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6.1. Identifying Major Accident Scenarios

6.1.1. Major Accident Hazard Identification Methodology

A detailed HAZID and risk assessment has been undertaken in support of the COMAH Safety Report, which included assessment of potential environmental impacts.

The safe design and operation of any process plant relies on the involvement of experienced engineering staff during the development phase. Furthermore, it is important to recognise situations that have been found to cause problems in the past and build upon this experience to avoid repetition. However, a reliance on experience alone can lead to omissions for two reasons:

- Uncommon hazards, possibly with severe consequences, may be outside this experience; and
- even if the hazards are known and understood, there is no guarantee that all possible triggering events will be considered.

Therefore, it is important that the methodology applied during the HAZID is systematic and thorough to ensure that all hazards are considered and all potential triggering events are identified.

The HAZID methodology is described in detail in Section 3.3.1 of the safety report. In the assessment, risk is assessed twice; once for people and once for the environment. The methodology as described in Section 3.3.1; refer to the following sections:

- 3.3.1.1: Attendees
- 3.3.1.2: HAZID Guidance Notes
- 3.3.1.3: Systems
- 3.3.1.4: Deviations
- 3.3.1.5: Initiating Events
- 3.3.1.6: HAZID Tables

The following sub-sections have variances that apply only to environmental assessed entries:

6.1.1.1. Risk Ranking

The principles behind risk ranking are the same as described in Section 3.3.1.7. However, the severity considerations are different, as shown in Table 6.1.1.1.1:

Table 6.1.1.1.1: Severity Considerations (Environment) for Incident Scenarios

Category	Effects on the Environment
E7	*Major Accident to the Environment* (MATTE).
E6	Significant off-site effects (listed sites).
E5	Minor off-site effects (listed sites).
E4	Significant off-site effects (*un-listed sites*).
E3	Minor off-site effects.
E2	Significant on-site effects.

Category	Effects on the Environment
E1	Minor on-site effects.
E0	No effects (*minor spill).*

It is noted that the HAZID methodology does not incorporate CDOIF MATTE Classes as it is not possible to perform such a level of assessment within the timeframes imposed by the workshop.

Likelihood considerations are the same as in Section 3.3.1.7 but replicated here for clarity:

Table 6.1.1.1.2: Likelihood Considerations

Likelihood Category	Description	Relative frequency (per year)*
10	*Likely to occur* **several times** *per* **year**.	>1
9	*Likely to occur* **once *per* year**.	1
8	*Likely to occur a* **few times during** *the* **lifetime** *of the plant*.	$\geq 10^{-1} < 1$
7	*Could occur during the lifetime of the plant;* **near misses have occurred**.	$\geq 10^{-2} < 10^{-1}$
6	*Possible during the lifetime of the plant;* **root causes** likely to **have occurred** *at the plant.*	$\geq 10^{-3} < 10^{-2}$
5	*Incidents are known of in industry*; *an* **unlikely** *event during the lifetime of the plant which probably requires* **two systems** *to fail*.	$\geq 10^{-4} < 10^{-3}$
4	*Incidents are known of in industry; an* **unlikely** *event not expected during the lifetime of the plant, which probably requires* **multiple systems** *to fail.*	$\geq 10^{-5} < 10^{-4}$
3	*Foreseeable event but with a very* **remote chance** *of occurring during the lifetime of the plant.*	$\geq 10^{-6} < 10^{-5}$
2	**Theoretically possible** *but with an extremely remote chance of occurrence.*	$\geq 10^{-7} < 10^{-6}$
1	**Practically impossible**.	$< 10^{-7}$

** Within the workshops, likelihood considerations are generally made qualitatively.*

6.1.1.2. Assessment of Risk

A different risk matrix is used for environmental harm, whereby the matrix definitions are also slightly different.

Table 6.1.1.2.1: HAZID Risk Matrix Definitions

Region	Interpretation
Low	Identified as the **green** area of the risk matrix. Consideration should be given to low cost risk reduction measures.
Medium	Identified as the **yellow** area of the risk matrix. Consider additional risk reduction measures.
High	Identified as the **red** area of the risk matrix. Immediate further action is essential to reduce the risks to an acceptable level within an agreed and specified time.

Table 3.3.1.8.3: HAZID Risk Matrix (Environment)

MATTE	**7**										
Significant off-site (listed)	**6**										
Minor off-site (listed)	**5**										
Significant off-site (unlisted)	**4**										
Minor off-site (unlisted)	**3**										
Significant on-site.	**2**										
Minor on-site.	**1**										
No effects (minor spill).	**0**										
Severity / **Likelihood**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
		$<10^{-7}$	$\geq10^{-7}$ $<10^{-6}$	$\geq10^{-6}$ $<10^{-5}$	$\geq10^{-5}$ $<10^{-4}$	$\geq10^{-4}$ $<10^{-3}$	$\geq10^{-3}$ $<10^{-2}$	$\geq10^{-2}$ $<10^{-1}$	$\geq10^{-1}$ <1	1	>1

6.1.1.3. HAZID Results

Below is a summary of the HAZID results:

Table 6.1.1.3: HAZID Results Summary (Environment)

System		No. of Events	No. of n/a Events	Residual risk		
				L	M	H
A	Ship Unloading / Loading (Jetty Operations)	31	7	1	23	0
B	Generics	9	5	3	1	0
C	Area 1 Tank Farm Activities	23	7	0	16	0
D	Area 2 Tank Farm Activities	35	15	0	20	0
E	Area 3 Tank Farm Activities	31	13	1	17	0
F	Area 6 Tank Farm Activities	36	12	1	23	0
G	Generic Road Tanker Operations (Ares 2, 3 and 6)	39	19	3	17	0
H	Area 1 Road Tanker Operations	42	18	5	19	0

No high-risk events were identified.

6.1.2. Representative Set

As part of Predictive Aspects (Section 3), a set of scenarios is generated from site hazard identification studies. These scenarios are intended to be representative of all hazards that could arise from activities carried out at the site and are thus termed the 'representative set'. Whilst useful as a validation tool in the development of source-pathway-receptor trios (see Section 6.5 and Appendix 6.4), they conflict with the requirements of environmental assessment given that they focus on a cause-consequence pairing rather than a source-pathway-receptor focus and may thus not focus on the worst case environmental releases.

The derivation of the representative set is described in Section 3.3.2, carried out in Appendix 3.4 and the final set is provided in Section 3.3.3. As specified, the same representative set is used as a validation tool in Appendix 6.4 to ensure that all credible sources to source-pathway-receptor discussions are identified. In doing so, the representative set remains valid.

6.2. Dangerous Substances

The following information has been obtained primarily from the ECHA database (Ref. [6.1]).

6.2.1. Names of Dangerous Substances

Chemical Name	Chemical Formula	Synonym	EINECS No	CAS Number	Concentration of Impurity or Additive	Proportion of Constituents in Mixtures	Additional Information	CLP Hazard Statement
Amine (AT1214)	$C_{14}H_{31}N$ $C_{16}H_{35}N$ $C_{18}H_{39}N$	Renamed Fentamine 1270 on-site. This report still refers to the older name.	203-943-8 204-002-4 203-997-2	112-18-5 112-75-4 112-69-6	None anticipated.	Mixture of 62-75% dodecyldimethylamine, 21-30% dimethyl(tetradecyl)amine and 2-8% hexadecyldimethylamine.	None relevant.	H302, H314, **H400**
Bitumen	Mixture	Asphalt	232-490-9	8052-42-4	None anticipated.	Bitumen (asphalt) (tar) is a mixture of chemicals left over at the end of a distillation process.	Stored at 160°C	Not classified.
Cyclopentane	C_5H_{10}	-	206-016-6	287-92-3	None anticipated.	Not a mixture.	None relevant.	H225, **H412**
Ethanol	C_2H_6O	-	200-578-6	64-17-5	None anticipated.	Not a mixture.	None relevant.	H225
Furnaceflame	Mixture	-	-	-	-	Alternative boiler fuel. See diesel / gas oil.	-	-
Gas Oil	Mixture	Diesel, Fuel oil	269-822-7	68334-30-5	CFPP (Cold Filter Plugging Point) additive that prevents gelling at low temperatures.	Mixture of long chain hydrocarbons.	None relevant	H226, H315, H332, H351, H373, **H411**
HLAS Alkyl Benzene Sulphonic Acid	4-C10-13-sec-alkyl derivs.	-	287-494-3	85536-14-7	None anticipated.	Mixture of 4-C10-13-sec-alkyl derivatives.	None relevant.	H302, H314, **H412**

Chemical Name	**Chemical Formula**	**Synonym**	**EINECS No**	**CAS Number**	**Concentration of Impurity or Additive**	**Proportion of Constituents in Mixtures**	**Additional Information**	**CLP Hazard Statement**
IMS96 IMS99	Mixture	Industrial Methylated Spirits	n/a	n/a	Methanol, 1-4%	96 or 99% ethanol, 1-4% methanol.	In following tables see ethanol.	H225
Industrial Denatured Alcohol	Mixture	IDA	n/a	n/a	See proportion…	Largely ethanol with small amounts of additives including IPA, acetone, MEK, MIK etc.	In following tables see ethanol.	H225
Isopropanol	C3H8O	Propan-2-ol	200-661-7	67-63-0	None anticipated.	Not a mixture.	None relevant.	H225, H319, H336
Kerosene	Mixture	Kerosine (petroleum)	232-366-4	8008-20-6	None anticipated.	Mixture of long chain hydrocarbons.	None relevant.	H226, H304, H315, H336, **H411**
LIAL 123	C10-16 mixture	Alcohols, C10-16	267-019-6	67762-41-8	None anticipated.	Mixture of long chain hydrocarbons.	Not fully REACH registered; see Gas Oil / Kerosene in following tables.	**H400**
Methanol	CH4O	Methyl alcohol	200-659-6	67-56-1	None anticipated.	Not a mixture.	None relevant.	H225, H301, H311, H331, H370
TSDA / DEB products (various)	C2H6O	Denatured Ethanol	200-578-6	64-17-5	See constituents.	Normally 999 parts Ethanol, 1 part tertiary Butanol and 10ppm Bitrex with variations upon.	See Ethanol in following tables.	H225
Ultra-low Sulphur Diesel	Mixture	Gas oil, Fuel oil	269-822-7	68334-30-5	None anticipated.	Mixture of long chain hydrocarbons.	See Gas Oil in following tables.	H226, H315, H332, H351, H373, **H411**

6.2.2. Physical and Chemical Behaviour of Dangerous Substances

Table 6.2.2: Physical and Chemical Behaviour of Dangerous Substances (ND = Not Determined)

Chemical Name	**Density** (kg/m^3 at @15-25ºC)	**Flash Point ⁰C**	**Ignition Point ⁰C**	**Flammable Limits** (%)		**Vapour Pressure** (mmHg at °C)	**Boiling Point ⁰C**	**Water Solubility** (mg/l @ °C)	**Reactivity**	**Partition Coefficient** (log Pow)	**Decomposition Data**	**Explosive Data**
				LEL	**UEL**							
Amine (AT1214)	778-805	116	215-225	ND	ND	<1 at 38	204	<19	No data specified (ECHA).	1.3-1.9	Material is stable under normal conditions.	Not thought to be explosive.
Bitumen	1,025	>180	>300	ND	ND	<0.1 at 28	>320	Insoluble	None under normal conditions	>6	Stable under normal conditions.	Not thought to be explosive.
Cyclopentane	750	-25	361	1.1	8.7	272 at 21	49.3	156 at 25	Avoid strong oxidisers (e.g. chlorine, bromine, fluorine)	3	Thermal decomposition emits acrid smoke and fumes.	May form explosive atmospheres.
Ethanol	790-800	13	455	2.5	13.5	0.75 at 20	64-65	Miscible	Stable under normal conditions.	-0.35	See reactivity.	May form explosive atmosphere in air.
Gas Oil	800-910	60	>225	ND	ND	3 at 20	141-462	Immiscible	No data specified (ECHA).	ND	Material is stable under normal conditions.	May form explosive atmospheres above flash point.
HLAS Alkyl Benzene Sulphonic Acid	1051	260	380	ND	ND	2E-10 at 25	189	~160,000mg/L at 20	Keep away from strong oxidising or reducing agents, or strong alkaline or amine solutions.	2.2	Product stable under normal conditions. Decomposition at temperatures >200°C with no unstable decomposition products.	Not thought to be explosive.

Chemical Name	Density (kg/m^3 at @15-25ºC)	Flash Point ºC	Ignition Point ºC	Flammable Limits (%)		Vapour Pressure (mmHg at °C)	Boiling Point ºC	Water Solubility (mg/l @ °C)	Reactivity	Partition Coefficient (log Pow)	Decomposition Data	Explosive Data
				LEL	UEL							
Isopropanol	800	12	455-456	ND	ND	33 at 20	82.5	Miscible	Avoid contact with strong acids.	0.05	Stable under normal conditions.	May form explosive atmosphere in air.
Kerosene	770-850	>38	220-250	ND	ND	7.5-27.7 at 37.8	146-299	Immiscible	Avoid contact with strong oxidants.	ND	Stable under normal conditions.	May form explosive atmospheres above flash point.
Methanol	790-800	10	420	ND	ND	127.5	65	Miscible	Not particularly reactive.	-0.74	Stable under normal conditions.	May form explosive atmosphere in air.

6.2.3. Possibility of Immediate and Delayed Harm to People or Environment

Dangerous Substance	**Health Hazards**	**Lethal / Harmful Concentrations**	**Harm caused by Fire or Explosions**	**Effects on the Environment**
Amine (AT1214)	Harmful if swallowed. Causes burns. Can cause severe eye irritation. Prolonged exposure can cause severe chemical burns. Can cause severe skin irritation. Prolonged exposure can cause severe chemical burns. Prolonged or repeated high-level exposures can lead to severe irritation of respiratory passages and/or lung congestion. Small mounts may cause injury by ingestion.	LD_{50} rat, oral 1080mg/kg.	Thermal decomposition produces oxides of carbon & nitrogen.	Very toxic to aquatic organisms. Readily biodegradable. • Fish, LC_{50} 96hrs, *Oncorhynchus mykiss*, 0.71-1.8mg/L • Invertebrate, EC_{50} 48hr, *Daphnia magna,* 0.083-0.93mg/L; • Algae, EL_{50} 72hr, *Desmodesmus subspicatus*, 14.6-46.6µg/L.
Bitumen	Not classified as hazardous to health under GHS.	WEL TWA (mg/m³) 5 mg/m³ (fumes) WEL STEL (mg/m³) 10 mg/m³ (fumes)	Decomposition products may include Carbon oxides (CO, CO_2), Hydrogen sulphide. Sulphur oxides. sulphuric acid.	According to the criteria of the European classification and labelling system, the substance/the product has not to be labelled as "hazardous to the aquatic environment". Material sets very quickly and thus there is little transport potential.
Cyclopentane	No associated risk phrases. However, precautionary statements suggest it could be harmful through ingestion, though not toxic.	LD_{50} rat, oral >5000mg/kg; inhalation >32.25mg/L.	Combustion produces oxides of carbon and may decompose at high temperature.	Harmful to aquatic life with long-lasting effects. • Fish, LL_{50} 96hr, *Oncorhynchus mykiss*, 29.3mg/L • Invertebrate, EL_{50} 48hr, *Daphnia magna*, 51.15mg/L • Algae, EL_{50} 72hr, *Pseudokirchneriella subcapitata,* 21.58mg/L • Bacteria, NOEL 48hr, *Tetrahymena pyriformis*, 25.16mg/L

Dangerous Substance	**Health Hazards**	**Lethal / Harmful Concentrations**	**Harm caused by Fire or Explosions**	**Effects on the Environment**
Ethanol	Inhalation of vapours in high concentrations may cause irritation of respiratory system. Irritating to eyes. Toxic if swallowed.	OEL: 1,000ppm (ST), 5,000ppm (LT). LD_{50} Rat Oral, 10,470mg/kg LD_{50} Rat Inhalation 60min >60,000ppm LD_{50} Rabbit Dermal, 17,100mg/kg	Highly flammable. Combustion produces oxides of carbon.	Readily biodegradable and evaporates. Ethanol is readily biodegradable after 15 days in non-acclimatised fresh water. Does not bioaccumulate. • Fish LC_{50} 96hr, *Pimephales promelas* 15,300mg/L • Invertebrates LC_{50} 48hr, *Ceriodaphnia dubai,* 5,012mg/L • Algae, EC_{50} 72hr, *Chlorella vulgaris,* 275mg/L • Microorganisms LC_{50} 4hr, *Paramecium caudatum* 5,800mg/L
Gas Oil	Limited evidence of carcinogenic effect. May cause lung damage if swallowed. Repeated exposure may cause skin dryness or cracking. Swallowing large amounts may cause irritation with diarrhoea and vomiting. Prolonged or repeated contact with the skin may cause dermatitis which could lead to irreversible skin disorders. May cause irritation to the eyes with short term redness and stinging. Inhalation of fumes or vapour may cause irritation to the eyes and mucous membranes and drowsiness leading to loss of consciousness.	OEL: 5mg/m^3 (LT), 10mg/m^3 (ST). LD_{50} Rat, Oral 8mL/kg, LC_{50} Rat, Inhalation 4.6mg/L air. LD_{50} Rabbit, Dermal >2,000mg/kg	Combustion products oxides of carbon and potentially sulphur dioxide.	Very toxic to aquatic organisms; may cause long-term effects in the aquatic environment. May bioaccumulate. Likely to biodegrade slowly. • Fish LC_{50} 96hrs, *Cyprinodon variegatus*, 56-94mg/L • Fish LC_{50} 96hrs, *Oncorhynchus mykiss* 65mg/L • Invertebrates EL_{50} 48hrs, *Daphnia magna*, 68-210mg/L • Algae EL_{50} 72hrs, *Pseudokirchneriella subcapitata*, 10-22mg/L • Microorganisms EL_{50} 72hrs, *Tetrahymena pyriformis*, >1000mg/L.
HLAS Alkyl Benzene Sulphonic Acid	Harmful if swallowed. Causes burns / corrosive.	LD_{50} rat, oral ~1,470mg/kg. Inhalation not determined. LD_{50} rat, dermal, >2000mg/kg.	Combustion produces oxides of carbon.	Biodegradable. Harmful to the aquatic environment. • Fish LC_{50} 96hr, *Lepomis macrochirus,* 1.67mg/L • Invertebrates, EC_{50} 48hr, *Brachionus calyciflorus,* 2mg/L • Algae, EbC_{50}/ErC_{50} 72hr, *Desmodesmus subspicatus,* 47.3-127.9mg/L

Dangerous Substance	Health Hazards	Lethal / Harmful Concentrations	Harm caused by Fire or Explosions	Effects on the Environment
Isopropanol	Irritating to eyes. Vapours may cause drowsiness and dizziness. Inhalation of vapours may cause drowsiness and dizziness. Irritating to eyes and mucus membrane. Prolonged skin contact may cause skin irritation.	OEL: 400ppm (LT), 500ppm (ST). LD_{50} Rat Oral 5840mg/kg LC_{50} Rat Inhalation >10,000ppm LD_{50} Rabbit Dermal 16.4mL/kg	Highly flammable. Combustion produces oxides of carbon.	Biodegradable. • Fish LC_{50} 96hr, *Pimephales promelas,* 9,000-10,000mg/L • Invertebrates LC_{50} 24hr, *Daphnia magna,* >10,000mg/L • Algae LC_{100} 7d, *Scenedesmus quadricauda,* 1,800mg/L • Microorganisms LC_{100} 16hr, *Pseudomonas putida,* 1,050mg/L
Kerosene	Irritating to skin. May cause lung damage if swallowed. Slightly irritating to eyes. Slightly irritating to respiratory system. Not a skin sensitizer.	LD_{50} Rat Oral >5000mg/kg LC_{50} Rat Inhalation >7.5mg/L 6hr LD_{50} Rabbit Dermal >2000mg/kg	Flammable.	Toxic to aquatic organisms; may cause long-term adverse effects in the aquatic environment. Major constituents are expected to be inherently biodegradable, but the product contains components that may persist in the environment. Contains components with the potential to bioaccumulate. • Fish LL_{50} 96hr, *Oncorhynchus mykiss,* 2-5mg/L • Invertebrates, EL_{50} 48hr, *Daphnia magna,* 1-2mg/L • Algae, EL_{50} 72hr, *Pseudokirchneriella subcapitata* 3.7mg/L • Microorganisms LL_{50} 72hr, *Tetrahymena pyriformis,* 677.9mg/L
Methanol	Toxic by inhalation, in contact with skin and if swallowed. Danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed. Inhalation of vapours in high concentration may cause irritation of respiratory system. Prolonged skin contact may defat the skin and produce dermatitis. Contact with the eye may cause irritation, redness and possible damage to cornea. Toxic if swallowed. Effects due to ingestion may include irritation of mucous membranes, narcosis, nausea, headache, vomiting and dizziness.	OEL: 200ppm (LT). LD_{50}, rat, oral 6,000mg/kg LC_{50} Rat Inhalation 85.41mg/L/4.5hr LD_{50} Rabbit Dermal 17,100mg/kg	Highly flammable. Combustion products may include oxides of carbon and hydrogen chloride gas.	Readily biodegradable. Not likely to bioaccumulate. • Fish LC_{50} 96hr, *Lepomis macrochirus,* 12,700-15,400mg/L • Invertebrates EC_{50} 96hr, *Daphnia magna,* 18,260mg/L • Algae EC_{50} 96hr, *Pseudokirchneriella subcapatia,* 22,000mg/L • Microorganisms IC_{50} 3hr, Activated Sludge >1,000mg/L

6.3. Potential Releases

6.3.1. Substance Inventory

The principal use of the site is for storage of chemicals in tanks. The storage tanks are within a secondary bunded area and there are six areas on the Dagenham site. Areas one, two and six can store flammable products whilst all areas could theoretically store environmentally hazardous products. Details on the main storage facilities is provided in Section 2.8.1.

The only exception to this is the drumming area where product is decanted to drums and IBCs. Once decanted, the drums and IBCs are stored in a warehouse area until required by the customer.

6.3.2. Physical Containment Measures

There are various sized tanks on site with all potentially hazardous products stored within a secondary bunded area. The bunds are divided into six areas yet there could be several bunds within each area. Some bunds have an earth floor whilst developed bunds have concrete bases. Bunds will be emptied either by natural outflow through a valve, normally kept closed, or using a pump.

The site has a concrete or tarmac surface to 90% of its area. Storages on site are bunded to varying standards. ‘Flammable’ and ‘Hazardous to the Aquatic Environment’ substances are stored within impervious bunds. Transfer pipelines run throughout the site and any release from these could be external to the secondary containment; however, they would be captured within the site’s tertiary containment comprising the drainage system and interceptor sumps.

Tertiary containment for the site is provided by the on-site drainage system as described in Section 2.8.7. Surface water from operational areas of the site will be directed to the site Effluent Treatment Plant through sumps and interceptors. After it has been treated, it will be discharged to the Thames Water public foul sewer, which transfers it to the local Wastewater Treatment Works.

The site is also bounded by a flood defence barrier wall along its boundary with the River Thames which would allow any releases to pool within the site hardstanding.

Some tertiary containment in the yard is provided by concrete hardstanding, the sea wall, and the site drainage system.

6.3.3. Topography and Drainage

Locations of drainage, retention sumps and interceptors are presented in Section 2 Appendices 2.9 to 2.14) covering all areas on-site. A simplified version, showing all areas of the site at once, has been included as Appendix 6.10.

Surface water drains from non-operational areas of the site are directed / drained along the river wall and are located in the old office carpark (south of Area 1 Tank Farm 2) and around the on-site laboratory (south of Area 5); the locations of these drains is provided in Appendix 6.3. Spill kits are located along the river wall for protection in the case of any spillage, see Appendix 6.2.

Surface water and captured bund water from Areas 1 (both TF1 and TF2), 2, 3 and TF3 (Bitumen) is directed to buried oil-water separators (Klargster System) before being discharged from site via the storm drain connection into Chequers Lane (discharge point ref. TQ4882901G). It is noteworthy that the water captured in the bund is assessed (to ensure its not contaminated) prior to release otherwise it is directed to the site effluent water treatment plant.

All other drains on the site (including Area 6) go to the effluent plant via sumps and through interceptors. The effluent then goes through an aeration process and tested by the lab prior to discharge. The drains from the office rest room and lab go to the public foul sewer under a Thames Water plc trade effluent discharge consent.

A single trade effluent sewer passes across the site, from the south-west corner, where it rises, to its point of discharge to the Thames Water public foul sewer in Chequers Lane. All trade effluent and surface water (except those referred to at the beginning of this section) from the site discharges to this drain.

The effluent discharged from the site flows to the Riverside STW (Creekside, Rainham, Essex RM13 8QS) which is approximately 2.5km east of the site in the London Borough of Havering. This WWTW is reported as treating sewage from an effective 400,000 people each day and serves a catchment area of 1,270km^2 (Ref. [6.15]).

