A63 Castle Street Improvements, Hull
Environmental Statement

Volume 3 Appendix 11.1

ROAD DRAINAGE AND THE WATER ENVIRONMENT – SURFACE WATER QUALITY IMPACT ASSESSMENT

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A63 Castle Street Improvements, Hull

Environmental Statement

Appendix 11.1 Surface water quality impact assessment

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Contents

1. Introduction

1.1.1 This appendix describes the approach and findings of the surface water quality impact assessment for the Stage 3 Preliminary Design Stage of the Highways Agency's A63 Castle Street Improvement Scheme which is referred to in this study as the "Scheme". This appendix should be read in conjunction with Chapter 11 Road drainage and the water environment. The methodologies and supporting calculations are presented in this appendix, whilst the assessment of the magnitude and significance of impacts and any subsequent requirements for mitigation are presented in Chapter 11 Road drainage and the water environment.

1.1.2 The only proposed discharge to a water body is from the underpass drainage to the Humber Estuary, an estuarine water body. The proposed drainage strategy for the Scheme is described in Chapter 2 The Scheme. The assessment methodology for estimating the routine runoff impacts and accidental spillage risk to the Humber water body during the operational phase of the Scheme is described in Section 2 of this report. The approach follows the guidance within the Design Manual for Roads and Bridges (DMRB) HD45/09[1]. The purpose of the assessments is to determine whether mitigation measures in the form of pollution control or spillage containment are required during the operational phase. Surface water quality impacts during construction are considered in Chapter 11 Road drainage and the water environment.

1.1.3 The DMRB HD45/09 guidance proposes the use of the Highways Agency Water Risk Assessment Tool (HAWRAT), a pollution risk screening tool to determine the routine runoff impacts of surface water discharges. However, HAWRAT is not designed for use with discharges to tidal waters such as the Humber Estuary. Therefore, a modified routine runoff impact assessment was agreed with the Environment Agency.

1.1.4 The assessment also considers the proposed discharge in the context of the Water Framework Directive (WFD).

[1] Highways Agency (2009). Design Manual for Roads and Bridges, Volume 11, Section 3, Part 10, HD45/09, Road Drainage and the Water Environment. http://www.dft.gov.uk/ha/standards/dmrb/

2. Assessment methodology

2.1 Introduction

2.1.1 The proposed drainage from the underpass would discharge either via an outfall into the Humber Estuary or to the existing Yorkshire Water sewer network. This is the subject of ongoing investigation; however, this assessment only considers a proposed discharge into the Humber Estuary. The Humber Estuary is located between 250m and 500m south of the Scheme, whose flow is tidally dominated. There are other water bodies within the 1km study area around the Scheme namely:

- The lower reaches of the River Hull, which lies approximately 100m east of the eastern edge of the Scheme, at its confluence with the Humber Estuary. This reach of the River Hull is also subject to tidal flow
- Albert Dock, an active port, which is subject to water level variation with the tidal cycle
- Humber Dock and Railway Dock, an active marina whose water is managed for navigation and recreation purposes. Humber Dock Basin, at the entrance to Humber Dock, is tidally influenced
- Princes Dock, this is now an ornamental water feature and is not considered to be hydraulically connected to the Humber. Part of the dock has been developed as the Princes Quay Shopping Centre

2.1.2 Consultation with British Waterways Marinas Ltd (BWML) suggested that Humber Dock and Princes Dock are no longer hydrologically connected.

2.1.3 All of these water bodies are classified under the same water body in the WFD known as ‘Humber Middle’, defined as a ‘heavily modified’ water body. The current water body status and potential impacts of the proposed discharge are considered in this assessment. The upper reaches of the River Hull (GB104026067212) is designated separately to the lower reach, which is part of the Humber Middle water body. Within the 1km study area, the River Hull is part of the Humber Middle transitional water body.

2.1.4 In this location, the Humber Estuary is designated as a Ramsar Site, Special Protection Area (SPA), Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI). The designated area includes the mouth of Albert Dock, Humber Dock Basin, the mouth of the River Hull up to the Hull Tidal Surge Barrier and Fleet Drain but Albert Dock, Railway Dock, Humber Dock and Princes Dock are not part of the designation (see Chapter 10 Ecology and nature conservation).

2.2 Methodology

2.2.1 During operation, the principal areas of concern arise from pollutants washed from the road surface by rainwater draining from the Scheme area and spillages of fuel or other contaminants as a result of road traffic accidents.

2.2.2 The method adopted to assess the effects of the proposed highway operation on surface waters takes into consideration:

- the DMRB guidance document HD45/09
- consultation with the Environment Agency, Natural England and the Marine Management Organisation (MMO)
- recommendations in the Scoping Opinion from the Planning Inspectorate

2.2.3 The DMRB guidance document HD45/09 requires an assessment of the potential effects of construction and operation of the highway on the quality of surface water and groundwater. Relevant to this assessment, Method A and Method B considers the effects of routine runoff (operational) on surface waters while Method D considers the pollution impacts from accidental spillages. The HAWRAT has been developed to assess the effects from these risks.

2.3 Routine runoff impacts

2.3.1 Method A considers the short-term effects of pollutants as well as long-term effects recognising that short-term event based effects may be masked when considering long-term averages. Method A considers soluble pollutants associated with acute pollution impacts, expressed as Event Mean Concentrations (EMCs) for dissolved copper and zinc. Method A also calculates long-term annual average concentrations of dissolved copper and zinc. These metals are used as indicators of the level of impact as they are generally the main metallic pollutants associated with road drainage and can be toxic to aquatic life.

2.3.2 Sediment-bound pollutants associated with chronic pollution impacts are also considered and expressed as Event Mean Sediment Concentrations (EMSCs) for total copper, zinc, cadmium, pyrene, fluoranthene, anthracene, phenanthrene and total polycyclical aromatic hydrocarbons (PAH).

2.3.3 The HAWRAT assessment Method A adopts a phased approach:

- Step 1 assesses the quality of direct highway runoff against toxicity thresholds, assuming no in-river dilution, treatment or attenuation
- Step 2 assesses the diluting capacity of the watercourse for acute impacts of soluble pollutants, and the likelihood and extent of sediment deposition for chronic impacts of sediment-bound pollutants

- Step 3 assesses the effectiveness of existing and proposed treatment systems for soluble pollutants and if the site is predicted to accumulate sediments, the percentage of settlement required to ensure that the extent of sediment coverage complies with the threshold deposition index value

2.3.4 The DMRB guidance states that care must be taken when considering the use of HAWRAT in urban highways and where the receiving water course is tidal such as this. In addition to this the input parameter ranges in Step 2 of the HAWRAT assessment prevent the application of the tool to this Scheme beyond Step 1 due to the large flow rates and large channel width associated with the Humber Estuary.

2.3.5 Therefore, in consultation with the Highways Agency[2] and the Environment Agency, it was agreed to undertake an adapted Step 2 assessment based on mass-balance calculation to assess the dilution in the receiving water. This is in principle the same approach as undertaken in HAWRAT with the following differences:

- Velocity in the receiving water is taken from the UK Hydrographic Office (UKHO) tidal stream diamond data for Albert Dock (53°43.85'N 0°20.92'W) which provides spring and neap tide velocities

- Discharge is estimated from the velocity data and approximate channel dimensions of the receiving estuarine channel in the Humber Estuary

2.3.6 If the in-river annual average concentrations of the soluble pollutants exceed the Environmental Quality Standard (EQS) there may be a need to undertake an assessment of the bioavailability of the soluble pollutant using a biotic ligand model (BLM). This is known as Method B – Detailed Assessment.

2.4 Accidental spillage impacts

2.4.1 The water quality impacts of accidental spillages on surface water bodies have been assessed using the DMRB Method D – Assessment of Pollution Impacts from Spillages. This method defines the risk as the probability that there will be a spillage of pollutant, which will subsequently reach and impact the water body to such an extent that either a Category 1 or 2 incident (a serious pollution incident) occurs. The methodology is applied as presented in the DMRB guidance.

2.5 Summary of consultation

2.5.1 Staff from Mott MacDonald Grontmij (now Mott Macdonald Sweco) met with the Environment Agency, Natural England and the MMO on 6 June 2013 to discuss potential locations of the discharge, water quality impact assessment requirements

[2] The Highways Agency is now known as Highways England

and other requirements of the stakeholders including consents associated with the construction and operation of the rising main and outfall to the Humber Estuary.

