Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

South Dublin County Council

Dún Laoghaire-Rathdown County Council Comhairle Contae Dhún Laoghaire-Ráth an Dúin

Fingal County Council
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DUBLIN WASTE TO ENERGY PROJECT

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Major Accident Hazard Assessment

August 2006

Elsam

NDP
NATIONAL DEVELOPMENT PLAN

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1. INTRODUCTION

Dublin City Council (the Authority) acting on behalf of the four local authorities for the Dublin Region, i.e. Dublin City Council, Fingal County Council, South Dublin County Council and Dún Laoghaire Rathdown County Council, proposes to establish a waste to energy (WtE) facility (the Facility) to thermally treat household, commercial and non-hazardous industrial waste. The proposed Dublin WtE facility will have a design capacity to thermally treat up to 600,000 tonnes of waste annually and will be located on the Poolbeg Peninsula in Dublin.

The quantities of dangerous materials to be stored at the facility (refer to Appendix A) are such as bring it under the requirements of under the EC *Seveso II* Directive (Council Directive 96/82/EC of 9 December 1996[1] as amended by Directive 2003/105/EC of the European Parliament and of the Council of 16 December 2003[2]), as implemented in Ireland by the *European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, 2006* (S.I. No. 74 of 2006) (herein referred to as 'the Regulations').

The site will be a "top tier" site under the Directive and the Regulations. As such the operator is obliged to submit a Safety Report to the Central Competent Authority for the Regulations (the Health and Safety Authority (HSA)) at least six months before commencement of construction. This report has been prepared to meet the requirements of the Directive and the Regulations.

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[1] O.J. L 10, 14.1.1997, p. 13
[2] O.J. L 345, 31.12.2003, p. 97

2. STRUCTURE OF THE MAJOR ACCIDENT HAZARD ASSESSMENT REPORT

This Major Accident Hazard Assessment Report is set out in seven sections. Sections 1 and 2 are the report introduction and structure respectively.

Section 3 sets out basic information on the facility:

- an overview of the establishment and its activities
- information about the dangerous substance in use
- information about the surrounding environment

Section 4 describes the Safety Management System (SMS) of the operator and the major elements necessary to prevent and control major accidents:

- Overview of the SMS objectives
- Safety and training procedures
- Fire safety systems

Section 5 addresses the major accident potential of the site. The consequences of each possible accident are qualitatively and quantitatively assessed in this section.

Section 6 gives information about the measures to prevent or limit the consequences of the major accidents identified in Section 5

Section 7 gives information about the emergency response measures to be implemented on site to limit the consequences of major accidents. This section describes the:

- objectives of the emergency plans
- information to be contained in the emergency plans
- procedures for the review of the emergency plans
- basis for implementation of the emergency plans

3. BASIC INFORMATION

3.1 Site and Operator

The proposed Dublin WtE Facility is being procured and developed as a public private partnership. Under the public private partnership arrangement it is proposed that the private company (the PPP Co) will be responsible for the design, construction and financing of the new WtE Facility as well as the ongoing operation of the Facility for a period of at least twenty-five years.

The tender competition for the design, build, finance and operation of the facility required certain minimum standards. In this context, it might be noted that the current intended operator is from the Elsam Group in Denmark.

All statutory licenses/permissions will be in the name of Dublin City Council and Elsam will operate the proposed facility under the requirements/conditions of such licenses/permissions. The address of Dublin City Council is Engineering Department, Block 1, Floor 4, Civic Offices, Wood Quay, Dublin 8.

For the purposes of the Seveso II Directive, the contact will be the Executive Manager, Engineering Department, Dublin City Council.

The site is rectangular in shape with dimensions 160 m x 340 m. It covers an area of approximately 5.5 hectares. To the north it adjoins Pigeon House Road, to the west Shellybanks Road, to the east a Waste Water Treatment Works and to the south an undeveloped area (refer to Figure 1).

Currently the northern part of the site is used by the company Clearway Disposal, while the centre part is occupied by Hibernian Molasses. The southern part of the site is presently used for parking space. Clearance of the present structures on the site will be necessary prior to commencing terrain works for the construction of the Facility.

There will be three buildings on the overall site, the main process building, the cooling water pump house, and a security building.

Main Process Building

The waste reception area, waste bunker, furnaces, boilers and flue gas treatment lines, turbine hall, and residue storage and handling areas will be accommodated in the main process building. The service areas including the control room, offices, staff facilities, administration area, workshop and stores will also be located in the main process building. The storages areas for residues and process materials will be located on the western side of the main building within the building shell.

The main building will be approximately 200 m long by 130 m wide by 52 m in height, at the highest point. The maximum height of the building is determined by the height of the process equipment, specifically the boiler. The ground floor level will be about 5.00mOD. The reception hall will have a floor level of about 12mOD. The bunker floor level will be about 0.00mOD and the hopper deck level will be about 30mOD. The process areas will generally be single storey.

The shape of the main building has been inspired by the shape of a snail shell. On all facades the walls will incline inwards with increasing height and the corners will be rounded. A lower outer zone will wrap around the high central core. Around the perimeter, at ground level will be a “heavy” base, consisting of pre-cast concrete panels. The upper parts of the external envelope will be formed in high quality architectural cladding panels and will incorporate large glazed panels. The flue gas treatment equipment will be visible through this glazed panel.

Two stacks will be located at the north-eastern corner of the main building. The stacks will be side by side and each will be about 3 m in diameter and 100 m in height.

Cooling Water Pump House

The cooling water pump house will be a two storey building and will contain a filter system, the main cooling water pumps and the biocide dosing system. It will be located north of Pigeon House Road.

Security Building

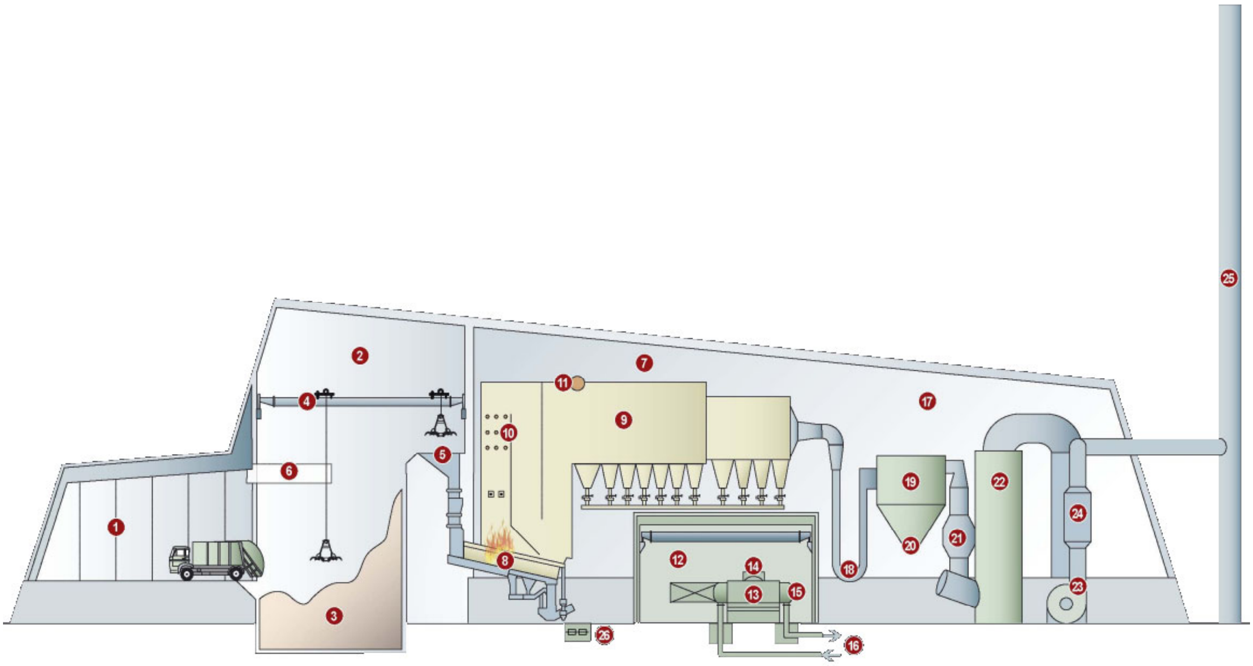
A security building will be located at the main access point. The ground floor levels of the building will also be about 5.00mOD.

