IMP4-3 2022

Flowback Reg 37A and 37B Report

Carpentaria-2H

EP187

Beetaloo Sub-basin

Northern Territory, Australia

Document Control

Revision	Description	Date	Author(s)	Reviewer
0	Draft 0	2/12/2022	CD	NF
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Contents

List of Abbreviations

Acronym/Abbreviation	Description
bbl	Billion barrels
EMP	Environmental Management Plan
EP	Exploration Permit
LEL	Lower Explosive Limit
NORM	Naturally Occurring Radioactive Material
NT	Northern Territory
PER	Petroleum (Environment) Regulations
SCF	Standard Cubic Feet
SCUF	Safe Control Unload and Flowback

1. Background

This report has been written to meet the requirements set out in the Northern Territory Petroleum (Environment) Regulations, section 37A and 37B Report about produced water. For the purposes of this report Imperial Oil and Gas Pty Ltd is "Imperial"

2. 37A Report about flowback fluid

An interest holder in relation to an activity that includes hydraulic fracturing must give the Minister a report about flowback fluid within 6 months of the flowback occurring. Flowback fluid means fluid that is a mixture of hydraulic fracturing fluid and formation fluid that is allowed to flow from the well following hydraulic fracturing. This report has been written to satisfy the requirement.

2.1. The report must contain the following information:

(a) the identity of any chemical or NORM found in the flowback fluid;

Identity of any chemical or Norm in the flowback water is listed in attachment 1 of this report.

(b) the concentration of any chemical or NORM found in the flowback fluid;

Concentration of chemicals in the flowback water is listed in attachment 1 of this report.

(c) details regarding how any chemical or NORM has been or will be managed;

Flowback water was directed to the storage tank in compliance with the Wastewater Management Plan in Appendix 06 of the approved EMP.

(d) details regarding how any chemical or NORM has been or will be transported;

All flowback fluid is stored at the wellsite and has not been transported, except for small volume samples sent for analysis.

Fluid will be transported by a licensed waste transporter as per the Wastewater Management Plan in Appendix 06 of the approved EMP and "Code of Practice: Onshore Petroleum Activities in the Northern Territory."

(e) details regarding how any chemical or NORM has been or will be treated;

Flowback fluid is temporarily stored at the wellsite in a above ground closed top double-lined tank with leak detection system and monitoring of the fluid level.

(f) details regarding any action proposed to be taken to prevent any chemical or NORM spill;

The approved Environmental Management Plan, IMP4-3 requires activities that involve wastewater or chemical storage will be carried out according to:

- The Wastewater Management Plan, Appendix 06.
- The Spill Management Plan, Appendix 07.

(g) details of the emergency contingency plan included in the environment management plan to which the activity relates;

The approved Environmental Management Plan, IMP4-3 requires that in the event of any spill the spill management plan was to be used. The Spill Management Plan is provided in Appendix 07 of the approved EMP.

(h) The requirements in relation to the management of any chemical or NORM of the prescribed chemical legislation.

The approved Environmental Management Plan, IMP3-4 requires activities that involve wastewater or chemical storage will be carried out according to:

- The Wastewater Management Plan, Appendix 06.

- The Spill Management Plan, Appendix 07.

3. 37B Report about Produced fluid

An interest holder in relation to an activity that includes hydraulic fracturing must give the Minister a report about produced water within 6 months of the produced water occurring.

The Petroleum (Environment) Regulations define produced water as "p*roduced water means naturally occurring water that is extracted from the geological formation following hydraulic fracturing*[1]" whereas flowback fluid is defined as "*flowback fluid means fluid that is a mixture of hydraulic fracturing fluid and formation fluid that is allowed to flow from the well following hydraulic fracturing*[2]".