2.5.2 The Environment Agency stated that the discharge from the outfall must not cause scour and sediment plumes downstream of the outfall location and should consider tidal locking (i.e., the prevention of discharge from an outfall when the outfall is submerged during a high tide). Natural England stated that any new outfall should be located as close as possible to existing outfalls which discharge onto existing rock armour. Therefore, the proposed location of the outfall (see Volume 2, Figure 2.5.6) is located above an area of existing rock armour, in the location of other outfalls, thereby minimising scour and the generation of a resultant sediment plume. The underpass drainage strategy[3] proposes that the main between the pumping station in the underpass and the new outfall is pressurised to prevent tidal locking.

2.5.3 Natural England stated that they would require construction and operational impacts to be considered including an assessment of the impacts on flow rates, volumes and water quality. The impact on discharge volume and flow rates is discussed in Chapter 11 Road drainage and the water environment.

2.5.4 It was agreed that any approach to the water quality impact assessment would need to be agreed with the Environment Agency as well as the Highways Agency[2]. Natural England confirmed that the Environment Agency should take the lead on this matter. Subsequent to this an impact assessment methodology document was drafted for discussion with the Highways Agency[2] and the Environment Agency and was subsequently accepted in principle by the Environment Agency in a letter dated 2 August 2013.

2.5.5 In the letter of 2 August 2013, the Environment Agency also requested that the following measures are incorporated into the drainage design:

- Adequate pollution control measures, e.g. oil/petrol interception facilities, are in place to remove residual oil/petrol contaminants, prior to discharge to the Humber
- Additional measures should be incorporated in the infrastructure of the drainage system, e.g. cut off valves, such that in the event of a major incident on the A63, any contaminants lost to the drainage system serving the carriageway can be isolated and contained

2.5.6 This assessment also considers the recommendations received in the Scoping Opinion. In addition to those items discussed above the relevant recommendations to this assessment are:

[3] Arup (2017) Underpass Drainage Strategy Report, September 2017

- Consideration of the impact on Water Framework Directive (WFD)
- Consider the requirements for on-going monitoring to ensure any mitigation measures are effective

2.5.7 The impact of the Scheme on the WFD is considered in ES Chapter 11 Road drainage and the water environment.

3. Surface water quality

3.1 Water Framework Directive status

3.1.1 The current WFD status of the 'Humber Middle' surface water body potentially affected by the Scheme is described in Table 1.

Table 1: Current status of the WFD 'Humber Middle' water body

Water body ID	GB530402609202
Water body name	HUMBER MIDDLE
River basin district	Humber
Typology description	Transitional Water
Hydromorphological status	Heavily Modified
2016 Cycle 2 current ecological quality	Moderate Potential
2016 Cycle 2 current chemical quality	Fail
2027 Predicted ecological quality	Moderate Potential
2027 Predicted chemical quality	Good
Protected area	Yes, Conservation of Wild Birds directive, Habitats and Species Directive and Nitrates Directive.

3.1.2 The 'Humber Middle' water body incorporates Albert Dock, Humber Dock, Princes Dock and the lower reaches of the River Hull. Although the assessment of fish population is considered to be good, with the tidal regime supporting good potential, the overall ecological potential is considered to be moderate. This is due to biological quality elements, specifically angiosperms, only achieving moderate potential, and its water quality, namely dissolved inorganic nitrogen, which has moderate potential. The predicted status by 2027 for angiosperms is good. However, dissolved inorganic nitrogen is predicted to remain at moderate as actions to achieve good are considered to be disproportionately expensive due to the cost involved in identifying and controlling unknown point and diffuse sources of nitrogen pollution.

3.1.3 The chemical status fails due to the presence of tributyltin compounds at the time of assessment. Tributyltin compounds are used in anti-fouling pesticides in marine paints and industrial water systems. The justification for not achieving good status in 2015 is that actions would be technically infeasible, due to lack of time to identify specific sources, although the sale and use of tributyltin compounds is now restricted. There are no future objectives set for tributyltin, however, the overall chemical status is predicted to be good.

3.2 Environment Agency water quality data

3.2.1 Water quality data provided by the Environment Agency indicates that the average concentration of dissolved copper in the Humber Estuary at Albert Dock between 2003 and 2008 was 4.9 µg/l from a total of 62 samples. This average is higher than the current EQS for marine waters (3.76 µg/l for dissolved organic carbon concentrations less than 1 mg/l). The average concentration of dissolved zinc for the same period was 9.2 µg/l (from a total of 60 samples) which is also higher than the current EQS for marine waters (6.8 µg/l). Maximum concentrations within this period are 11.8 µg/l and 51.8 µg/l dissolved copper and zinc respectively.

3.2.2 Apart from ad hoc sampling in 2012 for the anti-fouling agent tributyltin, Environment Agency water quality monitoring at Albert Dock ceased in 2008. From a total of 18 samples, the average concentration of tributyltin was 0.0024 µg/l

3.2.3 Water quality data is currently sampled by the Environment Agency at Salt End Jetty and Drypool Bridge which are located approximately 6.1km downstream along the Humber and 1.4km upstream along the River Hull respectively. The average concentration of dissolved copper in the Humber Estuary at Salt End Jetty between 2008 and 2017 was 3.36 µg/l, and that of dissolved zinc was 5.69 µg/l. Both of these average concentrations are less than the respective EQS values. Maximum concentrations within this period are 9.08 µg/l and 10.4 µg/l dissolved copper and zinc respectively; both of these maximum concentrations are greater than the respective EQS values. There was no obvious temporal trend in the measured concentrations of copper or zinc at Salt End Jetty.

3.2.4 The average concentration of dissolved copper in the River Hull at Drypool Bridge between 2008 and 2017 was 4.40 µg/l (greater than the EQS) and that of dissolved zinc was 3.99 µg/l (less than the EQS). Maximum concentrations within this period are 13.1 µg/l and 10.4 µg/l dissolved cooper and zinc respectively. Both of the maximum measured concentrations were greater than the relevant EQS. There was no obvious temporal trend in the measured concentrations of copper or zinc at Drypool Bridge.

3.3 Ground investigation water quality monitoring

3.3.1 Water quality sampling was undertaken as part of ground investigations[4] on three occasions between August and December 2013 from the Humber Estuary, the River Hull (upstream and downstream of the Scheme) and the Humber Dock, and

[4] Mott MacDonald Grontmij (2014) A63 Castle Street Improvements, Hull - Ground Investigation Report. 1168-09-152-RE-001-PD1

on seven occasions between August and December 2013 from Railway Dock (east and west). Additional samples have been taken at each of the sampling locations on four occasions between May and August 2014 to provide further background monitoring data. The approximate sampling locations are detailed in Figure 1.

Table 2, Table 3 and

3.3.2 Table 4 present a summary of the EQS exceedances from all of the monitoring data at the Railway and Humber Docks, Humber Quays (Humber Estuary) and the River Hull respectively (the full data is provided in Appendix B). The data set is approximately one year in length between August 2013 and August 2014, and is taken 5 years after the last available sampling at Albert Dock in the provided Environment Agency data, which doesn't allow direct comparison and identification of any trends. This highlights the need for monitoring of surface water quality in the vicinity of the Scheme area prior to, during and post construction to establish baseline conditions and monitor for any construction and operational impacts. Monitoring requirements will need to be agreed with the Environment Agency.

3.3.3 There are widespread exceedances in many parameters. Dissolved copper exceeded the EQS[5] value of 3.76 mg/l for all samples collected with measured concentrations ranging from 28 to 12,000 mg/l. Dissolved zinc exceeded the EQS value of 6.8 mg/l for 26 out of 33 samples with measured concentrations ranging from 4 to 41 mg/l/.