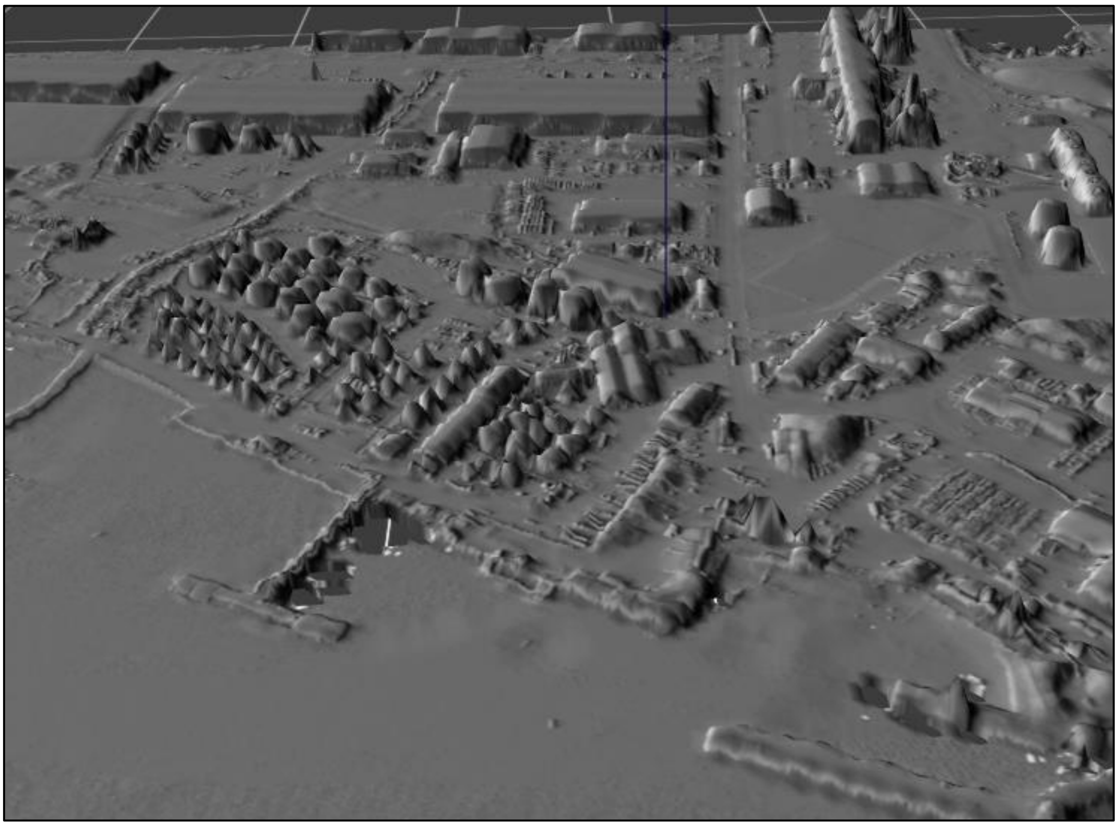
It is stated in Ref [6.23] that, historically, surface drainage (in the area) is understood to have flowed north to south towards the River Thames, via a network of shallow drainage ditches and brooks. Over the last century, following reclamation of the surrounding area, these drainage features have been canalised, culverted and straightened. Some of these surface water features are still present and, following the construction of the Thames flood defence sheet pile wall in the 1970s, discharge appears to have been via floodgates into the Thames, as shown in Figure 6.3.3.1 (source - Ref [6.23]).

Figure 6.3.3.1: Local Hydrology (site outline in red and drainage channels in blue)

Topographical maps have been produced for the site; these are shown at Appendix 6.5. The site contour map shows that the general site gradient slopes downwards from the south-west of the site (at a height of just above 4.5m AOD) to the north-east (approximately 2.0m AOD); because of this, it is concluded that a general flow of any flood water on the site would flow towards the north and north-east.

It is noted that, whilst this topographical map shows detail, it does not provide a quick-glance idea of the surrounding topography. As such, lidar data to a 50cm resolution (the most detailed resolution possible) has been downloaded from (Ref. [6.24]) and opened using the ADMS Mapper Tool (an visual add-on tool part of a Gaussian plume dispersion model software package, Ref. [6.25]).

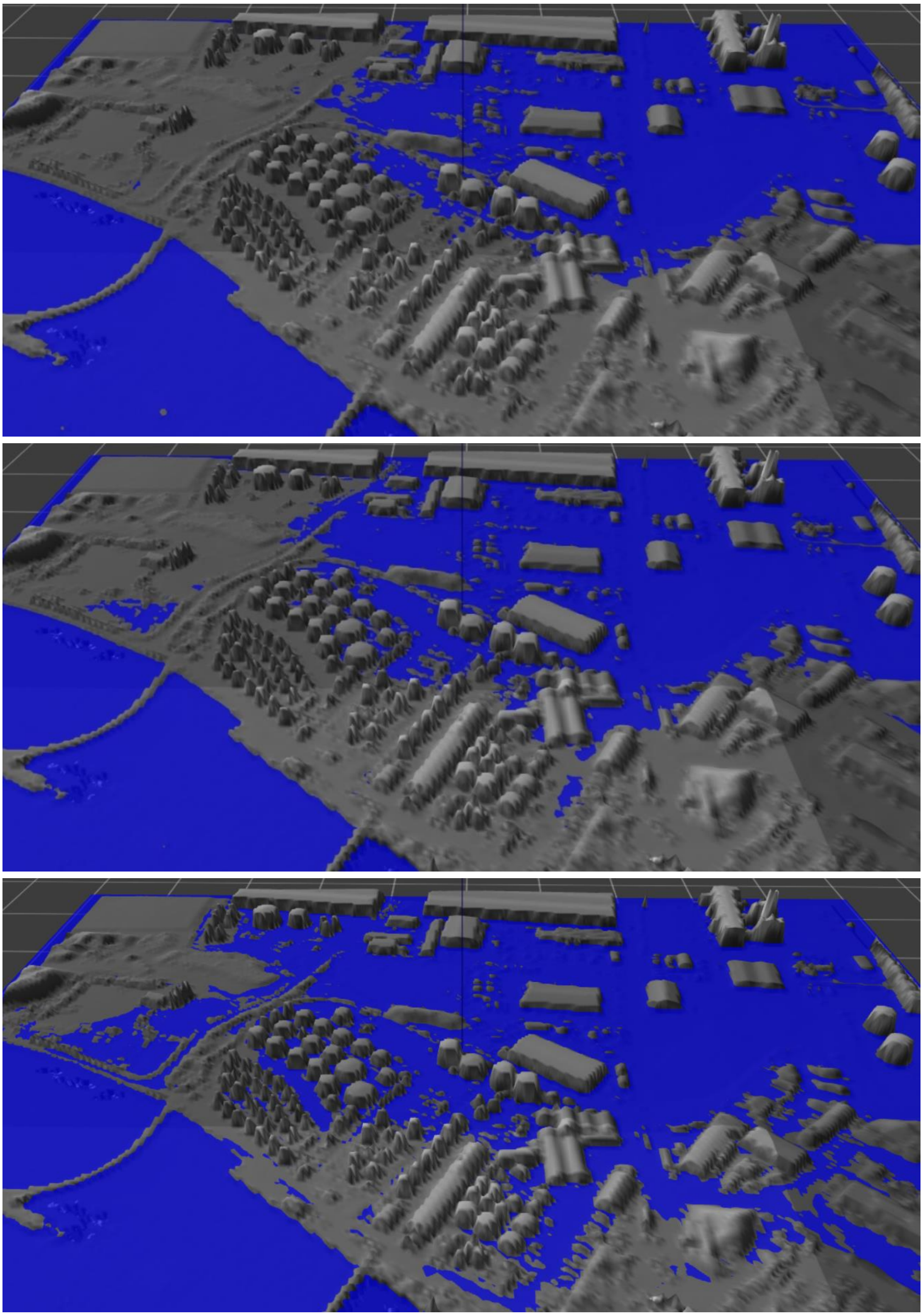
Figure 6.3.3.2: Lidar Data for the SDL Site



As can be seen above, the land in and around the site is very flat, with only minor changes in elevation. Flood water would be channelled by the locations of the bund walls enclosing the various areas of the site, but these would not interfere with the general direction overall.

The ADMS Mapper (Ref. [6.25]) has a 'flood' tool that can be used to look at changes in elevation. The flood tool does not include a release location but can be used to see incremental changes more clearly. The three images below show heights of 4.0, 4.5 and 5.0m Above Ordnance Datum (AOD) respectively.

Figure 6.3.3.3: Lidar Data with ADMS Mapper 'Flood' Tool (4-5m AOD)



The above model demonstrates that most of the site sits between 4 and 5m AOD.

6.3.4. Location of Barriers

Surface water in Area 1 will be directed to the site Effluent Treatment Plant through sumps and interceptors; the layout of this is shown in Appendix 6.3. After it has been treated, it will be discharged to the Thames Water public foul sewer, which transfers it to the local Wastewater Treatment Works. Tank and pump bunds are discharged to the site Effluent Treatment Plant. In the COMAH section of Area 3, this is done via an air operated manual valve and pumping via a permanent rigid line. In Areas 2 and 6, it is done by a sump pump, started and stopped by the operator.

There is a flood defence barrier wall between the site and the sea, consisting of steel sheet piling, constructed as part of the Thames defence raising works carried out in the 1970s. Given that this goes down to a level below the base of the river, and extends well above ground level, and that the site gradients favour flow away from the wall, it is considered unlikely that a major loss of containment will result in significant loss to the river via this route; however, note that surface water drains from non-operational areas exist in this area and may result in a slow discharge direct to the estuary.

Some tertiary containment in the yard is provided by concrete hardstanding.

6.3.5. Discharge Points

Operational Areas – Surface water from operational areas across the site is captured within the linked drainage system. The main environmental discharge point on the site is the aqueous trade effluent discharge to the foul sewer in Chequers Lane. The purpose of the trade effluent and wastewater system is to collect, segregate and treat all of the surface and wastewater that enters the drainage system. Trade effluent is controlled, and the terminal has to operate within the confines of the trade effluent consent.

Non-Operational – Surface water drains from non-operational areas of the site discharge along the river wall and are located in the main office carpark (south of Area 1 Tank Farm 2), around the weighbridge west of the main office (south-east of Area 2) and around the Labs (south of Area 5).

Sewage – The term trade effluent covers every type of wastewater excluding the following, which is classed as sewage:

- Wastewater from the office block;
- Wastewater from the mess room building;
- Wastewater from the security lodge;
- Wastewater from the domestic drains of the laboratory;
- Wastewater from the No.4 site office building;
- Wastewater from the domestic drains of the workshop and workshop mess room;
- Wastewater from the locker room.

Sewage can be disposed of into the foul sewer that runs across the terminal and connects to the foul sewer in Chequers Lane.

6.3.6. Overview of Critical Control Systems

Areas 1, 2, 3 and 6 are used for the storage of COMAH materials, including those that are hazardous to the aquatic environment. Areas 4 and 5 hold non-COMAH materials. The tanks in COMAH bunds are all fitted with a level transmitter (for high-level indication, with audible alarm in the control room, jetty and gatehouse if the set point is reached). All tanks in Area 1 and five tanks in Area 6 are also fitted with a high-high level switch, activation of which results in the tank ROSOV valve shutting.

Bund pumps are required in some bunds for removing any liquid accumulated; others simply drain under gravity via a manual drain valve, which are kept closed. Detailed descriptions are provided in Section 2.11.4.

The site is covered by a fixed firewater system that principally utilises electric pumps. Deluges are available on many tanks but are manually activated.

Area 1 is fitted with its own fire water system and utilises a combination of diesel pumps and an electrically driven jockey pump used to maintain system water pressure. Diesel foam pumps are also installed. Activation of deluges are automatically activated.

All fire water is supplied from the River Thames rather than install a dedicated fire water storage tank. The location of the water take-off is situated such that water is always available, even at low tide.

6.3.7. Off-site Barriers / Control Systems

The boundary with the River Thames includes a flood defence wall which would assist in containing releases from the site.

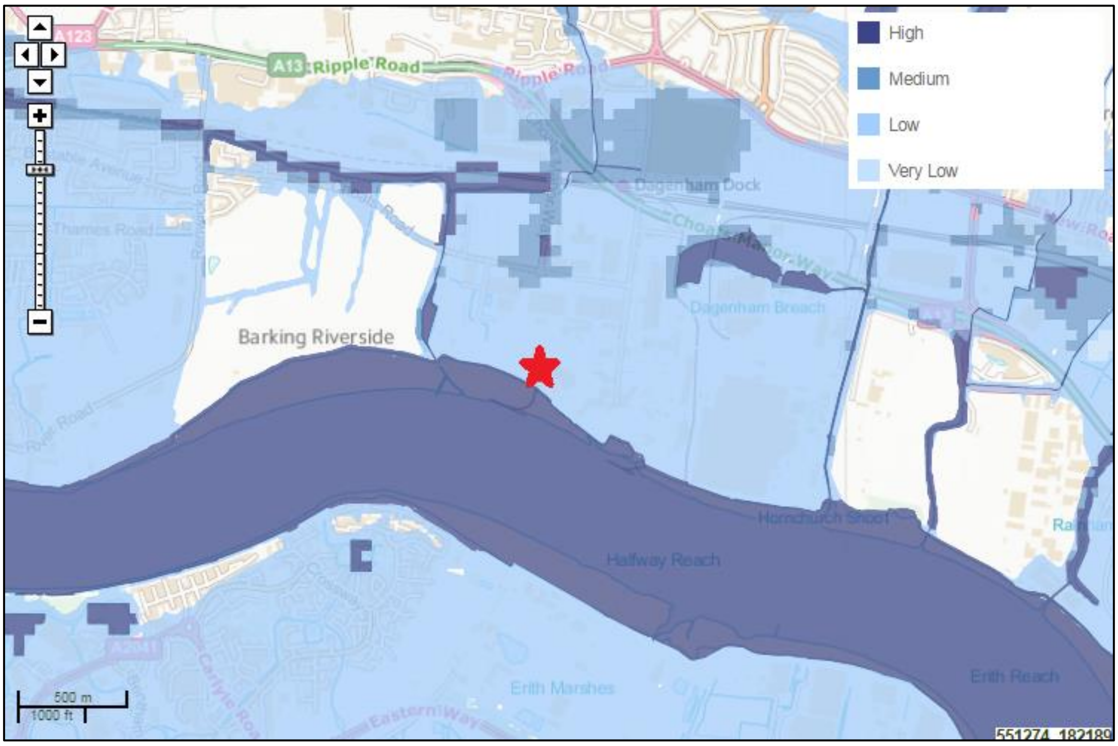
Releases into the foul sewer could be halted by the Riverside sewage treatment works (STW) at Rainham.

6.3.8. Climate and Meteorology

6.3.8.1. Flooding

The site is situated on the northern passive floodplain of the river; the floodplain is passive at this point due to the presence of flood defences. Due to the tidal nature of the Thames and as a result of its location the site may be at hazard from flooding. The Environment Agency Flood Risk zone maps for the area surrounding the site is shown below and addresses threat of flooding from rivers and the sea (Figure 6.3.8.1.1), surface water (Figure 6.3.8.1.2) and reservoirs (Figure 6.3.8.1.3).

Figure 6.3.8.1.1: Risk of Flooding from Rivers and Sea (Ref. [6.9])



The above map shows that the site is on a high-to-medium risk zone for flooding from rivers and the sea and that much of the surrounding roads may be flooded in such an event.

Figure 6.3.8.1.2: Risk of Flooding from Reservoirs (Ref. [6.9])

The above map shows that the site itself is not vulnerable to flooding from reservoir failure, but that many of the access roads to the north could be. The effects of flooding on emergency response is discussed in Section 6.12.4.

Figure 6.3.8.1.3: Risk of Flooding from Surface Water (Ref. [6.9])

The above map shows that the site itself is not vulnerable to flooding from surface water failure, but that many of the access roads to the site could be, e.g. after particularly heavy rainfall.

The site has understood the potential for the site to flood for a number of years and have therefore undertaken a flood risk assessment, the most recent 2013 copy of which may be found in Appendix 6.1.

It was concluded that the existing river wall flood defence provides protection to the site for at least a 1-in-1000 year flood event from the River Thames with a minimum freeboard of 0.58m (1-in-1000 year water level of 6.52m AOD versus a minimum flood defence crest level of 7.1m AOD). This is believed to be true up to the year 2107, including all events up to and including the 1-in-200-year event, with a minimum freeboard of 0.22. In considering climate change, there is believed to be a minimum freeboard of 0.06m above the 1-in-1000-year (plus climate change) flood level throughout the lifetime of the development (taken to be 60 years).

Tank bunds would provide further protection from flood waters in the event of overtopping of the river flood defences.

Flood defences, including the river wall and flood gate, were inspected during the report preparation. No major issues were identified at the time and minor recommendations were actioned.

In overview, the report concludes that the development has minimal risk from flooding, does not increase elsewhere and is compliance with the requirements of the NPPF.

The potential for any flood event to initiate an event is considered in Section 6.5.2 and to prevent or hinder emergency response is considered in Section 6.12.4. A flood risk assessment is provided in Appendix 6.1 and a flood management plan is available in Appendix 6.7.

6.3.8.2. Climate Change

Climate change may result in:

- Higher temperatures: Increases in temperatures are likely to be incremental. Materials with flash points marginally above current maximum UK temperatures (e.g. kerosene) may need to be periodically reviewed to ensure zoning requirements are still correct, though this would be picked up in regular reviews of documentation and temperatures would not be expected to infringe on upper flash points (e.g. diesel) in the foreseeable future;
- Lower temperatures: not likely to cause blockages given the freezing point of most materials on-site are below anticipated temperatures. Without additive, diesel will gel at -8.1°C which may cause process hazards – e.g. blocked in lines, dry running of pumps – however, diesel has a CFPP (Cold Filter Plugging Point) additive that prevents gelling at low temperatures and there are no other materials identified that are particularly vulnerable. The site does have a winterisation procedure, which is provided in Appendix 6.8a, along with a list of equipment with risk of failure during cold weather in Appendix 6.8b;
- Increased rainfall: Climate change may cause more extreme weather events. This could cause an increased frequency of surface water flooding events although ultimately the areas affected by the flood water would be no worse than shown in Figure 6.3.8.1.1.
- Prolonged drought: The site is not dependent upon towns water for firewater, instead taking water from the River Thames at a point located such that water is obtainable, even at low tide. The Thames is a major estuary and will always have a minimum amount of water in it that is not affected by upstream flows, i.e. if rainfall dried up the upper reaches of the Thames, this section would still be full of sea water. As such, prolonged drought is not expected to affect firefighting capability.
- Tidal surges: As indicated in Section 6.3.8.1, tidal flooding due to tidal surge is a real possibility at the site. There are flood defences at the river (see discussion in Section 6.3.8.1) and there are flood management plans in place (see Appendix 6.7), but the frequency of potential events could increase. However, in the flood risk assessment in Appendix 6.1 suggests that there is believed to be a minimum freeboard of 0.06m above the 1-in-1000 year (plus climate change) flood level throughout the lifetime of the development (taken to be 60 years). As such, it should not pose a significant threat. Flood management for the area is managed by the local councils and it would be hoped that Stolthaven would be involved in any such improvement works.
- Increases in lightning events: providing the design of any lightning protection on-site is against applicable risk assessments and reviewed on a regular basis, this should be controlled and increased events should therefore not significantly increase any likelihood considerations.

6.4. Pathways and Receptors

6.4.1. Designated Land or Water Sites of National Importance

6.4.1.1. Sites of Special Scientific Interest (SSSI)

The SSSI's within 10km of the site are shown below.

Figure 6.4.1.1.1: SSSI's Within 10km of the Site (Ref. [6.2])

Table 6.4.1.1.2: SSSI's within 10km of the Site (Ref. [6.3])

Name	**Dist.** (km)	**Area** (ha)	**Selected Citation Excerpts**
Inner Thames Marshes	2.7-7km, SEE	479.3	*Includes Rainham Marshes, Wennington Marshes and Aveley Marshes.* The inner Thames marshes form the largest remaining expanse of wetland bordering the upper reaches of the Thames estuary. The site is of particular note for its diverse ornithological interest and its support of a wide range of wetland plants and insects with a restricted distribution in the London area. The site comprises a major relic of low-lying grazing marsh with a variety of grassland communities dissected by a network of fresh to brackish water drains. These Marshes are divided into two main blocks by an extensive series of bunded lagoons used for the disposal of silt dredgings. The discharge of silt and river water into the lagoons produces a changing complex of dry or flooded mud flats and developing saltmarsh. These lagoon habitats are complemented by more restricted areas of naturally derived saltmarsh and intertidal mud along the Thames foreshore. The grazing marshes are dominated by the more common grasses of neutral soils and are of interest on account of their structural characteristics. An open, short, tussocky grassland structure has been created on the eastern Wennington and Aveley Marshes where traditional management by sheep and cattle grazing is continued. This contrasts with the tall ungrazed grasslands on the Western Rainham Marshes.
Ingrebourne Marshes	3.4-6.5km, NEE	74.8	The Ingrebourne valley supports the largest and one of the most diverse areas of freshwater marshland in Greater London. The variety of habitat includes extensive areas of reed sweet-grass (*Glyceria maxima*) and common reed (*Phragmites australis*) swamp; wet neutral grassland, and tall fen. These habitats also support associated invertebrates and breeding birds. Two large reed beds occur within the marshes, one on the western flood plain of the River Ingrebourne and the other within a reservoir named Berwick Pond. The reed is very dense and grows in almost single species stands. Together these form the largest area of reed bed left in London.
Abbey Wood	3.5km, S	6.3	Contains some of the most fossiliferous deposits in the Greater London area, providing remains of a diverse mammal assemblage of early Tertiary age. The deposits are also important for studies in the evolution of bird faunas.
Oxleas Woodlands	7-8.3km, SW	72.7	Oxleas, Jack and Shepherdleas Woods are one of the most extensive areas of long-established woodland on the London Clay in Greater London. The woodland has a rich mixture of tree and shrub species within which several woodland types can be recognised. The woods contain a number of species with a restricted distribution in Greater London.
Purfleet Road Aveley	7.2km, SEE	3.96	At Purfleet Road, Aveley interglacial deposits of the Thames terrace system have been recorded. The deposits form part of the Mucking formation which comprises Upper and Lower Mucking Formation Gravels separated by the Aveley Silts and Sands. The Aveley Silts and Sands have yielded important assemblages of molluscs, insects, pollen and mammal remains which are indicative of temperate, or interglacial, conditions.
Gilbert's Pit (Charlton)	7.5km, SWW	5.2	Gilbert's Pit provides one of the most complete sections through the Lower Tertiary beds in the Greater London area. It forms a key Tertiary site for stratigraphic studies and is particularly important for a paleogeographic reconstruction of the Woolwich and Reading Beds.

Name	Dist. (km)	Area (ha)	Selected Citation Excerpts
Hornchurch Cutting	8km, NE	0.8	Provides unique sections through a series of deposits that are of great stratigraphical importance for studies of the Pleistocene. In particular, the site is of considerable significance for correlating the formation of the Thames terrace sequence with the glacial stratigraphy of southern Britain.
Purfleet Chalk Pits	8-9.2km SEE	10.73	Mid-Pleistocene sand and gravel deposits overlying Chalk are exposed in a series of disused quarries at Purfleet, Essex. The complex lithostratigraphical and biostratigraphical evidence contained at Purfleet clearly indicates the importance of this site in the scientific study of both the evolution of the Thames and Northern European interglacial sequences.
Wansunt Pit	8.7km, SSE	1.91	This site provides exposures in the Dartford Heath Gravel, a deposit which has been the subject of considerable controversy since the turn of the century. It has been variously attributed to the Boyn Hill Terrace, part of the Swanscombe sequence or to an older, higher terrace. The presence or absence of archaeological material in the gravel itself is questionable, but a working floor of Acheulian age has been discovered in loam overlying the gravel in Wansunt Pit. The question of whether or not the Dartford Heath gravel is equivalent to any part of the Swanscombe sequence, and what its relationship is to the Thames Terraces, is one of the more burning issues in the Thames Pleistocene studies, and therefore the exposures here are of considerable importance.

The following SSSI's are further than 10km from the site but likely in immediate hydraulic continuity via the Thames, i.e. not dependent upon irregular occurrences to be affected by releases via the river.

Table 6.4.1.1.3: SSSI's in Hydraulic Continuity of the Site (Ref. [6.3])

Name	Dist. (km)	Area (ha)	Selected Citation Excerpts
West Thurrock Lagoon & Marshes	10-11.7km, SE	66.08	West Thurrock Lagoon and Marshes is one of the most important sites for wintering waders and wildfowl on the Inner Thames Estuary. The combination of extensive intertidal mudflats, together a large and secure high tide roost, attracts waders in nationally important numbers, with significant populations of other bird species. The adjacent Stone Ness saltmarsh is noted for the size and character of its high marsh plant community.
South Thames Estuary and Marshes	20.3-42km, SEE	5449.14	The South Thames Estuary and Marshes SSSI from Gravesend to the eastern end of the Isle of Grain forms a major component of the Greater Thames Estuary. The site consists of an extensive mosaic of grazing marsh, saltmarsh, mudflats and shingle characteristic of the estuarine habitats of the north Kent marshes. Freshwater pools and some areas of woodland provide additional variety and complement the estuarine habitats. The site supports outstanding numbers of waterfowl with total counts regularly exceeding 20,000. Many species regularly occur in nationally important numbers and some species regularly use the site in internationally important numbers. The breeding bird community is also of particular interest. The diverse habitats within the site support a number of nationally rare and scarce invertebrate species and an assemblage of nationally scarce plants.

Name	**Dist.** (km)	**Area** (ha)	**Selected Citation Excerpts**
Mucking Flats and Marshes	21.3-22.6km, E	311.56	Mucking Flats and Marshes comprise an extensive stretch of Thames mudflats and saltmarsh, together with sea wall grassland. Wintering wildfowl and waders reach both nationally and internationally important numbers on the mudflats, roosting and feeding on adjacent saltmarsh and disused silt lagoons.
Holehaven Creek	27.7km, E	272.87	The intertidal mudflats and saltmarsh habitats of Holehaven Creek support a nationally important number of black-tailed godwit (*Limosa limosa islandica*). This species also regularly occurs in numbers of international importance. The creek provides suitable conditions for black-tailed godwit, including an abundance of food in the mudflats (polychaete worms and bivalve molluscs), large areas of saltmarsh (e.g. Lower Horse) for high tide roosts and minimal levels of disturbance. These sheltered inner estuary conditions are rare within the Thames Estuary.
Medway Estuary and Marshes	31-43km, E	6,840.14	The Medway Estuary and Marshes form the largest area of intertidal habitats which have been identified as of value for nature conservation in Kent and are representative of the estuarine habitats found on the North Kent coast. A complex of mudflats and saltmarsh is present with in places grazing marsh behind the sea walls which is intersected by dykes and fleets. The area holds internationally important populations of wintering and passage birds and is also of importance for its breeding birds. An outstanding assemblage of plant species also occurs on the site.
Benfleet and Southend Marshes	33.5-44.3km, E	2,099.69	Benfleet and Southend Marshes comprise an extensive series of salt marshes, mudflats, scrub and grassland which support a diverse flora and fauna. The south-facing slopes of the downs, composed of London Clay capped by sand, represent the line of former river cliffs with several re-entrant valleys. At their foot lies reclaimed marshland, with its associated dyke system, based on alluvium. Outside the sea walls there are extensive salt marshes and mudflats, on which wintering wildfowl and waders reach both nationally and internationally important numbers. Nationally uncommon plants occur in all of the habitats and parts of the area are of outstanding importance for scarce invertebrates.
Foulness	44.3-66.6km, E	10,702	Foulness lies on the north shore of the Thames Estuary between Southend in the south and the Rivers Roach and Crouch in the north. It comprises extensive intertidal sand-silt flats, saltmarsh, beaches, grazing marshes, rough grass and scrubland. The flats are of national and international importance as winter feeding grounds for nine species of wildfowl and wader, with the islands, creeks and grazing land forming an integral part as sheltered feeding and roosting sites.

