000 <sup>(2)</sup> (200 mg/l)	-	-
Non-hazardous pollutant	Specific pollutant	Cyanide (Hydrogen cyanide)	-	50 <sup>(2)</sup> (0.05 mg/l)	1 <sup>(6a)</sup> (0.001 mg/l)	1 <sup>(6a)</sup> (0.001 mg/l)
Non-hazardous pollutant	-	Total ammonia <sup>§</sup> (ammonium (as NH <sub>4</sub> <sup>+</sup> ) plus ammonia (NH <sub>3</sub> ))	-	500 <sup>(2)</sup> (0.5 mg/l)	300 <sup>(6f)</sup> (0.3 mg/l)	-
Non-hazardous pollutant	Specific pollutant	Ammonia un-ionised (NH <sub>3</sub> )	-	-	-	21 <sup>(6a)</sup> (0.021 mg/l)
Non-hazardous pollutant	Specific pollutant	Chlorine	-	-	2 <sup>(6a)</sup> (0.002 mg/l)	10 <sup>(6d)</sup> (0.01 mg/l)
<i>(Not determined)</i>	-	Chloride	-	250,000 <sup>(2)</sup> (250 mg/l)	-	-
<i>(Not determined)</i>	-	Sulphate	-	250,000 <sup>(2)</sup> (250 mg/l)	-	-
<i>(Not determined)</i>	-	Nitrate (as NO <sub>3</sub> )	-	50,000 <sup>(2)</sup> (50 mg/l)	-	-
<i>(Not determined)</i>	-	Nitrite (as NO <sub>2</sub> )	-	500 <sup>(2)</sup> (0.5 mg/l)	10 <sup>(9)</sup> (0.01 mg/l)	-

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<b>Volatile organic compounds (VOC)</b>						
Non-hazardous pollutant	Other pollutant	Tetrachloroethene (tetrachloroethylene; PCE)	0.1 <sup>(7)</sup>	10 <sup>(2)</sup> sum of TCE and PCE	10 <sup>(6a)</sup>	10 <sup>(6a)</sup>
<b>Hazardous substance</b>	Other pollutant	Trichloroethene (trichloroethylene; TCE)	0.1 <sup>(7)</sup>		10 <sup>(6a)</sup>	10 <sup>(6a)</sup>
<i>None</i>	Specific pollutant	Tetrachloroethane	-	-	140 <sup>(6a)</sup>	-
<b>Hazardous substance</b>	Other pollutant	Carbon tetrachloride (tetrachloromethane)	0.1 <sup>(7)</sup>	3.0 <sup>(2)</sup>	12 <sup>(6a)</sup>	12 <sup>(6a)</sup>
Non-hazardous pollutant	Priority substance	1,2-Dichloroethane	1.0 <sup>(7)</sup>	3.0 <sup>(2)</sup>	10 <sup>(6a)</sup>	10 <sup>(6a)</sup>
Non-hazardous pollutant	-	1,2-Dichloroethene (DCE)	-	50.0 <sup>(4)</sup>	-	-
<b>Hazardous substance</b>	-	Vinyl chloride (chloroethene)	-	0.5 <sup>(2)</sup>	-	-
Non-hazardous pollutant	Priority substance	Dichloromethane	-	20 <sup>(4)</sup>	20 <sup>(6a)</sup>	20 <sup>(6a)</sup>
Non-hazardous pollutant	Priority substance	Trichlorobenzenes	0.01 <sup>(7)</sup>	-	0.4 <sup>(6a)</sup>	0.4 <sup>(6a)</sup>
<i>(Not determined)</i>	-	Trihalomethanes	-	100 <sup>(2a)</sup>	-	-