5 The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015

Figure 1: Ground investigation approximate surface water sampling locations (red squares)

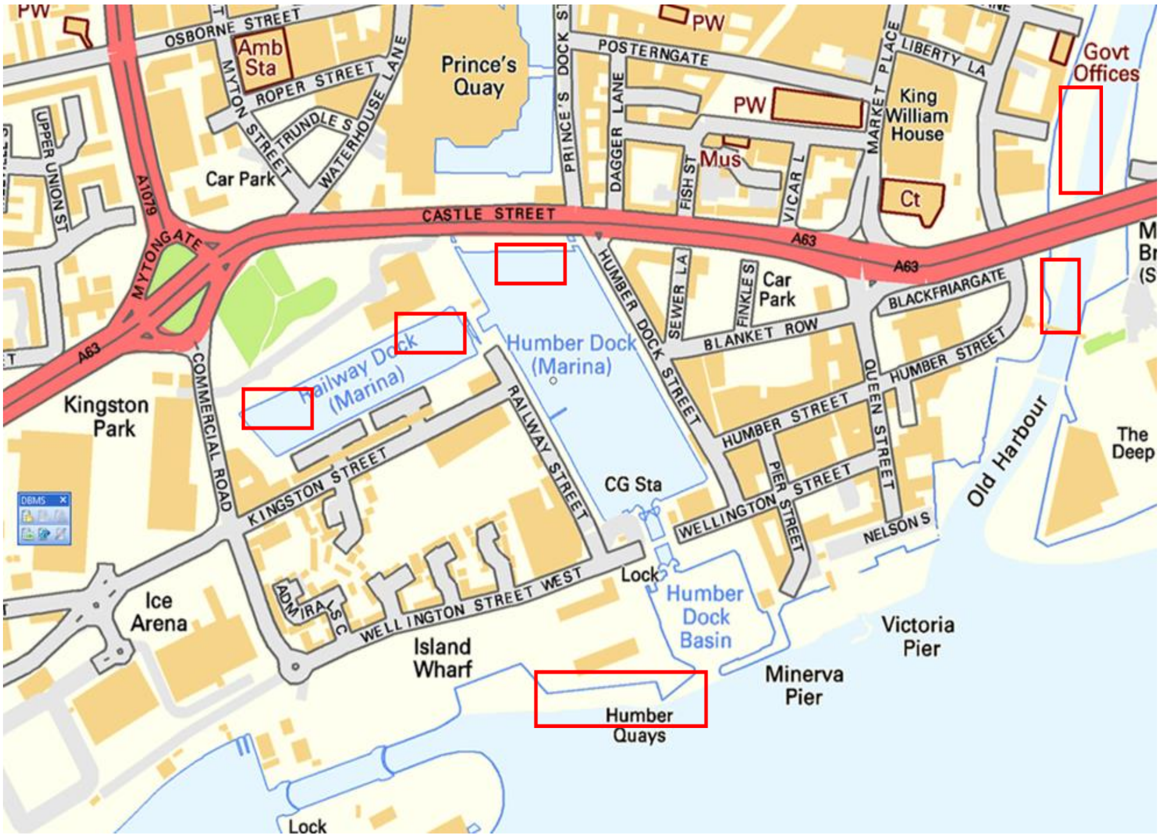

Table 2: Chemical exceedances of WFD EQSs during 2013 and 2014 sampling from the Humber Estuary

Parameter	AA-EQS[1]	MAC-EQS[1]	Range of measured values	Comments
Arsenic (µg/l)	25	-	37-120	6 out of 7 samples exceeded
Chromium (III dissolved) (µg/l)	4.7 [2]	32 [2]	3-12	4 out of 7 samples exceeded AA-EQS, zero exceedances of MAC-EQS
Chromium (VI dissolved) (µg/l)	0.6	32	<3-3	Zero exceedances of MAC-EQS
Copper (dissolved - µg/l)	3.76 [2,3]	-	28-8,900	7 out of 7 samples exceeded
Ammoniacal Nitrogen as N (mg/l)	0.021[4]	-	0.35-0.82	6 out of 7 samples exceeded
Ammoniacal Nitrogen as NH4 (mg/l)	0.027[4]	-	0.45-1.10	6 out of 7 samples exceeded
Indeno(1,2,3-cd)pyrene and	0.00017	-	<0.02-0.05	1 out of 3 samples exceeded

Parameter	AA-EQS[1]	MAC-EQS[1]	Range of measured values	Comments
benzo(ghi)perylene (µg/l)				
Zinc (dissolved - µg/l)	6.8	-	5-10	5 out of 7 samples exceeded
Cadmium (µg/l)	0.2	-	0.04-0.22	1 out of 7 samples exceeded
Benzo(a)pyrene (µg/l)	-	0.027	0.01-0.07	1 out of 7 samples exceeded
Cyanide (total) (µg/l)	1	5	<10-160	4 out of 7 samples exceeded both AA-EQS and MAC-EQS
Total PAHs	0.00017	-	<0.01-0.75	5 out of 7 samples exceeded
Fluoranthene	0.0063	0.12	<0.01-0.03	4 out of 7 samples exceeded AA-EQS, zero exceedances of MAC-EQS
Anthracene	0.1	0.1		Zero exceedances

Notes:
1. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
2. No EQS value for coastal waters available – freshwater EQS reported
3. DOC upstream of the River Hull was not observed to be over 1 mg/l (Álvarez-Salgado and Miller, 1998)[6]
4. Environment Agency (2007)[7]

[6] Álvarez-Salgado and Miller (1998). Dissolved Organic Carbon in a Large Macrotidal Estuary (the Humber, UK): Behaviour During Estuarine Mixing. Marine Pollution Bulletin Vol. 37, Nos. 3-7, pp. 216-224

[7] Environment Agency (2007). Proposed EQS for Water Framework Direction Annex VIII substances: ammonia (un-ionised) Science Report SC040038/SR2. Available online at https://www.wfduk.org/sites/default/files/Media/ammonia.pdf

Table 3: Chemical exceedances of WFD EQSs during 2013 and 2014 sampling from Humber and Railway Docks

Parameter	AA-EQS[1]	MAC-EQS[1]	Range of measured values	Comments
Arsenic (µg/l)	25	-	32-270	17 out of 17 samples exceeded
Chromium (III dissolved) (µg/l)	4.7 [2]	32 [2]	<3-13	9 out of 17 samples exceeded AA-EQS. Zero samples exceeded MAC-EQS
Chromium (VI dissolved) (µg/l)	0.6	32	<3-5	2 out of 17 samples exceeded AA-EQS. Zero samples exceeded MAC-EQS
Copper (µg/l)	3.76 [2,3]	-	28-12,000	17 out of 17 samples exceeded
Ammoniacal Nitrogen as N (mg/l)	0.021[4]	-	0.25-1.70	17 out of 17 samples exceeded
Ammoniacal Nitrogen as NH4 (mg/l)	0.027[4]	-	0.32-2.20	17 out of 17 samples exceeded
Indeno(1,2,3-cd)pyrene and benzo(ghi)perylene (µg/l)	0.00017	-	<0.02	Zero exceedances
Zinc (µg/l)	6.8	-	5-41	16 out of 17 samples exceeded
Cadmium (µg/l)	0.2	-	0.08-0.17	Zero exceedances
Benzo(a)pyrene (µg/l)	-	0.027	<0.01	Zero exceedances
Cyanide (total) (µg/l)	1	5	<10-350	8 out of 17 samples exceeded both AA-EQS and MAC-EQS
Total PAHs	0.00017	-	<0.01-0.23	7 out of 17 samples exceeded
Fluoranthene	0.0063	0.12	<0.01-0.03	1 out of 17 samples exceeded
Anthracene	0.1	0.1	<0.01	Zero exceedances

Notes:
1. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
2. No EQS value for coastal waters available – freshwater EQS reported
3. DOC upstream of the River Hull was not observed to be over 1 mg/l (Álvarez-Salgado and Miller, 1998)
4. Environment Agency (2007)[8]

[8] Environment Agency (2007). Proposed EQS for Water Framework Direction Annex VIII substances: ammonia (un-ionised) Science Report SC040038/SR2. Available online at https://www.wfduk.org/sites/default/files/Media/ammonia.pdf

Table 4: Chemical exceedances of WFD EQSs during 2013 and 2014 sampling from the River Hull

Parameter	AA-EQS[1]	MAC-EQS[1]	Range of measured values	Comments
Arsenic (µg/l)	25	-	34-63	8 out of 8 samples exceeded
Chromium (III dissolved) (µg/l)	4.7 [2]	32 [2]	<3-10	4 out of 9 samples exceeded AA-EQS. Zero samples exceeded MAC-EQS
Chromium (VI dissolved) (µg/l)	0.6	32	<3	Zero exceedances
Copper (µg/l)	3.76 [2,3]	-	290-1,283	8 out of 8 samples exceeded
Ammoniacal Nitrogen as N (mg/l)	0.021[4]	-	0.026-5.900	9 out of 9 samples exceeded
Ammoniacal Nitrogen as NH4 (mg/l)	0.027[4]	-	0.03-7.60	9 out of 9 samples exceeded
Indeno(1,2,3-cd)pyrene and benzo(ghi)perylene (µg/l)	0.00017	-	<0.01	Zero exceedances
Zinc (µg/l)	6.8	-	<2-12	5 out of 9 samples exceeded
Cadmium (µg/l)	0.2	-	0.04-0.16	Zero exceedances
Benzo(a)pyrene (µg/l)	-	0.027	<0.01	Zero exceedances
Cyanide (total) (µg/l)	1	5	<10-190	4 out of 9 samples exceeded both AA-EQS and MAC-EQS
Total PAHs	0.00017	-	<0.01-0.14	5 out of 9 samples exceeded
Fluoranthene	0.0063	0.12	<0.01-0.03	1 out of 9 samples exceeded
Anthracene	0.1	0.1	<0.01	Zero exceedances