6.4.1.2. National Nature Reserves (NNR)

There are no NNR sites within 10km of Stolthaven (Ref. [6.2]). The nearest is Swanscombe Skull approx. 13.7km south-east of the site and is not in hydraulic continuity.

Leigh NNR might be in hydraulic continuity. This is located within the Benfleet and Southend Marshes SSSI/SPA/Ramsar site, see Section 6.4.1.1.

6.4.1.3. Marine Conservation Zones (MCZ)

There is a proposed Marine Conservation Zone (MCZ) at Swanscombe in the Thames Estuary (Ref. [6.2]). If designated, this will cover an area of 335ha. However, for the purposes of this submission, it is not assessed further.

The Medway Estuary is also designated as an MCZ and covers an area of 5,996ha.

6.4.2. Designated Land or Water Sites of International Importance

6.4.2.1. Special Areas of Conservation (SAC)

There are no SAC sites within 10km of Stolthaven (Ref. [6.2]). The only site potentially within hydraulic continuity is the Essex Estuaries SAC (46,111ha), part of which includes the Foulness SSSI.

6.4.2.2. Special Protection Areas (SPA)

There are no SPA sites within 10km of Stolthaven (Ref. [6.2]). Downstream, the Thames Estuary Marshes, Benfleet and Southend Marshes, Medway Estuary and Marshes and Foulness are also designated as SPA sites. See Tables 6.4.1.1.2 and 6.4.1.1.3 for more information on all SPAs.

6.4.2.3. Ramsar Sites

There are no Ramsar sites within 10km of Stolthaven (Ref. [6.2]). Downstream, the Thames Estuary Marshes, Benfleet and Southend Marshes, Medway Estuary and Marshes and Foulness are also designated as Ramsar sites; see Table 6.4.1.1.3 for more information.

6.4.3. Other Designated Land

6.4.3.1. Environmentally Sensitive Areas (ESA)

Environmentally Sensitive Areas (ESAs) are specifically mentioned in the guidance although these were ten-year agreements superseded by environmental stewardship in 2005, thus with none remaining after 2014. The environmental stewardship agreements are divided into four schemes; entry level, organic entry level, higher and upland. The emphasis of the schemes is a payment scheme to encourage the owners of the land to deliver simple, yet effective environmental management and are thus technically no longer designations in themselves, as the stewardship designation would determine the level of assistance provided, rather than the removal of such assistance.

6.4.3.2. Areas of Outstanding Natural Beauty (AONB)

There are no AONB sites within 10km of Stolthaven (Ref. [6.2]). The nearest is the Kent Downs which starts some 15km south of the site and is not in hydraulic continuity.

6.4.3.3. National Parks

6.4.3.4. Local Nature Reserves (LNR)

Figure 6.4.3.4.1 shows LNR sites within 10km of Stolthaven (Ref. [6.2]).

Figure 6.4.3.4.1: LNR Sites within 10km of the Site

Table 6.4.3.4.2: LNR's within 10km of the Site (Ref. [6.2], [6.4])

Name	**Dist.** (km)	**Area** (ha)	**Description**
Scrattons Ecopark and Extension	1.4km, NNW	1.92	Former marshland and allotments with small areas of recently planted woodland areas of open grass, leaving blocks of bramble and preserving existing shrubs and trees. The overall aim being to create a diverse range of habitats for plants, birds, insects and mammals.
Crossness	1.4-2.2km, SE	25.5	A network of ditches and open water, scrub and rough grassland. The reserve is a water vole stronghold, and over 130 different species of bird have been recorded at Crossness Nature Reserve. A number of rare aquatic and terrestrial invertebrates are present, as well as some important flora species.
Ripple	2km NWW	3.68	The reserve (managed by London Wildlife Trust) is a tapestry of birch woodland, scrub and grassland. The dumping of fuel ash has created a soil that is very alkaline and therefore different to most soils in London. This means that many plant species that can tolerate the soils in the Ripple struggle to grow elsewhere locally. Pyramidal and southern marsh orchids, grey club rush and wild basil are the most important of these. The areas of meadow and scrub provide a suitable habitat for six red data book species of invertebrates.
Beam Valley	2.1-4.5km NE	39.29	Consists of former derelict land, woodland & scrub, neutral and acid grasslands, former gravel pits and River Beam and Wantz stream.
Rainham Marshes	2.7-3.8km, E	79.19	The grasslands, fringing reedbeds and network of ditches here support a number of rare plants, insects and birds and are also home to a large population of water voles.
Dagenham Village Churchyard	2.8km, NNE	0.87	The long grass, bramble and trees provide the obvious habitats. The old walls and headstones are valuable for lichens and mosses and are not common in the borough.
Lesnes Abbey Woods	3.2-4.1km S	73.13	Ancient woodland and coppice with amazing wildflowers and spring bulbs with one of the most important populations of wild daffodils in the south east. Other habitats include parks and open spaces, heathland, wetlands and hedgerows.
Parsloe's Park Squatts	3.3km, NNW	4.28	Neutral and small pockets of acid grassland with historic hedge (part of Parsloes Manor).
Mayesbrook Park, South	3.3km, NW	7.55	An attractive nature reserve and a newly restored river landscape. The southern section of the park features two large lakes which are rich in wildlife. Habitats include adjacent recently planted woodland and rough grassland.
Ingrebourne Valley	3.6-7.3km NE	146.62	The local nature reserve provides an excellent opportunity to explore and view a full range of habitats including secondary woodland, rough grassland, acid grassland, river, marshes, wetland grazing, and reedbeds.
East Brookend Country Park	4.1-5.2km, NNE	67.39	Large scale earth moving to develop an interesting, undulating landscape on what was formerly land filled derelict land. The landfill was capped with a layer of impermeable clay and topsoil; large scale seeding was undertaken using wildflower grassland mixes that are particularly suited to poor soils and more than 50,000 small trees (whips) were planted across the 84-hectare site.

Name	Dist. (km)	Area (ha)	Description
Dagenham Chase	4.5-5.6km NE	48.5	Offers a diverse mix of habitats including shallow wetlands, woodland, grassland and the River Rom support an abundance of wildlife. The Chase borders the Eastbrookend and Beam Valley Country Parks, together forming a regionally important area for wildlife.
Oxleas Wood	7-8.3km	72.7	See Table 6.4.1.1.3.
Danson Park Bog Garden	7.2km S	1.07	A large lake with a bog garden at its western end which, is part of the lake. Formal gardens near the car park and a rock garden with pools at the western end.
Maryon Wilson Park & Gilbert's Pit	7.7km SW	17.52	Part of the former Maryon Wilson family estate, Maryon Wilson Park is a large, hilly wooded site overlooking the Thames. Gilbert's Pit, with its visible strata of chalk and fossil material, has attracted geological interest over a century and offers a unique aspect on 55 million years of geological history. Maryon Park and Gilbert's Pit have a mix of acid grassland, with abundant mouse-ear hawkweed and a good assemblage of burrowing hymenoptera (bees and wasps), scrub of gorse and broom, and secondary woodland.
Cranham Marsh	9km NE	12.97	Habitats include unimproved grassland, wet woodland, reed and sedge beds. The site is good for Southern marsh orchid, reptiles, great crested newt and water voles.
Foots Cray Meadows	9.5-10.9km S	30.32	Foots Cray Meadows provide a wealth of diverse habitats for flora and fauna. It consists of a rolling landscape, ancient woodland, the River Cray and its adjacent woodlands and wildflower margins.

There are two additional LNR sites beyond 10km but potentially in hydraulic continuity with the site.

Table 6.4.3.4.3: LNR's Potentially within Hydraulic Continuity with the Site (Ref. [6.2], [6.4])

Name	Dist. (km)	Area (ha)	Description (Natural England)
Southend on Sea Foreshore	38km, E	1,083.92	Southend's foreshore at the mouth of the Thames Estuary supports an abundance of habitats and wildlife and is internationally important for migrating birds. Stretching 8.5 miles from Leigh to Shoeburyness.
Shoeburyness Old Ranges	45km, E	6.43	Neutral grassland over relict sand dunes.

6.4.3.5. Others

There is one RSPB nature reserve within 10km of the site. This is Rainham Marshes, which is also designated as a Local Nature Reserve, see Section 6.4.3.4.

6.4.4. Scarce Habitat

The Essex Biodiversity Project (Ref. [6.5]), an informal partnership of more than 40 organisations and individuals committed to preserving and enhancing biodiversity in Essex, was set up in 1999 for the purposes of implementing the Essex Biodiversity Action Plan, one of 162 local such Plans in the UK.

Many of the designated sites in the region will contain BAP habitats and species and thus these criteria may be applicable to determination of harm severity.

6.4.5. Non-Designated Land (Widespread Habitat)

The land immediately around the site is mainly used for industrial, warehousing purposes. Most of the surrounding industry is aggregates, recycling or storage.

There are no public facilities situated at the boundary of the terminal or within 250 metres of the terminal, the arbitrarily consultation distance for the site. The main areas of domestic population immediately surrounding the site are Dagenham and Barking which are located approximately 700 metres away from site.

According to the Forestry Commission (Ref. [6.6]) the nearest areas are Ingrebourne Hill, Berwick Glades, Bonnets Wood and Cely Woods, all of which are in the wider Ingrebourne Valley LNR.

There are no known market gardens in the vicinity of the site. There are no farms in the proximity of the site.

There are various allotments within 10km of the site (Ref. [6.7]). The councils closest to the site are Barking and Dagenham (website shows 16 allotments), Havering (website shows 26 allotments) and Bexley (website shows 35 allotments). These have been plotted onto satellite imagery and show that the nearest allotments at 2.6km away (one to the north and one to the south respectively).

6.4.6. Non-Designated Water (Widespread Habitat)

All discharges would be into minor brooks for no more than a few hundred metres before discharge into the River Thames.

There are a number of fishing locations along the river that may be in hydraulic continuity (Ref. [6.8]):

- Thamesmere Lake, Thamesmead; approx. 2.4km south-west; upstream; inland lake; mixed coarse fishing.
- Gordon Lake, Gravesend; approx. 18.5km south-east; downstream; inland lake; stocked coarse fishing including carp (likely *Cyprinus carpio*), perch (likely *Perca fluviatilis)* and tench (*Tinca tinca*).
- Stanford Fishery, The Warren and Wharf Pool, Stanford le Hope; approx. 20.5km east; downstream; inland lakes likely fed by Thames Tributaries; stocked mixed coarse fishing including carp, perch, tench, bream (likely *Abramis brama)*, pike (*Esox lucius)*, eels (likely *Anguilla anguilla* – see Particular Species) and roach (likely *Rutilus rutilus).*

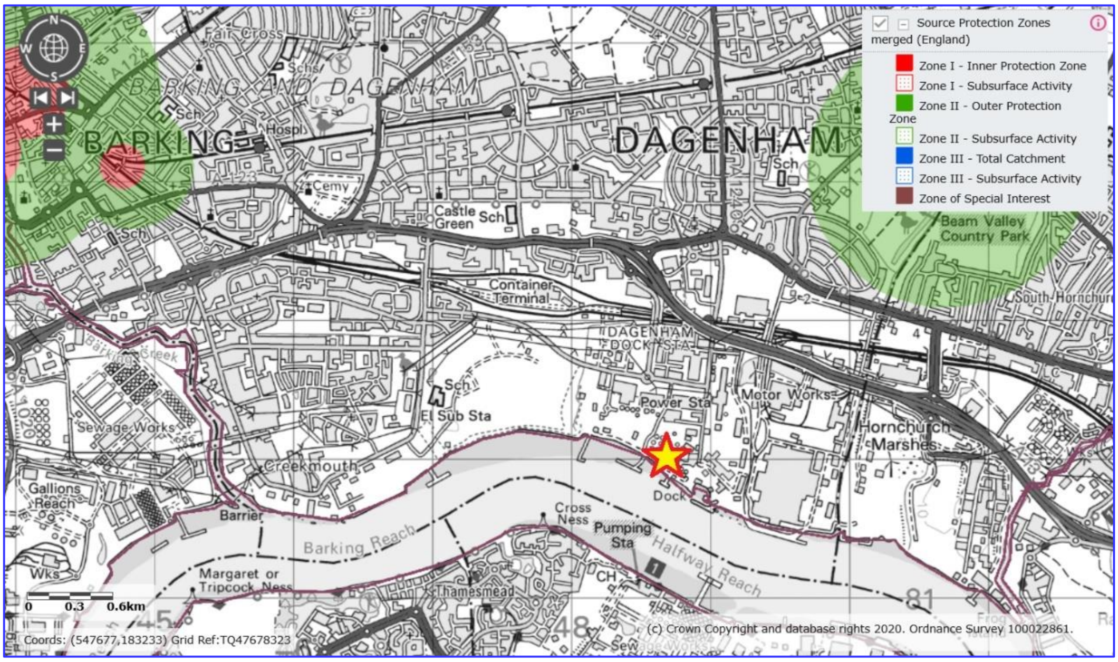
It is not likely that there is any aquaculture along the River Thames, which is normally conducted along coastlines rather than rivers, or inland on land-based constructions. There are no aquaculture activities known by the site in the immediate vicinity that are in hydraulic continuity.

There are likely a number of sailing clubs along the River Thames which is used for both commercial and private traffic.

6.4.7. Source of Public or Private Drinking Water

The site is not located on a groundwater source protection zone. Figure 6.4.7.1 shows the Groundwater Source Protection Zones closest to the Stolthaven site.

Figure 6.4.7.1: Groundwater Source Protection Zones (Ref. [6.2])



The zones show the risk of contamination from any activities that might cause pollution in the area, i.e., the closer the activity, the greater the risk. Groundwater flow is likely to be towards the south, i.e. baseflow into the River Thames and away from the nearest groundwater protection zones shown to the north-east and north-west.

There are no direct source drinking water abstractions within 250m of the site. However, the Beckton Desalination Plant is located approximately 3km west of SDL near Barking, which draws water directly from the Thames Estuary (this is just visible on the above figure, which sits on the north bank of the Thames Estuary and the west bank of Barking Creek.

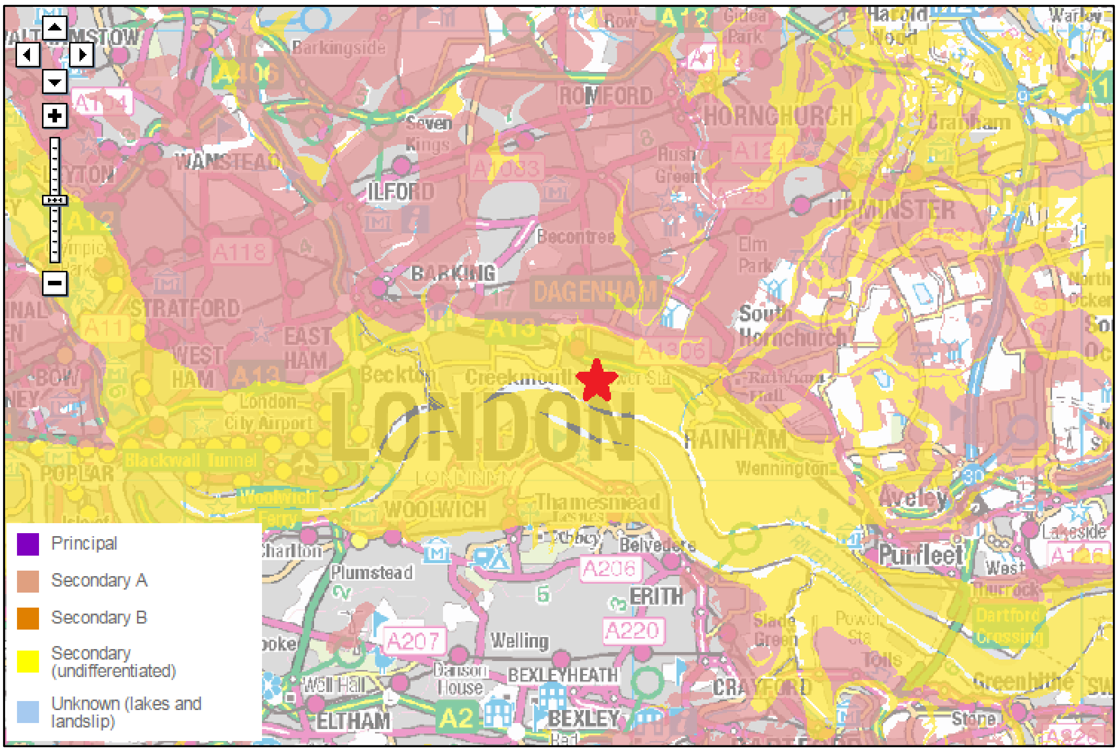
Owing to poor efficiency, it only has permission to operate during drought but has a design capacity of up to 150 million litres of water per day (Ref. [6.27]). A common but conservative figure used for calculation of sewer dry weather flow is 200 litres per person per day, which includes grey water which suggests potential catchment for 750,000 people for 24 hours, or 18,000,000 person hours for each day of operation.

The nearest drinking water safeguard zone is some 13km to the north east near Great Warley, Brentwood.

6.4.8. Groundwater Body (Non-Drinking Water)

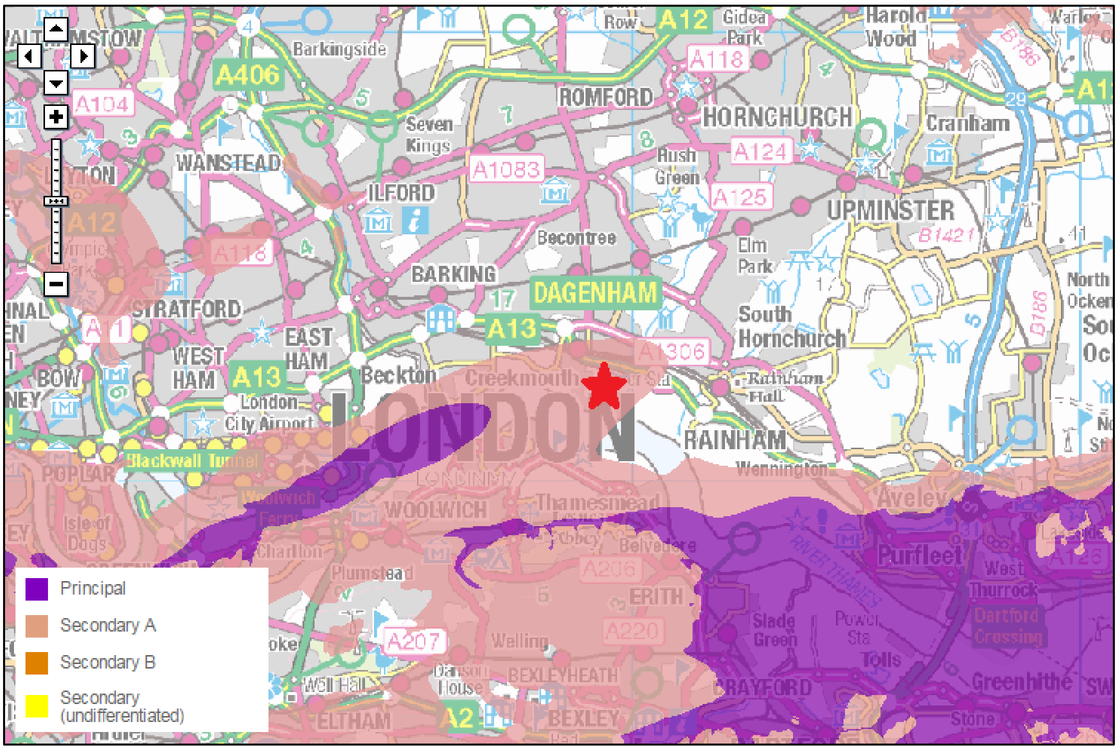
The figure below shows the secondary 'A' superficial deposits designation of the area with permeable layers capable of supporting water supplies at a local rather than strategic scale. These are generally aquifers formerly classified as minor aquifers. The site sits atop a secondary (undifferentiated) aquifer which is assigned where a mixture of A, B and non-aquifer superficial deposits are found.

Figure 6.4.8.1: Aquifer Map – Superficial Deposits Designation (Ref. [6.9])



The figure below shows the primary principal designation of the bedrock where layers of rock or drift deposits have a high intergranular and / or fracture permeability, thus providing a high level of water storage. They may support water supply and / or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

Figure 6.4.8.2: Aquifer Map – Bedrock Designation (Ref. [6.9])



The site sits atop a Secondary 'A' bedrock aquifer which is likely to provide base flow to rivers and supports the argument that groundwater flow is likely to be toward the south and into the River Thames.

Within the immediate vicinity of the site there are 2 surface water abstraction licenses, neither of which are taken directly from the Thames. The nearest groundwater abstraction locations are approx. 2.8km to the west and south-east respectively and not thought to be downstream of any groundwater flow.

As shown in Appendix 6.9 (Figure 3, page 31), there are a number of boreholes on-site used for the continual monitoring of groundwater. Borehole ground samples were taken prior to the purchase and analysed for contaminants. The tidal nature and high water table at the site makes leaching, into the River Thames, of long-term contamination a consideration. Therefore, deep ground contamination is currently monitored using borehole water samples. Samples are removed from the boreholes on a regular basis and the results are logged and monitored. All bore holes are capped when not in use.

The latest groundwater assessment report is provided in Appendix 6.9. It was undertaken in December 2018. Some of the boreholes show 'high' levels of Total Petroleum Hydrocarbon (PTH), chlorinated hydrocarbons and Polycyclic Aromatic Hydrocarbons (PAHs) which is put down to historical contamination. However, general results show that the recorded concentrations are generally decreasing.

6.4.9. Soil and Sediment

From the 1:50000 geological map (Romford, Sheet No. 257, Drift Edition), it appears that Alluvium deposits directly underlie the site. This is followed by Thanet Beds of between 12-23m in depth (silty sands), over upper, middle and lower chalk (Cretaceous). This has been validated using more recently available BGS data (Ref. [6.10]).

A report by Soil Mechanics Ltd. was compiled in 1961 to provide information relating to ground conditions across the site prior to the construction of additional tanks. The report concluded from data gathered from a number of boreholes across the site that beneath the site surface there is between 2.0m and 3.5m of made ground consisting of mainly ash/hardcore with some clay and gravel. This is followed by between 5.0m and 10.0m of soft blue/grey silty clay containing peat bands up to 2.5m thick and subsequently dense sandy gravel (Thames gravel).

Reference to the National Radiological Protection Board (NRPB) Radon Atlas of England indicates that the Site does not lie within an area affected by naturally elevated levels of Radon gas.

There is likely to be pollution in the land within and surrounding the site due to the progressive industrialisation of the site since 1900, the dominant industries being motor vehicle manufacturing and oil storage. Land adjacent to the site has been used for oil storage for over 30 years and the site itself has been utilised for bulk liquid storage for over 70 years. In addition, the site may have been subject to dumping of gasworks waste that can include a number of contaminants including heavy metals, polyaromatic hydrocarbons and phenols. A number of rail sidings were formerly present although these are unlikely to be significant in comparison with more recent land use. Underlying ground may, in part be composed from former marshland and therefore have a potential to generate land gas.

6.4.10. Built Environment

The Stolthaven Dagenham site is located approximately 3km south of Dagenham town centre. The nearest residential location is 1,300 metres to the north and northwest of the terminal boundary fence. There are no public facilities situated at the boundary of the terminal or within 250 metres of the terminal.

There are a number of industrial and other business premises located both adjacent to the boundary and within a radius of 250 metres from the terminal.

The A13 runs in an easterly/westerly direction and is situated 700 metres north of the terminal. Similarly, the London, Tilbury, Southend railway line and Channel tunnel rail link runs almost parallel at a similar distance. Barking Power station is situated 400 metres north-west of the site. Overhead power lines are found 400 metres north of the boundary.

6.4.10.1. Listed Buildings (Grade 1 / Category ‘A’)

There are several listed buildings within 10km of the site. The following have been located in the vicinity of the site:

Table 6.4.10.1: Listed Buildings within 1km of the Site (Ref. [6.2])

Name	Designation	Location	Details
Jetty Number 4 and Approach, Formerly at Samuel Williams and Company, Dagenham Dock	Grade II Listed	0.45km south-east	Important as being among Britain's earliest surviving reinforced-concrete structures, with additional interest arising from the invention and early development of William's patented piles, an important advance for civil engineering.
Crossness Pumping Station	Grade I Listed	0.95km south	Important case iron architectural treatment and 4 colossal beam engines.
Workshop Range to South-West of Main Engine House Crossness Pumping Station	Grade II Listed	1km south	One of a pair of workshops facing south elevation of the boiler house of Bazalgette's main engine house of 1862-5.
Workshop Range to South-East of Main Engine House Crossness Pumping Station	Grade II Listed	1km south	One of a pair of workshops facing south elevation of the boiler house of Bazalgette's main engine house of 1862-5.

The next nearest listed buildings are in Dagenham, some 2.8km to the north.

6.4.10.2. Ancient Monuments

There are several ancient monuments within 10km of the site. The nearest is Lesnes Abbey some 3.2km to the south of the site.

6.4.10.3. World Heritage Sites

There are no world heritage sites within 10km of the site. The nearest is Maritime Greenwich, which is 10.5km to the south-west of the site.

6.4.11. Particular Species

6.4.11.1. IUCN Red List Species

A review of the SSSI citations quoted in Section 6.4.1 and 6.4.2 have identified that Black-tailed Godwit (*Limosa limosa islandica)* – a 'Near Threatened' IUCN Red List species – could potentially be found within 10km of the site. There are no specific details on UK populations although it is thought that there are 90-165,000 individuals located across Western Europe.

European eel (*Anguilla anguilla)* – Critically Endangered – are also highly likely to be present in the River Thames. European eel are assessed as such through their decline around much of Europe previously due to overfishing and more recently due to closure of farms. However, they are extant throughout most of Great Britain and Ireland.

6.4.11.2. UK/EU Protected Species

The Thames contains over 100 different species of fish including a recent discovery of snub-snouted seahorses (*Hippocampus hippocampus)* at Southend, Tilbury and Dagenham (classified as IUCN vulnerable in 1996 but considered data deficient in 2003).