The current volume of water received back from the well is approximately 38% of the total injected volume, see Figure 2. Shale formations such as the Beetaloo Velkerri Shale B do not have enough formation permeability to produce free water (permeability of organic shale formations is in tens to hundreds of a nano-Darcy range, i.e. lower than that of construction concrete). Moreover, gas shales are characterised by a low water saturation and injected fluid is often lost when it imbibes the pore space in shale: "The fracturing fluid imbibition into matrix pores has been regarded as the primary mechanism for inefficient water recovery in shale gas[3]" (i.e., water is more likely to be lost to formation than come out of it). Possible exception is production of water stored in natural fractures. At this stage of exploration activity, we do not have an indication that water-filled fractures exist.

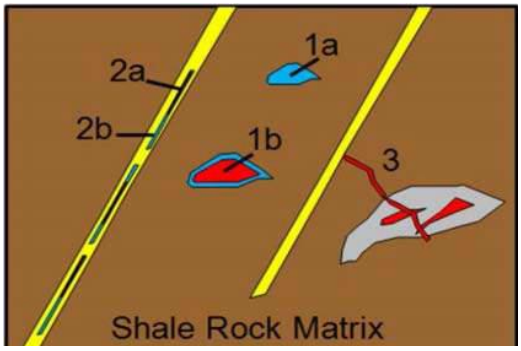

Figure 1 - shale rock matric and pore systems diagram[4]

Shales have a Variety of Pore Systems: Mixed Wettability[4]

- 1a – Water saturated inorganic pore
- 1b – Water wet, gas saturated inorganic pore
- 2a – Gas in fractures
- 2b – Water in fractures
- 3 – Gas in organic pores

Knowing that the volume flowed back out of the well is less than the volume injected and there is no availability for water to move within the pore space of this shale, using the definition of flowback vs produced water, the water received to date should be classified as flowback water and not as the produced water.

[1] Petroleum (Environment) Regulations 2016, produced water definition on page 29
[2] Petroleum (Environment) Regulations 2016, flowback water definition on page 28
[3] Yang, L.; Zhang, C.; Cai, J.; Lu, H. Experimental Investigation of Spontaneous Imbibition of Water into Hydrate Sediments Using Nuclear Magnetic Resonance Method. *Energies* 2020, *13*, 445. https://doi.org/10.3390/en13020445
[4] After Williams, 2012

At the Carpentaria-2H well the volume of water returned to the surface is less than what was used during hydraulic fracturing, so it is quite possible that formation did not contribute any appreciable amount of water. High percentage of fluid recovery is not unheard of in unconventional formations where induced fractures remain open for an extended period of time. Once flowback water reaches greater than 100% of injected water, Imperial can say with full confidence that the well is flowing formation water.