Notes:
1. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
2. No EQS value for coastal waters available – freshwater EQS reported
3. DOC upstream of the River Hull was not observed to be over 1 mg/l (Álvarez-Salgado and Miller, 1998)
4. Environment Agency (2007)[9]

[9] Environment Agency (2007). Proposed EQS for Water Framework Direction Annex VIII substances: ammonia (un-ionised) Science Report SC040038/SR2. Available online at https://www.wfduk.org/sites/default/files/Media/ammonia.pdf

4. Routine runoff quality

4.1 Overview

4.1.1 This section presents the results of the modified Method A assessment in three stages:

- Step 1 – using HAWRAT to assess routine runoff against toxicity thresholds
- Modified Step 2 – to assess the level of dilution in the receiving water for acute impacts of soluble pollutants and the propensity of sediment to accumulate near the outfall for chronic impacts of sediment-bound pollutants
- Modified Step 3 – to assess mitigation measures if required

4.1.2 A Method B assessment will be undertaken if the predicted annual average concentrations exceed the EQSs in the modified Step 2 assessment.

4.1.3 An assessment of the impacts on the WFD is also considered.

4.2 Data sources

4.2.1 The assessment requires the following data:

- Traffic flow data to estimate concentration of metals in the runoff – Step 1
- Tidal velocity at the tidal stream diamond at Albert Dock – Modified Step 2
- Road runoff discharge rate - Modified Step 2
- The estuarine (channel) dimensions in the location of discharge – Modified Step 2

4.2.2 Traffic data for the proposed underpass section of the Scheme is presented in Table 5. The predicted traffic flow information was estimated for two scenarios sets – "Do Minimum" associated with the current road layout and "Do Something" representing the Scheme. The current road drainage does not discharge directly to a watercourse, therefore the 'Baseline' and 'Do Minimum' scenarios are not considered further. Design year 2040 is selected as the worst-case scenario for the 'Do Something' scenario and is used in this assessment.

Table 5: Baseline and predicted traffic flow information

Horizon	Baseline	Do Minimum			Do Something		
	2015	2025	2033	2040	2025	2033	2040
AADT – Two Way Traffic	37,298	40,186	41,803	42,770	50,750	54,555	56,282

Horizon	Baseline	Do Minimum			Do Something		
	2015	2025	2033	2040	2025	2033	2040
Flow (vehicles/day)							
Max HGV (%)	16%	15%	14%	15%	12.5%	12%	12%

4.2.3 Tidal velocity data for Albert Dock was obtained from the UKHO in order to determine the dilution by the Humber Estuary. It is assumed that the contribution of fluvial flow is negligible (i.e. assuming a low summer river flow). The data supplied by the UKHO is presented in Table 6.

Table 6: Average velocity and direction of tidal flows during a spring and neap tide. Data supplied by UKHO from Admiralty Chart 3497

Time	Direction	Spring Rate		Neap Rate	
		Knots	m/sec	Knots	m/sec
-06h	063°	3.3	1.698	1.5	0.772
-05h	064°	2.2	1.132	0.1	0.051
-04h	241°	2.8	1.440	2	1.029
-03h	243°	5	2.572	3.2	1.646
-02h	245°	4.5	2.315	3.8	1.955
-01h	240°	3.7	1.903	2.7	1.389
HW	239°	1.8	0.926	1.5	0.772
+01h	103°	0.7	0.360	0.1	0.051
+02h	068°	3.1	1.595	1.2	0.617
+03h	067°	3.3	1.698	2.3	1.183
+04h	066°	3.4	1.749	2.3	1.183
+05h	063°	3.1	1.595	2.6	1.338
+06h	063°	3.5	1.801	1.9	0.977

4.2.4 Table 6 lists the mean velocity and direction for spring and neap tides at times relative to High Water at Immingham. All of the above information is published on Admiralty Chart 3497 which covers the Humber Estuary from Immingham to the Humber Bridge.

4.2.5 The underpass drainage would discharge via a new pumping station, rising main and outfall to the Humber Estuary at a constant flow rate of 100 l/s when operating during a rainfall event. This assessment assumes a worst-case scenario as it assumes the discharge is operating constantly.

4.2.6 The Humber Estuary in the reach to the south of the Project near Albert Dock splits into two channels at low tide. The dimensions (width and depth) of the channel passing by the north bank of the river in the area of discharge were obtained from Ordnance Survey (OS) maps and literature. The channel width in this section was measured as 650m. In the Humber Estuary History article, published by Associated British Ports on their website (www.humber.com), it is stated that the depth of the river channel in the area of Hull is around 9m. According to Humber Nature Partnership (http://www.humbernature.co.uk/estuary/index.php) the average depth across the estuary is 6.5m. In view of this information it is reasonable to assume that the depth in the river around the area of Albert Dock is around 6m; this represents a worst case scenario in terms of dilution.

4.3 HAWRAT step 1 assessment

4.3.1 Step 1 of Method A in the HAWRAT calculates the quality of the direct highway runoff against toxicity thresholds for all the rainfall events in a long-term rainfall series. This step assumes that there is no stream dilution and no treatment attenuation. The results are assessed on either a pass or fail basis against the toxicity thresholds described in paragraphs 3.12 and 3.17 of DMRB HD45/09.

4.3.2 The output of the HAWRAT Step 1 assessment based on the traffic flows described above and assuming a cold/dry climatic region represented by rainfall from the nearest available location at Lincoln results in a failure of toxicity tests for all soluble and sediment-bound pollutants (see Appendix A for the detailed HAWRAT output).

4.4 Modified step 2 assessment

Acute impacts for soluble pollutants

4.4.1 A mass balance calculation was performed to determine the dilution of the dissolved copper and zinc in the receiving water body using the following equation:

$$C_t \times Q_t = C_d \times Q_d + C_{ur} \times Q_{ur}$$

Where:

C_t = concentration downstream of outfall (µg/l)

Q_t = total flow downstream of outfall (l/s)

C_d = 95^{th} percentile event mean concentration in road runoff discharge (µg/l)

Q_d = flow from outfall (l\s)

C_{ur} = river concentration upstream of outfall (µg/l)

Q_{ur} = river flow upstream of outfall (l\s)

4.4.2 The Step 1 assessment from HAWRAT calculates the event mean highway runoff concentration of dissolved copper and zinc (Table 7). The 95th percentile value is quoted and is used as a conservative assessment in the mass balance assessment.

4.4.3 The flow from the outfall is pumped and will discharge at a constant rate of 100 litres per second when operating.

Table 7: Event mean concentrations from HAWRAT Step 1 assessment

	Dissolved Copper (µg/l)	Dissolved Zinc (µg/l)
Mean	18.09	69.88
95%ile	47.13	190.68

4.4.4 Upstream river concentrations are assumed to be zero in accordance with the WFD objectives but also with the guidance in the DMRB which states that existing water quality should not be taken into account.

4.4.5 The estimation of upstream tidal flow is based on the minimum velocity recorded at the UKHO Albert Dock tidal stream diamond which is 0.051m/s (Table 6). This represents the minimum level of dilution during a neap tide and thus is a worst-case scenario. It is noted that the tidal velocity would reach a maximum three hours later which would provide further dilution to any event.

4.4.6 The calculated concentration of dissolved copper and zinc in the in-river runoff is presented in Table 8 based on the 95th percentile predicted event mean concentration. A comparison of the effects of dilution by the Humber Estuary on the number of exceedances per year above the toxicity thresholds is not possible as the assessment is not undertaken within the HAWRAT so alternatively a comparison to the EQSs for dissolved copper and zinc suggests the proposed discharge does not result in an exceedance of the EQSs (Section 3) upon dilution with the receiving waters. It is understood that the calculated downstream river concentration based on the predicted event mean concentration represents the short-term pollution risk and is not directly comparable to EQSs for copper and zinc stated as annual average concentrations. However, it is considered that this represents a worst-case scenario for the assessment of impacts on the WFD.