The nearest EU protected species to the site are two locations holding great crested newts (*Triturus cristatus*) in Beam Valley Country Park approx. 27km north-east and one location holding common pipistrelle (*Pipistrellus pipstrellus)* and soprano pipistrelle (*Pipistrellus pygmaeus*) bats approx. 3.7km west. Within 10km there are a further three occurrences of great crested newts and another three occurrences of bats all further than 5km from the site.

6.4.12. Marine Environments

The River Thames eventually flows into the estuary and into the North Sea. The initial underlying seabed is fairly shallow, following the North Sea shelf until approx. 50km east of Southend-on-Sea. It is entirely possible that there could be sea mammals present in addition to large numbers of sea birds at Foulness.

6.4.13. Fresh and Estuarine Water Habitats

The nearest surface watercourse is the tidal River Thames just to the south of the site. Stolthaven Dagenham jetty is on a tidal part of the river approximately 25 miles from the Thames estuary.

Discharges from the northern parts of the site may join the lower reaches of Gorges Brook which is a heavily modified river with a catchment of 8.9km^2. From here flows may only continue for a few hundred metres before reaching the River Thames and thus unlikely to meet any harm severity criteria. However, it was classified as ecologically moderate (target for good by 2027) and chemically good in 2015 (Ref. [6.9]).

The majority of releases would first affect the Middle Thames Estuary which is a heavily modified transitional water flowing from Battersea in the west to Mucking Flats in the east; the site sits approximately half-way along this stretch. The stretch of river covers an area of approximately 43.9km^2 and has a significant catchment area. This stretch of the Thames was classified as ecologically moderate (with no future targets set) and chemically good in 2015 (Ref. [6.9]).

The Middle Thames becomes the Lower Thames Estuary around Mucking Flats covering an area as far east as Haven Point (north east of Southend-on-Sea on the north ‘bank’) to Warden Point (north-west of Leysdown-on-Sea on the south ‘bank’). This transitional water covers an area of 201km^2. It was classified as ecologically moderate (with no future targets set) and chemically good in 2015 (Ref. [6.9]).

Beyond this, the Lower Thames flows into two relatively small areas; the Thames Coastal North and the Thames Coastal South. These areas aim to look at the combined effects of the Thames with the Crouch Estuary and the Medway Estuary respectively. Both were classified as ecologically moderate (with no future targets set) and chemically good in 2015 (Ref. [6.9]).

At Sheerness the mean neap tidal range (taken to be the difference between the mean high-water neaps and the mean low water neaps) is 3.26m whilst at Harwich it is taken to be 2.22m (Ref. [6.11]).

There is no river flow data available for the Middle or Lower Thames estuaries. Following the River upstream, the first station reached is at Kingston, where a mean flow of 65.8m^3/s is recorded along with a 95% exceedance of 7.56m^3/s and a 10% exceedance of 162m^3/s (Ref. [6.21]) supporting the argument that there will be significant base flow into the Middle Thames are close to the Stolthaven site even under neap flow tidal ranges.

Releases from the STW would be discharged into the Ingrebourne River which was classified as ecologically moderate and chemically good in 2015 with no future targets set (Ref. [6.9]).

6.5. Identifying Source-Pathway-Receptor Trios

In Appendix 6.4, site and surrounding environmental knowledge described in this report is used along with a systematic methodology – based on the CDOIF guidance (Ref. [6.12]) – to identify and develop source-pathway-receptor trios for further discussion. This also serves as an opportunity to screen out those scenarios that would clearly not cause environmental harm. The methodology is as follows:

Stage One – Potential receptors are screened against CDOIF Harm Severity Categories (adapted from Ref. [6.12], and based upon DETR Guidance, Ref. [6.13]). Potential pathways affecting a particular MATTE can then be identified using a high-level guideword approach to identify a receptor/pathway pair and further discussion can identify the potential for a MATTE. Where a MATTE is judged to be possible, potential release scenarios (sources) can be identified. A list of suggested guidewords/pathways is provided in the table below:

Table 6.5.1: Suggested Guidewords for Use in Stage One Screening

Generic Harm Category	Suggested pathways*
Surface Water	Stormwater drainage, foul drainage, direct to water body, flooding, particulate deposition, toxic cloud, firewater, flooding.
Groundwater / Drinking Water	Direct to unmade ground, firewater, flooding.
Land	Direct to unmade ground, firewater, flooding, deposition, toxic.
Built Environment	Particulate deposition, corrosive vapour cloud, acid attack.

* Other pathways may also be possible and should be considered, where applicable.

Stage Two – The representative set of scenarios (see Section 3) are then reviewed against source-pathway-receptor trios identified in Stage One. This provides further evidence of scenario development and to ensure that all scenarios included in the representative set have been considered for MATTE assessment.

Stage Three – The on-site materials in Section 2 of the COMAH Safety Report (CSR) were then reviewed in Table 3 to select representative Dangerous to the Environment (DTE) materials (GHS Hazard Statements: H400/410/411).

For materials causing threat to terrestrial biodiversity through inhalation, the same toxicity index as used in the development of the representative set of scenarios (see Section 3 appendices) can be used. This is simply an available LD_{50} inhalation dose (ppm) divided by the vapour pressure of the material at a fixed temperature (mmHg @ ˚C). In this instance, the lower the number, the more dangerous the material is perceived to be.

Stage Four – The source-pathway-receptor trios are finalised in Table 4 and representative substances selected for discussion in Section 6.6.

The SPR development is conducted in Appendix 6.4 and identified the following SPR trios for further discussion:

Table 6.5.2: Source Pathway Receptor Trios

ID	Receptor(s)	Applicable CDOIF Categories	SPR	Source	Pathway	Representative Substance(s)
A	Underlying Alluvial Deposits and Groundwater	8, 10	A1	Loss of containment of bulk material from storage and/or pipework failures	Unmade ground or uncapped boreholes.	Diesel
			A2	Firewater	Unmade ground or uncapped boreholes.	Diesel
B	Listed Buildings within 1km of Stolthaven	5, 11	B	Multiple release events result in the formation of a vapour cloud.	Atmosphere to confined volume.	Ethanol, Cyclopentane
C*	Thames Estuary and associated Receptors	1, 2, 3, 13, 14, 15.	C1	Loss of containment of an environmentally hazardous material from bulk storage tanks along the southern edges of Bunds 1, 2 and 4, or from ship-to-shore pipework.	Surface Water Drains	Diesel, Ethanol
			C2	Firewater	Surface Water Drains	Amine (AT1214), Ethanol, Diesel.
			C3	Loss of containment from bulk storage, pipework or road tanker operations.	On-site ETP, foul sewer and Riverside STW.	Amine (AT1214), Ethanol, Diesel.
			C4	Firewater	On-site ETP, foul sewer and Riverside STW.	Amine (AT1214), Ethanol, Diesel.
			C5	Loss of containment from ship-to-shore operations.	Direct to Water Body	Ethanol, Diesel.

** Receptor C is specifically the Thames Estuary, as assessed under CDOIF Category 15. Further receptor IDs will be assigned in later discussion as D, E, F etc.*

6.5.1. Firewater

Several SPR-trios are associated with the effects of contaminated firewater which could cause harm to underlying alluvial deposits (and groundwater) and the Thames Estuary (and associated receptors).

The on-site drainage system is designed to control the flow of contaminated firewater, and prevent this water damaging the environment.

Emergency tanks have been selected to serve as containment for firewater run-off and / or emergency containment in the event of an incident. The tanks are located to the north of Area

3 bund and stand isolated from all other commercial storage tanks. This isolation makes the tanks ideal for this application. Under normal circumstances the tanks will be kept empty and available for the receipt of firewater or product from a commercial tank in the event of a major tank failure.

6.5.2. Flooding (as an Initiator)

In the 2019 submission, flooding was screened out as an initiating event in Appendix 6.4 as follows:

"*The site is situated on a potential flood plain from rivers/the sea only. Flood maps provided in Section 6.3.8.1 show that the site would not be flooded by an upstream reservoir failure or from typical surface water collection (i.e. from rainfall). Principal operations of the site are the storage of materials in large vessels that would require significant flooding to dislodge foundations and actually cause a loss of containment. Similarly, those road tankers that are full would not be 'knocked over' owing to weight carried.*

The only vulnerable areas would be the drums or IBCs that are held on-site when required. The primary containment used for these purposes will be UN approved and capable of withstanding bumps caused by any floatation. The consequences of such a failure would also be highly diluted by not only the floodwater but in the subsequent Thames which would also be taking water from multiple locations also flooded by the same event. As such, this event is not considered to form a significant proportion of the overall severity and frequency risk. It is also highly unlikely to result in a MATTE and is therefore screened out of further assessment."

As indicated in Section 6.3.8.1, the site is not at risk of flooding from a 1-in-1000-year event, including climate change over the next 60 years, and is not at risk of flooding from a 1-in-200-year event until 2107. This is based on the available freeboard.

As such, the only means by which the site would be expected to be flooded within the lifetime of the site is if it was assumed that flooding defences failed when a major flood occurred, at the 1-in-1000 year event frequency.

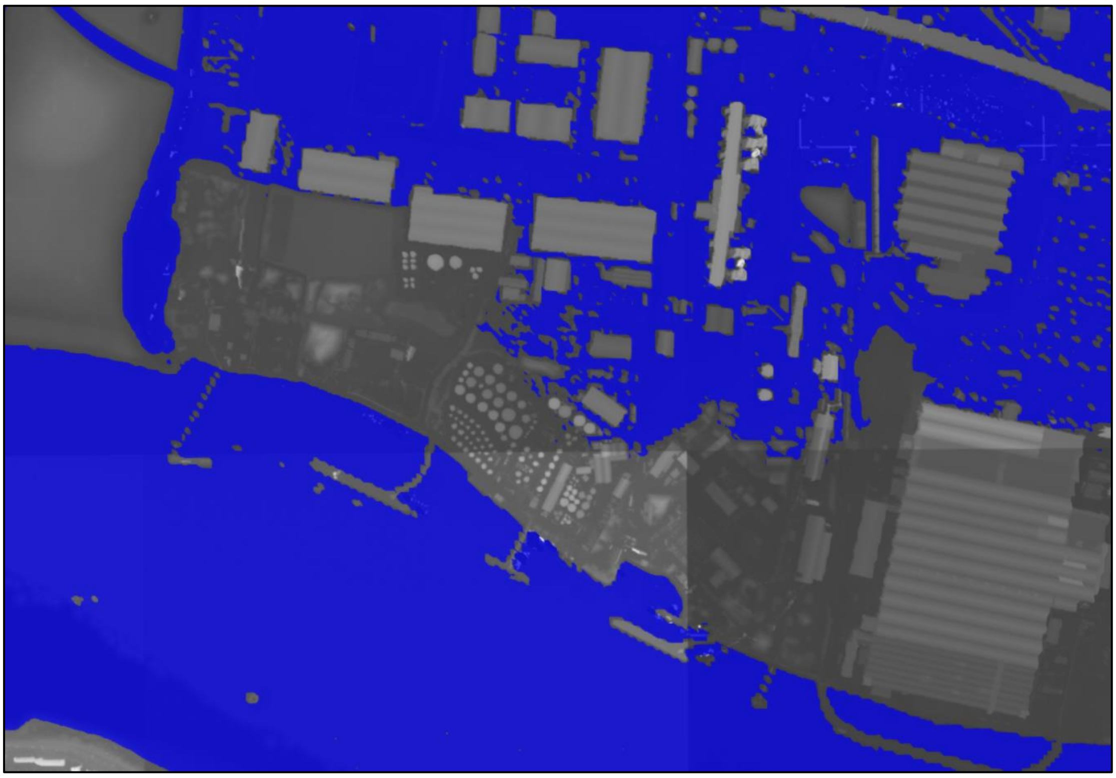
A breach of containment would not be total but a rupture in a single location, whereby water would enter into the site over time. The bunding in the area and roadways would facilitate the channelling of this water which would eventually start to drain down Hindman's Way

Figure 6.3.3.3 suggests that the lay of the land is sloped down toward the north of the site, which is where initial flooding would occur. Roads around the area and land to the north is much lower than the rest of the site, which would be flooded first, eventually backing up toward the south.

As such, Figure 6.3.3.3 shows that the first area that might experience high levels of flooding might be the northern wall of Area 3, which sits slightly more than 3.8m AOD. There are no brick walls along the northern side of the main side suggesting this would all have to be flooded first. In measuring the area north of Area 3, shown flooded in Figure 6.3.3.3, an area of 170,000m^2 can be ascertained. To raise the flood levels to a height that would start to breach Area 3, a <u>minimum</u> of 170,000m^3 of water would need to flow in from the breach before the level of the bund wall was even reached.

On this basis, it is taken to be extremely unlikely that tank bunds could ever be flooded owing to the sheer volume provided by the wider site to the north, this is demonstrated in Figure 6.5.2 below using the same lidar data and ADMS mapper as referred to in Section 6.3.3:

Figure 6.5.2: Wider Site Flooding Potential (Flood at 3.8m AOD) (Ref. [6.24] [6.25])



As such, it is far more likely that the roadways would flood, not the bunds. As discussed above the tanks are also extremely heavy, even when empty, and unlikely to float.

Any flooding of the roads could knock out power to the site – i.e. if the water managed to penetrate the right areas – but all systems are designed to fail safe. This leaves limited amounts of drums and road tankers that may be affected by the flood water but, for the same reasons already identified above, they are not taken to initiate a major loss of containment.

Therefore, SDL believe that they are an FMAS3 (Flooding Major Accident Scenario Level 3, Ref. [6.26]) site in that flooding would principally occur outside of the establishment which may prevent access to the site and exacerbate any major accident risk and challenge protection layers. This is discussed in more detail in Section 6.12.4.

6.5.3. Domino Sites

There are no other COMAH establishments in close proximity to the Stolthaven site with the local area being used for industrial, warehousing purposes. Accidents at any of these sites are unlikely to trigger events at the Stolthaven site, though smoke could affect the site if the wind direction was unfavourable.

Many events have the potential to domino into much larger scenarios, though it is felt that these are represented by the set of SPR-trios given the limited routes available off-site.

6.6. Extent and Severity of Source-Pathway-Receptor Trios

6.6.1. Receptor A – Underlying Alluvium Deposits and Groundwater

The site is situated atop a secondary undifferentiated aquifer, meaning there is either insufficient information or wide-ranging variants to the condition of the aquifer to provide either a secondary A or B designation. However, the water within the aquifer could provide base-flow to surface waters in the area and may be retained for a long period of time.

6.6.1.1. SPR-A1 – General Losses of Containment to Ground

Source: Loss of containment of diesel (or similarly slowly biodegrading material) from tank farms, transfer pipework or road tanker operations on-site.

Pathway: Material pools on hard standing with potential flow to unmade ground and seepage into the soil. Alternatively, an uncapped borehole could provide a route into the underlying soil. Long-term migration down into the underlying alluvium deposits holding groundwater.

Receptor: Secondary undifferentiated aquifer underlying the site, potentially with flow south towards the River Thames.

Discussion: The largest loss of containment of diesel (or similar products) is likely to be from Area 6 T811 (10,987m^3) or from Area 3 T20 (3,198m^3), both of which are located close to outer bund walls and both of which are located not too far from unmade ground (65m south and 75m west respectively). It is noted that diesel, like most other materials held on-site, is less dense than water. It is likely that, being so close to the Thames, the groundwater table in the area is quite high, which would limit the spread of the diesel via this medium. However, to obtain worst-case consequences it is assumed that the water table level is sufficiently depleted that a pathway does exist.

Pooling of either material – assuming minor elevations in natural topography develops a pool approx. 5cm deep – could result in pools of 219,740m^2 (22ha) and 63,960m^3 (6.4ha) respectively. Either release could therefore comfortably cover a significantly large area to the west of the main site and – if left undisturbed – soak into the ground. Alternatively, if a borehole was left uncapped, a slightly different pathway might exist. However, the volume of the borehole would be limited in size (<1m^3) and, once filled, any flows would be subject to the same hydraulic flow restrictions as material passing through dry soil from the surface.

A site Conceptual Site Model (CSM) is provided in Section 1.4.3 of Appendix 6.9. This considers hydraulic continuity between shallow soils directly beneath the made ground (MG), potentially into deeper groundwater aquifers within the local river terrace gravel (RTG) or laterally into surface water receptors (i.e. the Thames estuary). However, the following observations were made:

- "*The underlying RTG deposits have been previously not considered to be a sensitive receptor as no widespread impact has been recorded; they are protected by a 5m covering thickness of alluvial clay and peat aquitard, and are also impacted by saline* *intrusion, with daily reversals of flow direction due to tidal influences. Dilution of any downward vertical flux with underlying RTG groundwater is also likely to be significant*."

- "*The River Thames is not considered to be in continuity with the perched MG ground water due to the existence of the River Thames sheet pile flood defences and is therefore not considered to be a receptor*."

Any loss of containment to the ground may therefore enter groundwater of some classification. Based on the above observations, the principal area for contamination would be the underlying superficial deposits, which are observed as flowing in variable directions in each area of the site:

- Main Terminal:
  - MG aquifer: north-easterly, consistent throughout monitoring
  - RTF deposits: northerly, consistent throughout monitoring
- Area 6:
  - MG aquifer: easterly to south-easterly, variable throughout monitoring
  - RTF deposits: easterly to north-easterly, mainly, variable throughout

Groundwater levels in the RTG were found to be changed by tidal influence of the Thames Estuary (+0.5 to -1.5m AOD) whilst groundwater levels were shown to drop further north, i.e. away from the estuary.

Using groundwater superficial deposit maps from Section 6.4.8 of this report along with the flows witnessed in the groundwater studies suggest that groundwater is strongly affected by the tides (even if there is no hydraulic continuity), but ultimately there is no one single direction of flow.

Harm severity for this scenario is determined through CDOIF Categories 8 (groundwater, non-drinking water) and 10 (soil and sediment).

Category 8 "Groundwater body (non-drinking water)" is assessed through the lowering of a water framework directive (WFD) status by area (in hectares, min. 1ha). CDOIF states that all primary and secondary aquifers meet criteria for classification under WFD though it doesn't suggest how a WFD status can be removed or lowered. As such, through inference it becomes difficult to establish how a WFD status can be lowered when the case of secondary designation is related to the *physical* properties of the aquifer. The CDOIF guidance elaborates further by suggesting that a groundwater standard can be 'exceeded where pollution is discernible', i.e. increase in concentration against natural or existing background levels of a hazardous material; GP3 (Ref. [6.16]) suggests that diesel would be classified as a hazardous substance therefore a release may cause 'harm' to aquifers. However, there is still confusion about what this 'discernible' increase is preventing or damaging and how that links to WFD classification.

Secondary aquifers are largely designated as such for slow movements of groundwater as base-flows to river and not necessarily capable of sustainable extraction as a drinking water source using current technology. This suggests that there could be argument that the water could be valuable as a future resource and thus this is taken as the criteria for removal (or lowering) of WFD status for the purposes of this MATTE assessment. By doing so then the location of the aquifer, the undesignated secondary classification and likely infiltration of saltwater from the estuarine Thames practically renders this aquifer as having no future value to drinking water supplied in the Greater London area (historical contamination may also be a factor although information is not readily available and thus unjustifiable at this time).

Furthermore, groundwater sampling shows background contamination exceeding generic assessment criteria (GAC) protection of controlled waters levels. A few examples are provided below and could apply to both the MG and RTG groundwater bodies:

- Significant: ethylbenzene, vinyl chloride, 1-1,dichloroethane, cis-1,2-dichloroethene, trichloroethane;
- Moderate: aromatics, MTBE

Heavy metals (including arsenic, copper, lead, nickel, vanadium, zinc and chromium III) are also present in elevated concentrations, though the report did not highlight them as a key potential contaminant of concern.

Diesel breaks down in water to release TPH, BTEX and various other contaminants, many of which are already present in the groundwater.

As such, even though a wide area could be further contaminated, the background contamination of the aquifer would mean that any damage has already been done and thus a MATTE is arguably not plausible through this assessment criterion.

Category 10 "Soil and Sediment" is assessed through combined contamination of land through area (in hectares, min. 10ha) as well as an estimation of environmental damage against the Environmental Liability Directive (ELD). The ELD (Article 2, Definitions) specifies that "*environmental damage means damage to protected species and natural habitats"* which affect a "*favourable conservation status*" whilst land damage is specifically stated as that which "*creates a significant risk of human health being adversely affected"* (Ref. [6.17]). The surrounding environment has been industrial for several decades suggesting high potential for underlying ground contamination. There is no agricultural land and the underlying groundwater is not likely suitable for abstraction as a drinking water source. There are no groundwater abstraction points nearby the site that are subject to the Water Act 2003; the closest appears to be at Creekmouth (Ref. [6.9]) over 2.5km to the west although the website doesn't show it as being active. As such, it is taken that there are very little ways by which a contamination of this land can indirectly affect human health and thus ELD criteria is not met, even though the larger releases affect large-enough area.

Groundwater flows towards the Thames will be slow and the area contaminated will be only a minute contribution of the total base-flow to the estuary, especially considering that base-flow in itself will be a minute contribution of the overall water addition to the Thames (see Section 6.4.13). In addition, the silty-clay sands of the Thames would not promote high levels of water transfer, reducing this interaction further.

As such, this scenario is judged to be a sub-MATTE event, potentially with off-site effects.

As far as remediation is concerned, the contaminants would likely remain in the aquifer and spread would only occur slowly through dispersion and breakdown over time, given the natural groundwater flow is likely to the south. Diesel although largely persistent, will break down through both aerobic and anaerobic digestion over time with some trace materials potentially present after time. It is likely that advice would be to leave the contaminants and monitor through borehole analysis.

6.6.1.2. SPR-A2 – Firewater to Ground

Source: Initiation of a fire at the site, most likely caused by the loss of containment of a flammable material from bulk storage, pipework or road tanker failures. Rapid rates of fire spread may result in the fire service electing to tackle the fire with firewater under the impression that it can be contained.

Pathway: Material pools on hard standing with potential flow to unmade ground and seepage into the soil. Alternatively, an uncapped borehole could provide a route into the underlying soil. Long-term migration down into the underlying alluvium deposits holding groundwater.

Receptor: Secondary undifferentiated aquifer underlying the site, potentially with flow south towards the River Thames.

Discussion: The main difference between this scenario and SPR-A1 is the potential for the loss of containment from multiple tanks due to escalation, the dilution of that material with large volumes of added firewater and the addition of firefighting foam to the list of potential contaminants.

Most of the materials held on-site – including the applied firefighting foam – are lighter than water. As such, pooling material and thus initial discharges into the groundwater would be largely water, albeit contaminated with the solute parts of whichever materials might be involved in the incident. The soil would therefore become quickly saturated with water, limiting any loss of containment directly into the groundwater unless left for a sustained period of time.

After which the same arguments as provided in SPR-A1 – i.e. around the suitability of the receptor as a sustainable future source and the potential for harm upon humans – apply also to this scenario and the hazard can also be termed as being sub-MATTE with off-site effects.

6.6.2. Receptor B – Listed Buildings within 1km of the Site

Source: Loss of containment of flammable material (a) from tank farms or pipework on-site, or (b) from the jetty, or (c) flame impingement on a pressurised vessel, or (d) ignition within a storage vessel containing flammable material.

Pathway: Either (a) the formation of a sizable vapour cloud which drifts towards a confined zone where it finds an ignition source resulting in a Vapour Cloud Explosion (VCE), or (b) forms a pool on water which ignites and flows downstream towards the jetty, or (c) escalation into a Boiling Liquid Expanding Vapour Explosion (BLEVE).

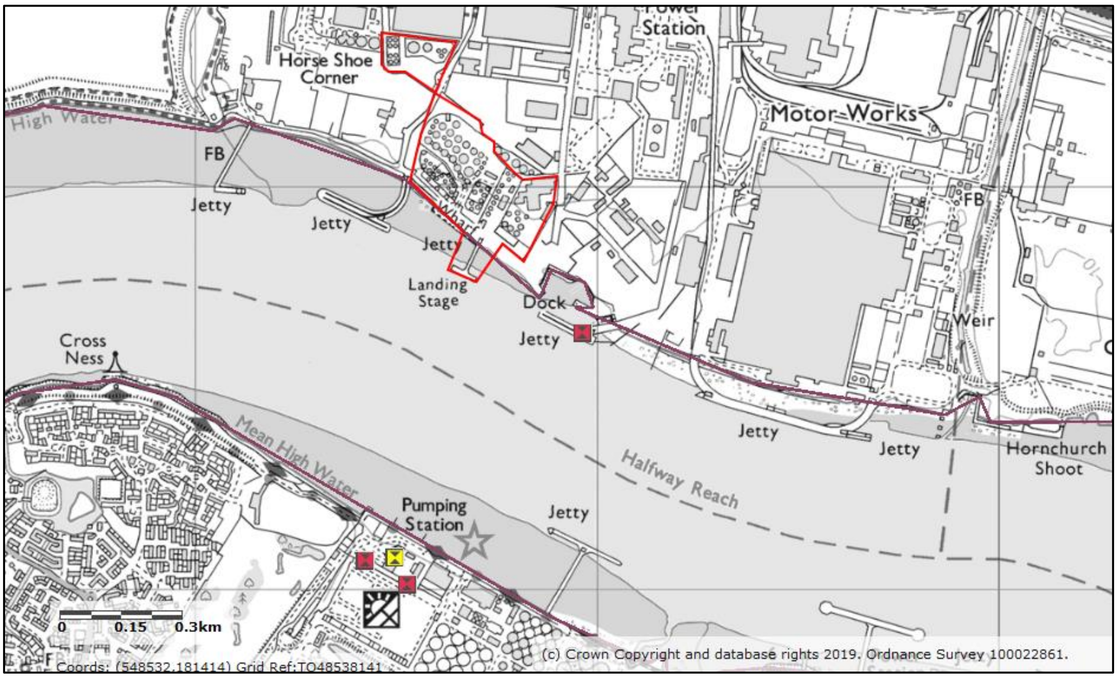
Receptor: One of four listed buildings within 1km of the site.