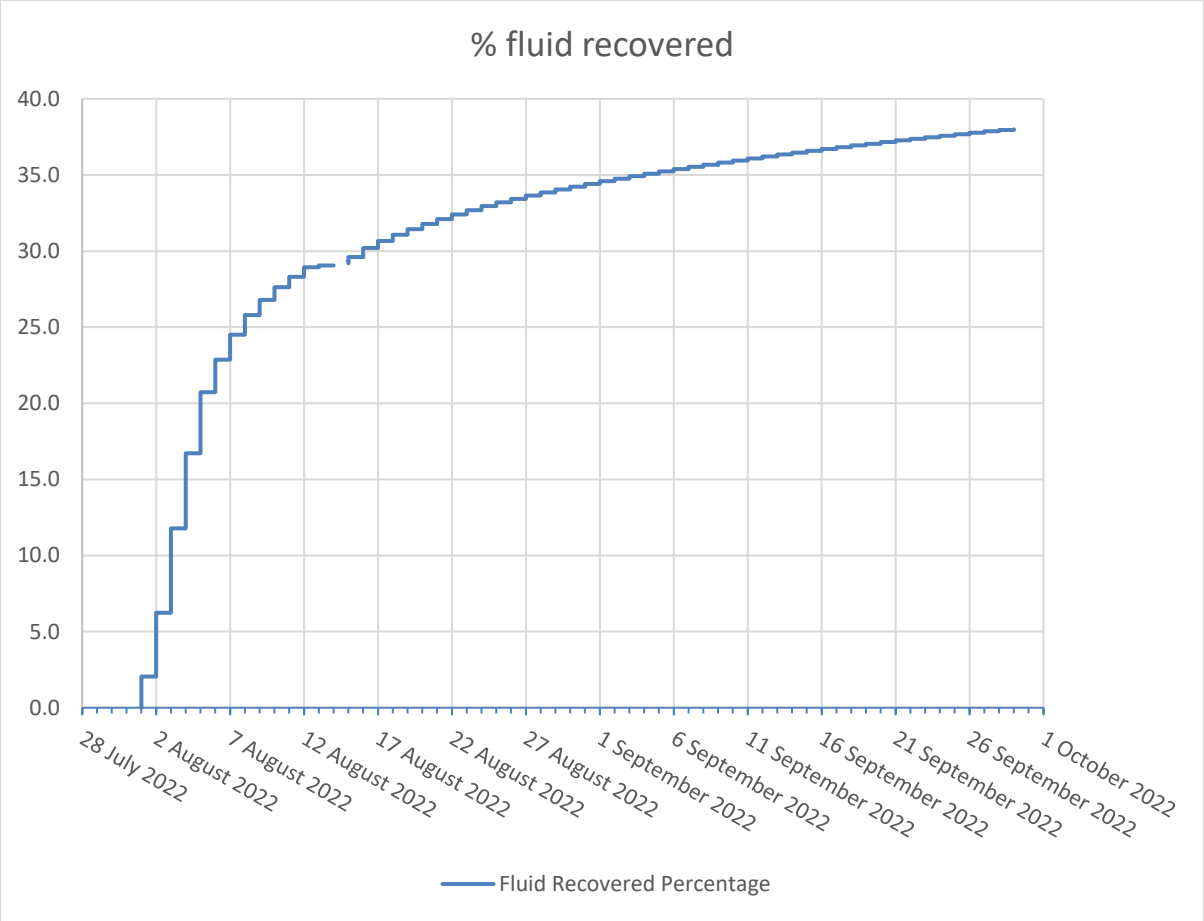

Figure 2 - time v fluid percentage recovery from the Carpentaria-2H well

3.1. The report must contain the following information:

(a) the identity of any chemical or NORM found in the produced water;

No produced water occurred.

(b) the concentration of any chemical or NORM found in the produced water;

No produced water occurred.

(c) details regarding how any chemical or NORM has been or will be managed;

Produced water when it occurs will be managed compliance with the Wastewater Management Plan in Appendix 06 of the approved EMP.

(d) details regarding how any chemical or NORM has been or will be transported;

Produced water when it occurs will be transported by a licensed waste transporter in compliance with the Wastewater Management Plan in Appendix 06 of the approved EMP and "Code of Practice: Onshore Petroleum Activities in the Northern Territory."

(e) details regarding how any chemical or NORM has been or will be treated;

No produced water occurred, should it occur, it will be temporarily stored at the wellsite in a above ground double-lined tank with leak detection system and monitoring of the fluid level.

(f) details regarding any action proposed to be taken to prevent any chemical or NORM spill;

The approved Environmental Management Plan, IMP4-3 requires activities that involve wastewater or chemical storage will be carried out according to:

- The Wastewater Management Plan, Appendix 06.
- The Spill Management Plan, Appendix 07.

(g) details of the emergency contingency plan included in the environment management plan to which the activity relates;

The approved Environmental Management Plan, IMP4-3 requires that in the event of any spill the spill management plan was to be used. The Spill Management Plan is provided in Appendix 07 of the approved EMP.

(h) the requirements in relation to the management of any

The approved Environmental Management Plan, IMP4-3 requires activities that involve wastewater or chemical storage will be carried out according to:

- The Wastewater Management Plan, Appendix 06.
- The Spill Management Plan, Appendix 07.