3.2 Overview of the Establishment, its Activities and Products

The waste to energy process will consist of the following main elements:

- Waste acceptance
- Waste intake and storage
- Combustion process
- Energy recovery process
- Flue gas cleaning.

Schematic diagram of the WtE process



1. Waste reception hall
2. Waste bunker compartment
3. Waste bunker
4. Waste crane for feeding the boiler grate
5. Waste hopper
6. Control room
7. Boiler area
8. Grate
9. Boiler, where the heat energy is transferred from the flue gas to the boiler water
10. NOx reduction by spraying ammonia water into the flue gas
11. Boiler drum, where water and steam are separated
12. Turbine room
13. Steam turbine
14. Generator, producing electricity
15. Condenser, where the remaining heat energy in the steam is cooled
16. Cooling system
17. Flue gas treatment area
18. Activated carbon and lime are added to the flue gas to bind dioxins and other components
19. Fabric filter, where the flue gas treatment residue is removed from the flue gas
20. Extraction point for flue gas treatment residues
21. Flue gas cooler
22. Two-stage wet scrubber for reduction of HCl, SO2, HF and Hg emissions
23. ID fan
24. Silencer
25. Stack
26. Bottom ash for recycling

3.3 Surrounding Industrial Sites and Residential Areas

The Synergen Dublin Bay Power Plant is adjacent to the west of the site across Shellybanks Road. It is a 400 MW Combined Cycle Gas Turbine (CCGT), and is located on Pigeon House Road within the south port area. The principal fuel is natural gas, but distillate oil is stored on site as a back-up or reserve fuel. Further industrial activities and Dublin Port quays are located to the north.

The Seveso sites in the south port area are:

- Poolbeg ESB Generating Station
- Synergen Dublin Bay Power Plant

The Poolbeg ESB Generating Station is situated at the eastern end of the Poolbeg peninsula. Both the Poolbeg and Synergen Dublin Bay Power stations are establishments covered by the Seveso Directive i.e. they are potential major accident hazard sites subject to the requirements of SI No 74 of 2006.

The Poolbeg ESB Generating Station stands on ninety acres of land, a large part of which was reclaimed from the sea. The basic generating system (500 MW) is a steam turbine system. A 470 MW CCGT was added in 1999. As in the case of the Synergen Dublin Bay Power Plant, the principal fuel is natural gas, but distillate oil (gas oil) is stored on site as a back-up or reserve fuel.

The Seveso sites in the north port area are:

- CalorGas - LPG storage and filling depot
- Minchem – waste handling and blending facility
- Albion Chemical Distribution (Irl) Ltd – chlorine gas cylinder and drum storage
- Irish Shell, Statoil, Esso and Tedcastle – bulk oil storage

Irishtown Nature Park is located to the southeast of the site. The established residential areas of Irishtown and Ringsend lie approximately 1km to the west of the site. The established residential area of Sandymount lies approximately 1 km to the south of the site. The main facilities of Dublin port are located across Dublin harbour, to the north of the site.

3.4 Dangerous Substances and Seveso Threshold Quantities

The dangerous substances to be stored at the facility are compared to their threshold quantities in the Regulations in Appendix A. The dangerous substances making the main contribution to the facilities upper tier status are as follows:

- Ammonium hydroxide (used for abatement of emissions to atmosphere of nitrogen oxide)
- Diesel oil (gas oil) (used as a standby fuel)
- Flue Gas Treatment (FGT) residues (the high content of heavy metals results in classification as toxic to aquatic organisms)

The rationale for classification of FGT residues as risk phrase R51/53, toxic to aquatic organisms/may cause long-term adverse effects in the aquatic environment, is described below.

A report by the European Environment Agency (EEA) (Technical report No 38 Dangerous substances in waste, February 2000), gives information on the composition of solid wastes from Municipal Waste Incineration:

Table 1 Composition of Solid Wastes from Municipal Waste Incineration

Substances	Contents (mg/kg)		
	Slags*	**Fly Ash**	**Residues from Gas Cleaning**
Cd	<0,5 — 10	50 — 1000	300 —500
Tl	< 2	0 — 50	0 — 2
Hg	<0,05 — 5	2 — 30	10 — 30
As	0,5 — 50	10 — 100	40 — 100
Co	15 — 35	30 — 100	5 — 20
Cr	50 — 1000	50 — 2000	50 — 200
Cu	500 — 1500	300 — 5000	500 — 1500
Ni	25 — 100	100 — 400	30 — 100
Pb	100 — 3500	1000 — 12000	4000 — 10000
Sb	20 — 200	300 — 1000	300 — 1000
Sn	100 — 250	500 — 3000	—
Zn	500 — 2500	5000 — 40000	20000 — 30000
	Contents ngTE/kg		
PCDD/F	4-25 ngTE/kg	100-10000 ngTE/kg	100-10000 ngTE/kg

* Bottom Ash
Source: T. Leclaire: Behandlung und Verwertung von HMV-Rückständen, Gerhard Mercator-Universitat-GH Duisburg; 1998

The above figures are similar to those reported by T. Astrup in 2005 for incinerators in Denmark.

Classification of Heavy Metals

The EEA report referred to above states that a high percentage of metals are gasified by the incineration process. These metals are transferred to the gas phase and partly condense before entering the gas cleaning unit. The condensed metals are mostly adsorbed on the surface of small fly ash particles. The fly ash tends to concentrate metals. The remaining vaporised metals are transported to the gas cleaning unit and washed out.

Hence some of the metals are present as pure metals, and some as inorganic compounds. The following is the classification of each metal assumed for this assessment.

Cadmium (Cd)

Cadmium and cadmium oxide are both classified as very toxic (T+) and dangerous to the aquatic environment (N) by the International Labour Organization (ILO) and cadmium compounds as a group are classified as harmful (Xn) and N-R50/53 by the EC. Therefore the Cd portion of the FGT Residues are classified as N-R50/53.