Discussion: Screening carried out in Appendix 6.4 identified the threat of explosions at the site upon listed buildings and selected 1km as a conservative distance to which overpressure *might* be sufficient to cause significant damage. There are four listed buildings, no ancient monuments and no world heritage sites within 1km of the centre of the main part of the site, which are as follows:

- "*Jetty Number 4 and Approach, Formerly at Samuel Williams and Company, Dagenham Dock*" – Grade II – 450m south-east; and
- "*Crossness Pumping Station"* - Grade I – 950m south; and
- "*Workshop Range to South-West"* … and "*South-East of Main Engine House, Crossness Pumping Station"* – Grade II – both 1,000m south.

The location of these buildings is shown below:

Figure 6.6.2: Location of Listed Buildings within 1km of the Site (Ref. [6.2])



The effects upon each of these buildings needs to be extracted from consequence modelling conducted as part of COMAH Section 3 Predictive Aspects.

There are two components to a vapour cloud explosion; the drifting of the cloud to a confined area and the explosion itself. As such, first closest viable ignition location must be identified based on the initial modelling assumptions. Much of the surrounding environment is largely open and thus the original confined zone was based on the site tank farms and a representative worst-case confined source was defined in the model. The closest would be:

- "*Jetty Number 4…*" – Area 4, the centre of which is 100-130m from Tank Farms 1 and 2, approx. 220m from the closest point of the listed jetty and approx. 775m from the nearest tank in Area 6;
- "*Crossness Pumping Station"* – Tank Farm 2, the centre of which is 0-75m from Tank Farms 1 and 2 and approx. 900m from the closest point of the building and greater than 1.2km from Area 6; and
- *"Workshop range…"* – Tank Farm 2 (both), as above but 950m from the tank farm.

The scenarios are then screened to determine whether harmful overpressure could be experienced at any of these buildings identifying the following scenarios potentially posing threat of ≥30mbarg.

This identified the following scenarios:

- 1.4E: an explosion within a Tank Farm 1 vessel with 30mbarg experienced up to 267m (1,000m^3 vessel) and 458m (5,000m^3 vessel). The average from the four Tank Farm 1 vessels to the closest part of the jetty is 355m which Table 3.5.1.4.2 suggests a maximum overpressure of 40mbarg. Whilst this may be sufficient to break windows it is unlikely to cause significant damage to wood or steel and thus the jetty should remain largely intact. The other buildings at Crossness should be unaffected;
- 3.2V: a VCE following a loss of containment from the cyclopentane tank in Tank Farm 2 with 30mbarg experienced up to 189m from the centre of the explosion (note that only under low wind speeds does the overpressure exceed 130m). A similar range of overpressure would be expected as discussed above in 1.4E and little damage would be expected to the jetty, whilst other identified buildings would not be adversely affected;
- 3.4E: an explosion with the cyclopentane tank in Tank Farm 2 with 30mbarg experienced up to 183m. Note that was assumed that the internal ignition of tanks with other flammable materials in this area would result in a similar consequence. A similar range of overpressure would be expected as discussed above in 1.4E and 3.2V and little damage would be expected to the jetty, whilst other identified buildings would not be adversely affected;
- 3.6O: a 'Buncefield-type' Open Flammable Cloud Explosion (OFCE) following an overfill event in calm weather, with 30mbarg reaching up to 650m from the explosion epicentre. If it were taken that the epicentre is around the cyclopentane tank, the jetty is approx. 490m away, where the overpressure would also be in the region of 40mbarg. As such, the same conclusions are met as above.

Overpressure scenarios are therefore judged not to be of concern to all listed buildings in the area. However, pool fire scenarios could be a threat to the jetty. These could occur from failures of pipework or hoses at the jetty where a large quantity of flammable material (ethanol) could collect on the surface of the water before igniting. If this floated toward "*Jetty 4…"* it could set fire to the surrounding structure and cause significant if not total destruction.

This structure is a Grade II listed building. Under CDOIF guidance, to determine harm severity to a Grade II building, Category 5 and 6 "*Widespread habitat – non-designated land/water"* should be used which has a single relevant criterion referring to removal of access to the public.

This is where the criteria become vague and difficult to apply. Arguably this jetty is within a larger industrial estate not normally accessible to the public, but that depends on how the public is defined. It's entirely possible that this jetty is still used to some degree by the surrounding premises – strongly suggested by evidence of an accepted planning application for "*erection* [of a building] *for use as jetty offices, workshop store and electrical substation"* obtained through Ref. [6.14] – whose access could be removed through destruction of the wider structure.

Secondly, the wording around prevention of access under these two topics suggests that it is the *contamination* that causes the criteria to be met, not purely the removal of access, though this may be an oversight.

Thirdly, the jetty itself is likely high risk due to tidal movements or flooding potential which would be a likely restriction against granting of Grade I status, should it ever be sought, due to the high costs of maintaining sufficient long-term structural integrity. There is thus no guarantee that even minor damage caused would be repairable.

As such, based *solely* on the wording of the guidance, it is determined that the event would be sub-MATTE. However, the frequency will still be calculated and a measure of sensitivity analysis will be conducted to ensure that the risks are ALARP.

6.6.3. Receptor C – Thames Estuary (and associated receptors)

Losses of containment via all routes will first affect the River Thames as a watercourse, eventually dispersing/spreading and affecting other receptors. To assess the effects upon this group of receptors, some commonalities are required to determine the extent to which a release can cause harm.

For insoluble materials, the method is relatively simple; estimate the maximum area that could be affected from spreading of a slick on the waters' surface and determine the potential level of harm.

The determination of harm from soluble materials is less straightforward. Normally to assess the potential for dilution of soluble materials down a river, a series of river flow data can be obtained to estimate increases in water flow and use this to estimate a concentration at particular points along the river. However, the nearest river flow data available is at Kingston-upon-Thames, some 7-8km upstream of the start of what is the Thames Estuary at Richmond Lock. As such, this data is not usable and would even be at odds with the tidal nature of the Thames Estuary. Most ecotoxic data is based on a period of 48-72hrs so the estimation of a single ebb and flow movement may be more apt for estimating the minimum concentration dilutions. Data on expected tidal ranges has been obtained from the Port of London Authority (Ref. [6.18]) and scrutinised over a year period to estimate maximum and minimum tidal heights to estimate a minimum volumetric inflow. 2106 data is available at several points down the estuary and thus for the purposes of assessment the Thames Estuary has been split up into:

- Silvertown (8km upstream) to Tilbury (19km downstream), covering an approximate 18,500,000m^2 area;
    - Silvertown: Neap high tide estimated ~5.5m, spring low tide estimated at ~1.9m or a minimum tidal range of 3.6m.
    - Tilbury: Neap high tide estimated at ~5.1m, spring low tide estimated at ~1.8m, or a minimum tidal range of 3.3m.
    - Averaged this is be a 3.45m conservative tidal range over the area quoted, or a minimum volumetric tidal inflow of 63,825,000m^3 over six hours, or 2,955m^3/s.
- Tilbury to Coryton (34km downstream), covering an approximate 27,900,000m^2;
    - Tilbury: as above;
    - Coryton: Neap high tide estimated at ~4.8m, spring low tide estimated at ~1.8m, or a minimum tidal range of 3m.
    - Averaged this is a 3.15m conservative tidal range of the area quoted, or a minimum volumetric tidal inflow of 87,885,000m^3 over six hours, or 4,069m^3/s.
- Coryton to Southend-on-Sea (50km downstream), 69,600,000m^2;
    - Coryton: as above;

  - Southend-on-Sea: Neap high tide estimated at ~4.5m, spring low tide estimated at ~1.7m, or a minimum tidal range of 2.8m.
  - Averaged this is a 2.9m conservative tidal range of the are quoted, or a minimum volumetric tidal inflow of 201,840,000m^3 over six hours, or 9,344m^3/s.

The Thames Estuary as an entity assessed under CDOIF Category 15 (fresh and estuarine water habitats) is discussed as Receptor C. However, it is noted that there are a large number of receptors associated with the estuary that may need to be individually assessed and include:

- Thames Estuary, including
  - Inner Thames Marshes SSSI
  - Ingrebourne Marshes SSSI
  - West Thurrock Lagoon and Marshes SSSI
  - Holehaven Creek SSSI
  - Thames Estuary Marshes SPA, Ramsar and ESA, including
    - South Thames Estuary and Marshes SSSI
    - Mucking Flats and Marshes SSSI
  - Benfleet and Southend Marshes SSSI, SPA and Ramsar, including
    - Southend-on-Sea Foreshore LNR
  - Rainham Marshes LNR and RSPB area
- Medway Estuary and Marshes MCZ, SSSI, SPA and Ramsar
- Foulness SSSI, SPA and Ramsar, including
  - Shoeburyness Old Ranges LNR
- Beckton Desalination Plant
- Various fishing lakes and boating clubs.

These receptors can be assessed under some or multiple CDOIF categories including 1 (designated land – national importance), 2 (designated land – international importance), 3 (other designated land), 4 (scarce habitat), 6 (non-designated water), 7 (source of public or private drinking water), 13 (particular species) 14 (marine) and 15 (as above). Where potential for a MATTE is identified, receptor IDs will be applied to each as D, E, F etc.

6.6.3.1. SPR-C1 – Direct Loss of Containment via Surface Water Drains

Source: Loss of containment of an environmentally hazardous material from pipework located close to the sea wall.

Pathway: Across made ground in the direction of a select number of surface water drains in the southern part of the site. Material transfer through surface water drains directly off-site and into…

Receptor: The Thames Estuary, potentially affecting multiple receptors.

Discussion: Diesels, kerosene and ethanol are imported from ship; the effects of kerosene are considered alongside diesel for reasons outlined in Appendix 6.4. All other materials are imported and exported by road tanker.

Imports are potentially huge, though it would take a significant length of time to discharge an entire ship tanker via pipework. As such, it is taken that the release could be isolated after onehour, either by stopping the pumps, re-routing or at least preventing further loss of containment from site; granted, this is not fully unmitigated loss of containment but is considered to be *very* conservative when addressing the grander scheme – a *full* loss of containment is considered under Receptor C5.

Transfers typically take place at up to 150m³/hr and at 7barg pressure. Consequence modelling conducted in Section 3.5.9 addressed four failure types (based on available failure rate data) with discharges of ethanol (min. 790kg/m³) as follows:

- Guillotine failure – based on 150m³/hr which is calculated in PHAST as 33.1kg/s or a total of 119,160kg of ethanol;
- ⅓ pipework diameter failure – estimated a discharge rate greater than this thus 150m³/hr. was retained as a worst case maximum;
- 25mm hole failure – 10.8kg/s × 3,600s = 38,880kg of ethanol which is equivalent to 38,880kg ÷ 800kg/m³ (min.) = 48.6m³ of diesel.
- 4mm hole failure – 0.28kg/s × 3,600s = 1.008kg of product which is equivalent to 1,008kg ÷ 800kg/m³ (min.) = 1.26m³ of diesel.

There is no direct discharge potential to the river from this location (this is discussed later in SPR-C5) and thus the flow rate of the material through the surface water drains is not considered to be a mitigating factor, rather a requirement for the scenario to occur. However, given the tidal nature, there are periods where the entire material could be allowed to discharge and accumulate before being transported upstream or downstream and thus this is not estimated.

Diesel

The diesel will spread out on the surface of the water with very little interaction below. Assuming that the material is allowed to spread out to a uniform depth of 1mm an area of:

- Guillotine / ⅓ failures: 150m³ ÷ 0.001m = 150,000m² or 15ha;
- 25mm hole failure: 48.6m³ ÷ 0.001m = 48,600m² or 4.86ha; and
- 4mm hole failure: 1.26m³ ÷ 0.001m = 1,260m² or 0.126ha.

could be affected and effectively screens out the 4mm hole failure as a credible MATTE causing incident.

Due to the variations in high and low tide over the lunar calendar, deposition on banks could be instant or rising levels would expose areas for small periods of time with re-deposition further downstream over time. However, harm to an estuary should be assessed through area affected with the minimum criteria set at 2ha or 10% indicating that only a guillotine or ⅓ diameter failure could meet harm severity criteria of 2 "severe", assuming that any assessment conducted during the release event would lower the WFD status from the existing status of ecologically moderate and chemically good (applicable throughout).

Taking note that the estuary is assessed *separately* to the other associated receptors, given that much of the underlying water quality would not be significantly affected during the short duration of release and effect, any recovery of the ecological and chemical quality of the river would be relatively short, even if other ecological receptors could be harmed. Fish stocks would therefore be expected to remain largely unaffected and the receptor would recover within 1 year (*harm duration 1 – no MATTE).*

Other receptors may be more severely affected requiring much longer durations to recovery. Potential for harm upon each additional receptor is discussed in turn below:

Table 6.6.3.1: SPR-C1 Effects of Diesel on Thames-Associated Receptors

Receptor	Cat.	Discussion	SPR
Inner Thames Marshes SSSI (479.3ha)	1	Deposition onto the marshes would cover an area of larger than 0.5ha but the larger spill would only cover ~3%. A MATTE for this type of receptor means removal of a designation. Inner Thames Marshes is designated as such for low-lying grazing marsh and grassland communities, i.e. it is notified for several habitat types, most of which will sit above the water line. Review of the designation using Magic Maps suggests that this is perhaps <1% of the total designation. The marshes would be affected most following a receding tide, though this would be alleviated sometime later. Diesel would likely stick to fine particles such as sand and silt, but in the consistently changing waters of a marshland along with the properties of diesel, it would float away after several tides allowing quick recovery. As such, the designation would not be removed in the first instance and thus the event is (*harm severity 1*) sub-MATTE.	-
	4	Deposition onto the marshes would cover an area larger than 2ha, but only from larger spills. This could damage the scarce habitat, but not significantly such that recovery would take a long time. It is thus taken that recovery would be within 1 year and thus a sub-MATTE event.	-
	On the basis that physical harm to this receptor is implausible, it is not discussed further.		
Ingrebourne Marshes SSSI (74.8ha)	1, 4	Deposition onto the marshes would cover an area of larger than 0.5/2ha but the larger spill could cover ~20% The land is designated again due to marshland habitat. However, the two marshes are situated either side of the River Ingrebourne in areas designated as floodplain. As such, not only would the diesel need to be released at a time where it can be transported *up* into the Ingrebourne, but it must also coincide with a flooding event. Given that the Ingrebourne is therefore upstream, the two events would be working against one another and therefore, no harm is judged to occur.	-
	On the basis that physical harm to this receptor is implausible, it is not discussed further.		
West Thurrock Lagoon and Marshes SSSI (66.08ha)	1, 4	Again, deposition could constitute >0.5/2ha but larger spills could affect ~23% of the total receptor. Unlike other designations already discussed, this receptor is largely intertidal mudflats and designated on the basis of importance to wading birds as a feeding ground during winter months. Birds will be less hardy to diesel, which will soak into feathers and prevent flight, may prevent ability to feed and would discourage birds from using the area. Contamination of these flats may therefore constitute removal of designation, at least during the contamination, for the receptor (*harm severity 2 – severe)*. However, the same arguments ring true as previously, i.e. the contamination will only likely to occur for a few tidal movements allowing bacteria/algae to quickly recover and thus mudflat insects that the birds feed on (the birds themselves are assessed later under Cat. 13/14), reinstating the receptor as a viable food source for bird species. The duration to recovery would therefore be low (*harm duration 1 – no MATTE)*.	-

Receptor	Cat.	Discussion	SPR
Thames Estuary Marshes SPA (4,802.47ha) / Ramsar (5,553.59ha) (including Mucking Flats and Marshes SSSI (311.56ha) and South Thames Estuary and Marshes SSSI (5449.14ha))	1	**Mucking Flats and Marshes:** Larger spills could affect >0.5ha but ~5% of the total receptor. Otherwise the argument is the same as for West Thurrock Lagoon and Marshes SSSI (*harm severity 2 – severe, harm duration 1 – no MATTE).* **South Thames Estuary and Marshes**: Much of the marshland is inland and thus similar to the Inner Thames Marshes SSSI. Larger spills could still affect >0.5ha but <1% of the total receptor. Otherwise the same argument applies (*harm severity 2 – severe, harm duration 1 – no MATTE).*	-
	2	Large spills could affect >0.5ha but <0.1% of the total receptor. See above, no MATTE.	-
	4	Large spills could affect >2ha. See above, no MATTE.	-
Holehaven Creek SSSI (272.87ha)	1	Like the Ingrebourne Marshes, much of this designation is in-land, though not on a flood plain and thus where conditions are right, it could still be contaminated. Large spills could affect >0.5ha or 5% of the total receptor, particularly around the Upper and Lower Horse areas (each approx. 8ha) which likely spend long periods uncovered by water, save for greater flow conditions (e.g. following a sustained period of rainfall). The creek is designated due to importance to wading birds notably food in the mudflats that is preferred by a particular rare species (see later entries). This could result in this species not being able to feed at the location and moving on, thus arguably removing the designation (*harm severity 2 – severe based on >0.5ha affected)*. However, as previously, the contamination will only likely to occur for a few tidal movements – or until a heavy rainfall event – allowing bacteria/algae to quickly recover and thus mudflat insects that the birds feed on (the birds themselves are assessed later under Cat. 13/14), reinstating the receptor as a viable food source for bird species. The duration to recovery would therefore be low (*harm duration 1 – no MATTE*).	-
Benfleet and Southend Marshes SSSI (2,099.69ha) / SPA (2,283.97ha) / Ramsar (2,283.97ha)	1, 2, 4	Much of this designation is based on the mud flats sustaining food source for important wintering birds. Large spills could affect >0.5ha but <1% of the total receptor. Otherwise the same discussion remains as previous. Yes, contamination may render a small section unusable for the birds that depend upon it (*harm severity 2 – severe)*, but contamination would only likely occur for a few tidal movements (*harm duration 1 – no MATTE).*	-
Southend-on-Sea Foreshore LNR (1,083.92ha)	3, 4	Large spills would affect <10ha or ~1% of the total designation and thus no MATTE is expected (*harm severity 1).*	-
Medway Estuary and Marshes MCZ (5,996ha) / SSSI (6,840.14ha) / SPA (4,686.32ha) / Ramsar (4,697.93ha)	1, 2, 4	Much of this designation is based on the mud flats sustaining food source for important wintering birds. Large spills could affect >0.5ha but <0.5% of the total receptor. Otherwise the same discussion remains as previous. Yes, contamination may render a small section unusable for the birds that depend upon it (*harm severity 2 – severe)*, but contamination would only likely occur for a few tidal movements (*harm duration 1 – no MATTE).*	-
Foulness SSSI (10,702ha) / SPA (10,942.13ha) / Ramsar (10,942.13ha)	1, 2, 3, 4	Much of this designation is based on the mud flats sustaining food source for important wintering birds. Large spills could affect >0.5ha but <0.2% of the total receptor. Otherwise the same discussion remains as previous. Yes, contamination may render a small section unusable for the birds that depend upon it (*harm severity 2 – severe)*, but contamination would only likely occur for a few tidal movements (*harm duration 1 – no MATTE).*	-

Receptor	Cat.	Discussion	SPR
Beckton Desalination Plant	7	Water will be abstracted to the desalination plant from the estuary from a level that sits below the low tide mark and designed for use with drought conditions. Diesel floats at the surface of the water so would not be pulled through, though abstraction could be halted for the duration of river contamination, which could be a couple of days before it is washed out into the North Sea over multiple tidal movements. This would be equivalent to >1E7 person hours, or a *harm severity 3 – major.* The harm would be less than 6 years, *harm duration 3 – long term* indicating a **Class 'C' MATTE**. This is designated as a new receptor, Receptor H.	**H1**
North Sea Marine Environments	14	Sub-littoral and benthic communities would not be affected by a diesel release that would be limited to the surface. A number of sea-birds could be affected by a slick of diesel but unlikely of this size which would deposit over small areas but more likely form a central slick thus it is expected that <100 seabirds and <500 gulls would be harmed. There could be a number of sea mammals in the Estuary when this product is released, but again, many would be under the slick with limited size and on this basis, no harm is expected at these criteria – though could be expected from larger releases (*harm severity 1 – no MATTE*).	-

The limited volume of release therefore suggests that in most instances the harm duration of the event would be limited to a few tidal movements where the diesel would flow downstream before temporary deposition on marshland or mudflats with the next tide causing dispersion and deposition further downstream, aided by the volumetric flow of water from the upper reaches of the Thames into the estuary.

The only MATTE is therefore expected from a release of immiscible material through this route, affecting Beckton Desalination Plant. Note that the unmitigated, total loss of containment from a ship is addressed through C5.

Ethanol

In the worst case, 150m^3 pure ethanol (i.e. not DEB, IMS, IDA etc.) would be discharged into river. At a density of 790kg/m^3 this is equivalent to 118,500kg. Discharge would be limited by the drains as a physical condition of the pathway although as previously, this could collect in the water and dilute during a period of still movement (high or low tide). Where 150m^3 of ethanol could mix with the volumes of water determined earlier in Section 6.6.3, the concentration could be lowered using a ratio:

- Silvertown to Tilbury: 118,500kg diluted with 63,825,000m^3 of tidal water reducing the concentration to 0.002kg/m^3 or 2mg/L.

This is significantly below the 4hr bacteria ecotoxic concentration of 5,800mg/L for ethanol. On this basis, only those receptors close to the discharge points could realistically be affected and these concentrations are unlikely to halt the Beckton Desalination Plant, which will expect certain levels of background contamination as part of the treatment process. However, within the second tidal movement, the concentration would drop further and the harm would stop. It is therefore highly unlikely that there would be any significant damage and thus *harm severity 1 – no MATTE.*

No MATTEs are therefore expected from a release of miscible material through this route. Note that the unmitigated, total loss of containment from a ship is addressed through C5.

6.6.3.2. SPR-C2 – Firewater Discharge via Surface Water Drains

Source: Initiation of a major fire on-site leads to the Fire & Rescue Service (F&RS) electing to tackle the event through the direct application of firewater.

Pathway: Firewater pools and flows across made ground in the direction of a select number of surface water drains in the southern part of the site. Material transfer through surface water drains directly off-site and into…

Receptor: The Thames Estuary, potentially affecting multiple receptors.

Discussion: A major fire could potentially involve several tanks.

A similar site wide fire – albeit initiated through differing circumstances than would be expected with ethanol and diesel – the Buncefield incident took 32 hours to extinguish most of the tanks. However, due to the initiating events, this incident would more likely be physically restricted to one of the tank farm areas and thus not continue for as long. In addition, the worst case would actually be a smaller volume of firewater application that may otherwise provide some means of mitigation.

CIRIA 736 provides a literature review of firewater application rates citing the ICI method of placement on severity rating suggesting that the ethanol bund is high severity, the diesel bund is perhaps medium severity and the Amine – though not currently held on-site – could be held in Area 3, assuming the largest tank 4,532m^3, where firefighting water would be a minimum of 1,620m^3/hr and 1,080m^3/hr respectively, over a period of four hours, and thus:

Diesel

For diesel the worst case is likely to be one of the bunds in the western part of Area 3 where – using the current tank list – there are 10 tanks, 7 of which contain diesel products contributing up to 11,432m^3. Assuming 10% of this remains unburnt and seeds into the firewater there would be 1,143m^3 available for discharge. Most of the site drains divert into the main sewer trunk (as discussed under SPR-C4). Only a few drains situated at the southern part of the site discharge directly into the Thames thus many hours of firewater would need to pool across the whole site and thus only a fraction of the material would discharge via this route, estimated again at no more than 10% or 114m^3.

Until the firewater subsides, most of the diesel would likely float on the surface and not discharge into the river. However, on an unmitigated basis, it could be assumed to emulsify and find its way into the Thames Estuary. Assuming that the material is allowed to spread out to a uniform depth of 1mm an area of 114m^3 ÷ 0.001m = 114,000m^2 (11.4ha). A release of this scale would likely affect biodiversity, potentially lowering the ecological quality of the water under the WFD from moderate to poor. For the estuary, assessment under CDOIF Category 15 suggests that this could occur over more than 2ha indicating *Harm Severity 2 – Severe.*

Recovery would begin fairly quickly owed in part to underwater species. Periods of rain are commonplace contributing heightened rates of material discharge downstream indicating a quick start of recovery. As such, whilst most of the river banks may remain contaminated, the majority of the receptor (the waterbody, not the designations associated with it) would recover quite quickly to remain as a moderate body of water for ecological purposes and good on a chemical scale. It is expected this would occur within one year indicating a harm severity 1 – no MATTE.