Matrix:	WATER	**Sample Type:**	**REG**
Workgroup:	ES2238034	**ALS Sample Number:**	ES2238034001
Project name/number:	EP187	**Sample Date:**	19/10/2022
		Client sample ID (1st):	Carp 2 Flowback
		Client sample ID (2nd):	
		Depth Type:	
		Depth (m):	
		Site:	
		Purchase Order:	

Analyte grouping/Analyte	CAS Number	Unit	Limit of reporting	
EA005P: pH by PC Titrator				
pH Value		pH Unit	0.01	**6.74**
EA010P: Conductivity by PC Titrator				
Electrical Conductivity @ 25°C		µS/cm	1	**72600**
EA015: Total Dissolved Solids dried at 180 ± 5 °C				
Total Dissolved Solids @180°C		mg/L	10	**56100**
EA025: Total Suspended Solids dried at 104 ± 2°C				
Suspended Solids (SS)		mg/L	5	**36**
Suspended Solids (SS)		mg/L	1	**----**
EA250: Gross Alpha and Beta Activity				
Gross beta		Bq/L	0.10	**26.6**
ED037P: Alkalinity by PC Titrator				
Hydroxide Alkalinity as CaCO3	DMO-210-001	mg/L	1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	mg/L	1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	mg/L	1	**319**
Total Alkalinity as CaCO3		mg/L	1	**319**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA				
Sulfate as SO4 - Turbidimetric	14808-79-8	mg/L	1	<50
ED045G: Chloride by Discrete Analyser				
Chloride	16887-00-6	mg/L	1	**29100**
ED093F: Dissolved Major Cations				
Calcium	7440-70-2	mg/L	1	**4170**
Magnesium	7439-95-4	mg/L	1	**938**
Sodium	7440-23-5	mg/L	1	**12900**
Potassium	7440-09-7	mg/L	1	**108**
ED093F: SAR and Hardness Calculations				
Sodium Adsorption Ratio			0.01	**47.0**
ED093T: Total Major Cations				
Calcium	7440-70-2	mg/L	1	**----**
Magnesium	7439-95-4	mg/L	1	**----**

Sodium	7440-23-5	mg/L	1	**----**
Potassium	7440-09-7	mg/L	1	**----**
EG020F: Dissolved Metals by ICP-MS				
Aluminium	7429-90-5	mg/L	0.01	<0.10
Antimony	7440-36-0	mg/L	0.001	**0.011**
Arsenic	7440-38-2	mg/L	0.001	**0.015**
Beryllium	7440-41-7	mg/L	0.001	<0.010
Barium	7440-39-3	mg/L	0.001	**338**
Cadmium	7440-43-9	mg/L	0.0001	<0.0010
Chromium	7440-47-3	mg/L	0.001	<0.010
Cobalt	7440-48-4	mg/L	0.001	<0.010
Copper	7440-50-8	mg/L	0.001	<0.010
Lead	7439-92-1	mg/L	0.001	<0.010
Lithium	7439-93-2	mg/L	0.001	**11.0**
Manganese	7439-96-5	mg/L	0.001	**7.73**
Molybdenum	7439-98-7	mg/L	0.001	**0.028**
Nickel	7440-02-0	mg/L	0.001	**0.018**
Selenium	7782-49-2	mg/L	0.01	<0.10
Silver	7440-22-4	mg/L	0.001	<0.010
Strontium	7440-24-6	mg/L	0.001	**292**
Thorium	7440-29-1	mg/L	0.001	<0.010
Tin	7440-31-5	mg/L	0.001	<0.010
Uranium	7440-61-1	mg/L	0.001	<0.010
Vanadium	7440-62-2	mg/L	0.01	<0.10
Zinc	7440-66-6	mg/L	0.005	**0.145**
Boron	7440-42-8	mg/L	0.05	**23.0**
Iron	7439-89-6	mg/L	0.05	**42.2**
EG020T: Total Metals by ICP-MS				
Aluminium	7429-90-5	mg/L	0.01	<0.10
Antimony	7440-36-0	mg/L	0.001	**0.016**
Arsenic	7440-38-2	mg/L	0.001	**0.012**
Beryllium	7440-41-7	mg/L	0.001	<0.010
Barium	7440-39-3	mg/L	0.001	**345**
Cadmium	7440-43-9	mg/L	0.0001	<0.0010
Chromium	7440-47-3	mg/L	0.001	**0.014**
Cobalt	7440-48-4	mg/L	0.001	<0.010
Copper	7440-50-8	mg/L	0.001	<0.010
Lead	7439-92-1	mg/L	0.001	<0.010
Lithium	7439-93-2	mg/L	0.001	**10.7**
Manganese	7439-96-5	mg/L	0.001	**8.01**
Molybdenum	7439-98-7	mg/L	0.001	**0.026**
Nickel	7440-02-0	mg/L	0.001	**0.024**
Selenium	7782-49-2	mg/L	0.01	<0.10
Silver	7440-22-4	mg/L	0.001	<0.010
Strontium	7440-24-6	mg/L	0.001	**285**
Thorium	7440-29-1	mg/L	0.001	<0.010
Tin	7440-31-5	mg/L	0.001	<0.010
Uranium	7440-61-1	mg/L	0.001	<0.010
Vanadium	7440-62-2	mg/L	0.01	<0.10
Zinc	7440-66-6	mg/L	0.005	**0.156**