Thallium (Tl)

Thallium is classified by the EC as T+ and R53. Thallium compounds are classified as T+ and R51/53. Therefore, the Tl portion of the FGT Residues is classified as N-R51/53.

Mercury (Hg)

The ILO classifies mercury metal as toxic (T) and N-R50/53 and mercury oxide (HgO) as T+ and N-R50/53. The EC classifies inorganic mercury compounds as T+ and N-R50/53. Therefore the Hg portion of the FGT Residues is classified as N-R50/53.

Arsenic (As)

The ILO classifies arsenic metal as T and N-R50/53, and the EC classifies arsenic compounds as T and N-R50/53 also. The ILO classifies arsenic trioxide as T and N-R50-53, and arsenic pentoxide as T+ and N-R50/53. Therefore the As portion of the FGT Residues is classified as N-R50/53.

Cobalt (Co)

The EC classifies cobalt oxides as harmful N-R50/53, but the ILO classifies cobalt metal as harmful (Xn). It is considered prudent to classify the Co portion of the FGT residues as N-R50-53.

Chromium (Cr)

The EC and the ILO classify Cr(VI) compounds as T and N-R50/53, but Cr(III) compounds are not classified as hazardous. The ILO classifies chromium metal as N, but does not assign risk phrases. It is considered prudent to classify the Cr portion of the FGT Residues as N-R50/53.

Copper (Cu)

The ILO classifies cuprous oxide (Cu) as N-R50/53, but does not classify copper metal as hazardous. The EC classifies copper oxides as harmful, but not as N. Therefore the Cu portion of the FGT Residues is not classified as hazardous.

Nickel (Ni)

The ILO and the EC classify nickel monoxide (NiO) as toxic (T) but not N. The ILO classifies nickel metal as harmful. Therefore the Ni portion of the FGT Residues is not classified as hazardous.

Lead (Pb)

The EC classifies lead compounds as T and N-R50/53. The ILO does not classify lead metal as hazardous, the EC has not classified lead metal. Fischer Laboratories classifies lead metal as T and N-R50/53. Therefore the Pb portion of the FGT Residues is classified as N-R50/53.

Antimony (Sb)

The EC classifies antimony compounds as T and N-R50/53. The ILO has not classified antimony metal as hazardous. It is considered prudent to classify the Sb portion of the FGT Residues as N-R50/53.

Tin (Sn)

Neither the EC or the ILO has classified tin or its compounds as hazardous, and the Sn portion of the FGT Residues is therefore not classified as N.

Zinc (Zn)

The EC and the ILO have classified zinc oxide (ZnO) as N-R50/53. Zinc metal is not classified as N. It is considered prudent to classify the Zn portion of the FGT Residue as N-R50/53.

3.4.1 Basis for Classification

The EC Dangerous Preparations Directive 1999/45/EC gives the basis for classification of mixtures or preparations containing dangerous substances.

Table 2 Annex II Part B Concentration Limits to be used in the Evaluation of Health Hazards, Non-Gaseous Preparations, Acute Lethal Effects

Classification of the Substance	Classification of the Preparation		
	T^+	T	X_n
T^+ with R26, R27, R28	$C \geq 7\%$	$1\% \leq C < 7\%$	$0.1\% \leq C < 1\%$
T with R23, T24, T25		$C \geq 25\%$	$3\% \leq C < 25\%$
X_n with R20, R21, R22			$C \geq 25\%$

Table 3 Annex III Part B Concentration Limits to be used for the Evaluation of Environmental Hazards, Acute Aquatic Toxicity and Long-term Adverse

Classification of the Substance	Classification of the Preparation		
	N, R50-53	N, R51-53	R52-53
N, R50-53	$C_n \geq 25\%$	$2.5\% \leq C_n < 25\%$	$0.25\% \leq C_n < 2.5\%$
N, R51-53		$C_n \geq 25\%$	$2.5\% \leq C_n < 25\%$
N, R52-53			$C_n \geq 25\%$

3.4.1.1 Application to FGT Residues

On the basis of the above, the concentrations of metals classified as N with risk phrase R50/53 are as follows:

Table 4 Concentrations of Metals Classified as N with Risk Phrase R50/53

Substances	Classification	Concentration (mg/kg)
Cd	N-R50/53	300 - 500
Hg	N-R50/53	10 - 30
As	N-R50/53	40 - 100
Co	N-R50/53	5 - 20
Cr	N-R50/53	50 - 200
Pb	N-R50/53	4,000 - 10,000
Sb	N-R50/53	300 - 1,000
Zn	N-R50/53	20,000 - 30,000
Total		**24,705 - 41,850**

The total is equivalent to a concentration of 2.4705% to 4.1850%. Taking the minimum as 2.5% approximately, this results in classification of the mixture as N-R51/53.

3.5 Environment

3.5.1 Water

There will be no direct discharge to surface water of rainwater, sewage or process wastewater from the facility. Rainwater from roof areas and paved areas will be collected in an underground Surface Water Tank/Reservoir and will be used for recycling in the process water system. The reservoir will be designed with an overflow to the main combined sewer pipeline. The reservoir will be equipped with a monitoring station to continuously monitor pH-values. Ammonium hydroxide and diesel will be isolated from surface waters by primary containment (storage tanks), secondary containment (bunds) and tertiary containment (the facility's closed drainage system). In the event of a fire/emergency an automatic shutoff valve will prevent any discharge of firewater to the reservoir.

The area of interest comprises the Liffey estuary and Dublin Bay.

Dublin Bay is a shallow bay with water depths not greater than 20 m at low tide at its outer limit between Sorrento Point and Baily at Howth. The water depth decreases towards the harbour with depths of less than 5m occurring in the inner half of the Bay. North of the harbour at Bull Island and south around Sandymount extensive areas dry out at low tide.

The Liffey enters Dublin Bay between Clontarf and Ringsend in the channel formed by the North Bull Wall and the Great South Wall. The North Bull Wall is a natural bank reinforced by a stone embankment that is only inundated at half tide. It therefore holds back the water flowing out of the harbour at and after half ebb. The navigation channel runs close to the South Wall and extends from the Port area through the mouth of the harbour. This navigation channel is maintained at a depth of 7 to 8 metres below chart datum by dredging and natural scouring. To the north of this channel are extensive areas which dry out at low water. These mudflats extend from the mouth of the River Tolka almost to the end of the Bull Wall and north-eastwards to the Bull Island Causeway at St. Annes.

3.5.2 The Natural Environment – Land Based Flora and Fauna

Biosphere Environmental Services completed the terrestrial ecology assessment.

3.5.2.1 Habitats, Vegetation and Flora Around Site

The site is surrounded by developed land to the north, east and west. These areas include buildings, hard surfaces and some ground with a weedy vegetation (Recolonising bare ground). Some bare ground and spoil heaps also occurs to the south of the site, along with further recolonising bare ground. The Shellybanks Road skirts the western boundary of the site and associated with this is a line of planted sycamore trees and a strip of shrubbery.

The sycamore trees can be classified as a low **Treeline**. There is approximately 26 trees, all sycamore, which were planted along the eastern side of the Shellybanks Road. These are in the region of 7-8 m in height. A strip of shrubbery (**Ornamental/non-native shrub**) has been planted along the western side of the road. This is dense and predominantly of Escallonia (*Escallonia* spp.), with brambles and such species as butterfly bush. Some trees also occur, including cypress (*Cypressus* spp.), white poplar (*Populus alba*) and sycamore.