Designated sites though similarly affected, may not recover quite so quickly:

Table 6.6.3.2.1: SPR-C2 Effects of Diesel-Contaminated Water on Thames-Associated Receptors

Receptor	Cat.	Discussion	SPR
West Thurrock Lagoon and Marshes SSSI (66.08ha)	1, 4	Again, deposition could constitute >0.5/2ha or 17% of the total receptor. Unlike other designations already discussed, this receptor is largely intertidal mudflats and designated on the basis of importance to wading birds as a feeding ground during winter months. Birds will be less hardy to diesel, which will soak into feathers and prevent flight, may prevent ability to feed and would discourage birds from using the area. Contamination of these flats may therefore constitute removal of designation, at least during the contamination, for the receptor (*harm severity 2 – severe)*. However, the same arguments ring true as previously, i.e. the contamination will only likely to occur for a few tidal movements allowing bacteria/algae to quickly recover and thus mudflat insects that the birds feed on (the birds themselves are assessed later under Cat. 13/14), reinstating the receptor as a viable food source for bird species. The duration to recovery would therefore be low (*harm duration 1 – no MATTE)*.	-
Thames Estuary Marshes SPA (4,802.47ha) / Ramsar (5,553.59ha) (including Mucking Flats and Marshes SSSI (311.56ha) and South Thames Estuary and Marshes SSSI (5449.14ha))		The receptor is designated through importance to wintering wading birds.	
	1	If deposited unimpeded by other factors the spill could affect 0.2% of the South Thames Estuary and Marshes SSSIs. Harm severity is debateable. Designation removal is based on the reason for designation which is bird presence. If only 0.04% was affected, birds may not be deterred and micro fauna may be able to support species and allow quick recovery once diesel has passed through tidal movements. Harm severity is thus 1 – No MATTE.	
		If deposited unimpeded by other factors the spill could affect 3.7% of the Mucking Flats and Marshes SSSI. Discussion is thus the same as for South Thames Estuary and Marshes SSSI, i.e. 1 – No MATTE.	
	2	If deposited unimpeded by other factors the spill could affect <1% of the SPA/Ramsar area. Discussion is thus the same as for South Thames Estuary and Marshes SSSI, i.e. 1 – No MATTE.	
	4	If deposited unimpeded by other factors the spill could affect <1% of the scarce habitat associated with the marshes. Discussion is thus the same as for South Thames Estuary and Marshes SSSI, i.e. 1 – No MATTE.	
		The worst-case effects upon this receptor are thus judged to be sub-MATTE.	-
Holehaven Creek SSSI (272.87ha)	1	The receptor consists mainly of partially exposed mudflats, designated through importance to wintering wading birds. Discussion on determination of designation 'removal' is the same as above, for West Thurrock Lagoon and Marshes SSSI. If deposited unimpeded by other factors the spill could affect 0.8% of the SSSI. Harm severity is thus the same as above for Mucking Flats and Marshes, i.e. no MATTE.	-

Receptor	Cat.	Discussion	SPR
Benfleet and Southend Marshes SSSI (2,099.69ha) / SPA (2,283.97ha) / Ramsar (2,283.97ha)	1, 2, 4	The receptor consists mainly of intertidal mudflats, designated through importance to wintering wading birds. If deposited unimpeded by other factors the spill could affect <1% of the SSSI/SPA/Ramsar. Given that this is a smaller proportion of a huge area, there would still be plenty of land remaining that could support the micro-fauna required to support wintering birds and thus arguably the designation would not be removed. On this basis recovery time would be relatively quick indicating no MATTE.	-
Southend-on-Sea Foreshore LNR (1,083.92ha)	3, 4	Large spills would affect <10ha or ~1% of the total designation and thus no MATTE is expected (*harm severity 1).*	-
Medway Estuary and Marshes MCZ (5,996ha) / SSSI (6,840.14ha) / SPA (4,686.32ha) / Ramsar (4,697.93ha)	1, 2, 4	The receptor consists mainly of intertidal mudflats, designated through importance to wintering wading birds. If deposited unimpeded by other factors the spill could affect <1% of the MCZ/SSSI/SPA/Ramsar. Given that this is a smaller proportion of a huge area, there would still be plenty of land remaining that could support the micro-fauna required to support wintering birds and thus arguably the designation would not be removed. On this basis recovery time would be relatively quick indicating no MATTE.	-
Foulness SSSI (10,702ha) / SPA (10,942.13ha) / Ramsar (10,942.13ha)	1, 2, 4	The receptor consists mainly of intertidal mudflats, designated through importance to wintering wading birds. If deposited unimpeded by other factors the spill could affect <0.1% of the SSSI/SPA. Given that this is a smaller proportion of a huge area, there would still be plenty of land remaining that could support the micro-fauna required to support wintering birds and thus arguably the designation would not be removed. On this basis recovery time would be relatively quick indicating no MATTE.	-
Beckton Desalination Plant	7	Water will be abstracted to the desal plant from the estuary from a level that sits below the low tide mark and designed for use with drought conditions. Diesel floats at the surface of the water so would not be pulled through, though abstraction could be halted for the duration of river contamination, which could be a couple of days before it is washed out into the North Sea over multiple tidal movements. This would be equivalent to >1E7 person hours, or a *harm severity 3 – major.* The harm would be less than 6 years, *harm duration 3 – long term* indicating a **Class ‘C’ MATTE**. This is designated as a new receptor, Receptor H.	**H2**

Receptor	Cat.	Discussion	SPR
North Sea Marine Environments	14	Sub-littoral and benthic communities would not be affected by a diesel release that would be limited to the surface. A number of sea birds could be affected by a slick this size; this could easily account for >100 sea bird kills though it's likely that this would be less than 1,000 total on the basis that this is a distilled material, not a raw crude oil (*harm severity 2 – severe*). However, given that these areas are used for large colonies of breeding birds (perhaps in the hundreds of thousands) any effects upon a small proportion would not affect the overall colonies any more than might be expected from a particularly cold or stormy winter and thus the populations could be argued to recover immediately (*harm duration 1 – No MATTE)*. Similarly, there could be sea mammals such as porpoises, seals etc. using the estuary at times though sightings are rare. Significant impairment could result to 5 though less than 50 – no shoals would be expected in large numbers (*harm severity 2 – severe)* although again the effects would be no greater than experienced in nature and thus populations would recover immediately (*harm duration 1 – no MATTE)*. It is worth noting at this point that all 'rare' species identified have been screened out as being unlikely to be present in sufficient numbers to cause a MATTE.	-

Ethanol

For ethanol the worst case would be Tank Farm 1 (north bund) in Area 1 where escalation to all four tanks of ethanol could result in a loss of up to 20,104m^3 of ethanol to ground. Assuming 10% of this remains unburnt and seeds into the firewater there would be 2,010m^3 available for discharge. Again, 10% of this is assumed to discharge via the surface water drains in the south of the site, i.e. 201m^3.

At 790kg/m^3, 201m^3 of ethanol represents is 158,790kg of ethanol diluted with 6,480m^3 of water is 24.5kg/m^3.

The combined discharge (201m^3 + 6,480m^3 = 6,681m^3) will then be diluted over 6-hours with the estuary water between Silvertown and Tilbury at a ratio of (6,681m^3 ÷ 63,825,000m^3) 0.0001 reducing that content down to 0.02kg/m^3 or 20mg/L.

This is significantly below the 4hr bacteria ecotoxic concentration of 5,800mg/L for ethanol. On this basis, only those receptors close to the discharge points could realistically be affected and these concentrations are unlikely to halt the Beckton Desalination Plant, which will expect certain levels of background contamination as part of the treatment process. However, within the second tidal movement, the concentration would drop further and the harm would stop. It is therefore highly unlikely that there would be any significant damage and thus *harm severity 1 – no MATTE.*

Amine (AT1214)

The following ecotoxic data is applicable to AT1214:

- Fish, LC_{50} 96hrs, Rainbow Trout (*Oncorhynchus mykiss)*, 0.71-1.8mg/L
- Invertebrate, EC_{50} 48hr, *Daphnia magna,* 0.083-0.93mg/L;
- Algae, EL_{50} 72hr, *Desmodesmus subspicatus*, 14.6-46.6μg/L.

There is no AT1214 currently held, but it was identified as a worst case partially soluble material. It is classified as hazardous to the aquatic environment (H400) and would therefore be stored in Area 3. If this was held in the largest tank there would be up to 4,532m^3 present. Assuming 10% of this remains unburnt and seeds into the firewater there would be 453m^3 available for discharge. Again, only 10% is judged to discharge via surface water drains, i.e. 45.3m^3.

As identified in Section 6.2.1, the ecotoxic components of the AT1214 could be present in a mixture at a concentration of up to 75% therefore it is assumed that there = 45.3m^3 × 0.75 = 34m^3 of harmful materials present at a maximum density of 805kg/m^3 indicating 27,370kg of unburnt material available for firewater seeding. Where this is diluted with 6,480m^3 of fire water there is a concentration of 4.2kg/m^3.

The combined discharge (45.3m^3 + 6,480m^3 = 6,525m^3) will then be diluted over 6-hours with the estuary water between Silvertown and Tilbury at a ratio of (6,525m^3 ÷ 63,825,000m^3) 0.0001 reducing that content down to 0.004kg/m^3 or 4mg/L. The solubility of AT1214 components is a maximum of 19g/L thus this appears sensible.

This volume of firewater added to the estuary water (6,933m^3 + 63,825,000m^3 = 63,831,933m^3) will then dilute into estuary water downstream at Tilbury to Coryton at a ratio of (63,831,993m^3 ÷ 87,885,000m^3) = 0.73 × 4mg/L = 2.9mg/L.

This volume (63,831,993m^3 + 87,885,000m^3 = 151,716,993m^3) will then dilute into estuary water downstream at Tilbury to Coryton at a ratio of (151,716,993m^3 ÷ 201,840,000m^3) = 0.75 or down to 2.2mg/L.

This is clearly above all ecotoxic values and thus large numbers of fish kills should be expected for the full stretch of the river from the point of discharge from the site down to the North Sea, and a small proportion further upstream should the release coincide with an ebb tidal movement. Treated as a river, this would be a clear reduction in ecological quality constituting a lowering of the estuary's WFD status for a stretch of estuary up to an estimated 58km (*harm severity 3 – major*).

Many of the species present in the estuary will live throughout it including upstream from which recovery could quickly begin. However, many other species may use the estuary as a breeding ground and may return to the same place each year, e.g. sea fish that breed in shallow streams (such as salmon and trout) or lay eggs in the shallows of estuarine mud flats (such as rays and flatfish). As such, natural recovery is unlikely to be within 1-year, but is likely to be within 10-years, based on typical recovery of highly contaminated water bodies similar to the Thames Estuary. Harm duration is thus taken to be *2 – Medium Term* indicating potential of a **Class 'B' MATTE** from this release event (i.e. a major fire in Area 3) upon this receptor (the Thames Estuary).

Other associated receptors could be affected are:

- West Thurrock Lagoon and Marshes SSSI;
- Thames Estuary Marshes SPA/Ramsar/ESA (including Mucking Flats and Marshes SSSI and South Thames Estuary and Marshes SSSI);
- Holehaven Creek SSSI;
- Benfleet and Southend Marshes SSSI/SPA/Ramsar (including Southend-on-Sea Foreshore SSSI);

- Medway Estuary and Marshes MCZ/SSSI/SPA/Ramsar; and
- Foulness SSSI/SPA/Ramsar.

The argument for these sites is largely the same given their designation as importance wildlife areas for birds. Areas below water level could experience ecotoxic effects from the diluted amine, possibly resulting in significant harm to algal blooms that may temporarily remove an important food source for micro-fauna that the birds feed on. The birds themselves are unlikely to be harmed and thus designation would not be removed on the basis of bird deaths, rather removal of the birds to other feeding grounds. On this basis, an area of the designation could be affected, but as soon as food stocks returned, the birds would also indicate that recovery would be within 1 year and thus harm duration 1 – No MATTE.

As with diesel, these levels of contaminant may be sufficient to halt abstraction at Beckton Desalination Plant. As per earlier scenarios, this would be equivalent to >1E7 person hours, or a harm severity 3 – major. The harm would be less than 6 years, harm duration 3 – long term indicating a **Class 'C' MATTE**.

Finally, there could be harm to marine environments. Sub-littoral and benthic communities are unlikely to be significantly affected due to high dilution rates in the wider estuary and the North Sea. Sea birds including gulls are unlikely to be affected in significantly large numbers to cause a MATTE. Concentrations of harm to rats through the oral pathway for this material is 1,080mg/kg and thus poisoning of sea mammals is unlikely, although the amine itself is very acidic and may cause chemical burns contributing to 'significant impairment'. The more significant harm would occur in the estuary than in the outer North Sea due to significant dilution where there are only likely to be one or two (max. 5) present (*harm severity 2 – severe)* although effects should be relatively short lived in that the wider 'community' would be largely unaffected by the harm to one or two individuals, which may or may not be impaired for the remainder of their lives (*harm duration 1 – no MATTE).*

6.6.3.3. SPR-C3 – Indirect Discharge via Foul Sewer and Riverside STW

Source: Any loss of containment on-site.

Pathway: Pooling within bunds or on hard standing with eventual transfer to site drains. Flow of material via various combinations of sumps and interceptors with eventual collection in the on-site effluent treatment plant (ETP). Failure to adequately treat, isolate or remove the material at this stage could result in discharge into the main foul sewer which eventually reaches the Riverside Sewage Treatment Works (STW) in Rainham. Failure to adequately treat the effluent here would result in a discharge into Rainham Creek and the Ingrebourne River with eventual discharge into:

Receptor: The Thames Estuary and associated receptors.

Discussion: Any discharges to the sewer – assuming no dilution on-site through the ETP – would flow toward the Riverside STW in Rainham. This STW has a catchment area of an effective 400,000 people per day. Dry flow rates through the WWTW can be estimated using this population equivalent (PE). As outlined in Ref. [6.20] *"1 PE is the amount of sewage* *generated by one person living in a domestic dwelling and is generally taken as 200L of flow per day…*" indicating 80,000m^3 of dry flow each day which will dilute any miscible substances – this is not considered to be a mitigation, rather a physical condition associated with the pathway.

Diesel

The difference for diesel is that if it were to be released through this pathway, the immiscible nature of the substance would not be diluted and the area affected – at least on an unmitigated basis – would be the same as the volume released.

The diesel largest tank at the site is in Area 6 (T811) which can hold 10,987m^3. This is a greater volume of material than discussed under SPR-C1 and C2. However, the conclusions are largely the same. For conservatism, the results are taken to be the same as for SPR-C5, i.e. Class 'B' MATTEs to West Thurrock Lagoon and Marshes SSSI, Mucking Flats and Marshes SSSI and Holehaven Creek SSSI, with a Class 'C' MATTE to Beckton Desalination Plant (exposure would still only be a couple of days) and a Class 'A' MATTE to Seabirds in the estuary and North Sea.

Ethanol

The largest release of ethanol from a single event would be from one of the storage tanks in Area 1 Tank Farm 1, where 5,026m^3 of ethanol could be discharged to site drains and into the sewer. Using a density of 790kg/m^3 this is equivalent to 3,970,540kg which at the point of the ETP would be diluted with a minimum of 80,000m^3 of water down to 49kg/m^3.

If assumed to be discharged over a day, a flow rate of (5,026m^3 + 80,000m^3) ÷ (24hr × 3,600s) = 0.98m^3/s. This would be discharged into the Ingrebourne River which is a relatively slow moving river, quoted at a mean flow of 0.33m^3/s (Ref. [6.21]) at Gaynes Park, some 6km north-east of the STW; the flow rate would therefore be expected to increase to 1.31m^3/s. .

This would discharge into the Thames near approx. 2.5km east of the site into a flow rate calculated at the start of this section of approx. 2,955m^3/s providing a dilution ratio (1.31 ÷ 2,955 = 4E-4) sufficient to reduce the effective concentration of the discharge down to 0.02kg/m^3 or 20mg/L.

This is significantly below ecotoxic data and thus the Thames Estuary (Receptor C) and associated receptors (including Beckton Desalination Plant) would not be affected such to cause a MATTE.

However, the release could still cause harm to the Ingrebourne River and the associated receptor, the Ingrebourne Marshes SSSI and Ingrebourne Valley LNR. The Ingrebourne River runs for approx. 1.3km from the STW to the Thames. As such, even if there were significant harm along this river causing a reduction in WFD status it would not meet the minimum 2km criteria under CDOIF Category 15 indicating *harm severity 1 – no MATTE*. Both the Ingrebourne Marshes SSSI and Ingrebourne LNR are located upstream of the STW thus no harm is expected.

Amine (AT1214)

There is no AT1214 currently held, but it was identified as a worst case partially soluble material. It is classified as hazardous to the aquatic environment (H400) and would therefore be stored in Area 3. If this was held in the largest tank there would be up to 4,532m^3 present. The harmful products could be present up to 75% therefore it is assumed that there is 3399m^3 of harmful materials present at a maximum density of 805kg/m^3 indicating a loss of containment of 2,736,195kg to ground which at the point of the ETP would be diluted with a minimum of 80,000m^3 of water down to 34.2kg/m^3.

This would be discharged into the Ingrebourne River which is a relatively slow moving river, quoted at a mean flow of 0.33m^3/s (Ref. [6.21]) at Gaynes Park, some 6km north-east of the STW; the flow rate would therefore be expected to be marginally higher though not significantly so.

This would discharge into the Thames near approx. 2.5km east of the site into a flow rate calculated at the start of this section of approx. 2,955m^3/s providing a dilution ratio sufficient to reduce the effective concentration of the discharge down to 0.004kg/m^3 or 4mg/L.

The effects would therefore be similar to those conclusions from SPR-C2 Amine, i.e. worst-case **Class 'B' MATTE** due to effects upon biodiversity in the Thames Estuary or a **Class 'C' MATTE to Beckton Desalination Plant**, but little long-term effects on designated receptors.

6.6.3.4. SPR-C4 – Firewater via Foul Sewer and Riverside STW

Source: Initiation of a major fire on-site leads to the Fire & Rescue Service (F&RS) electing to tackle the event through the direct application of firewater.

Pathway: Pooling within bunds or on hard standing with eventual transfer to site drains. Flow of material via various combinations of sumps and interceptors with eventual collection in the on-site effluent treatment plant (ETP). Failure to adequately isolate the material at this stage could result in discharge into the main foul sewer which eventually reaches the Riverside Sewage Treatment Works (STW) in Rainham. Failure to adequately treat the effluent here would result in a discharge into Rainham Creek and the Ingrebourne River with eventual discharge into:

Receptor: The Thames Estuary and associated receptors.

Discussion: The discussion follows a combination of SPR C2 and C3.

Diesel

For diesel the worst case is likely to be one of the bunds in the western part of Area 3 where – using the current tank list – there are 10 tanks, 7 of which contain diesel products contributing up to 11,432m^3. Assuming 10% of this remains unburnt and seeds into the firewater there would be 1,143m^3 available for discharge.

If the diesel was able to pass through the Riverside STW dilution would not be factor given diesel floats. Therefore, assuming that the material is allowed to spread out to a uniform depth of 1mm an area of 1,143m^3 ÷ 0.001m = 1,143,000m^2 (114.3ha).

The worst consequences are therefore similar to SPR C2, i.e. sub-MATTE with off-site effects for most receptors, but the potential for a **Class 'C' MATTE** to Beckton Desalination Plant.

Ethanol

For ethanol the worst case would be Tank Farm 1 (north bund) in Area 1 where escalation to all four tanks of ethanol could result in a loss of up to 20,104m^3 of ethanol to ground. Assuming 10% of this remains unburnt and seeds into the firewater there would be 2,010m^3 available for discharge.

At 790kg/m^3, 2,010m^3 of ethanol represents is 1,587,900kg of ethanol diluted with 6,480m^3 of water is 245kg/m^3.

This 8,490m^3 of contaminated firewater would then be diluted with a minimum dry flow of 80,000m^3 through the sewer network – see SPR C3 – at a ratio of 0.1 down to 24.5kg/m^3.

If assumed to be discharged over a day, a flow rate of (2,010m^3 + 80,000m^3) ÷ (24hr × 3,600s) = 0.95m^3/s. This would be discharged into the Ingrebourne River which is a relatively slow moving river, quoted at a mean flow of 0.33m^3/s (Ref. [6.21]) at Gaynes Park, some 6km north-east of the STW; the flow rate would therefore be expected to increase to 1.28m^3/s.

This would discharge into the Thames near approx. 2.5km east of the site into a flow rate calculated at the start of this section of approx. 2,955m^3/s providing a dilution ratio (1.31 ÷ 2,955 = 4E-4) sufficient to reduce the effective concentration of the discharge down to 0.02kg/m^3 or 20mg/L.

This is significantly below ecotoxic data and thus the Thames Estuary (Receptor C) and associated receptors (including Beckton Desalination Plant) would not be affected such to cause a MATTE.

Amine (AT1214)

There is no AT1214 currently held, but it was identified as a worst case partially soluble material. It is classified as hazardous to the aquatic environment (H400) and would therefore be stored in Area 3. If this was held in the largest tank there would be up to 4,532m^3 present. Assuming 10% of this remains unburnt and seeds into the firewater there would be 453m^3 available for discharge.

The harmful products could be present up to 75% therefore it is assumed that there is 340m^3 of harmful materials present at a maximum density of 805kg/m^3 indicating a loss of containment of 273,700kg to ground. Where this is diluted with 6,480m^3 of fire water there is a concentration of 42kg/m^3.

This 6,933m^3 of contaminated firewater would then be diluted with a minimum dry flow of 80,000m^3 through the sewer network – see SPR C3 – at a ratio of 0.08 down to 3.4kg/m^3.

This would be discharged into the Ingrebourne River which is a relatively slow moving river, quoted at a mean flow of 0.33m^3/s (Ref. [6.21]) at Gaynes Park, some 6km north-east of the STW; the flow rate would therefore be expected to be marginally higher though not significantly so.

This would discharge into the Thames near approx. 2.5km east of the site into a flow rate calculated at the start of this section of approx. 2,955m^3/s providing a dilution ratio (0.33 ÷ 2,955) sufficient to reduce the effective concentration of the discharge down to 0.0004kg/m^3 or 0.4mg/L.

This is marginally above ecotoxic concentrations thus similar effects would be expected as for SPR-C2, i.e. i.e. worst case **Class 'B' MATTE** due to effects upon biodiversity in the Thames Estuary or a **Class 'C' MATTE** to Beckton Desalination Plant, but little long term effects on designated receptors.

6.6.3.5. SPR-C5 – Direct to Water Body from the Jetty

Source: Loading arm, hose or pipework failure at any point along the jetty between the ship and the sea wall.

Pathway: Direct loss of containment; partial bunding is available on the jetty but this could be quickly overwhelmed.

Receptor: The Thames Estuary and associated receptors.

Discussion: A loss of containment at the jetty could result in a direct loss of containment to the River Thames. Ships are offloaded at up to 150m^3/hr. but could be variable in capacity. The maximum discharge is therefore based on an assumed maximum delivery size, assuming that all ethanol/diesel tanks within a single area are filled from empty.

Diesel

Diesel is held in Area 6 in 11 tanks and a combined 25,610m^3 or in Area 3 in up to 14 tanks with a potential combined 22,591m^3. These figures are broadly in line with expected delivery sizes albeit conservative. The former is therefore used as the worst case.

The diesel will spread out on the surface of the water with very little interaction below. Assuming that the material is allowed to spread out to a uniform depth of 1mm an area of 25,610m^3 ÷ 0.001m = 25,610,000m^2 or 2,561ha. A release of this scale would likely affect biodiversity, potentially lowering the ecological quality of the water under the WFD from moderate to poor. For the estuary, assessment under CDOIF Category 15 suggests that this could occur over more than 200ha indicating *Harm Severity 4 – Catastrophic.*

Recovery would begin fairly quickly owed in part to underwater species. Periods of rain are commonplace contributing heightened rates of material discharge downstream indicating a quick start of recovery. As such, whilst most of the river banks may remain contaminated, the majority of the receptor (the waterbody, not the designations associated with it) would recover quite quickly to remain as a moderate body of water for ecological purposes and good on a chemical scale. It is expected this would occur within one year indicating a harm severity 1 – no MATTE.

However, other receptors may be more severely affected requiring much longer durations to recovery. Potential for harm upon each additional receptor is discussed in turn below:

Table 6.6.3.5: SPR-C5 Effects of Diesel on Thames-Associated Receptors

Receptor	Cat.	Discussion (512ha)	SPR
West Thurrock Lagoon and Marshes SSSI (66.08ha)	1, 4	If deposited unimpeded by other factors the spill could affect 100% of the total receptor. Diesel deposition across the receptor could cause significant harm to small numbers of birds but most importantly the food stocks that these birds depend on. Designation would not likely be removed entirely on basis of duration of recovery, but for the purposes of this assessment it is assumed it is and thus harm severity is *3 – Major* (under both category 1 and 4). Recovery would begin as soon as the diesel is carried off downstream toward the North Sea which would be relatively quick given tidal movements and heavy rainfall events experienced in the UK on a regular basis. However, it may take time for the micro-fauna to recover to a point that would sustain these birds indicating a duration to recovery of more than 1 year but less than 10 (*harm duration 2 – medium term)* indicating potential for a **Class 'B' MATTE**.	D5
Thames Estuary Marshes SPA (4,802.47ha) / Ramsar (5,553.59ha) (including Mucking Flats and Marshes SSSI (311.56ha) and South Thames Estuary and Marshes SSSI (5449.14ha))		The receptor is designated through importance to wintering wading birds.	
	1	If deposited unimpeded by other factors the spill could affect 46% of the South Thames Estuary and Marshes SSSI. Harm severity is debateable. Designation removal is based on the reason for designation which is bird presence. If only half of the receptor was affected, birds may not be deterred and micro fauna may be able to support species and allow quick recovery once diesel has passed through tidal movements. Harm severity is thus 1 – No MATTE.	
		If deposited unimpeded by other factors the spill could affect 100% of the Mucking Flats and Marshes SSSI. Harm severity is thus 3 – Major (>50% affected) whilst duration is 2 – Medium Term (>1 but <10 years to natural recovery); i.e. a **Class 'B' MATTE**.	
	2	If deposited unimpeded by other factors the spill could affect 53% of the SPA/Ramsar area. Discussion is thus the same as for South Thames Estuary and Marshes SSSI, i.e. 1 – No MATTE.	
	4	If deposited unimpeded by other factors the spill could affect 53% of the scarce habitat associated with the marshes. Discussion is thus the same as for South Thames Estuary and Marshes SSSI, i.e. 1 – No MATTE.	
		The worst-case effects upon this receptor are thus a **Class 'B' MATTE** from this event, but only upon Mucking Flats and Marshes which is designated Receptor E.	E5
Holehaven Creek SSSI (272.87ha)	1	The receptor consists mainly of partially exposed mudflats, designated through importance to wintering wading birds. Discussion on determination of designation 'removal' is the same as above, for West Thurrock Lagoon and Marshes SSSI. If deposited unimpeded by other factors the spill could affect 100% of the SSSI. Harm severity is thus the same as above for Mucking Flats and Marshes, i.e. 3 (>50% affected) whilst duration is 2 – Medium Term (>1 but <10 years to natural recovery) indicating a **Class 'B' MATTE**.	F5
Benfleet and Southend Marshes SSSI (2,099.69ha) / SPA (2,283.97ha) / Ramsar (2,283.97ha)	1, 2, 4	The receptor consists mainly of intertidal mudflats, designated through importance to wintering wading birds. If deposited unimpeded by other factors the spill could affect 24% of the SSSI/SPA/Ramsar. Given that this is a smaller proportion of a huge area, there would still be plenty of land remaining that could support the micro-fauna required to support wintering birds and thus arguably the designation would not be removed. On this basis recovery is anticipated quickly and no MATTE is anticipated.	-

Receptor	Cat.	Discussion (512ha)	SPR
Southend-on-Sea Foreshore LNR (1,083.92ha)	3	100% of the LNR could be affected by the spill, though not all of it is situated on the waterfront. However, the key to this receptor is that designation of harm is on the basis of amenity and aesthetics reasons that wouldn't be affected for more than 1 year. On this basis recovery is anticipated quickly and no MATTE is anticipated.	-
Medway Estuary and Marshes MCZ (5,996ha) / SSSI (6,840.14ha) / SPA (4,686.32ha) / Ramsar (4,697.93ha)	1, 2, 4	The receptor consists mainly of intertidal mudflats, designated through importance to wintering wading birds. If deposited unimpeded by other factors the spill could affect 55% of the MCZ/SSSI/SPA/Ramsar. Given that this is a smaller proportion of a huge area, there would still be plenty of land remaining that could support the micro-fauna required to support wintering birds and thus arguably the designation would not be removed. On this basis recovery time would be relatively quick indicating no MATTE.	-
Foulness SSSI (10,702ha) / SPA (10,942.13ha) / Ramsar (10,942.13ha)	1, 2, 4	The receptor consists mainly of intertidal mudflats, designated through importance to wintering wading birds. If deposited unimpeded by other factors the spill could affect 24% of the SSSI/SPA. Given that this is a smaller proportion of a huge area, there would still be plenty of land remaining that could support the micro-fauna required to support wintering birds and thus arguably the designation would not be removed. On this basis recovery time would be relatively quick indicating no MATTE.	-
Beckton Desalination Plant	7	Water will be abstracted to the desal plant from the estuary from a level that sits below the low tide mark and designed for use with drought conditions. Diesel floats at the surface of the water so would not be pulled through, though abstraction could be halted for the duration of river contamination, which could be a couple of days before it is washed out into the North Sea over multiple tidal movements. This would be equivalent to >1E7 person hours, or a *harm severity 3 – major.* The harm would be less than 6 years, *harm duration 3 – long term* indicating a **Class 'C' MATTE**. This is designated as a new receptor, Receptor H.	**H5**
North Sea Marine Environments	14	Sub-littoral and benthic communities would not be affected by a diesel release that would be limited to the surface. A number of sea birds could be affected by a slick this size; this could easily account for >100 sea bird kills though it's likely that this would be less than 1,000 total on the basis that this is a distilled material, not a raw crude oil (*harm severity 2 – severe*). Given that these areas are used for large colonies of breeding birds (perhaps in the hundreds of thousands) and a much larger spill than considered previously, there could be a small decline in the population that may not recover immediately. It would, however, be expected within 10 years and thus *harm duration is 2 – medium term* and potentially a **Class 'A' MATTE**. Similarly, there could be sea mammals such as porpoises, seals etc. using the estuary at times though sightings are rare. Significant impairment could result to 5 though less than 50 – no shoals would be expected in large numbers (*harm severity 2 – severe)* although again the effects would be no greater than experienced in nature and thus populations would recover immediately (*harm duration 1 – no MATTE)*. It is worth noting at this point that all 'rare' species identified have been screened out as being unlikely to be present in sufficient numbers to cause a MATTE.	G5 -

Ethanol

Using the same method of estimation, the worst-case ethanol area would be Area 1 Tank Pit 1 of which 20,104m^3 could theoretically be delivered in one operation. At a density of 790kg/m^3 this is equivalent to 15,882,160kg.