Boron	7440-42-8	mg/L	0.05	**22.8**
Iron	7439-89-6	mg/L	0.05	**45.4**
EG032: Arsenic Speciation by LC-ICPMS				
Arsenious Acid (As (III))		µg/L	0.5	**8.8**
Arsenic Acid (As (V))		µg/L	0.5	<8.0
EG035F: Dissolved Mercury by FIMS				
Mercury	7439-97-6	mg/L	0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS				
Mercury	7439-97-6	mg/L	0.0001	<0.0001
EG052G: Silica by Discrete Analyser				
Reactive Silica		mg/L	0.05	**----**
EK010-1: Chlorine				
Total Residual Chlorine		mg/L	0.02	<0.10
Free Chlorine		mg/L	0.02	<0.10
EK026SF: Total CN by Segmented Flow Analyser				
Total Cyanide	57-12-5	mg/L	0.004	<0.004
EK040P: Fluoride by PC Titrator				
Fluoride	16984-48-8	mg/L	0.1	**1.2**
EK055G: Ammonia as N by Discrete Analyser				
Ammonia as N	7664-41-7	mg/L	0.01	**65.2**
EK057G: Nitrite as N by Discrete Analyser				
Nitrite as N	14797-65-0	mg/L	0.01	<0.10
EK058G: Nitrate as N by Discrete Analyser				
Nitrate as N	14797-55-8	mg/L	0.01	<0.10
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser				
Nitrite + Nitrate as N		mg/L	0.01	<0.10
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser				
Total Kjeldahl Nitrogen as N		mg/L	0.1	**82.8**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser				
Total Nitrogen as N		mg/L	0.1	**82.8**
EK067G: Total Phosphorus as P by Discrete Analyser				
Total Phosphorus as P		mg/L	0.01	<1.00
EK071G: Reactive Phosphorus as P by discrete analyser				
Reactive Phosphorus as P	14265-44-2	mg/L	0.01	**0.89**
EN055: Ionic Balance				
Total Anions		meq/L	0.01	**827**