3.5.2.2 Fauna

Mammals, Amphibians and Reptiles

Brown rat *Rattus norvegicus* was the only mammal species recorded within the site.

House mouse *Mus domesticus* would also be expected, and probably the ubiquitous pygmy shrew *Sorex minutus*. The low number of species reflects the low diversity of habitats present.

Signs of fox *Vulpes vulpes* were found near the boundary fence of the Irishtown Nature Park and this species, which has a permanent presence in the port area, could pass through the site at times. Long-tailed field mouse *Apodemus sylvaticus* may also occur, and possibly rabbits *Oryctolagus cuniculus*. The site does not have suitable roost sites for bats.

The habitats on site or in the immediate vicinity are not suitable for amphibians such as the common frog *Rana temporaria* or for the common lizard *Lacerta vivepara*.

Birds

Few bird species occur within the site owing to the low diversity of habitats present. Only two species, wren *Troglodytes troglodytes* and dunnock *Prunella modularis*, were considered to nest within the site, and these were confined to the strip of vegetation along the southern and south-west boundary lines. Starlings *Sturnus vulgaris* and pied wagtail *Motacilla alba* were noted in the vicinity of the buildings on site and could breed in suitable holes or gaps within the buildings.

A small number of other species were recorded in the shrubbery along the Shellybanks Road, with robin *Erithacus rubecula*, blackbird *Turdus merula*, great tit *Parus major*, blue tit *Parus caerulea,* greenfinch *Carduelis chloris* and chaffinch *Fringilla coelebs* all nesting. A single reed bunting *Emberiza schoeniclus* was recorded in August in the rough vegetation to the south of the site and could nest locally. At least one pair of skylarks was present in the recently cleared ground south of the site. Other birds which nest in the general vicinity include woodpigeon *Columba palumbus*), jackdaws *Corvus monedula*, hooded crow *Corvus corone cornix* and magpie *Pica pica*.

A flock of c.30 linnets *Carduelis cannabina* was present on the rough ground to the south of the site in August, along with a small number of goldfinches *Carduelis carduelis*.

Recently planted grassland within the adjacent Ringsend Waste Water Treatment Works, and also to the south of it, supports brent geese *Branta bernicla horta* during winter. Gulls, mostly black-headed *Larus ridibundus*, are common in the vicinity of the Ringsend Waste Water Treatment Works during winter.

Irishtown Nature Park

The Irishtown Nature Park physically consists of an elevated central plateau of land, which slopes down to the sea on its southern side and is bounded on its northern edge by amenity grassland adjacent to the Ringsend Waste Water Treatment Works. Its eastern boundary contains a small area of sand dune in front of the main road whilst its western edge culminates in a path linking the Park with the road at Sandymount.

The vegetation and plant species present reflect the past use of the site together with its current management as a park and amenity area. Most of the southern side is under the influence of the sea and especially salt spray and this has allowed coastal vegetation to develop in places. As might be expected from the past use of the area and from the planting that has been carried out, there is little in the way of natural or semi-natural habitats to be found within the Park. The only piece, which has not been directly influenced in its development by humans, lies on the eastern side in the corner between the Park proper and the main road. Here a small area of sand dune occurs.

Over most of the Park a habitat of coarse grassland is found, which mostly corresponds to the category **Amenity Grassland**. Species such as perennial rye grass *Lolium perenne*, red fescue *Festuca rubra*, creeping bent *Agrostis stolonifera* and creeping thistle *Cirsium arvense* are present. Blackberry *Rubus fruticosus* is invading this in parts. Also invading this grassland are stretches of scrub consisting mostly of native species such as blackthorn *Prunus spinosa*, elder *Sambucus nigra* and ash *Fraxinus excelsior*. However, two exotic species, sycamore *Acer pseudoplatanus* and Japanese knotweed *Reynoutria japonica,* are acting invasively here. This habitat can be broadly accommodated within the category of **Scrub**.

Non-native, planted shrubs have formed a scrub of sorts, and includes escallonia

Escallonia macrantha, butterfly bush *Buddleja davidii*, field maple *Acer campestre* and 2 species of Cotoneaster. Trees are present in the form of evergreen oak *Quercus ilex,* sessile oak *Quercus petraea* and Italian alder *Alnus cordata*. This habitat is that of **Ornamental, non-native shrubs**.

The stony, rock and boulder-dominated areas adjacent to the sea, reflect the infilled nature of the area and the species cover is sparse and very scattered. Weedy species such as teasel, *Dipsacus fullonum,* mugwort *Artemisia vulgaris*, red valerian *Centranthus ruber* and common mallow *Malva sylvestris* are found here. This habitat can be included within **Buildings and artificial surfaces** and nearer the sea, the influence of salt spray has allowed the growth of a number of coastal species notably sea beet *Beta maritima* and sea mayweed *Matricaria maritima*.

The habitat **Re-colonizing bare ground** is common throughout and the principal species here is coltsfoot *Tussilago farfara* and hoary mustard *Hirschfeldia incana*.

In summary, the Park, whilst not of significant conservation importance, is rich in plant species as they have come from a number of sources.

3.5.3 The Natural Environment – Aquatic Flora and Fauna

Ecological Consultancy Services Ltd (EcoServe) were commissioned by M.C. O'Sullivan Ltd in 2003 to conduct a baseline marine and estuarine ecological study of the area.

3.5.3.1 Littoral Survey

Irishtown

The biotopes[3] along the shore were mapped in accordance with the procedures detailed by Davies *et al*. (2001) and Emblow *et al*. (1998) (refer to Figures 2-4). The survey, a total of 11 biotopes were recorded in the study area of Irishtown. These included five sediment and six hard or mixed substrata biotopes. Four core samples were taken in total.

Core 1 (C1) was taken in muddy sand towards the west of the study area. The presence of the cockle *Cerastoderma edule* and polychaetes allowed for a biotope code of LMS.PCer to be assigned indicating *Cerastoderma edul*e and polychaetes in fine sand or muddy sand shores. However, the polychaeta species recorded were not typical of this biotope.

Core 2 (C2) was taken in the sandier areas to the east of Core 1. Polychaetes and amphipods were recorded although species diversity and abundance was low, it was considered high enough to assign a biotope code of LGS.AP indicating burrowing amphipods and polychaetes to this site. However, it should be noted that this is not a good example of the biotope, primarily as the sand has a significant anoxic element just below the surface.

Core 3 (C3) was taken towards the eastern end of the study area near the start of the Bull Wall. Significant numbers of the bivalve *Angulus tenuis* were recorded. However, an absence of other significant fauna did not allow for the assignation of a lower biotope. A higher biotope of LGS was assigned indicating littoral gravels and sands.

Core 4 (C4) was taken from the sediments approximately half way along the Poolbeg peninsula where species abundance and diversity was again relatively low. A biotope code of LMU.HedMac was assigned using the principle of best fit. This indicates *Hediste diversicolor* and *Macoma balthica* in sandy mud shores.