Table 8: Routine runoff assessment

Routine runoff assessment		Units	Value
Input data			
Cu (C_{ur})	Upstream dissolved copper concentration	µg/l	0.0
Zn (C_{ur})	Upstream dissolved zinc concentration	µg/l	0.0
Flow from outfall (Q_d)	Constant pump flow rate	l/s	100

Routine runoff assessment		Units	Value
Tidal velocity	Minimum neap tide velocity	m/s	0.051
Estuary/channel dimensions assuming a trapezoidal shape	Width surface/width bottom/depth	m	650/600/6
Calculations			
Cu in road runoff discharge (C_d)	95%ile from HAWRAT Step 1	µg/l	47.13
Zn in road runoff discharge (C_d)	95%ile from HAWRAT Step 1	µg/l	190.68
Cu flux in road discharge (C_d x Q_d)	47.13 x 100	µg/sec	4,713
Zn flux in road discharge (C_d x Q_d)	190.68 x 100	µg/sec	19,068
Flow upstream of outfall (Q_{ur})	(6 x (650 + 600) / 2) x 0.051 x 1000	l/sec	191,250
Cu concentration downstream of outfall (C_t)	(47.13 x 100 + 0.0 x 191,250) / (191,250 + 100)	µg/l	0.0246
Zn concentration downstream of outfall (C_t)	(190.68 x 100 + 0.0 x 191,250) / (191,250 +100)	µg/l	0.0997

4.4.7 Based on this assessment it is considered that routine runoff from operational use of the highway will have a negligible impact on the Humber water quality without the need for mitigation. Therefore, there is no requirement to undertake the modified Step 3 of Method A or the Method B detailed assessment.

4.4.8 Comparison to the WFD standards in Table 2 shows the resultant Humber water quality would continue to meet the requirements for good chemical status \ supporting ecological status. The additional pollutant load is very unlikely to result in a deterioration of the existing water quality status and is very unlikely to prevent the Humber Middle water body from maintaining moderate ecological potential by 2027.

Chronic impacts for sediment-bound pollutants

4.4.9 For sediment-bound pollutants the HAWRAT calculates a velocity from low flow data for the river and compares this to a threshold velocity of 0.1 metres per second to assess if the sediment is likely to remain in suspension or be deposited near the outfall.

4.4.10 The tidal velocity data in Table 6 shows that the velocity is only less than the threshold for short periods of time, of about 0.5 hour, about one hour after high tide and low tide. In addition to this, tidal velocities quickly increase to 1.95 metres per second in the neap cycle within three hours suggesting that the potential for sediment accumulation is a short-term phenomenon. On this basis, it is considered that sediment is not accumulating over a semi-diurnal tidal cycle and therefore it is considered that there is a negligible risk of chronic pollution impacts from sediment-bound pollutants.

4.5 Summary of routine runoff assessment

4.5.1 A summary of the routine runoff assessment is provided for the proposed Humber outfall in Table 9 which indicates that there is no impact following dilution in the tidal channel and therefore there is no requirement for mitigation measures.

Table 9: Summary of routine runoff impact assessment

Assessment stage	Soluble: Acute impacts	Sediment: Chronic impacts	Compliance with EQSs (where applicable)
HAWRAT Step 1	Fail	Fail	N\A
Modified Step 2 (without mitigation)	Pass	Pass	Pass

4.5.2 The proposed discharge is very unlikely to prevent the Humber Middle from maintaining moderate ecological potential by 2027.

5. Accidental spillage assessment

5.1 Overview

5.1.1 This section presents the results of the Method D assessment that considers the risk of pollution impacts from spillages onto the underpass drainage catchment should it discharges to the Humber Estuary.

5.2 Data sources

5.2.1 The assessment requires the following data:

- The length of road in each of the categories specified in Table D1.1 of DMRB HD45/09 Method D
- The AADT two-way flow for each section of road
- The percentage of the AADT two-way flow that comprises HGVs

5.2.2 The length of the underpass road section is approximately 0.550 km.

5.2.3 The two way AADT traffic flow and the %HGV was presented earlier in Table 5. Design year 2040 was used as the worst-case scenario.

5.2.4 The road categories as specified in Table D1.1 of DMRB are presented in Table 10 below for reference.

Table 10: Serious spillage in billion HGV (km/year)

	Motorways	Rural Trunk Roads	Urban Trunk Roads
No Junction	0.36	0.29	0.31
Slip Road	0.43	0.83	0.36
Roundabout	3.09	3.09	5.35
Crossroad		0.88	1.46
Side Road		0.93	1.81
Total	0.37	0.45	0.85

5.2.5 The underpass section of the Scheme is categorised as “No junction” and “Urban Trunk Roads” with spillage rate of 0.31.

5.2.6 The probability of a serious accidental spillage occurring was calculated using the equation given in DMRB HD 45/09 Annex I Method D[10]:

$$P_{SPL} = RL \times SS \times (AADT \times 365 \times 10^{-9}) \times \%HGV / 100)$$

Where:

P_{SPL} = annual probability of spillage with potential to cause a serious pollution incident

RL = road length in km

SS = spillage rates from Table D1.1 of DMRB (Table 9 above)

AADT = annual average daily traffic

%HGV = percentage of HGVs

5.2.7 Accidental risk is translated into a pollution incident risk using a risk reduction factor, based on emergency service response time. This is incorporated in the following formula:

$$P_{INC} = P_{SPL} \times P_{POL}$$

Where:

P_{INC} = the probability of a spillage with an associated risk of a serious pollution incident occurring;

P_{POL} = the probability, given a spillage, that a serious pollution incident will result.

5.2.8 This will depend on the sensitivity of the water course and how soon it can be reached by the emergency services. The relevant values for these probabilities are given in Table D1.2 of Appendix D in DMRB and are presented in Table 11 below. It is assumed that the response time to the site is less than 20 minutes and thus P_{POL} equals 0.45.

Table 11: Probability of serious pollution incident occurring as a result of a serious spillage (P_{POL}).

Receiving water body	Urban (response time to site <20 min)	Rural (response time to site <1 hr)	Remote (response time to site >1 hr)
Surface watercourse	0.45	0.6	0.75

[10] Highways Agency (2009). Design Manual for Roads and Bridges, Volume 11, Section 3, Part 10, HD45/09, Road Drainage and the Water Environment. http://www.dft.gov.uk/ha/standards/dmrb/

5.3 Assessment results

5.3.1 Table 12 summarises the assessment inputs and results to estimate the spillage risk and the probability of a serious pollution incident. The HAWRAT output is provided in Appendix A.

Table 12: Spillage risk and probability of a serious pollution incident calculations

Input Data		Units	Design Year 2040
Input data			
RL	Road Length	m	467
SS	Road Spillage rate for No Junction and Urban Trunk Rd (Table 8)	%	0.31
P_{POL}	Probability that a serious pollution incident will result (Table 9)	%	0.45
AADT	Annual average daily traffic	vehicles per day	56,282
%HGV	% Heavy goods vehicles	%	12
Calculations			
P_{SPL} = annual probability of spillage (year 2040)	550 x 0.31 x (60,001 x 365 x 10^{-9})x 11.85/100	%	0.00036
P_{INC} (year 2040)	0.00043 x 0.45	%	0.00016

5.3.2 DMRB HD45/09 states that for outfalls discharging in close proximity to sensitive sites (e.g. Ramsar) as is the case here the acceptable risk of serious pollution incident occurring should have an annual probability of less than 0.5%. The results presented in Table 12 for design year 2040 indicate that the risk of serious pollution incident is considerably less than 0.5% and therefore according to the DMRB guidance no pollution reduction measures would be required.

6. Summary of impacts and recommendations

6.1.1 The routine runoff assessment was undertaken using the HAWRAT step 1 and a modified step 2 of Method A. The assessment indicates that there is a negligible impact following dilution in the tidal channel for both soluble and sediment-bound pollutants and therefore there is no requirement for mitigation measures.

6.1.2 The outfall discharge is very unlikely to prevent the 'Humber Middle' water body from maintaining moderate ecological potential by 2027.

6.1.3 The accidental spillages assessment was undertaken using the HAWRAT Method D. The assessment indicates that the risk of serious pollution incident is considerably less than the annual acceptable threshold of 0.5% for discharge to a sensitive site. Therefore, according to the guidance no pollution reduction measures would be required.

6.1.4 During consultation, the Environment Agency specified that adequate pollution control measures are in place to remove residual oil/petrol contaminants prior to discharge to the Humber. The proposed underpass drainage incorporates an oil interceptor to meet this requirement.