Total Cations		meq/L	0.01	**849**
Ionic Balance		%	0.01	**1.31**
EP002: Dissolved Organic Carbon (DOC)				
Dissolved Organic Carbon		mg/L	1	**382**
EP005: Total Organic Carbon (TOC)				
Total Organic Carbon		mg/L	1	**414**
EP010: Formaldehyde				
Formaldehyde	50-00-0	mg/L	0.1	**8.6**
EP025: Oxygen - Dissolved (DO)				
Dissolved Oxygen		mg/L	0.1	**2.7**
EP033: C1 - C4 Hydrocarbon Gases				
Methane	74-82-8	µg/L	10	**----**
Ethane	74-84-0	µg/L	10	**----**
Propane	74-98-6	µg/L	10	**----**
EP075(SIM)A: Phenolic Compounds				
Phenol	108-95-2	µg/L	1.0	**36.6**
2-Chlorophenol	95-57-8	µg/L	1.0	<1.0
2-Methylphenol	95-48-7	µg/L	1.0	<1.0
3- & 4-Methylphenol	1319-77-3	µg/L	2.0	**101**
2-Nitrophenol	88-75-5	µg/L	1.0	<1.0
2.4-Dimethylphenol	105-67-9	µg/L	1.0	<1.0
2.4-Dichlorophenol	120-83-2	µg/L	1.0	<1.0
2.6-Dichlorophenol	87-65-0	µg/L	1.0	<1.0
4-Chloro-3-methylphenol	59-50-7	µg/L	1.0	<1.0
2.4.6-Trichlorophenol	88-06-2	µg/L	1.0	<1.0
2.4.5-Trichlorophenol	95-95-4	µg/L	1.0	<1.0
Pentachlorophenol	87-86-5	µg/L	2.0	<2.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons				
Naphthalene	91-20-3	µg/L	1.0	<1.0
Acenaphthylene	208-96-8	µg/L	1.0	<1.0
Acenaphthene	83-32-9	µg/L	1.0	<1.0
Fluorene	86-73-7	µg/L	1.0	<1.0
Phenanthrene	85-01-8	µg/L	1.0	<1.0
Anthracene	120-12-7	µg/L	1.0	<1.0
Fluoranthene	206-44-0	µg/L	1.0	<1.0
Pyrene	129-00-0	µg/L	1.0	<1.0
Benz(a)anthracene	56-55-3	µg/L	1.0	<1.0
Chrysene	218-01-9	µg/L	1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	µg/L	1.0	<1.0
Benzo(k)fluoranthene	207-08-9	µg/L	1.0	<1.0
Benzo(a)pyrene	50-32-8	µg/L	0.5	<0.5
3-Methylcholanthrene	56-49-5	µg/L	1.0	<1.0
Indeno(1.2.3.cd)pyrene	193-39-5	µg/L	1.0	<1.0
7.12-Dimethylbenz(a)anthracene	57-97-6	µg/L	1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	µg/L	1.0	<1.0

Benzo(g.h.i)perylene	191-24-2	µg/L	1.0	<1.0
Sum of polycyclic aromatic hydrocarbons		µg/L	0.5	<0.5
Benzo(a)pyrene TEQ (zero)		µg/L	0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons				
C6 - C9 Fraction		µg/L	20	<100
C10 - C14 Fraction		µg/L	50	**900**
C15 - C28 Fraction		µg/L	100	**570**
C29 - C36 Fraction		µg/L	50	**130**
C10 - C36 Fraction (sum)		µg/L	50	**1600**
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions				
C6 - C10 Fraction	C6_C10	µg/L	20	<100
C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	µg/L	20	<100
>C10 - C16 Fraction		µg/L	100	**1040**
>C16 - C34 Fraction		µg/L	100	**480**
>C34 - C40 Fraction		µg/L	100	<100
>C10 - C40 Fraction (sum)		µg/L	100	**1520**
>C10 - C16 Fraction minus Naphthalene (F2)		µg/L	100	**1040**
EP080: BTEXN				
Benzene	71-43-2	µg/L	1	<5
Toluene	108-88-3	µg/L	2	<5
Ethylbenzene	100-41-4	µg/L	2	<5
meta- & para-Xylene	108-38-3 106-42-3	µg/L	2	<5
ortho-Xylene	95-47-6	µg/L	2	<5
Total Xylenes		µg/L	2	<2
Sum of BTEX		µg/L	1	<2
Naphthalene	91-20-3	µg/L	5	<5
EP132A: Phenolic Compounds				
m-Cresol	108-39-4	µg/L	0.1	**0.3**
p-Cresol	106-44-5	µg/L	0.1	**146**
Hexachlorophene	70-30-4	µg/L	0.1	<0.2
4-Nitrophenol	100-02-7	µg/L	0.1	<0.2
EP132B: Polynuclear Aromatic Hydrocarbons				
3-Methylcholanthrene	56-49-5	µg/L	0.1	----
2-Methylnaphthalene	91-57-6	µg/L	0.1	----
7.12-Dimethylbenz(a)anthracene	57-97-6	µg/L	0.1	----
Acenaphthene	83-32-9	µg/L	0.1	----
Acenaphthylene	208-96-8	µg/L	0.1	----
Anthracene	120-12-7	µg/L	0.1	----
Benz(a)anthracene	56-55-3	µg/L	0.1	----
Benzo(a)pyrene	50-32-8	µg/L	0.05	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	µg/L	0.1	----
Benzo(e)pyrene	192-97-2	µg/L	0.1	----
Benzo(g.h.i)perylene	191-24-2	µg/L	0.1	----
Benzo(k)fluoranthene	207-08-9	µg/L	0.1	----
Chrysene	218-01-9	µg/L	0.1	----
Coronene	191-07-1	µg/L	0.1	----
Dibenz(a.h)anthracene	53-70-3	µg/L	0.1	----