A number of other sediment biotopes were observed during the study. On sandy areas above the high tide mark, the sand had no obvious infauna. Below areas of barren sand areas of decomposing drift algae occurred, supporting talitrid amphipods. The extreme north western corner of the site consisted of a black anoxic mud covered with a grey pink coloured sewage fungus. There were also smaller patches of sewage fungus along the stream running beside the rock armour.

Overall the sediment biotopes of the Irishtown area varied from mud to sandy mud in places through muddy sand to fine sand. Boundaries between the sediment types were frequent and indistinct and as such not possible to map clearly for this report.

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[3] A biotope is defined by the EU as a "small area with uniform biological conditions (climate, soil, altitude, etc.)." (http://ec.europa.eu/research/biosociety/library/glossarylist_en.cfm?Init=B)

An almost continuous band of "rock armour" stretched from the western end of the study area to the start of the Bull Wall to the east of the study area. The highest points of this were generally not intertidal and thus barren of marine life. They are shown on the map as "rock armour". The lower sections of this armour were colonised by various organisms and have been assigned biotopes. It should be noted that the hard substrata biotopes have become established on the rock armour itself and are such, in part, man-made habitats.

Two areas supported a biotope dominated by the channelled wrack *Pelvetia canaliculata*, and were assigned the biotope code SLR.Pel, indicating *P. canaliculata* on sheltered fringe rock. The areas supporting this biotope were an area at the western extreme of the study area and a significant length above the biotope SLR.Fves towards the centre of the study area. Other species present in this biotope included *Fucus spiralis* and *Enteromorpha* sp. SLR.Pel is found above the biotope SLR.Fspi.

An almost unbroken line of the biotope SLR.Fpi indicating Fucus spiralis on moderately exposed to very sheltered upper eulittoral rock, was recorded along the rock armour. The biotope was dominated by growths of *Fucus spiralis*, recorded as common, and also by the ephemeral green algae *Enteromorpha* sp. The barnacles *Semibalanus balanoides* were recorded frequently as was the periwinkle *Littorina saxatilis*. The small gastropod *Hydrobia* sp. was also present in high numbers. While much of the length of this biotope was considered a good example of SLR.Fspi, there was an area on the corner about half way along the study area where the principle of best fit was applied. *F. spiralis* was sparse but was still the dominant algae present.

Two similar biotopes formed an almost continuous band below SLR.Fspi along the length of the rock armour where the stream flowed. SLR.Asc characterised by the seaweed *Ascophyllum nodosum* on very sheltered mid eulittoral rock dominated much of the western end of the study area. Whilst SLR.Fves characterised by the seaweed *Fucus vesiculosus* on sheltered mid eulittoral rock dominated the eastern side and an area in the northwest corner of the site. SLR.Asc was dominated by *A. nodosum* but also contained other brown seaweeds *F. spiralis*, *F. vesiculosus*, the green seaweed *Enteromorpha* sp., barnacles *Semibalanus balanoides*, mussels *Mytilus edulis*, sea anemones *Actinia equine* and amphipods. The epiphytic red algae *Polysiphonia lanosa* was present on the *A. nodosum*. SLR.Fves was dominated by the fucoid *Fucus vesiculosus* and also contained *Enteromorpha* sp., *A. nodosum*, *Ulva* sp., the periwinkle *Littorina littorea*, amphipods, the crab *Carcinus maenas* and *Mytilus edulis*.

Below the combined line of SLR.Asc and SLR.Fves towards the edge of the stream that runs along much of the study area, there was a continuous if at times narrow line of *Enteromorpha* sp. This was assigned a biotope code of SLR.EphX indicating ephemeral green and red seaweeds on variable salinity or disturbed eulittoral mixed substrata. There were a number of gravely / cobble areas scattered on the sediment biotopes. This slightly more stable substrata allowed for the growth of ephemeral algae such as *Enteromorpha* sp. and was also assigned a biotope code of SLR.EphX. The stream itself did not comprise a distinct biotope. However, cobbles contained within the stream supported growths of the red algae including *Ceramium* sp. One area of about 50 m on the beach side of the stream supported a narrow band of the sand mason *Lanice conchilega*. This was assigned a biotope code of LGS.Lan indicating dense *Lanice conchilega* in tide swept lower shore sand.

Along the western end of the rock armour away from the stream, the substrata was more exposed and dry. The dominant seaweeds along this area were the ephemeral algae *Enteromorpha* sp. and *Porphyra* sp. although both were sparse. Other species recorded as present included *Fucus spiralis*, *Fucus vesiculosus* and *Semibalanus balanoides*. A biotope code of MLR.EntPor was assigned indicating *Porphyra purpurea* or *Enteromorpha* spp. on sand scoured mid or lower eulittoral rock.

Liffey Estuary

The two littoral sites examined in the Liffey estuary were structures away from the actual shoreline and were hard substratum sites. A species list was taken for each site, which was also subdivided into obvious zones although a full biotope map was not produced.

Site La was located on a combined wooden and metal structure immediately downstream of the Ringsend Power Station. There were a number of obvious zones recorded. Reasonable water clarity allowed for the identification of abundant plumose anemones *Metridium senile* and red algae just below the surface, forming a distinct band below the low water mark to about 20 cm below. The zone immediately above this, extending above the low water mark was dominated by superabundant mussels *Mytilus edulis* covered with growths of hydroids, and barnacles *Semibalanus balanoides*. The ephemeral green algae *Enteromorpha* sp. and Ulva sp. were also present. A second littoral zone was dominated by healthy growths of the fucoids *Fucus spiralis* (frequent), *Fucus ceranoides* and *Fucus serratus* (both present) and a red algae in poor condition. A single crab *Cancer pagurus* was observed in a hollow. The flora and fauna of the lower littoral zone all extended up into the upper zone. There was a zone of green algae higher up the structure that corresponds to the splash zone.

Site Lb was located on a block structure downstream of the container facility on the south side of the estuary. Below the low watermark to about 20 cm, abundant red algae were observed, together with sessile fauna that were possibly tunicates. The zone extending up from the low water mark was dominated by bryozoan crusts and barnacles which were abundant, the occasional limpet *Patella vulgata*, and algae *Fucus serratus*, *Porphyra* sp., *Enteromorpha* sp. and *Ulva* sp., all of which were recorded as present. The zone above this was also dominated by algal species. *Fucus spiralis* was recorded as common, *Fucus ceranoides* was present, *Enteromorpha* sp. and *Porphyra* sp. were common. Barnacles were abundant beneath the algae. A number of isopods were also observed. Thin hydroid growths were recorded.

Tolka Estuary

Three of the four littoral sites within the Tolka estuary were low in both species diversity and abundance. Only one polychaeta or polychaeta fragment was recorded from each of the sites Lc, Ld and Le. This is only sufficient to assign a more general biotope. The biotope code of LMU.Mu was assigned to each of these sites, and indicates soft mud shores.

Site Lf on the Clontarf (north) side of the estuary recorded significant numbers of both the

ragworm *Hediste diversicolor* and the bivalve *Scrobicularia plana*. A biotope code of LMU.HedScr was assigned indicating *Hediste diversicolor* and *Scrobicularia plana* in reduced salinity mud shores.