6.1.5 The Environment Agency also specified that additional measures should be incorporated in the infrastructure of the drainage system such that in the event of a major incident on the A63, any contaminants lost to the drainage system serving the carriageway can be isolated and contained. The proposed underpass drainage incorporates a shut off valve to meet this requirement.

6.1.6 The surface water quality monitoring from the ground investigation in 2013, and further background monitoring in 2014, found many pollutants exceeded the EQSs. This highlights the need for monitoring of surface water quality in the vicinity of the Scheme prior to, during and post construction to establish baseline conditions and monitor for any construction and operational impacts. Monitoring requirements will need to be agreed with the Environment Agency.

7. Appendices

7.1 Appendix A: HAWRAT parameters and results

HAWRAT parameter settings

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Location Details				
Road Number	A63		Assessment type	Non-cumulative assessment (single outfall)
HA Area/DBFO number				
OS grid reference of assessment point (m)	Easting	509731	Receiving watercourse	River Humber
	Northing	428023	EA receiving water Detailed River Network ID	
OS grid reference of outfall structure (m)	Easting	509879	Assessor and affiliation	NS Sweco
	Northing	427828	Date of assessment	20/02/2018
Outfall number	1		Version of assessment	1
List of outfalls in cumulative assessment				
Notes				

Parameter	Units	Default Value	Value used	Notes (Enter notes in the left-hand cells only)	
Runoff Risk Assessments					
AADT	vpd	>10,000 and <50,000	***>=50,000 and <100,000***		
Climatic Region	-	Warm Dry	***Colder Dry***		
Rainfall Site	-	Ashford (SAAR 710mm)	***Lincoln (SAAR 600mm)***		
95%ile River flow	m3/s	0	***0***		
Baseflow Index	-	0.5	***0.5***		
Impermeable road area drained	ha	1	***1***		
Permeable area draining to outfall	ha	1	***1***		
Is the discharge in or within 1 km upstream of a protected site for conservation?	-	No	***No***		
Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge?	-	No	***No***		
Hardness	-	Low = <50mg CaCO3/l	***Low = <50mg CaCO3/l***		
Use Tier 1	-	TRUE	***TRUE***		
Use Tier 2	-	FALSE	***FALSE***		
Tier 1 Estimated river width at Q95	0	5	***5***		
Tier2 Bed width	m	3	***3***		
Tier2 Side slope	m/m	0.5	***0.5***		
Tier2 Long slope	m/m	0.0001	***0.0001***		
Tier2 Mannings' n	-	0.07	***0.07***		
Existing treatment for solubles	%	0	***0***	***description for existing measures***	
Existing attenuation -restricted discharge rate	l/s	Unlimited	***Unlimited***		
Existing settlement of sediments	%	0	***0***		
Proposed treatment for solubles	%	0	***0***	***description for proposed measures***	
Proposed attenuation -restricted discharge rate	l/s	Unlimited	***Unlimited***		
Proposed settlement of sediments	%	0	***0***		
Spillage Risk Assessments					
A MainRoad					
Water body type	-	-	***Surface watercourse***		
Length of road draining to outfall	m	-	***550***		
Road Type (A-road or Motorway)	-	-	***A***		
If A road, is site urban or rural?	-	-	***Urban***		
Junction type	-	-	***No junction***		
Location	-	-	***< 20 minutes***		
Traffic flow (AADT two way)	-	-	***60001***		
% HGV	-	-	***11.5***		
Spillage factor	no/109HGVkm/year	-	***0.31***		
Existing measures factor	-	-	***1***		
Proposed measures factor	-	-	***1***		

Method A – HAWRAT Step 1 output

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Summary of predictions — Soluble - Acute Impact / Sediment - Chronic Impact

Prediction of impact	Soluble Copper	Soluble Zinc	Sediment Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Step1										
Step2										
Step3										

DETAILED RESULTS

In Runoff

Step 1 – Soluble

RST24	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	**33.00**	**43.30**
No. of exceedances/worst year	41	51

RST6	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	**6.90**	**16.10**
No. of exceedances/worst year	14	25

	Copper (ug/l)	Zinc (ug/l)
Thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	18.09	69.88
90%ile	35.48	145.14
95%ile	47.13	190.68
99%ile	68.61	446.32

Step 1 – Sediment (Toxicity Threshold)

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Allowable Exceedances/year	1	1	1	1	1	1	1	1
No. of exceedances/year	**51.80**	**83.70**	**1.20**	**34.80**	**82.10**	**34.80**	**16.10**	**67.10**
No. of exceedances/worst year	58	92	4	41	87	41	22	72
Units	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Toxicity	197	315	3.5	16770	875	2355	245	515
Event Statistics Mean	261	1170	1	15514	2684	2575	164	726
90%ile	608	2704	2	28184	4876	4679	299	1319
95%ile	783	3590	3	35481	6138	5890	376	1661
99%ile	1122	5892	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

RST24	Copper	Zinc
Allowable Exceedances/year	2	2
No. of exceedances/year	-	-
No. of exceedances/worst year	-	-
No. of exceedances/summer	-	-
No. of exceedances/worst summer	-	-

RST6	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	-	-
No. of exceedances/worst year	-	-
No. of exceedances/summer	-	-
No. of exceedances/worst summer	-	-
Annual average concentration (ug/l)	-	-

	Copper (ug/l)	Zinc (ug/l)
Thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	-	-
90%ile	-	-
95%ile	-	-
99%ile	-	-

Velocity: - m/s — Tier 1 is used for the calculation

DI: -

% settlement needed: - %

River (with mitigation)

Step 3

RST24	Copper	Zinc
Allowable Exceedances/year	2	2
No. of exceedances/year	-	-
No. of exceedances/worst year	-	-
No. of exceedances/summer	-	-
No. of exceedances/worst summer	-	-

RST6	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	-	-
No. of exceedances/worst year	-	-
No. of exceedances/summer	-	-
No. of exceedances/worst summer	-	-
Annual average concentration (ug/l)	-	-

	Copper (ug/l)	Zinc (ug/l)
Thresholds thresholds RST24	21	60
Thresholds RST6	42	120
Event Statistics Mean	-	-
90%ile	-	-
95%ile	-	-
99%ile	-	-

DI: -

Details of the chosen rainfall site	
SAAR (mm)	600
Altitude (m)	40
Easting	4976
Northing	3718
Coastal distance (km)	55

Method D - HAWRAT output – design year 2040

HIGHWAYS AGENCY

View Spillage Assessment Parameters | Reset | Go To Runoff Risk Assessment Interface

Assessment of Priority Outfalls

Method D - assessment of risk from accidental spillage

			Additional columns for use if other roads drain to the same outfall						
		A (main road)	B	C	D	E	F	Totals	Return Period
D1	Water body type	Surface watercourse							
D2	Length of road draining to outfall *(m)*	467							
D3	Road Type *(A-road or Motorway)*	A							
D4	If A road, is site urban or rural?	Urban							
D5	Junction type	No junction							
D6	Location	< 20 minutes							
D7	Traffic flow (AADT two way)	56,282							
D8	% HGV	12							
D8	Spillage factor *(no/10^9 HGVkm/year)*	0.31							
D9	Risk of accidental spillage	0.00036	0.00000	0.00000	0.00000	0.00000	0.00000		
D10	Probability factor	0.45							
D11	Risk of pollution incident	0.00016	0.00000	0.00000	0.00000	0.00000	0.00000		
D12	Is risk greater than 0.01?	**No**							
D13	Return period without pollution reduction measures	0.00016	0.00000	0.00000	0.00000	0.00000	0.00000	0.0002	6227
D14	Existing measures factor	1							
D15	Return period with existing pollution reduction	0.00016	0.00000	0.00000	0.00000	0.00000	0.00000	0.0002	6227
D16	Proposed measures factor	1							
D17	Residual with proposed Pollution reduction measures	0.00016	0.00000	0.00000	0.00000	0.00000	0.00000	0.0002	6227

Justification for choice of existing measures factors

Justification for choice of proposed measures factors

Table D1

	Serious Accidental Spillages *(Billion HGV km/year)*	Motorways	Rural Trunk	Urban Trunk
Location	No junction	0.36	0.29	0.31
	Slip road	0.43	0.83	0.36
	Roundabout	3.09	3.09	5.35
	Cross road	-	0.88	1.46
	Side road	-	0.93	1.81
	Total	0.37	0.45	0.85

Table 7.1

System	Optimum Risk Reduction Factor
Filter Drain	0.6
Grassed Ditch / Swale	0.6
Pond	0.5
Wetland	0.4
Soakaway / Infiltration basin	0.6
Sediment Trap	0.6
Unlined Ditch	0.7
Penstock / valve	0.4
Notched Weir	0.6
Oil Separator	0.5

The worksheet should be read in conjunction with DMRB 11.3.10.