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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<b>Hazardous substance</b>	Priority substance	Trichloromethane (Chloroform)	0.1 <sup>(7)</sup>	(see "Trihalomethanes" above)	2.5 <sup>(6a)</sup>	2.5 <sup>(6a)</sup>
Non-hazardous pollutant	<b>Priority hazardous substance</b>	Di(2-ethylhexyl) phthalate (bis(2-ethylhexyl) phthalate, DEHP)	-	8 <sup>(4)</sup>	1.3 <sup>(6a)</sup>	1.3 <sup>(6a)</sup>
<i>None</i>	Specific pollutant	Benzyl butyl phthalate	-	-	7.5 <sup>(6a)</sup>	0.75 <sup>(6e)</sup>
<b>Hazardous substance</b>	<b>Priority hazardous substance</b>	Hexachlorobutadiene	0.005 <sup>(7)</sup>	0.6 <sup>(4)</sup>	0.6 <sup>(6c)</sup>	0.6 <sup>(6c)</sup>
<b>Semi-volatile organic compounds (SVOC)</b>						
<i>(Not determined)</i>	-	Acenaphthylene (C12-C16)	-	-	5.8 <sup>(10)</sup>	
<b>Hazardous substance</b>	<b>Priority hazardous substance</b>	Anthracene (C16-C21)	-	-	0.1 <sup>(6a)</sup>	0.1 <sup>(6a)</sup>
Non-hazardous pollutant	Priority substance	Naphthalene (C10-C12)	-	-	2 <sup>(6a)</sup>	2 <sup>(6a)</sup>

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<b>Hazardous substance</b>	Priority substance	Fluoranthene (C21-C35)	-	-	0.0063 <sup>(6a)</sup>	0.0063 <sup>(6a)</sup>
<b>Hazardous substance(s)</b>	<b>Priority hazardous substance(s)</b>	Benzo(a)pyrene (C21-C35)	-	0.01 <sup>(2)</sup>	0.00017 <sup>(6a)</sup>	0.00017 <sup>(6a)</sup>
		Benzo(b)fluoranthene (C21-C35)	-	0.1 <sup>(2)</sup> sum of the concentration of the four specified compounds	No EQS for these substances. B(a)P should be used as the indicator compound instead.	
		Benzo(k)fluoranthene (C21-C35)	-			
		Benzo(g,h,i)perylene (C21-C35)	-			
		Indeno(1,2,3-cd)pyrene (C21-C35)	-			
Non-hazardous pollutant	Specific pollutant	Phenol		-		
<b>Hazardous substance</b>	Specific pollutant	2,4-Dichlorophenol	0.1 <sup>(7)</sup>	-	4.2 <sup>(6a)</sup>	0.42 <sup>(6a)</sup>
<b>Hazardous substance</b>	Priority substance	Pentachloro-phenol (PCP)	0.1 <sup>(7)</sup>	g <sup>(4)</sup>	0.4 <sup>(6a)</sup>	0.4 <sup>(6a)</sup>

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<b>Petroleum hydrocarbons</b>						
<b>Hazardous substance</b>	-	Total petroleum hydrocarbons	-	See Table 2 for individual (non-statutory) TPH CWG fractions with respect to drinking water receptors	See individual risk driving compounds (i.e. BTEX and PAH) for specific EQS	
<b>Hazardous substance</b>	Priority substance	Benzene (C5-C7)	1 <sup>(7)</sup>	1 <sup>(2)</sup>	10 <sup>(6a)</sup>	8 <sup>(6a)</sup>
<b>Hazardous substance</b>	Specific pollutant	Toluene (C7-C8)	4 <sup>(7)</sup>	700 <sup>(4)</sup>	74 <sup>(6a)</sup>	74 <sup>(6a)</sup>
<b>Hazardous substance</b>	-	Ethylbenzene (C8-C9)	-	300 <sup>(4)</sup>	-	-
<i>(Not determined)</i>	-	Xylenes (C8-C10)	3 <sup>(7)</sup>	500 <sup>(4)</sup>	30 <sup>(11)</sup>	-
Non-hazardous pollutant	-	Methyl tertiary butyl ether (MTBE)	-	15 <sup>(12)</sup>	-	
<b>Pesticides, fungicides, insecticides and herbicides</b>						
<b>Hazardous substance(s)</b>	Other pollutant (Cyclodiene)	Aldrin	0.003 <sup>(7)</sup>	0.03 <sup>(2)</sup>	0.01 <sup>(6a)</sup> (sum of all four)	0.005 <sup>(6a)</sup> (sum of all four)
		Dieldrin	0.003 <sup>(7)</sup>	0.03 <sup>(2)</sup>		