Where 20,104m^3 of ethanol could mix with the volumes of water determined earlier in Section 6.6.3, the concentration could be lowered using a ratio:

- Silvertown to Tilbury: 15,882,160kg diluted with 63,825,000m^3 of tidal water reducing the concentration to 0.25kg/m^3 or 250mg/L.

This is significantly below the 4hr bacteria ecotoxic concentration of 5,800mg/L for ethanol. On this basis, only those receptors close to the discharge points could realistically be affected and these concentrations are unlikely to halt the Beckton Desalination Plant, which will expect certain levels of background contamination as part of the treatment process. However, within the second tidal movement, the concentration would drop further and the harm would stop. It is therefore highly unlikely that there would be any significant damage and thus *harm severity 1 – no MATTE.*

6.7. Unmitigated Likelihood of a MATTE

As per the guidance, likelihoods are calculated only for MATTE scenarios.

6.7.1. Drought

For harm to occur to Beckton Desalination Plant (Receptor H), there would need to be drought conditions. The plant does not run unless there is drought and thus this is a condition for contamination and is thus not mitigation. The CEH drought tool (Ref. [6.28]) shows Standardized Precipitation Indices (SPIs) within an interactive map tool. Data has been sought based on a 12-month accumulation period between 1961-2019.

Sustained periods of dryness, i.e. SPR ≤-1.5 (where -1.5 is 'seriously dry') occurred in this area in:

- September 1972 – August 1973 (12 months)
- April 1976 – November 1976 (8 months)
- October 1989 – November 1989 (2 months)
- February 1991 (1 month)
- June 1996 – May 1997 (12 months)
- September 1997 – November 1997 (3 months)
- August 2005 – December 2005 (5 months)

This accounts for 43 months out of 696 months, or a probability of 0.06. Climate change is likely to bring wetter winters but potentially dryer summers, thus this is rounded to 0.1 for conservatism.

6.7.2. Bulk Losses of Containment to Ground

SPR-trios C3, D3, E3, F3 and G3 all involve general losses of containment of diesel to ground from all site operations. These operations include failure of bulk storage and failure of transfer pipework; however, road tanker operations are not considered to result in a MATTE due to limited volume of release. SPR-C3 results in a MATTE only from AT1214 (and other similar highly ecotoxic) releases whilst the remainder result in a MATTE only from diesel (and other similar immiscible) releases.

Most vessels are >450m^3 capacity. HSE FRED (Ref. 3.16]) provides item failure rates for large vessels as follows:

- Catastrophic failure at 5×10^{-6}/vessel/year;
- Major failure at 1×10^{-4}/vessel/year; and
- Minor failure at 2.5×10^{-3}/vessel/year.

Combined this is 2.91×10^{-3}/vessel/year. Other vessels may be <450m^3 in capacity though failure rates are lower and thus continued use of the larger vessel frequencies is considered conservative.

Failures could also result from pipework which is typically up to 6in diameter. HSE FRED provides an item failure rate for pipework 150-299mm diameter as follows:

- Guillotine failure at 2×10^{-7}/metre/year;
- ⅓ diameter failure at 4×10^{-7}/metre/year;
- Large hole failure at 7×10^{-7}/metre/year; and
- Small hole failure at 1×10^{-6}/metre/year.

Combined this is 2.3×10^{-6}/metre/year. This allows the calculation for each relevant SPR to be calculated:

- For SPR D3, E3, F3 and G3 from the current site inventory there are 22 vessels holding **diesel** or similar substances (such as gas oil) exclusively in Areas 3 and 6. Based on similar assumptions made in Section 6.7.2, it is assumed there is up to 2,000m of diesel transfer pipework around site. The failure frequency thus = (2.91×10^{-3}/vessel/year × 22) + (2.3×10^{-6}/metre/year × 2,000m) = 6.86×10^{-2}/year.
- For SPR C3 there is only likely to be one **AT1214** vessel. In Appendix 6.4 a hazardous materials review was conducted for which an ecotoxicity index (EI) was calculated for each material; more details are available in Section 6.5. For AT1214 the EI was calculated as 1,301 (for comparison, the EI for ethanol for the site was 4). The only other materials with an EI close to this are hexylene glycol and HLAS (alkyl benzene sulphonic acid) at EI 160 and 96 respectively. Assuming these all three are on site at the same time and each stored in a single vessel the failure rate for tanks would be 2.91×10^{-3}/vessel/year × 3 = 8.73×10^{-3}/year.
- For H3, the probability of loss of containment is the summation of the two bullet points above plus the probability of drought conditions, as calculated above, i.e. one of diesel and one for AT1214, i.e. 7.73×10^{-2}/year × 0.1 = 7.74×10^{-3}/yr.
- For H1 it is only pipework that is included, i.e. 4.6×10^{-3}/yr.

6.7.3. Firewater Scenarios

These unmitigated frequencies are applicable to SPR-trios C2 and C4; these are associated with AT1214 (and similarly ecotoxic materials) only. For a fire scenario, a flammable substance needs to be discharged to ground. This then must ignite causing a pool fire which escalates to other tanks and necessitates the need for firewater application. The dominating contributors are taken to be due to tank failure, a loss of containment from pipework or the failure or a road tanker hose during an offloading operation.

Tank Failures: Consequences are associated AT1214 (and other similarly ecotoxic materials) which can only be stored in either in Area 3 or 6; it is taken that there is sufficient separation such that escalation will not occur between areas.

- Areas 3 and 6 where the flash point of all materials is above typical ambient temperatures the only likely cause of ignition would be where a spray could be atomised or where a wicking effect could be caused, i.e. a loss of containment from a high pressurised spray (see pipework below) or a loss of containment onto grass, which is not present on site.
- Area 6 where the material flash point is greater than typical ambient temperature: There would be a maximum of 5 tanks containing ethanol (and similar products) thus – where method is same for Area 3 – 2.5×10^{-3}/year × 5 × 0.08 = 1×10^{-3}/year.

The initiating frequency from tank failures is thus 1×10^{-3}/year.

Pipework: In Section 3.5.9 it was estimated that there is approx. 2,000m of pipework transferring flammable (i.e. less than ambient temperature) materials whilst no more than a quarter of this (500m) would be passing through or close to Areas 3 or 6. Ignition probabilities are used from Section 3.2.4.3. The probability of a fire in Area 3 or 6 initiated by failure of pipework during ethanol transfer is:

- Guillotine (33.1kg/s, Table 3.5.9.1) = 2×10^{-7}/m/yr. × 500m × 0.03 = 3×10^{-6}/year.
- 1/3 dia. hole (<33.1kg/s) = 4×10^{-7}/m/yr. × 500m × 0.03 = 6×10^{-6}/year.
- Large hole (10.8kg/s, Table 3.5.9.3) = 7×10^{-7}/m/yr. × 500m × 0.03 = 1.05×10^{-5}/year.
- Small hole (0.28kg/s, Table 3.5.9.4) = 1×10^{-6}/m/yr. × 500m × 0.01 = 5×10^{-6}/year.

Spray failures from diesel pipework might also cause spray sufficient to cause atomisation where ignition could be easier; spray release frequency supplied by HSE FRED (Ref. [3.16]) is 1×10^{-6}/metre/year. There would be more pipework involved here given pipework within the bunds will hold diesel (assumed to be 2,000m based on earlier assumptions) but the ignition probability would arguably be less (however not claimed). The release rate would likely be similar to a small hole failure, i.e. <1kg/s. On this basis, the contributing frequency = 1×10^{-6}/m/yr. × 2000m × 0.01 = 2×10^{-5}/year.

The initiating event frequency from pipework failures is thus 4.45×10^{-5}/year.

Road Tanker Operations: HSE FRED provides item failure rates for hoses and couplings based on three types of system. In Section 3 it was judged that the site met average facilities and thus:

- Guillotine (69.5kg/s, Table 3.5.3.1) = 4×10^{-6}/operation/year;
- Large hole (2.7kg/s, Table 3.5.3.2) = 4×10^{-7}/operation/year; and
- Small hole (0.11kg/s, Table 3.5.3.3) = 6×10^{-6}/operation/year.

There are an estimated 200 operations per month involving flammable materials in Area 1 and 60 per month in Area 6. A similar number is taken for Diesel. It is therefore taken that there are 60 per month of ethanol initiating a fire in Area 6 and 260 per month initiating a diesel fire in Area 3 or 6. However, diesel fires are only taken to occur where a spray can be formed, i.e. guillotine releases are ignored. Therefore:

- Ethanol initiator in Area 6:
  - Guillotine = 4×10^{-6} × (60 × 12) × 0.08 = 2.3×10^{-4}/year;
  - Large hole = 4×10^{-7} × (60 × 12) × 0.03 = 8.64×10^{-6}/year; and
  - Small hole = 6×10^{-6} × (60 × 12) × 0.01 = 4.32×10^{-5}/year.
- Diesel initiator in Area 3 or 6 (ignition reduced by an order of magnitude to account for high flash point and possibility of a spray release occurring):
  - Large hole = 4×10^{-7} × (260 × 12) × 0.008 = 9.98×10^{-6}/year; and
  - Small hole = 6×10^{-6} × (260 × 12) × 0.001 = 1.87×10^{-5}/year.

The initiating event frequency from road tanker failures is thus 3.11×10^{-4}/year.

The **total unmitigated fire frequency** is thus taken as being 1.36×10^{-3}/year.

For H2 and H4 this would drop by an order of magnitude to 1.36×10^{-4}/year.

6.7.4. Jetty Releases

These unmitigated frequencies are applicable to SPR trios D5, E5, F5 and G5. Releases at the jetty could be as a result of hard-arm failures or pipework failures on the jetty.

HSE FRED (Ref. [3.16]) provides the following failure rates for ship hard-arms. Delivery frequency can be variable though it is assumed that there is approx. 1 per week over the year; this is considered conservative.

- Guillotine break = 7×10^{-6}/operation/year × 52 = 3.64×10^{-4}/year.
- Hole (10% dia.) = 8×10^{-6}/operation/year × 52 = 4.16×10^{-4}/year.

There is approx. 260m of pipework from the ship to the other side of the sea wall defences which could also result in the same scenario. The failure rate is thus 2.3×10^{-6}/metre/year (see Section 6.7.1) × 260 = 5.98×10^{-4}/year.

The total unmitigated jetty release frequency is thus taken as being 1.38×10^{-3}/year.

For H5 this would drop by an order of magnitude to 1.38×10^{-4}/year.

6.7.5. Unmitigated Results Summary

Table 6.7.4: Unmitigated Environmental Risk Results Summary

Ref.	Receptor	SPR	Consequence	MATTE Frequency (per year)				
				'D'	'C'	'B'	'A'	Receptor
A1	Underlying Alluvium Deposits and Groundwater	General Losses to Ground	Sub-MATTE with off-site harm	-	-	-	-	-
A2		Firewater to Ground	Sub-MATTE with off-site harm	-	-	-	-	-
B	Listed Buildings within 1km	Vapour Cloud Explosion	Sub-MATTE with off-site harm	-	-	-	-	-
C1	Thames Estuary (as a waterbody)	Direct loss of containment to surface water drains	Sub-MATTE with off-site harm	-	-	-	-	
C2		Firewater Discharge via Surface Water Drains	Class 'B' MATTE (AT1214 only)	-	-	1.36E-03	-	
C3		Indirect via ETP and STW	Class 'B' MATTE (AT1214 only)	-	-	8.73E-03	-	
C4		Firewater via ETP and STW (all Diesel tanks)	Class 'B' MATTE (AT1214 only)	-	-	1.36E-03	-	
C5		Direct Discharge from Jetty Operations	Sub-MATTE with off-site harm	-	-	-	-	1.15E-02
D3	West Thurrock Lagoon and Marshes SSSI	Indirect via ETP and STW	Class 'B' MATTE (Diesel only)	-	-	6.86E-02	-	
D5		Direct Discharge from Jetty Operations	Class 'B' MATTE (Diesel only)	-	-	1.38E-03	-	7.00E-02
E3	Mucking Flats and Marshes SSSI	Indirect via ETP and STW	Class 'B' MATTE (Diesel only)	-	-	6.86E-02	-	
E5		Direct Discharge from Jetty Operations	Class 'B' MATTE (Diesel only)	-	-	1.38E-03	-	7.00E-02
F3	Holehaven Creek SSSI	Indirect via ETP and STW	Class 'B' MATTE (Diesel only)	-	-	6.86E-02	-	
F5		Direct Discharge from Jetty Operations	Class 'B' MATTE (Diesel only)	-	-	1.38E-03	-	7.00E-02
G3	Seabirds	Indirect via ETP and STW	Class 'A' MATTE (Diesel only)	-	-	-	6.86E-02	
G5		Direct to water from jetty	Class 'A' MATTE (Diesel only)	-	-	-	1.38E-03	7.00E-02

Ref.	Receptor	SPR	Consequence	MATTE Frequency (per year)				
				'D'	'C'	'B'	'A'	Receptor
H1	Beckton Desalination Plant	Direct loss of containment to surface water drains	Class 'C' MATTE (Diesel only)	-	4.60E-03	-	-	
H2		Firewater Discharge via Surface Water Drains	Class 'C' MATTE (Diesel or AT1214 only).	-	1.36E-04	-	-	
H3		Indirect via ETP and STW	Class 'C' MATTE (Diesel or AT1214 only).	-	7.74E-03	-	-	
H4		Firewater via ETP and STW (all Diesel tanks)	Class 'C' MATTE (Diesel or AT1214 only).	-	1.36E-04	-	-	
H5		Direct Discharge from Jetty Operations	Class 'C' MATTE (Diesel or AT1214 only).	-	1.38E-04	-	-	1.28E-02
			Aggregation: Class 'C'	**1.28E-02**				
			Aggregation: Class 'B'	**2.34E-01**				
			Aggregation: Class 'A'	**3.04E-01**				

6.7.6. Aggregation of Unmitigated Risk

Aggregation of unmitigated risk is calculated in Table 6.7.5.

- The aggregated risk of a Class 'D' MATTE is the sum of all events resulting in a Class 'D' MATTE. There are no such events.
- The aggregated risk of a Class 'C' MATTE is the sum of all events resulting in a Class 'C' or worse. The unmitigated frequency for this aggregation is 1.28×10^{-2} per year and is plotted on the following risk matrix as 'Agg-C'.
- The aggregated risk of a Class 'B' MATTE is the sum of all events resulting in a Class 'B' MATTE or worse. The unmitigated frequency for this aggregation is 2.34×10^{-1} per year and is plotted on the following risk matrix as 'Agg-B'.
- The aggregated risk of a Class 'A' MATTE is the sum of all events resulting in a Class 'A' MATTE or worse. The unmitigated frequency for this aggregation is 3.04×10^{-1} per year and is plotted on the following risk matrix as 'Agg-A'.

6.7.7. Unmitigated Environmental Risk Summary Matrix

Note that the following risk matrix is intentionally discoloured to avoid confusion between the two risk matrices.

Table 6.7.6: Unmitigated Environmental Risk Summary Matrix

Consequence Cat									
Class 'D' MATTE									
Class 'C' MATTE					*H2, H4, H5*	*H1, H3*	**Receptor H** ***Agg-C***		
Class 'B' MATTE						*C2, C3, C4, D5, E5, F5, G5* **Receptor G**	*D3, E3, F3* **Receptors C, D, E and F**	***Agg-B***	
Class 'A' MATTE						*G5*	*G3* **Receptor G**	***Agg-A***	
Event Frequency (/yr.)	$<10^{-7}$	$\geq 10^{-7} < 10^{-6}$	$\geq 10^{-6} < 10^{-5}$	$\geq 10^{-5} < 10^{-4}$	$\geq 10^{-4} < 10^{-3}$	$\geq 10^{-3} < 10^{-2}$	$\geq 10^{-2} < 10^{-1}$	$\geq 10^{-1} < 1$	1
Frequency Category	Extremely Unlikely **1**		Very Unlikely **2**	Unlikely **3**	Quite Unlikely **4**	Somewhat Unlikely **5**	Fairly Probable **6**	Probable **7**	(Highly) Likely **8-9**

6.8. MATTE Prevention and Mitigated Likelihood

6.8.1. Beckton Desalination Plant

As estimated in Section 6.7.4, drought is estimated to occur at a probability of 0.06, which was rounded up to 0.1 to account for uncertainty in climate change estimations.

However, there is a mitigation that can be claimed. During a drought period the Desalination Plant would only be expected to operate to make up any short fall and thus, even when operating, it is unlikely that it would do so at full capacity. For most of any drought period, water levels would exist in reservoirs or other storage mediums and thus if it were taken that the desal plant would be required for 50% of the drought period (a conservative estimation), the probability could be reduced to 0.05.

No probability is taken for ebb or flow conditions in the estuary as it is assumed that material could be present for a few days.

In addition, no probability is taken for the plant to be able to treat the material anyway, thus not interrupting drinking water supplies at all.

6.8.2. Bulk Losses of Containment to Ground

SPR-trios C3, D3, E3, F3 and G3 all involve general losses of containment of diesel to ground from all site operations and follow the same pathway toward the River Thames. Site operations include failure of bulk storage and failure of transfer pipework; however, road tanker operations are not considered to result in a MATTE due to limited volume of release. SPR-C3 results in a MATTE only from AT1214 (and other similar highly ecotoxic) releases whilst the remainder result in a MATTE only from diesel (and other similar immiscible) releases.

The failure rates determined in Section 6.7.1 do not account for any mitigation and thus require modification.

- Catastrophic failure at 5×10^{-6}/vessel/year is factored by the probability of formation of a bow wave that causes the bund to overtop, or the probability that the material is knowingly transferred into the on-site drainage system toward the on-site effluent treatment plant (ETP). A bow wave will be formed by a particular type of catastrophic failure (e.g. where a panel causes a quick discharge through a large area) whilst others (a splitting effect caused by base weld failure) would lose contents to the bund but not force a bow wave; in the absence of information it is estimated that each will occur 50% of the time. The site protocol would be to recover as much of the lost material as possible to other available tanks on-site, though there is a possibility that an individual may elect to do otherwise by pumping the material to the on-site ETP. The following probabilities of human intervention are used under BS:EN 61511 layers of protection analysis (LOPA) methodology (Ref. [6.22]):
    - High stress response: 0.5;
    - Response to alarms (medium stress): 0.1; and
    - Low stress (e.g. routine tasks): 0.01.

Given that this is not a routine task but is in response to an incident a probability of 0.1 is considered appropriate. The catastrophic failure rate is thus modified to = 5×10^{-6}/vessel/year × (0.5 + 0.1) = 3×10^{-6}/vessel/year.

- Major hole failures at 1×10^{-4}/vessel/year would not have sufficient liquid head pressure to cause a spigot flow capable of overtopping the bund wall. However, the probability of erroneously emptying the bund still stands as above, thus 1×10^{-4}/vessel/year × 0.1 = 1×10^{-5}/vessel/year.
- Again, minor hole failures at 2.5×10^{-3}/vessel/year would not have sufficient liquid head pressure to cause a spigot flow capable of overtopping the bund wall. However, the probability of erroneously emptying the bund still stands as above, thus 2.5×10^{-3}/vessel/year × 0.1 = 2.5×10^{-4}/vessel/year.

Combined this is now 2.63×10^{-4}/vessel/year. Vessels in Area 1 are fitted with a static mode alarm, although this would not stop the release and may still result in an erroneous discharge into the site ETP.

Failures could also result from pipework. The failure rate frequency is the same as in Section 6.7.1 at 2.3×10^{-6}/metre/year but can be modified by a probability of identifying a leak and isolating it before a major release occurs. When a tank is receiving, discrepancy monitoring would highlight an issue. For smaller releases, the site has high occupancy and releases would need to continue for a very long time to result in a discharge of sufficient volume to cause a MATTE. If time was a factor in the isolation then it would be considered a high stress situation, but given the ability to quickly isolate pumps and the time required to accumulate sufficient volume to cause a MATTE, there would be ample opportunity to respond and a probability of 0.1 is claimed, reducing the probability of release to the ETP to 2.3×10^{-7}/metre/year.

Initiating event frequencies are thus:

- For SPR D3, E3, F3 and G3 from the current site inventory there are 22 vessels holding **diesel** or similar substances (such as gas oil) exclusively in Areas 3 and 6. Based on similar assumptions made in Section 6.7.2, it is assumed there is up to 2,000m of diesel transfer pipework around site, although a large proportion of this will be within bunded areas and is thus halved. The failure frequency thus = (2.63×10^{-4}/vessel/year × 22) + (2.3×10^{-7}/metre/year × 1,000m) = 6.02×10^{-3}/year.
- For SPR C3 there is only likely to be one **AT1214** vessel. In Appendix 6.4 a hazardous materials review was conducted for which an ecotoxicity index (EI) was calculated for each material; more details are available in Section 6.5. For AT1214 the EI was calculated as 1,301 (for comparison, the EI for ethanol for the site was 4). The only other materials with an EI close to this are hexylene glycol and HLAS (alkyl benzene sulphonic acid) at EI 160 and 96 respectively. Assuming these all three are on site at the same time and each stored in a single vessel the failure rate for tanks would be 2.63×10^{-4}/vessel/year × 3 = 7.89×10^{-4}/year.

There are then layers of protection between the release location and the Thames Estuary:

- Any discharge into site drains would first flow through one of several sumps and interceptors. However, these could quickly become overwhelmed with the volumes of material that are likely to be involved and thus no probability is claimed as a means of isolation from these events.

- The site effluent treatment plant, however, is isolatable and will be managed by a different individual to the one who made the initial error to empty the bunds. Whilst dealing with such volumes of material would not be a routine task, it would not be high stress and thus it is claimed as a response to an incident at a PFD of 0.1.
- Discharges will flow through the sewer into the off-site sewage treatment works (STW) at Rainham. The STW will be set-up to identify and isolate many types of releases. Sewage treatment works regularly treat household materials (such as bleach, washing powder, garden pesticides etc.) as well as those associated with industry (such as diesel, gasoline, solvents etc.). Diesel will float on the top of the tank during the settling stage allowing isolation and removal off-site whilst AT1214 (and other similarly ecotoxic materials) will likely cause harm to the activated sludge in the final stages which will be immediately obvious to any individual working at the plant. This is therefore a response during a routine task and thus a PFD of 0.01 is considered to be conservatively appropriate and includes any automatic systems that may be present in the STW to identify and isolate (e.g. via penstock valves or sluice gates) the plant from the Ingrebourne River.
- Finally, at least for diesel, there is the emergency response. There are a number of boats that can be deployed to limit the spread of diesel slick and allow isolation. However, if in the earlier two stages the associated personnel are not aware of such an incident, it is not guaranteed that emergency response protocol can be initiated before damage occurs. It is therefore not claimed as a guaranteed layer or protection against significant harm.

Factoring these into the initiating event frequencies above, the frequency of harm for each of the SPR-trios of:

- SPR C3 = 7.89×10^{-4}/year × 0.1 × 0.01 = 7.89×10^{-7}/year; and
- SPR D3/E3/F3/G3 = 6.02×10^{-3}/year × 0.1 × 0.01 = 6.02×10^{-6}/year;

SPR H3 is the summation of the two bullets above, multiplied by the probability that the desal plant is running = (7.89×10^{-7}/year + 6.02×10^{-6}/year) × 0.05 = 3.4×10^{-7} per year.

Only pipework applies to H1, i.e. (2.3×10^{-7} per metre per year × 1,000m) × 0.1 × 0.01 = 2.3×10^{-7} per year.

6.8.3. Firewater Scenarios

These frequencies are applicable to SPR-trios C2 and C4; these are associated with AT1214 (and similarly ecotoxic materials) only. The probability of a fire is the same as calculated in Section 6.7.2, i.e. 1.36×10^{-3}/year.

However, it is likely that the fire service would perform a controlled burn in such an event to keep firefighters as far from the thermal radiation as possible. In such an instance, firewater would only be applied to tanks in other bunds if there were signs of potential escalation and such firewater would be held within bunds, sumps and interceptors.