7.2 Appendix B: Ground investigation – surface water quality monitoring result

highways england

Multiplier: 1 x"<" **A63 Castle Street - SURFACE WATER EQS** (shaded) =exceedance of EQS value

Screening Level	Substance	Units	RIVER HUMBER							DOCKS (Railway Dock, west)				DOCKS (Railway Dock, east)			
	Strata																
	Observed Contamination																
	Sample Description		ROUND 1	ROUND 2	ROUND 3					ROUND 1	PRELIM RD 1	ROUND 2	ROUND 3	ROUND 1	PRELIM RD 1	ROUND 2	ROUND 3
	Date	-	22-Aug-13	23-Oct-13	17-Dec-13	19-May-14	17-Jun-14	15-Jul-14	19-Aug-14	20-Aug-13	05-Sep-13	23-Oct-13	17-Dec-13	20-Aug-13	05-Sep-13	23-Oct-13	17-Dec-13
	Sample ID	-	SW1	SW1	SW1	SW1	SW1	SW1	SW1	SW2	SW2	SW2	SW2	SW3	SW3	SW3	SW3
	Depth	m				n/a	n/a										
Screening Level	Substance	Units															
-																	
-	pH		7.7	7.6	7.8	7.5	7.8	7.8	7.6	7.7	7.7	7.7	7.7	8	7.9	7.7	7.7
-																	
25	Arsenic	ug/l	42	120	52	37	51	51	62	32	270	110	48	34	260	93	59
7000	Boron	ug/l	2200	1900	1600	1400	1.2	1800	2000	1800	1800	1900	1500	1800	1800	1900	1400
0.2	Cadmium	ug/l	0.22	0.13	0.08	0.1	0.12	0.12	0.15	0.15	0.15	0.13	0.08	0.15	0.12	0.1	0.12
-	Chromium (total)	ug/l	3	12	8	5	5	3	5	2	18	12	10	2	16	9	10
4.7	Chromium (III)	ug/l	<3	12	8	<3	5	3	5	<3	13	12	10	<3	12	9	10
0.6	Chromium (VI)		<3	<3	<3	3	<3	<3	<3	<3	5	<3	<3	<3	4	<3	<3
3.76	Copper	ug/l	320	8900	190	130	28	100	35	170	67	12000	170	250	67	10000	200
7.2	Lead	ug/l	0.5	0.6	<0.3	<0.3	0.3	<0.3	<0.3	<0.3	4.5	<0.3	0.4	<0.3	0.5	<0.3	0.5
0.05	Mercury	ug/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
20	Nickel	ug/l	7	19	10	15	8	18	8	6	13	18	10	6	13	15	12
-	Selenium	ug/l	120	<0.5	<0.5	<0.5	120	230	89	67	120	<0.5	<0.5	75	95	<0.5	<0.5
6.8	Zinc	ug/l	13	8	10	7	5	8	6	36	41	26	28	36	35	21	31
-																	
-	Calcium	ug/l	190000	180000	170000	180000	170000	250000	230000	230000	160000	180000	160000	220000	160000	180000	160000
-	Magnesium	ug/l	640000	600000	490000	380000	340000	640000	580000	540000	520000	590000	430000	520000	540000	610000	430000
-	Potassium	ug/l	280000	240000	200000	160000	140000	280000	240000	230000	210000	230000	180000	220000	220000	240000	170000
-	Sodium	ug/l	4300000	4800000	4100000	2900000	2500000	4900000	480000	3500000	3900000	4600000	3700000	3000000	4000000	4700000	3600000
1000	Iron (dissolved)	ug/l		480	85							220	76			200	84
-	Iron (total)	ug/l		20000	200000							370	330			400	500
-	Manganese (dissolved)	ug/l		<10	<10							49	54			27	51
-	Manganese (total)	ug/l		700	15000							66	62			72	66
-																	
-	Nitrate	mg/l	3.6	1.6	1	1.8	7.2	1	1.2	3.8	1.7	2.3	4.9	4.1	1.8	3.4	5
-	Nitrite	mg/l	<0.1	<0.1	<0.1	0.2	0.1	<0.1	<0.1	0.2	0.2	<0.1	<0.1	0.2	0.2	<0.1	<0.1
-	TON	mg/l	0.8	0.4	1	0.4	1.6	0.3	0.3	0.9	0.4	0.5	1.1	1	0.4	0.8	1.1
400	Sulphate	mg/l	1400	1300	990	1100	860	1400	1400	1300	1300	1300	970	1300	1300	1300	980
-	Sulphide	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
-	Sulphur	mg/l	490	440	400	330	290	0.04	470	410	450	430	370	400	450	430	370
250	Chloride	mg/l	11000	9900	7200	7400	5800	9700	10000	9100	9700	9800	6800	9000	9700	10000	6900
0.021	Ammoniacal Nitrogen as N	mg/l	0.49	0.47	0.75	0.54	0.35	0.82	0.56	0.6	0.57	0.55	0.69	0.55	0.52	0.65	1.6
0.027	Ammoniacal Nitrogen as NH4	mg/l	0.63	0.6	0.97	0.69	0.45	1.1	0.72	0.76	0.73	0.71	0.88	0.7	0.67	0.83	2.1
-	Total Suspended Solids	mg/l	47	500	160	3200	6800	450	30	<10	<10	<10	<10	<10	<10	<10	14
-	Electrical Conductivity	uS/cm	2900	26000	22000	16000	17000	29000	28000	2500	27000	26000	21000	2500	27000	26000	21000
-	Total Alkalinity as CaCO3	mg/l	130	150	130					130	130	160	110	120	120	160	120
-																	
7.7	Phenols (total)	ug/l	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	1.1	<0.5
1	Cyanide (total)	ug/l	<10	<10	<10	30	82	89	160	<10	<10	<10	26	<10	<10	<10	<10
1	Cyanide (free)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
-																	
-	Acenaphthene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
-	Acenaphthylene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	0.02	<0.02	<0.01
0.1	Anthracene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
-	Benzo(a)anthracene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
0.027	Benzo(a)pyrene	ug/l	<0.01	<0.01	0.07	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	0.01
-	Benzo(b)fluoranthene	ug/l	<0.01	<0.01	0.03	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
-	Benzo(ghi)perylene	ug/l	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.10	<0.01	<0.01	<0.10	<0.10	<0.02	<0.01
-	Benzo(k)fluoranthene	ug/l	<0.01	<0.01	0.02	<0.01	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
-	Chrysene	ug/l	<0.01	<0.01	0.02	0.02	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
-	Dibenzo(ah)anthracene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.10	<0.01	<0.01	<0.10	<0.10	<0.02	<0.01
0.0063	Fluoranthene	ug/l	<0.01	<0.01	0.01	0.03	0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
-	Fluorene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
-	Indeno(1,2,3cd)pyrene	ug/l	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.10	<0.01	<0.01	<0.10	<0.10	<0.02	<0.01
1.2	Naphthalene	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.65	<0.01	0.11	<0.01	0.06	<0.01	0.21	<0.02	0.03
-	Phenanthrene	ug/l	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
-	Pyrene	ug/l	<0.01	<0.01	0.01	0.03	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01
0.00017	Polyaromatic Hydrocarbons (Total)	ug/l	<0.01	<0.01	0.21	0.09	0.06	0.14	0.75	<0.01	0.17	<0.01	0.06	<0.10	0.23	<0.02	0.04
-	Sum of 4No. PAHs	ug/l	<0.04	<0.04	0.1					<0.04	<0.22	<0.04	<0.04	<0.22	<0.22	<0.08	<0.04
0.03	Sum of benzo(b) and benzo(k)fluoranthene	ug/l	<0.02	<0.02	0.05					<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.02
0.00017	Sum of indeno(123cd)pyrene and benzo(ghi)perylene	ug/l	<0.02	<0.02	0.05					<0.02	<0.2	<0.02	<0.02	<0.2	<0.2	<0.04	<0.02
-		ug/l															
-	TPH (C8-C10)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
-	TPH (C10-C12)	ug/l	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
-	TPH (C12-C16)	ug/l	<10	<10	<10	<10	<10	<10	20	<10	<10	23	<10	<10	<10	<10	<10
-	TPH (C16-C21)	ug/l	<10	46	<10	15	<10	<10	60	<10	<10	24	<10	<10	<10	29	<10
-	TPH (C21-C35)	ug/l	<10	76	<10	65	<10	<10	100	<10	<10	17	<10	<10	<10	28	<10
-	TPH (C35-C40)	ug/l	<10	20	<10	<10	<10	<10	30	<10	<10	<10	<10	<10	<10	<10	<10
-	Total TPH (C8-C40)	ug/l	<10	150	<10	90	<10	<10	210	<10	<10	60	<10	<10	<10	60	<10
-																	