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
	pesticides)	Endrin	0.003 <sup>(7)</sup>	0.1 <sup>(2b)</sup>		
		Isodrin*2	0.003 <sup>(7)</sup>	0.1 <sup>(2b)</sup>		
<b>Hazardous substance</b>	Other pollutant	DDT (total)	0.002 <sup>(7)</sup>	1 <sup>(4)</sup>	0.025 <sup>(6a)</sup>	0.025 <sup>(6a)</sup>
<i>(Not determined) – assume to be Hazardous Substance</i>	-	Total pesticides	-	0.5 <sup>(2)</sup>	-	-
<i>(Not determined) - assume to be Hazardous Substance</i>	-	Other individual pesticides	-	0.1 <sup>(2)</sup>		
<b>Hazardous substance</b>	Specific pollutant	Carbendazim	-	-	0.15 <sup>(6a)</sup>	-
<b>Hazardous substance</b>	Specific pollutant	Chlorothalonil	-	-	0.035 <sup>(6a)</sup>	-
<b>Hazardous substance</b>	Specific pollutant (until 22/12/18, after which it becomes a Priority substance)	Cypermethrin	-	-	0.0001 <sup>(6a)</sup> From 22/12/18: 8.0E-5 <sup>(6a)</sup>	0.0001 <sup>(6a)</sup> From 22/12/18: 8.0E-6 <sup>(6a)</sup>
<b>Hazardous substance</b>	Specific pollutant	Dimethoate	0.01 <sup>(7)</sup>	-	0.48 <sup>(6a)</sup>	0.48 <sup>(6a)</sup>

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<i>(Not determined)</i>	Specific pollutant	Glyphosate	-	-	196 <sup>(6a)</sup>	196 <sup>(6a)</sup>
<b>Hazardous substance</b>	Specific pollutant	Linuron	-	-	0.5 <sup>(6a)</sup>	0.5 <sup>(6a)</sup>
Non-hazardous pollutant	Specific pollutant	Mecoprop	0.04 <sup>(7)</sup>	-	18 <sup>(6a)</sup>	18 <sup>(6a)</sup>
Non-hazardous pollutant	Specific pollutant	Methiocarb	-	-	0.01 <sup>(6a)</sup>	-
Non-hazardous pollutant	Specific pollutant	Pendimethalin	-	20 <sup>(4)</sup>	0.3 <sup>(6a)</sup>	-
<b>Hazardous substance</b>	Specific pollutant	Permethrin	0.001 <sup>(7)</sup>	-	0.001 <sup>(6a)</sup>	0.0002 <sup>(6a)</sup>
<b>Hazardous substance</b>	Priority substance	Alachlor	-	20 <sup>(4)</sup>	0.3 <sup>(6a)</sup>	0.3 <sup>(6a)</sup>
<b>Hazardous substance</b>	Priority substance	Atrazine	0.03 <sup>(7)</sup>	100 <sup>(4)</sup>	0.6 <sup>(6a)</sup>	0.6 <sup>(6a)</sup>
<b>Hazardous substance</b>	Priority substance	Diuron	-	-	0.2 <sup>(6a)</sup>	0.2 <sup>(6a)</sup>
<b>Hazardous substance</b>	<b>Priority hazardous substance</b>	Endosulphan	0.005 <sup>(7)</sup>	-	0.005 <sup>(6a)</sup>	0.0005 <sup>(6a)</sup>

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Non-hazardous pollutant	Priority substance	Isoproturon	-	9 <sup>(4)</sup>	0.3 <sup>(6a)</sup>	0.3 <sup>(6a)</sup>
<b>Hazardous substance</b>	Priority substance	Simazine	0.03 <sup>(7)</sup>	2 <sup>(4)</sup>	1 <sup>(6a)</sup>	1 <sup>(6a)</sup>
<b>Hazardous substance</b>	<b>Priority hazardous substance</b>	Trifluralin	0.01 <sup>(7)</sup>	20 <sup>(4)</sup>	0.03 <sup>(6a)</sup>	0.03 <sup>(6a)</sup>
<i>(Not determined)</i>	From 22/12/18: Priority substance	Dichlorovos	-	-	From 22/12/18: 6.0E-4 <sup>(6a)</sup>	From 22/12/18: 6.0E-5 <sup>(6a)</sup>
<b>Hazardous substance</b>	From 22/12/18: Priority substance	Heptachlor and heptachlor epoxide	-	0.03 <sup>(2)</sup>	From 22/12/18: 2.0E-7 <sup>(6a)</sup>	From 22/12/18: 1.0E-08 <sup>(6a)</sup>
<b>Miscellaneous</b>						
<i>None</i>	Specific pollutant	Triclosan (antibacterial agent)	-	-	0.1 <sup>(6a)</sup>	0.1 <sup>(6a)</sup>
<b>Hazardous substance</b>	<b>From 22/12/18: Priority hazardous substance</b>	Perfluoro-octane sulfonic acid (and its derivatives) (PFOS)	-	-	From 22/12/18: 6.5E-4 <sup>(6a)</sup>	From 22/12/18: 1.3E-4 <sup>(6a)</sup>
<b>Hazardous substance</b>	<b>From 22/12/18: Priority hazardous substance</b>	Hexabromo cyclododecane (HBCDD)	-	-	From 22/12/18: 0.0016 <sup>(6a)</sup>	From 22/12/18: 0.0008 <sup>(6a)</sup>