With regard to SPR-trio C2, it is worth noting that in a controlled burn policy, the materials in the bund on fire would be largely retained or again held within tertiary sumps and interceptors long before they overtopped in such volumes that they could reach the surface water drains, and even then the volumes that could be released would be significantly less than considered in harm assessment.

Where significant harm might be expected there could be a decision taken to tackle the fire with firewater, although this would not be likely and even if initiated would more likely be done so for a short period of time to allow evacuation, create means for isolation etc. The most likely intervention is therefore from an external source – e.g. what happened at the Buncefield incident – which is now arguably less likely to be heeded due to the recent understanding of the ecological damage that this caused. On this basis, it is judged to be an error in judgement in line with a 1-in-10 probability, i.e. 0.1, reducing the frequency of firewater application to 1.36×10^{-4}/year.

- For SPR-trio C2, there is little mitigation available although it may be possible for the fire service to erect means of isolating the firewater within bunds including pumping of wastewater from one bund to another. However, given the aforementioned controlled burn policy, it cannot be guaranteed and is thus not claimed. The frequency of either of these events is thus 1.36×10^{-4}/year.
    - For H2, this is reduced by a factor of 0.05 to account for the desal plant operation, which reduces to 6.8×10^{-6}/year.
- For C4, the routes of discharge are the same as discussed under Section 6.8.1, i.e. via on-site sumps, interceptors, ETP and off-site STW. There would be potential to isolate the ETP although that may lead to site overtopping and discharge either through surface water drains (see C2 above) and directly via the sewer and thus the original 0.1 is considered perhaps overly conservative and thus not claimed as an effective means of isolation given later requirement to utilise pumps to contain firewater in free tanks or bunds (this may not be possible if the site has been evacuated). However, the off-site STW should still be effective in the isolation and treatment of any contamination for the same reasons given under Section 6.8.1, plus the obviousness of the event, especially as they would be informed through the external emergency plan. The frequency of a loss of containment via this route is therefore 1.36×10^{-6}/year.
    - For H2, this is reduced by a factor of 0.05 to account for the desal plant operation, which reduces to 6.8×10^{-8}/year.

6.8.4. Jetty Releases

These unmitigated frequencies are applicable to SPR trios D5, E5, F5 and G5. Releases at the jetty could be as a result of hard-arm failures or pipework failures on the jetty as determined in Section 6.7.3 as occurring at a frequency of 1.38×10^{-3}/year.

There will be members of both Stolthaven and the ship who will be monitoring the transfer, the former through receiving mode alarms on the tanks and the latter through visual means. Both can isolate the transfer and both are in communication with one another. Such a release should be identified quickly allowing isolation that would normally be claimed as a high stress situation. However, there are effectively two people available to isolate, time is not as important factor in isolation for this event given large volumes would need to be released to cause a MATTE and the actual dependency is upon the pump isolation itself. As such, if a probability of 0.1, i.e. a response to alarms was taken for both Stolthaven AND the ship operators, and another was taken for a mechanical failure of the emergency pump shutdown, the probability of failure would = (0.1 × 0.1) + 0.1 = 0.11, and reduce the frequency of release of a sizable volume of diesel (or similar immiscible product) to 1.51×10^{-4}/year.

Beyond this there are little measures available to isolate the release. There is bunding available but if isolation failed this would be quickly overwhelmed (or even not effective if the release was a spray from pipework). Again, external emergency response includes potential for providing ship-mounted booms, but there is no guarantee that response would be executed in time and is not claimed.

For H5, this is reduced by a factor of 0.05 to account for the desal plant operation, which reduces to 7.55×10^{-6}/year.

6.8.5. Mitigated Results Summary

Table 6.8.5: Mitigated Environmental Risk Results Summary

Ref.	Receptor	SPR	Consequence	MATTE Frequency (per year)				
				'D'	'C'	'B'	'A'	Receptor
A1	Underlying Alluvium Deposits and Groundwater	General Losses to Ground	Sub-MATTE with off-site harm	-	-	-	-	-
A2		Firewater to Ground	Sub-MATTE with off-site harm	-	-	-	-	-
B	Listed Buildings within 1km	Vapour Cloud Explosion	Sub-MATTE with off-site harm	-	-	-	-	-
C1	Thames Estuary (as a waterbody)	Direct loss of containment to surface water drains	Sub-MATTE with off-site harm	-	-	-	-	
C2		Firewater Discharge via Surface Water Drains	Class 'B' MATTE (AT1214 only)	-	-	1.36E-04	-	
C3		Indirect via ETP and STW	Class 'B' MATTE (AT1214 only)	-	-	7.89E-07	-	
C4		Firewater via ETP and STW (all Diesel tanks)	Class 'B' MATTE (AT1214 only)	-	-	1.36E-06	-	
C5		Direct Discharge from Jetty Operations	Sub-MATTE with off-site harm	-	-	-	-	1.38E-04
D3	West Thurrock Lagoon and Marshes SSSI	Indirect via ETP and STW	Class 'B' MATTE (Diesel only)	-	-	6.02E-06	-	
D5		Direct Discharge from Jetty Operations	Class 'B' MATTE (Diesel only)	-	-	1.51E-04	-	1.57E-04
E3	Mucking Flats and Marshes SSSI	Indirect via ETP and STW	Class 'B' MATTE (Diesel only)	-	-	6.02E-06	-	
E5		Direct Discharge from Jetty Operations	Class 'B' MATTE (Diesel only)	-	-	1.51E-04	-	1.57E-04
F3	Holehaven Creek SSSI	Indirect via ETP and STW	Class 'B' MATTE (Diesel only)	-	-	6.02E-06	-	
F5		Direct Discharge from Jetty Operations	Class 'B' MATTE (Diesel only)	-	-	1.51E-04	-	1.57E-04
G3	Seabirds	Indirect via ETP and STW	Class 'A' MATTE (Diesel only)	-	-	-	6.02E-06	
G5		Direct to water from jetty	Class 'A' MATTE (Diesel only)	-	-	-	1.51E-04	1.57E-04

Ref.	Receptor	SPR	Consequence	MATTE Frequency (per year)				
				'D'	'C'	'B'	'A'	Receptor
H1	Beckton Desalination Plant	Direct loss of containment to surface water drains	Class 'C' MATTE (Diesel only)	-	2.30E-07	-	-	
H2		Firewater Discharge via Surface Water Drains	Class 'C' MATTE (Diesel or AT1214 only).	-	6.80E-06	-	-	
H3		Indirect via ETP and STW	Class 'C' MATTE (Diesel or AT1214 only).	-	3.40E-07	-	-	
H4		Firewater via ETP and STW (all Diesel tanks)	Class 'C' MATTE (Diesel or AT1214 only).	-	6.80E-08	-	-	
H5		Direct Discharge from Jetty Operations	Class 'C' MATTE (Diesel or AT1214 only).	-	7.55E-06	-	-	1.50E-05
			Aggregation: Class 'C'	**1.50E-05**				
			Aggregation: Class 'B'	**6.24E-04**				
			Aggregation: Class 'A'	**7.81E-04**				

6.8.6. Aggregation of Mitigated Risk

Aggregation of unmitigated risk is calculated in Table 6.8.4.

- The aggregated risk of a Class 'D' MATTE is the sum of all events resulting in a Class 'D' MATTE. There are no such events.
- The aggregated risk of a Class 'C' MATTE is the sum of all events resulting in a Class 'C' or worse. The unmitigated frequency for this aggregation is 1.51×10^{-5} per year and is plotted on the following risk matrix as 'Agg-C'.
- The aggregated risk of a Class 'B' MATTE is the sum of all events resulting in a Class 'B' MATTE or worse. The unmitigated frequency for this aggregation is 6.24×10^{-4} per year and is plotted on the following risk matrix as 'Agg-B'.
- The aggregated risk of a Class 'A' MATTE is the sum of all events resulting in a Class 'A' MATTE or worse. The unmitigated frequency for this aggregation is 7.81×10^{-4} per year and is plotted on the following risk matrix as 'Agg-A'.

6.8.7. Mitigated Environmental Risk Summary Matrix

Table 6.8.7: Mitigated Environmental Risk Summary Matrix

Consequence Cat									
Class ‘D’ MATTE									
Class ‘C’ MATTE	*H4*	*H1, H3*	*H2, H5*	**Receptor H** ***Agg-C***					
Class ‘B’ MATTE		*C3*	*C4, D3, E3, F3*		*C2, D5, E5, F5* **Receptors C, D, E, F** ***Agg-B***				
Class ‘A’ MATTE			G3		G5 **Receptor G** ***Agg-C***				
Event Frequency (/yr.)	$<10^{-7}$	$\geq 10^{-7} <10^{-6}$	$\geq 10^{-6} <10^{-5}$	$\geq 10^{-5} <10^{-4}$	$\geq 10^{-4} <10^{-3}$	$\geq 10^{-3} <10^{-2}$	$\geq 10^{-2} <10^{-1}$	$\geq 10^{-1} <1$	1
Frequency Category	Extremely Unlikely **1**		Very Unlikely **2**	Unlikely **3**	Quite Unlikely **4**	Somewhat Unlikely **5**	Fairly Probable **6**	Probable **7**	(Highly) Likely **8-9**

6.8.8. Bow Tie Diagrams

Bow tie diagrams have been provided for each source-pathway and are available in Appendix 6.6:

- Route 1 – Direct Product Discharge via Surface Water Drains (H1);
- Route 2 – Direct Firewater Discharge via Surface Water Drains (C2, H2);
- Route 3 – Indirect Product Discharge via ETP & WWTW (C3, D3, E3, F3, G3, H3);
- Route 4 – Indirect Firewater Discharge via ETP & WWTW (H4); and
- Route 5 – Direct Product Discharge from Jetty (D5, E5, F5, G5, H5).

6.8.9. ALARP Demonstration

An ALARP review was initially conducted as part of preparation of Section 3 – Predictive Aspects, which remains a valid ALARP demonstration tool. However, the Regulator have requested that this is redone for the environmental scenarios using a focus on environmental pathways, rather than predictive aspects release (source) scenarios. As such, as secondary ALARP demonstration has been carried out with focus on environmental pathways discussed in this report, avoiding repetition as carried out in the Predictive. Both studies use the following methodology:

- Select an ALARP System (defined by similar events with a tolerable if ALARP risk profile – *see Table 6.8.9 below*);
- Summarise the System, any existing risk assessments which have been conducted and existing safeguards that relate to the scenario;
- Identify potential further measures which could be taken to reduce the risk using the **fundamental safety hierarchy** (*see Section 3.8.3.2*);
- Using professional judgement and/or maximum justifiable spend (*see Section 3.8.3.3*), apply an **initial screening**. The outcome of this screening may determine a measure as being:
    - Not reasonably practicable;
    - Grossly disproportionate;
    - Low cost and should be implemented;
    - Requiring further consideration or cost benefit analysis.
- Where further consideration of a potential measure is required, professional judgement, feasibility studies, or internal decision-making protocols that may include separate cost benefit analysis to reach a decision;
- Repeat for all scenarios.

ALARP systems are developed in Appendix 6.11. In summary, the eALARP systems are as follows:

A. Direct to Ground (including made / unmade ground and damaged drainage)
B. Surface Water Drains
C. Bunding (including firewater containment)

D. On-Site Effluent Treatment Plant
E. Jetty Containment Systems

The eALARP focusses on all materials and use, though the scope from a mechanical / engineering perspective is that primary containment has breached. This is because all initiating events are considered already in the main ALARP studies for all equipment (pending a high-level review).

The eALARP is provided in Appendix 6.11 and should be read alongside Appendix 3.8.

6.9. Technical Details for Containment

6.9.1. Primary

The storage tanks are designed and constructed to relevant industry standards e.g. BS 2654 of a material suitable for the prescribed contents, either Carbon Steel or 316L SS. The structural support calculations were based on standard methods e.g. BS 8110 for the concrete, BS 449 for the steel, BS 6399 Part 1 for Dead and Imposed Loading for Buildings and BS CP3 Chapter 5 for wind loading.

The new tanks have been built to Standard EN 14015 *Specification for the design & manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded steel tanks for the storage of liquids at ambient temperature and above.* Design pressure range is -5 to +100mbarg, and design temperature range -20 to +100°C.

6.9.2. Secondary

Bunds are designed by consultant civil engineers to take into account loading on the walls if the largest vessel failed catastrophically. All the new, and replaced, bulk storage tanks in Area 1 are being located in two separate bunds, in accordance with HSG176. Bunds will be emptied either by natural outflow through a valve, normally kept closed, or using a pump.

Older bunds where design intent is not recorded are upgraded or replaced when appropriate; this includes strengthening walls with reinforced concrete and lining them to resist erosion. Since the last submission of the safety report, existing bunds in Areas 2 and 3, have been improved through the provision of impervious bund floors; these bunds now have concrete floors with bentonite lining and concrete walls – documents providing specifications are available subject to request.

Areas 4 and 5 do not contain COMAH products; these areas are nevertheless being improved as part of the ongoing site redevelopment.

6.9.3. Tertiary

The on-site drainage system is designed to control the flow of contaminated firewater, and prevent this water damaging the environment.

The effluent treatment plant was designed to enable the isolation or treatment of all materials expected on the site; new materials brought to site are handled through a management of change procedure which should determine any additional technical requirements.

6.10. Safety Management System

There is a Safety Management System established at site. Safety Health and Environment are managed through a number of Safety Policies, Safe Working Procedures and effective and proven good practices developed over many years.

Wider information on general aspects of the MAPP & SMS are provided in Section 4, this section focuses on the specific environmental aspects of the system.

6.10.1. Environmental Management system

There is no specific environmental management system. Environmental aspects are incorporated in the wider MAPP & SMS and is an integral part of the Stolthaven Dagenham Health, Safety and Environmental Management System (HSEMS).

The site's aim is to control the major accident hazards from dangerous substances handled, stored and used at the Dagenham site, to limit the potential effects to both people and to the environment.

The implementation of the MAPP is aimed at minimising the risk from hazardous substances capable of causing a major accident; specifically, the MAPP addresses the following areas:

- The roles and responsibilities of persons involved in the management of major hazards;
- Organisation and personnel;
- Hazard identification and risk assessment;
- Operation control;
- Management of change;
- Planning for foreseeable emergencies;
- Process safety improvement measures;
- Measuring performance; and
- Audit and review.

Responsibility for Health & Safety is clearly assigned within the Company's Health Safety and Environmental Policy. The primary function of the Health, Safety and Environmental (SHEQ) Manager is to advise the Board and General Managers/Department Heads on all Safety, Health, Environmental and welfare matters to ensure the company's compliance with its statutory obligations and appropriate best practice. However, all personnel on-site have some means of responsibility with respect to the environment.

6.10.2. Audit

The Safety Management System and Major Accident Prevention Policy will be internally audited annually by a qualified Lead Auditor independent of the element being audited. The company Safety, Health, Environment & Quality department will also carry out an audit once every two years. The results of all audits carried out on these documents will be reviewed at the Management Review Meeting.

In the event of failure to meet the objectives of the Major Accident Prevention Policy or non-conformances found in either the Major Accident Prevention Policy or the Safety Management System the following procedure will be followed:

- The General Manager will perform an investigation to find the root cause of the non-compliance.
- The General Manager will determine corrective actions necessary; these actions will be put into a plan which will include necessary resources, including human, training, changes to plant or maintenance schedule and the costing to implement these actions.
- This plan will be sent to the Sector Operations Director for approval.
- The Sector Operations Director will report the non-compliance to the Managing Director for comment.

Senior management including the Sector Operations Director will review the performance and suitability of the MAPP and the SMS. The result of that meeting reported to the Managing Director and the Group Safety, Health, Environment & Quality Manager for approval prior to re-issue. Any reissued documents will be sent to the competent authorities (HSE and EA) for assessment prior to being implemented

Performance is monitored proactively by the implementation of a system of safety audits and inspections; and reactively through the accident and near miss reporting and investigation system; this covers personal injury, property and environmental incidents.

6.11. Plans and Equipment to Limit Major Accident Consequences

6.11.1. Spillages – Confinement and Recovery

The jetty area has a drainage system that is pumped backed to an effluent tank. Surface water and fugitive release of product (drips from pig trap doors, breaking hose connections after line blowing, etc.) are returned to the site via this system.

Uncontrolled small releases will be dealt with using strategically placed spill kits with larger releases being isolated in the effluent tank. Very large uncontrolled releases will also utilise the Port of London Authority (PLA) Pollution Response Plan if necessary.

Emergency tanks have been selected to serve as containment for firewater run-off and/or emergency containment in the event of an incident. The tanks are located to the north of Area 3 bund and stand isolated from all other commercial storage tanks. This isolation makes the tanks ideal for this application. Under normal circumstances the tanks will be kept empty and available for the receipt of firewater or product from a commercial tank in the event of a major tank failure.

Emergency tanks have been selected to serve as containment for firewater run-off and / or emergency containment in the event of an incident. The tanks are located to the north of Area 3 bund and stand isolated from all other commercial storage tanks. This isolation makes the tanks ideal for this application. Under normal circumstances the tanks will be kept empty and available for the receipt of firewater or product from a commercial tank in the event of a major tank failure. Material from any leaking tanks would be transferred into these emergency holding tanks or any other suitable empty storage tank available at the terminal to allow remedial repairs to be undertaken.

Spillages outside bunds can be contained by damming with earth or sand. Materials suitable for use as damming agents are available in close proximity to the site.

6.11.2. Monitoring / Sampling

In the event of a major emergency provision for monitoring and sampling of air, the local authority Environmental Health department will continue to cover ground and water, and the Terminal has arrangements in place with an inspecting laboratory to sample and analyse as required. Staff from the inspecting laboratory are available 24/7.

Provision is made on-site to monitor for flammable gas and stored toxic substances using a portable analyser for any firewater containing flammables or toxic substances which enter drains or other areas.

Monitoring and sampling facilities are also available within the on-site effluent treatment plant (ETP) and should also be available for use by the sewage treatment works (STW) at Rainham.

Discharges off-site could be monitored though this would be drawn up in any potential remediation plan and likely handled by a third party.

6.11.3. Wastewater Treatment

The site on-site ETP will provide some means of isolation for recovery or treatment of spillages. Similarly, the off-site STW at Rainham will have similar facilities. Many of the materials held on-site will be familiar to the STW – e.g. ethanol, diesel – and should be easily identifiable and thus isolatable/treatable.

6.12. Alert and Intervention

6.12.1. Internal Emergency Plan

Any person who sees an emergency situation is required to raise the alarm, which will set the emergency response in progress.

During an emergency the Supervisor acts as the Main Incident Controller and directs Company support. The Main Incident Controller determines the nature and extent of the incident and, if appropriate, declares an emergency, ensures the emergency services have been notified.

A Security Officer mans the site 24 hours/day. When the site is unmanned, only the Security Officer is on site. In these circumstances, his role in the event of an emergency is to raise the alarm and alert the emergency services and call out company staff as defined in the Internal Emergency Plan.

More information is provided in Section 7.

6.12.2. External Emergency Plan

Stolthaven would notify both TOSCA and the Port of London Authority, and the local WWTW as part of the External Emergency Plan, in the event of any incident which may cause any release to sewer off-site.

Stolthaven have access to the Port of London Authority Pollution Response Plan in the event of any releases to the river. Procedures are incorporated in the site Emergency Plan detailing the actions to be taken.

Plans are in place with Harbour Authorities to control, contain and remove spillage on water in accordance with the Port of London Authority (PLA) Pollution Response Plan.

The Port of London Authority undertakes regular site visits and inspections of the terminal.

Stolthaven will continue to co-operate with the Local Authority regarding the provision of information for inclusion in the External Emergency Plan.

6.12.3. Training in Emergency Response

Quarterly fire exercises take place that are scheduled to ensure all Stolthaven personnel are involved in at least one exercise per year. Stolthaven personnel are externally trained in fire extinguisher training by competent trainers. Refresher training is undertaken every three years.

On-site exercises continue to be carried out in co-operation with the local Emergency Services.

6.12.4. Effects of Meteorology on Emergency Response

Flood maps in Section 6.3.8.1 suggest that in following a flooding event, the Fire & Rescue Service (F&RS) may have access to the site impeded:

- Rivers & Sea: From a typical flooding event, high risk areas would flood to the south-west of the site impeding access from Hindman's Way or Chequers Lane (Low risk for each).
- Reservoirs: Most of the flooding would be caused around the main access route to the docks though alternative access may be available via Choats Road. Beyond this, access should be generally free through Hindman's Way, though Chequers Lane may be flooded.
- Surface Water: Generally, there are small pockets of high risk areas around the roundabout on Choats Road/Manor and Chequers Lane though access should not be significantly impeded.

Restriction of access to the site during a major accident hazard may reduce the potential for the F&RS to respond to an incident. A flood risk assessment was thus carried out and a flood risk management plan implemented, this is provided in Appendix 6.7. An external tabletop emergency exercise was conducted in December 2018; key actions and learning from this exercise has been incorporated into the external emergency plan.

Further discussion has been undertaken in Section 6.5.2, which suggests that the SDL site is an FMAS3 (Flooding Major Accident Scenario Level 3, Ref. [6.26]) site in that flooding would principally occur outside of the establishment which may prevent access to the site and exacerbate any major accident risk and challenge the following protection layers.

- Access / egress: There are multiple access / egress points to the terminal, high ground clearance vehicles are available to the SLD to drive through flooded areas of the site to access areas for isolation or to help stranded individuals.
- Emergency response: Emergency response vehicles have a high ground clearance thus should be able to drive through flooded areas surrounding the terminal. If they were unable to attend site, terminal staff are trained on the firefighting systems that are installed and could tackle small fires.
- Power: The new firefighting system has a UPS back up for the electrical panels, the system works on a pressure drop and the diesel pumps after initial start-up will run without electrical power. Each pump (3 for the water 2 for the foam) has 2 sets of batteries.
- Communications: Handheld radios work back-to-back, batteries generally last for 8 hours, and an emergency mobile phone is programmed with key numbers; this is located in the main office. Senior staff all have company mobile phones. Emergency contact details for all personnel are on a cloud-based system for remote access.
- Workforce: Phones are located in all buildings (except the MCC), all operational staff carry handheld radios, supervisors are aware of their workers location and current tasks.

6.13. Mobilizable Resources

9kg powder, 9-litre foam and 2kg portable extinguishers are strategically located around the site in accordance with the Fire Certificate and Fire Risk Assessment of Stolthaven Dagenham. Locations and testing details are presented in Appendix 7.3.

Stolthaven Dagenham also has a portable foam generator capable of being moved around site manually to provide foam coverage on pools of flammable product. Portable pumps are also available to transfer contaminated liquid from drains, interceptors or bunded areas into bulk tanks or other bunds within the site as instructed by the Site Incident Controller.

Spill kits are located strategically throughout the terminal and at the Jetty containing a variety of absorbent materials. Locations are provided in Appendix 6.2. Spill kits are easily identifiable yellow bins each containing absorbent granules, clay drain mat covers, hydrophobic oil absorbent mats and oil booms.

Any material collected in drums / IBC’s must be tested by an analyst, or arranged to be tested by an external laboratory, to allow a decision on its disposal or reuse route. The contents of spill kits are presented in Appendix 6.2 and 6.3.

6.14. Technical / Non-Technical Measures

Firewater systems are described in Section 6.3. The on-site ETP is the only technical measure available for isolation and treatment.

Many non-technical measures may be available, e.g. booms, though these are not held on-site. Spill kits are available for smaller releases. See Section 6.13.

6.15. Restoration and Clean-up

6.15.1. Remediation

Stolthaven has made a commitment to contain and clean up any spillage and to ensure that disposal is in accordance with statutory requirements. In the event of a major incident, Stolthaven would liaise with the relevant Competent Authorities that could access the affected areas in developing and implementing an acceptable restoration plan to minimise the environmental impact of the incident.

Equipment is available both on site and with local contractors to contain and remove contaminated materials from the sites.

If spilt material cannot be reclaimed or recycled, it is disposed of according to current regulations, using approved licensed waste disposal contractors. All recovered product and contaminated ground will be disposed of off-site through appropriately licensed waste disposal operators.

Any clean-up and remediation undertaken at the terminal would be after consultation with the Competent Authorities. Stolthaven would, where appropriate, gain agreement for the method of restoration from the appropriate authorities such as Emergency Services, the London Borough of Barking and Dagenham Council Environmental Health Department, HSE, and Environment Agency.

Plans are in place with Harbour Authorities to control, contain and remove spillage on water in accordance with the Port of London Authority (PLA) Pollution Response Plan.

In the event of an incident causing ground contamination, the incident would be assessed and, if necessary, specialist advice / assistance obtained. Following the assessment, an action plan would be formulated to contain any further contamination, to remove contaminated soil and for its safe disposal. The action plan would be risk assessed using the existing procedures. Where necessary topsoil is removed and replaced as required to a suitable depth to reduce the impact of ground and ground water contamination.

Stolthaven have a pollution liability insurance policy in place.

6.15.2. Restoration Plan

Once the situation has been brought under control the site may be returned to a safe condition. The restoration procedure will involve cleaning and decontamination of the affected area. Contaminated materials, including any fire-runoff water held on site, will be disposed of by appropriate means.

After a major accident with off-site consequences, Stolthaven will consult with the Agencies listed in Table 6.15.1, and with relevant landowners, to identify the most appropriate actions to be taken to affect the rapid clean-up and restoration of the affected environment and to initiate the agreed procedures.

Table 6.15.2: Environmental Clean-Up and Restoration

Remedial Work	**Lead Agency / Advisor**
Making safe and removal of chemicals	Environment Agency and the London Borough of Barking and Dagenham Council.
Making safe and removal of contaminated water	
Removal/Neutralisation of contaminated soil and debris	
Removal of dead animals	Stolthaven in conjunction with the London Borough of Barking and Dagenham Council.
Removal of affected trees and plants	
Restricting foodstuffs	Food Standards Agency / DEFRA
Restricting access to areas	Police
Restocking Watercourses, Rivers, Woods	Environment Agency
Restoring/Neutralising surface and groundwater supplies	United Utilities and Environment Agency
Cleaning / Repair of Public Buildings	Stolthaven in conjunction with building owners / insurance companies & the London Borough of Barking and Dagenham Council.
Replacing contaminated soil	
Replanting of vegetation	Environment Agency
Restoration of habitats	
Reintroducing species	