1																		
Strata																		
Observed Contamination																		
Sample Description				**DOCKS (Humber Dock)**						**RIVER HULL (Upstream/North of A63)**						**RIVER HULL (Downstream/South of A63)**		
				ROUND 1	ROUND 2	ROUND 3				ROUND 1	ROUND 2	ROUND 3				ROUND 1	ROUND 2	ROUND 3
Date	**17-Jun-14**	**15-Jul-14**	**19-Aug-14**	**20-Aug-13**	**23-Oct-13**	**17-Dec-13**	**17-Jun-14**	**15-Jul-14**	**19-Aug-14**	**22-Aug-13**	**23-Oct-13**	**17-Dec-13**	**17-Jun-14**	**15-Jul-14**	**19-Aug-14**	**22-Aug-13**	**23-Oct-13**	**17-Dec-13**
Sample ID	**SW3**	**SW3**	**SW3**	**SW4**	**SW4**	**SW4**	**SW4**	**SW4**	**SW4**	**SW5**	**SW5**	**SW5**	**SW5**	**SW5**	**SW5**	**SW6**	**SW6**	**SW6**
Depth	n/a						n/a						n/a					
Substance																		
pH	7.9	8	7.6	7.9	7.6	7.7	8	7.8	7.7	7.8	7.6	7.8	8.1	7.9	7.7	7.7	7.5	7.8
Arsenic	**38**	**38**	**55**	**33**	**65**	**51**	**51**	**37**	**56**	**40**	**54**	**40**		**63**	**34**	**35**	**58**	**34**
Boron	1.1	1500	1700	1800	1900	1400	1.1	1500	1700	2100	780	900	0.04	2400	1400	2200	910	1100
Cadmium	0.12	0.15	0.17	0.15	0.08	0.12	0.12	0.12	0.13	0.14	0.07	0.04	<0.02	0.16	0.16	0.13	0.08	0.1
Chromium (total)	2	3	4	2	10	10	5	3	4	2	10	10	3	4	2	2	9	8
Chromium (III)	<3	3	4	<3	**10**	**10**	**5**	3	4	<3	**10**	**10**	<3	4	<3	<3	**9**	**8**
Chromium (VI)	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**	**<3**
Copper	**29**	**85**	**52**	**230**	**370**	**170**	**28**	**83**	**51**	**280**	**210**	**92**		**140**	**19**	**170**	**290**	**82**
Lead	0.6	<0.3	<0.3	<0.3	<0.3	0.5	0.3	<0.3	<0.3	0.6	<0.3	<0.3	1.4	<0.3	<0.3	0.7	<0.3	0.3
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel	7	14	8	6	10	11	8	14	8	6	8	7	3	**24**	5	6	9	7
Selenium	97	200	88	69	19	<0.5	120	210	79	110	24	35	2.2	290	70	100	19	33
Zinc	**19**	**23**	**28**	**28**	**7**	**31**	5	**22**	**29**	**12**	6	**8**	<2	**8**	4	**12**	6	**8**
Calcium	160000	190000	200000	210000	180000	160000	140000	190000	200000	170000	120000	130000	110000	260000	180000	170000	130000	150000
Magnesium	320000	440000	490000	490000	610000	430000	280000	450000	480000	650000	210000	260000	8200	680000	380000	600000	260000	320000
Potassium	130000	200000	200000	200000	240000	170000	110000	190000	200000	280000	78000	110000	5400	300000	150000	260000	100000	120000
Sodium	2200000	3200000	3900000	3200000	4600000	3500000	2100000	3400000	4000000	4300000	1600000	2100000	38000	5300000	3200000	4000000	1900000	2600000
Iron (dissolved)					210	82					180	71					190	73
Iron (total)					2400	1900					34000	59000					52000	72000
Manganese (dissolved)					18	50					<10	<10					<10	<10
Manganese (total)					150	150					1500	2900					2000	3800
Nitrate	7.1	4.5	1.6	4.3	2	5.6	7.3	3.6	1.7	2.5	19	15	33	0.6	13	1.9	15	12
Nitrite	0.2	<0.1	0.2	0.2	<0.1	<0.1	0.2	<0.1	0.2	<0.1	<0.1	<0.1	0.3	<0.1	0.2	<0.1	<0.1	<0.1
TON	1.6	0.8	0.4	1	0.4	1.3	1.7	0.8	0.4	0.6	4.3	3.4	7.5	0.2	3	0.5	3.4	2.6
Sulphate	**800**	**1000**	**1300**	**1300**	**1300**	**930**	**800**	**1000**	**1300**	**1500**	**540**	**610**		**1600**	**680**	**1400**	**630**	**730**
Sulphide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sulphur	270	0.04	400	390	430	360	270	0.04	400	470	170	240	12	0.05	310	490	200	290
Chloride	**5400**	**6900**	**8900**	**8900**	**10000**	**6700**	**5400**	**6700**	**8900**	**12000**	**3500**	**4100**		**11000**	**4500**	**12000**	**4200**	**5000**
Ammoniacal Nitrogen as N	**0.28**	**1.1**	**0.52**	**0.54**	**0.55**	**0.74**	**0.25**	**1.7**	**1.5**	**0.44**	**0.026**	**0.18**	**0.33**	**5.9**	**0.3**	**0.39**	**0.04**	**0.26**
Ammoniacal Nitrogen as NH4	**0.36**	**1.5**	**0.66**	**0.69**	**0.7**	**0.95**	**0.32**	**2.2**	**1.9**	**0.57**	**0.03**	**0.22**	**0.43**	**7.6**	**0.39**	**0.5**	**0.05**	**0.34**
Total Suspended Solids	<10	<10	<10	27	41	21	<10	<10	<10	<10	1900	130	420	310	14	30	2900	120
Electrical Conductivity	16000	21000	24000	2400	26000	21000	16000	20000	24000	2900	11000	14000	780	31000	19000	2800	13000	16000
Total Alkalinity as CaCO3				120	160	130				110	170	160				110	150	120
Phenols (total)	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	2.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	<0.5	0.7	0.8	<0.5
Cyanide (total)	**24**	**350**	**60**	**<10**	**<10**	**12**	**22**	**85**	**180**	**<10**	**<10**	**<10**	**30**	**190**	**70**	**<10**	**<10**	**21**
Cyanide (free)	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**	**<10**
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Benzo(ghi)perylene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(ah)anthracene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.02**	**<0.01**	**<0.01**	**0.03**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.03**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
Fluorene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3cd)pyrene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.14	<0.01	<0.01	<0.01
Phenanthrene	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Pyrene	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Polyaromatic Hydrocarbons (Total)	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**0.02**	**0.03**	**<0.01**	**0.08**	**<0.01**	**0.01**	**<0.01**	**0.06**	**<0.01**	**0.07**	**0.14**	**<0.01**	**<0.01**	**0.03**
Sum of 4No. PAHs				<0.04	<0.08	<0.04				<0.04	<0.04	0.04				<0.04	<0.04	<0.04
Sum of benzo(b) and benzo(k)fluoranthene				<0.02	**<0.04**	<0.02				<0.02	<0.02	0.02				<0.02	<0.02	<0.02
Sum of indeno(123cd)pyrene and benzo(ghi)perylene				**<0.02**	**<0.04**	**<0.02**				**<0.02**	**<0.02**	**0.02**				**<0.02**	**<0.02**	**<0.02**
TPH (C8-C10)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TPH (C10-C12)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
TPH (C12-C16)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	21	<10	<10	<10	<10	<10	13	<10
TPH (C16-C21)	<10	<10	<10	<10	19	<10	<10	<10	<10	<10	68	<10	<10	<10	<10	<10	53	<10
TPH (C21-C35)	<10	<10	<10	<10	16	<10	<10	<10	<10	<10	70	<10	<10	<10	<10	<10	54	<10
TPH (C35-C40)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	<10	<10	<10	<10	<10	10	<10
Total TPH (C8-C40)	<10	<10	<10	<10	40	<10	<10	<10	<10	<10	170	<10	<10	<10	<10	<10	120	<10