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Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors <sup>(5)</sup>	Surface water receptors <sup>(6)</sup>		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
<p><b>Notes:</b></p> <p>‘-’ A target concentration is not available.</p> <p>§Please note that total ammonia (NH<sub>4</sub><sup>+</sup> and NH<sub>3</sub>) is equivalent to ammoniacal nitrogen in laboratory reports</p> <p>*<sup>1</sup> Please note that although iron is listed in the 2015 Direction as 1.000 µg/l, the EQS remains at 1mg/l in Scotland and it is assumed this is an error and should read either 1,000 or 1000µg/l.</p> <p>*<sup>2</sup> Please note that although Isodrin is not listed in name within the group of “Cyclodiene pesticides” in Table 1 of Schedule 3 Part 3 of the 2015 Direction<sup>(6)</sup>, the CAS number for Isodrin (465-73-6) <u>is</u> listed and therefore it is assumed that it has been missed off the named list of substances.</p> <p>*<sup>3</sup> Total petroleum hydrocarbons is used for consistency, but is an analytical method-defined measurement for a mixture of hydrocarbons subject to environmental analysis<sup>11</sup>.</p> <p>“Bioavailable” in relation to copper, zinc, nickel and manganese (but not lead) is the generic EQSbioavailable<sup>(6a)</sup> derived from the Metal Bioavailability Assessment Tool (M-BAT) developed by the Water Framework Directive UK Technical Advisory Group (WFDTAG). Exceedance of this value should prompt a site-specific assessment using the M-BAT with pH, DOC and Ca to derive a site-specific EQS termed the PNEC<sub>dissolved</sub>.  <a href="http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat">http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat</a>.</p> <p>For zinc, if there is an exceedance of the EQSbioavailable in an initial GQRA, Tier 2 required that the EQS for zinc should also have the ambient background concentration of zinc added as well</p>						

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**Table 2: World Health Organization (WHO) guide values for TPH CWG fractions in drinking water<sup>(13)</sup> (as referenced in CL:AIRE, 2017<sup>(11)</sup>)**

TPH CWG fraction	WHO guide value for drinking water <sup>(13)</sup> (µg/l)
<b>Aliphatic fractions:</b>	
Aliphatic EC5-EC6	15,000
Aliphatic >EC6-EC8	15,000
Aliphatic >EC8-EC10	300
Aliphatic >EC10-EC12	300
Aliphatic >EC12-EC16	300
Aliphatic >EC16-EC21	-
Aliphatic >EC21-EC35	-
<b>Aromatic fractions:</b>	
Aromatic EC5-EC6	10 (benzene)
Aromatic >EC6-EC8	700 (toluene)
Aromatic >EC8-EC10	300 (ethyl benzene) 500 (xylenes)
Aromatic >EC10-EC12	90
Aromatic >EC12-EC16	90
Aromatic >EC16-EC21	90
Aromatic >EC21-EC35	90
Reference: World Health Organisation (WHO), 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/05.08/123. World Health Organisation, Geneva <sup>(13)</sup> .	