The edge of the estuary on the south side was dominated by growths of the knotted wrack

Ascophyllum nodosum where the substratum was coarse boulders and rubble. The ephemeral algae *Porphyra* sp. and *Enteromorpha* sp. were also present. The smoother surfaces were dominated by ephemeral algae or by fucoids. The hard substrata upper shore on the north side was also dominated by *Ascophyllum nodosum* with occasional growths of the channelled wrack *Pelvetia canaliculata*, *Fucus vesiculosus* and ephemeral green algae.

Dollymount Strand

The transect down the fine sandy beach of Dollymount Strand on Bull Island was divided into three biotopes. Site Lg on the upper shore did not contain any fauna and was assigned the biotope of LGS.BarSnd indicating barren sand.

Site Lh on the mid shore contained a number of polychaeta species including the catworm *Nephtys* sp. and the spionid *Scolelepis squamata*, and a single bivalve *Angulus tenuis*.

While species abundance was low and no amphipods were recorded, a biotope code of LGS.AP was assigned indicating burrowing amphipods and polychaetes in clean sand.

Site Li on the lower shore contained significant numbers of the bivalve *Angulus tenuis*, a single amphipod *Bathyporeia* sp. and two polychaeta species, *Nephtys* sp. and *Magelona* provide an exact fit for this biotope, the presence in significant numbers of *Angulus tenuis* in particular allows for its assignation.

Sutton Area

The shallow, coarse, mobile sand of site Lj was found to contain only one crab, *Carcinus maenas*. The sediment had a patchy distribution around bedrock outcrops. The bedrock outcrops supported thick growths of the knotted wrack *Ascophyllum nodosum*, together with the fucoids *Fucus serratus*, Fucus vesiculosus and *Fucus spiralis*. The ephemeral green algae *Ulva* sp. and *Enteromorpha* sp. were also recorded. Fauna included abundant barnacles, together with the limpet *Patella vulgata* and the mussel *Mytilus edulis*. The dog whelk *Nucella lapillus* was also recorded.

Overall

None of the species or biotopes recorded during the survey was of specific nature conservation importance or interest. All the species, biotopes and habitats recorded are typical of the east coast of Ireland (Picton & Costello, 1998).

3.6 External Factors Contributing to a Major Accident

3.6.1 Neighbouring Facilities

The proposed facility is to be located on the reclaimed lands of the Poolbeg Peninsula in the administrative area of Dublin City Council.

The area surrounding the proposed Dublin WtE facility is mainly industrial in character, primarily consisting of port related activities such as freight storage, power generation and wastewater treatment. Across the Liffey Estuary, the North Dockland area includes a number of ferry terminals. Residential areas in closest proximity to the site are Irishtown, Ringsend and Sandymount.

The Seveso sites in the port area include:

Table 5 Seveso Sites in the Dublin Port

Company	Industrial Activity
North Port	
CalorGas	LPG storage and filling depot
Minchem	Waste handling and blending facility
Albion Chemical Distribution (Irl) Ltd	Chlorine gas cylinder and drum storage
Irish Shell, Statoil, Esso and Tedcastle	Bulk oil storage
South Port	
Poolbeg ESB Generating Station	Electricity generation
Synergen Dublin Bay Power Plant	Electricity generation

The planning authority must seek technical advice from the Health and Safety Authority (HSA) in assessing planning applications for certain categories of developments where they are to be located within the consultation distance of an industrial facility. SI No 600 of 2001 stipulates consultation distances for certain types of industrial facilities. The consultation distance for non-pressurised bulk storage of flammable materials is 300 m from the site perimeter.

The site of the proposed waste to energy facility lies outside the consultation distance (as specified in SI No 600 of 2001) for all the facilities in the North Port. It lies within the consultation distance of the Synergen Dublin Bay Power Plant (refer to Figure 5).

3.6.2 Earthquake

The risk of earthquakes in the area is very low. "The whole of Ireland is practically free of earthquakes."[4] Should an earthquake occur, this could cause a major accident through loss of

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[4] Seismicity and Earthquake Hazard in the UK, Roger Musson (British Geological Survey)

containment of diesel or ammonium hydroxide at the facility. The consequences of these scenarios are reported in section 5.

3.6.3 Aircraft Impact

Dublin Airport is located approximately 9 km to the Northwest. The facility is not under a normal flight path to or from the airport. Some overflying might occur in unusual weather conditions, or if the main runway is out of use.

The Canvey Report (1978) presents data on accidents involving aircraft and helicopters. These data show a frequency of about 1×10^{-6} for impact from an aircraft for a 3 km² site. Canvey Island is about 10 km from the airport at Southend-on-Sea, 50 km from Stansted Airport, and about 75 km each from Heathrow, Gatwick and Luton Airports.

The proposed facility has a site area of 5.5 hectares (0.055 km²). On the basis of site area alone, the probability of the proposed facility being hit by a falling aircraft is $1 \times 10^{-6} \times (0.055/3) = 1.83 \times 10^{-8}$.

The site is not in a normal flight path and the density of air traffic is much less than that in the southeast of England.

Dublin Port Company advises that there is currently 1 helicopter landing site in the Port area, located at Molloy & Sherry on Bond Road in the north Port. This is approximately 2km from the site. As the majority of helicopter crashes happen within 200 m of the takeoff/landing site, the risk of impact of a helicopter on the site of the proposed WtE facility is considered negligible.

3.6.4 Subsidence

The facility is built on reclaimed land, i.e. made ground. However, this has been well compacted, and the facility is to be piled. It is not expected that subsidence will occur, and if it does, it would be of such a limited nature that it would not be expected to result in a major accident at the facility.

3.6.5 Tide Level

Currently the site level varies from about 5mOD Malin in the northern part to about 3.5mOD Malin in the southern part. Various options in relation to site level and ground floor level for the process lines were considered. In order to minimize the amount of excavation required to construct the bunker and balance the amount of soils to be excavated and filled, an optimum site level of about 5mOD Malin was chosen. This also ensures that the site is safe from risk of flooding as it is at least 1 m above the 1/200 year predicted flood level for Dublin (3.4 m Malin AOD[5]).

Following the IPCC 2001 Climate Change Report a value of 480 mm was taken as the design standard for sea level rise in the Dublin area by 2100. However this figure is now under review and a value of 900 mm for sea level rise by 2100 is being use for some recent developments.

Assuming a value of 0.9 m for sea level rise then the 1 in 200 year event in 2100 would have a value of 4.3m OD Malin. The proposed site level is about 5mOD Malin, and therefore the risk from flooding is extremely remote.

[5] Greater Dublin Strategic Drainage Study, Regional Drainage Policies Vol 5 Climate Change. Dublin City Council, March 2005

4. SAFETY MANAGEMENT SYSTEM

As part of this facility, the operator will implement an environmental management system and safety management system accredited to ISO 14001 and OHSAS 1800.

The operator will obtain independent accreditation to the OHSAS 18001:2004, the international standard for safety management systems.

The main features of the safety management system are to set goals and targets and to have standard operating procedures, staff training, audits, annual report etc.