Fluoranthene	206-44-0	µg/L	0.1	----
Fluorene	86-73-7	µg/L	0.1	----
Indeno(1.2.3.cd)pyrene	193-39-5	µg/L	0.1	----
Naphthalene	91-20-3	µg/L	0.1	----
Perylene	198-55-0	µg/L	0.1	----
Phenanthrene	85-01-8	µg/L	0.1	----
Pyrene	129-00-0	µg/L	0.1	----
Sum of PAHs		µg/L	0.05	----
Benzo(a)pyrene TEQ (zero)		µg/L	0.05	----
EP247: Phenolics and Related Compounds				
2,4-Dinitrophenol	51-28-5	µg/L	0.01	<0.01
2-Methyl-4.6-dinitrophenol	8071-51-0	µg/L	0.05	<0.05
Dinoseb	88-85-7	µg/L	0.10	<0.10
ED009: Anions				
Bromide	24959-67-9	mg/L	0.010	**353**
EA250CA: Gross Alpha and Beta Activity				
Gross alpha		Bq/L	0.05	**49.3**
Gross beta activity - 40K		Bq/L	0.10	----
EP075(SIM)S: Phenolic Compound Surrogates				
Phenol-d6	13127-88-3	%	1.0	17.0
2-Chlorophenol-D4	93951-73-6	%	1.0	48.0
2.4.6-Tribromophenol	118-79-6	%	1.0	75.6
EP075(SIM)T: PAH Surrogates				
2-Fluorobiphenyl	321-60-8	%	1.0	53.8
Anthracene-d10	1719-06-8	%	1.0	67.2
4-Terphenyl-d14	1718-51-0	%	1.0	70.3
EP080S: TPH(V)/BTEX Surrogates				
1.2-Dichloroethane-D4	17060-07-0	%	2	117
Toluene-D8	2037-26-5	%	2	113
4-Bromofluorobenzene	460-00-4	%	2	115
EP132S: Acid Extractable Surrogates				
2-Fluorophenol	367-12-4	%	0.1	55.4
Phenol-d6	13127-88-3	%	0.1	62.6
2-Chlorophenol-D4	93951-73-6	%	0.1	71.5
2.4.6-Tribromophenol	118-79-6	%	0.1	62.0
EP132T: Base/Neutral Extractable Surrogates				
2-Fluorobiphenyl	321-60-8	%	0.1	72.2
Anthracene-d10	1719-06-8	%	0.1	73.3
4-Terphenyl-d14	1718-51-0	%	0.1	72.0