## References

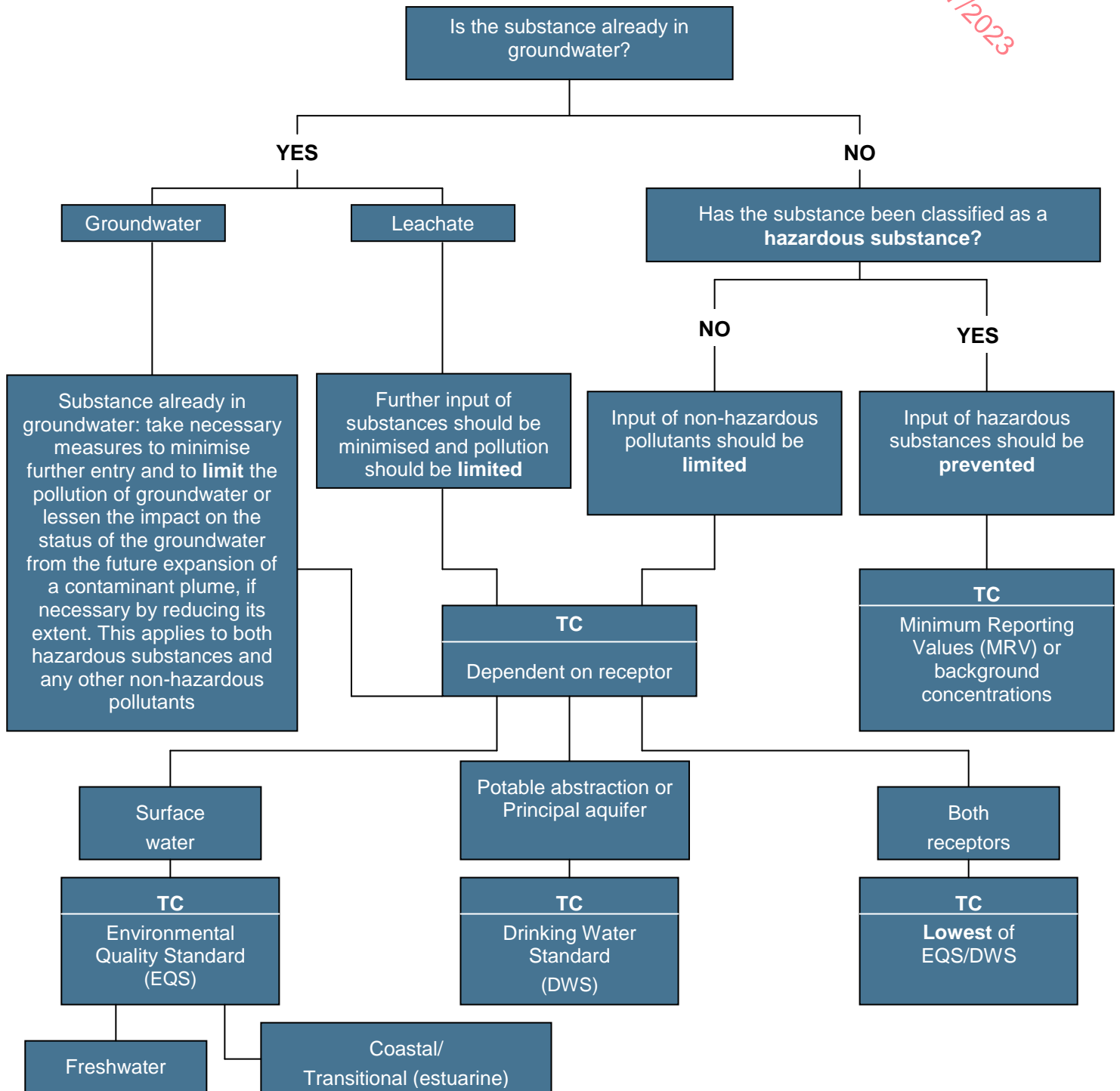
1. Environment Agency (2017), 'The Environment Agency's approach to groundwater protection', version 1.0, March 2017 (formerly contained within GP3) [accessed 29 March 2017].  
<https://www.gov.uk/government/collections/groundwater-protection>
- 1a. Environment Agency (2017), 'Land contamination groundwater compliance points: quantitative risk assessments', March 2017 (formerly contained within GP3) [accessed 29 March 2017].  
<https://www.gov.uk/government/collections/groundwater-protection>
2. The Water Supply (Water Quality) Regulations 2016 (SI 2016/619)
  - 2a. Sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane
  - 2b. Standard applies to individual pesticides except aldrin, dieldrin, heptachlor and heptachlor epoxide, for which a separate standard is defined.
3. The Private Water Supplies (England) Regulations 2016. SI 2016 / 618
4. WHO (2011), *Guidelines for drinking-water quality*, 4th edn
5. JAGDAG hazard substance determinations: This list contains substances that are determined to be hazardous substances or non-hazardous pollutants for the purposes of the groundwater directive 2006/118/EC. The absence of an assessment or substance from the list means an assessment has not been done yet and is presented as 'Not yet determined'; if a substance has been assessed but does not fall into either category it is presented as 'None'. For further details on how substances are assessed, see the Joint Agencies Groundwater Directive Advisory Group (JAGDAG) 'Methodology for the determination of hazardous substances in groundwater for the purposes of the groundwater directive 2006/118/EC' which is available from the JAGDAG website. The methodology is a UK-wide framework that sets criteria for how to assess whether a substance is a hazardous substances in groundwater. The list of substances can be found at:  
<https://www.wfduk.org/stakeholders/jagdag>
6. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.
  - 6a. The EQS for these substances are based on a "long term mean" or an "annual average (AA)" EQS.
  - 6b. For cadmium and its compounds the EQS values vary depending on the hardness of the water as specified in five class categories (Class 1: < 40 mg CaCO<sub>3</sub>/l, Class 2: 40 to < 50 mg CaCO<sub>3</sub>/l, Class 3: 50 to < 100 mg CaCO<sub>3</sub>/l, Class 4: 100 to < 200 mg CaCO<sub>3</sub>/l and Class 5: ≥ 200 mg CaCO<sub>3</sub>/l).
  - 6c. The EQS for Mercury and hexachlorobutadiene are based on a "maximum acceptable concentration (MAC)" EQS in absence of an "annual average (AA)" EQS.
  - 6d. The EQS for chlorine in saltwater is based on the 95<sup>th</sup> percentile concentration of total residual oxidant, which refers to the sum of all oxidising agents existing in water, expressed as available chlorine.
  - 6e. The recommended saltwater standard is derived using a safety factor of 100. Where the standard is failed, it is recommended that supporting evidence of ecological damage should be obtained before committing to expensive action.
  - 6f. EQS for total ammonia is as per Schedule 3, Part 1, Table 7 of of the above directions. EQS applies to river types 1, 2 and 4 and 6 (namely upland and low alkalinity). The EQS for a lowland and high alkalinity rivers (types 3, 5 and 7) is 600µg/l (0.6mg/l).