4.1 Outline of System

The following issues will be covered in the Dublin WtE facility's Safety Management System:

- Organisation and personnel: the roles and responsibilities of personnel involved in the management of major hazards at all levels in the organisation. The identification of training needs of such personnel and the provision of the training so identified. The involvement of employees and, where appropriate, subcontractors.
- Identification and evaluation of major hazards: adoption and implementation of procedures for systematically identifying major hazards arising from normal and abnormal operation and the assessment of their likelihood and severity.
- Operational control: adoption and implementation of procedures and instructions for safe operation, including maintenance of plant, processes, equipment and temporary stoppages.
- Management of change: adoption and implementation of procedures for planning modifications to, or the design of new installations, processes or storage facilities.
- Planning for emergencies: adoption and implementation of procedures to identify foreseeable emergencies by systematic analysis and to prepare, test and review emergency plans to respond to such emergencies.
- Monitoring performance: adoption and implementation of procedures for the ongoing assessment of compliance with the objectives set by the operator's Major-Accident Prevention Policy and Safety Management System, and the mechanisms for investigation and taking corrective action in case of non-compliance. The procedures will cover the operator's system for reporting major accidents of near misses, particularly those involving failure of protective measures, and their investigation and follow-up on the basis of lessons learnt.
- Audit and review: adoption and implementation of procedures for periodic systematic assessment of the major-accident prevention policy and the effectiveness and suitability of the safety management system; the documented review of performance of the policy and safety management system and its updating by senior management.
- Means for prevention, detection, isolation and mitigation of the effects of potential major accidents will be covered by emergency plans (adoption and implementation of procedures to identify foreseeable emergencies).

4.2 Safety Training and Procedures

The operations staff will undergo training in safety procedures. The safety training includes the following WtE specific training:

a) Training and education course in Denmark to obtain competence within working safety specific for WtE facilities

b) Fire fighting including fire fighting with breathing apparatus

c) First aid treatment

d) Emergency evacuation procedures

e) Training in plant start up and shutdown procedures

f) Training in safety plans for maintenance periods

g) Training/education from specific equipment and material suppliers to the facility.

In addition the staff will be trained and educated in the following standard items relating to power plants in general.

a) Marking and closing of work areas

b) Securing of plant before work is initiated

c) Earthing of motors and transformers

d) Work in containers, tanks and on platforms

e) Inspection of movable hoisting tackles and hangers

f) Inspection of electrical manual tools and extension cords

g) Inspection of grinding machines and grinding wheels

h) Inspection of battery system

i) Inspection of measuring instruments for personal safety

4.3 Fire Safety Systems

4.3.1 General

Fire safety will be of key importance in the design, construction and operation of the plant.

This will be ensured by the following key measures:

- The plant will be designed by experienced and skilled staff to internationally recognised design codes and standards. This will use the competences of Elsam Engineering which has long term design experience of WtE facilities combined with a local fire consultant who will be able to provide services in connection with relevant guidance and fire safety standards.
- Hazard and operability studies will be undertaken of operating equipment and procedures.
- The following fire prevention measures will be implemented in the facility:
  - a) In the waste bunker a foam suppression system will be established. There is an established track record with using a foam system for the bunker area.
  - b) A pressurised fire hydrant system will be established to comply with the relevant standards and applicable technical guidelines.
- The main building will be divided into fire compartments. At present the following individual fire compartments are anticipated:
  - a) Ramp, reception hall and waste bunker
  - b) Boiler house and flue gas treatment area
  - c) Turbine area
  - d) Rooms for electrical equipment
  - e) Area for handling and storage of equipment
  - f) Administration and Service area

At penetrations of fire compartment walls special precautions will be taken, such as fire stopping of pipes and cables, water curtains or sprinkler systems at the primary air intake in the waste bunker and in the duct for the bottom ash conveyor.

- On the site and inside all the process buildings fire hydrants will be located. On the hopper deck in the waste bunker the fire hydrant and foam systems will be located to be able to control a fire in the waste bunker. Furthermore, hand-operated fire extinguishers will be located at strategic locations in the facility.

4.3.2 Firewater Retention

The storm water drainage system of the facility is connected to an internal storm water tank where the water is collected for reuse in the process. The water tank is, however, equipped with an overflow option, which overflows to the combined sewer pipeline. The automatic shut-off valve prevents discharge to the tank and diverts firewater to the waste bunker.

Should a fire occur, firewater would be collected in the drainage system and transferred to the storm water storage tank. If the storm water tank reaches capacity, firewater will overflow to the waste bunker, which will act as a firewater retention tank.

The waste bunker has a capacity of approximately 65,000 m^3. The area may be partially filled with waste, but as the waste can absorb a significant amount of water it is estimated that significant volumes of firewater can be retained in the bunker. The density of the waste is approximately 750 kg/m^3. The firewater retention capacity of the waste bunker is thus approximately 25% of the total bunker capacity.

5. MAJOR ACCIDENTS

5.1 Major Accident Scenarios

The following major accident hazards have been identified:

- Diesel bund fire
- LPG BLEVE (Boiling Liquid Expanding Vapour Explosion)
- Loss of containment of LPG leading to a fireball
- Failure of flue gas treatment equipment
- Loss of containment of FGT residues
- Loss of containment of ammonium hydroxide
- Loss of containment of biocide
- Fire in waste bunker
- Loss of containment of firewater

5.2 Qualitative Assessment of the Consequences of Major Accidents

5.2.1 Diesel Bund Fire

A fire in the diesel bund could result from the loss of containment of diesel into the bund through pipe/tank leakage, rupture of a hose connection from a road tanker wagon or through catastrophic rupture of a tank and subsequent ignition of the material in the bund.

A bund fire could escalate to other parts of the facility.

On release to the environment the lighter components of gas oil will generally evaporate and be photooxidised by reaction with OH radicals[6]. Depending on the circumstances, the remainder may become dispersed in the water column or adsorbed to soil or sediment. Higher molecular weight components may also be subject to photooxidation. On release into water, gas oils will tend to float on the surface and spread out; the components are generally poorly soluble in water, but the most soluble will dissolve and be dispersed.

No data are available on the behaviour of gas oils in standard tests for biodegradability. Although a gas oil would not be expected to be "readily biodegradable" as defined by OECD guideline tests, most of the hydrocarbon species present are known to be degraded by micro-organisms; in a modified Sturm test (OECD method 301B) approximately 40% biodegradation was recorded over 28 days.

The aquatic toxicity data on gas oils indicates that acute $LL_{50}/EL_{50}/IL_{50}$ values for aquatic organisms are in the range 1 to 100 mg/l. However there is little available data generated using accepted protocols for oil products and the current database should be interpreted with caution.

5.2.2 LPG BLEVE

An LPG bottle battery will be provided for the ignition of the oil-fired burners. The LPG system will be used for start-up of the oil burners. The LPG system will therefore, during normal operation, be in use for 10 seconds approximately 20 times per year. The location and design of the bottle battery will be in accordance with all relevant Irish codes and standards.

A BLEVE (Boiling Liquid Expanding Vapour Explosion)/Fireball) involving one or more of the LPG cylinders could occur in the event of a fire. Such an event would result in a fireball and generation of projectiles from the ruptured cylinder.