Additional information on the Metal Bioavailability Assessment Tool (M-BAT) is available at <http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat>

7. Minimum reporting values listed at <https://www.gov.uk/government/publications/values-for-groundwater-risk-assessments/hazardous-substances-to-groundwater-minimum-reporting-values> (updated 13 January 2017; accessed 29 March 2017). Note target concentration for xylenes is 3 µg/l each for o-xylene and m/p xylene as it may not be possible to separate m- and p-xylene; 135 tcb, 124 tcb, 123 tcb each to 0.01 µg/l
8. The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 (as amended). SI 1996 / 3001
9. Council Directive on the Quality of Fresh Waters Needing Protection or Improvement in Order to Support Fish Life (Freshwater Fish Directive) (78/659/EEC)
10. WRc plc (2002), R&D Technical Report P45.
11. CL:AIRE, 2017. Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies. V1.1.
12. Drinking Water Inspectorate (London, UK). Environmental Information Request on MTBE in drinking water. Ref. DWI 1/10/18; dated 28 November 2006. Value is based on the odour threshold for MTBE, which is lower than a health-based guideline value
13. World Health Organisation (WHO), 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/05.08/123. World Health Organisation, Geneva. [accessed 29 March 2017] [http://www.who.int/water\\_sanitation\\_health/dwq/chemicals/petroleumproducts\\_2add\\_june2008.pdf](http://www.who.int/water_sanitation_health/dwq/chemicals/petroleumproducts_2add_june2008.pdf)

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# FLOW CHART TO ASSIST WITH SELECTION OF TARGET CONCENTRATIONS



**TC = Target concentration**

When leachate is being assessed the 'compliance point' is the groundwater body. Therefore dilution within the groundwater body may be applied with caution before comparing with the TC.

When directly assessing a receptor, e.g., a river, the appropriate TC should be selected.