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[6] CONCAWE (1996) *Gas oils (diesel fuels/heating oils)* product dossier no. 95/107

Another major accident scenario is leakage of LPG from a cylinder or the piping system, which would form a flammable or explosive cloud of gas. Ignition of such a cloud would cause a vapour cloud explosion (VCE). A VCE would generate overpressures and possibly cause damage to plant and equipment.

5.2.3 Failure of Flue Gas Treatment Equipment

This scenario envisages the failure of the flue gas treatment equipment and emission of untreated gases for a short period.

Air dispersion modelling was carried out using the United States Environmental Protection Agency's (USEPA) regulatory model AERMOD. The aim of the study was to assess the impact in the ambient environment of emissions from the facility under typical conditions and at the emission limits outlined in Council Directive 2000/76/EC. Modelling was also conducted under abnormal operating conditions to assess any short-term impact due to these infrequent events. Abnormal operating conditions refer to short-term periods in which the limits detailed in EU Directive 2000/76/EC are exceeded.

The study demonstrates that all substances which will be emitted from the proposed facility will be at levels that are well below even the most stringent ambient air quality standards and guidelines. The study constitutes a full cumulative assessment of significant releases from the site taking into account the releases from all other significant industry in the area.

Currently, no internationally recognised ambient air quality concentration or deposition standards exist for PCDD/PCDFs (Dioxins/Furans). Modelled total dioxin particulate deposition flux indicates that deposition levels under typical, maximum and abnormal operations will also be significantly less than that experienced in urban background locations.

5.2.4 Loss of containment of FGT Residues

FGT residues will be stored in enclosed silos equipped with HEPA filters which will be located inside the main process building. In the unlikely event of loss of containment, the FGT residues would spill to ground within the building.

The residues would be contained within the building, which is totally contained at ground level. Some residue might be entrained in the air and be extracted from the building by the ventilation system. It is not credible that residues would enter surface waters.

5.2.5 Loss of Containment of Ammonium Hydroxide

Loss of containment of ammonium hydroxide could occur from either of the two storage tanks proposed for location within the facility. In the unlikely event of the failure of a storage tank or leakage from a pipe flange or valve ammonia vapour would be released from the surface of the released material, and would be extracted from the building by the extract fans. Ammonia odour might be detectable outside the site boundary.

5.2.6 Loss of Containment of Biocides

Biocide (sodium hypochlorite, i.e. household bleach) will be used for treating cooling water pipes. This material will be stored in a bulk container in a bunded area within the facility. Any leaks from the bulk tank will be retained in the bunded area, and are not likely to give rise to any risk to human health or the environment.

The biocide will be dosed to the cooling water. A conservative dosage plan has been assumed, i.e. that the dosage of biocide takes place 2 hours per day, but at a higher dosage level than 0.2 - 0.4 mg/l. The required dosage during winter time will be lower. Dosing will be by means of a metering pump and small diameter pipe. Failure of the dosing control system could result in continued pumping of biocide to the cooling water. The impact on the environment of continuous dosing of biocide would be local to the proposed cooling water outfall, and could include some diminution in population of aquatic organisms.

5.2.7 Fire in Waste Bunker

A fire in the waste bunker could be caused by, for example, hot ashes igniting combustible materials in the bunker. Contamination of surface water offsite would be prevented by the containment of firewater runoff. Waste will be contained in a bunker with dimensions 75 m x 25 m x 35 m, i.e. a gross volume of approximately 65,000 m^3. Fires would be automatically extinguished using water or foam. The area may be partially filled with waste, but as the waste will absorb a significant amount of water, it is estimated that significant volumes of firewater will be retained in the bunker.

In a fire event, smoke would be vented from the building through the smoke vents. Hot smoke rises, and therefore it is not likely that such smoke would descend to ground level within the immediate vicinity of the facility. Dispersion and dilution of the smoke would occur before it descends to ground level, some distance from the facility.

5.3 Quantitative Assessment of the Consequences of Major Accidents

5.3.1 Major Accident Scenarios Modelled

Modelling was carried out for the following scenarios:

- Catastrophic rupture of the diesel bulk tank
  - retention of 100% of tank contents within the bund, heat effects
  - overtopping by 63% of tank contents, heat effects
- LPG BLEVE heat and explosion effects
- LPG fireball
- Catastrophic rupture of the ammonium hydroxide bulk tank
  - retention of 100% of tank contents within the bund, dispersion of vapour
  - overtopping by 68% of tank contents, dispersion of vapour
- Abnormal emissions due to failure of flue gas treatment equipment

Fire in the waste bunker was not modelled as this scenario is not unique to the proposed facility. Modelling of the loss of containment of FGT residues was not considered necessary as most residues would be contained within the building.

5.3.2 Software

The models used were the DNV Technica package PHAST v 6.42 for fires and explosions and Aermod for abnormal emissions.

5.3.3 Materials

DNV Technica supplied the data for diesel oil.

In order to model the vaporisation of ammonia from the ammonium hydroxide liquid surface, a 25:75 ammonia/water mixture was created.

5.3.4 Meteorological Conditions

As the western side of the building will be open to allow truck access (open surface area will be approximately 480 m^2) the major accident hazard scenarios have been modelled as outdoor events.

All scenarios were modelled under 3 weather conditions recommended by DNV as representative of weather conditions in Ireland:

Table 6 Weather Conditions used in Model

Windspeed (m/s)	Pasquill (Atmospheric) Stability Category
1.5	F
1.5	D
5	D

5.3.5 Heat Effects

The model was used to predict the distances to specified thermal radiation levels as follows:

Table 7 Health and Safety Authority (HSA) Thermal Radiation Benchmarks for Land Use Planning

Fatality Risk (%)	TDU*	Thermal Radiation (kW/m^2)	Observed Effect	Zone
50	1,800	29.22	50% fatality risk	Inner Zone
1	1,000	18.8	1% fatality risk	Middle Zone
0	500	11.2	Threshold of fatality for vulnerable persons	Outer Zone

* Thermal dose units:

TDU = $(kW/m^2)^{4/3}.t$

t = exposure time = 20 sec

The maximum recommended thermal radiation levels recommended by the Institute of Petroleum (*Liquefied Petroleum Gas: Volume 1: Large Bulk Pressure Storage and Refrigerated LPG: Model Code of Safe Practice Part 9*, Table 1) are:

Table 8 Maximum Recommended Thermal Radiation Levels Recommended by the Institute of Petroleum

Site (Receptor)	Maximum Thermal Radiation Level (kW/m²)
The outer surfaces of adjacent pressure storage vessels:	
Thermally protected	44
Unprotected	8
The outer surfaces of adjacent storage tanks containing flammable products and process facilities:	
Thermally protected	32
Unprotected	8
Filling/discharge points	8
Personnel inside boundary:	
Process area	8
Protected work area	8
Work area	5
Critical area	1.5
Plant boundary:	
Remote area	13
Urban area	5
Critical area	1.5

5.3.6 Explosion Effects

The model was also used to predict distances to the following overpressures:

Table 9 Overpressures Modelled

Overpressure (barG)	Overpressure (psig)	Effect
0.0207	0.3	"Safe distance" (probability 0.95 no serious damage beyond this value); projectile limit; some damage to house ceilings; 10% window glass broken
0.14	2	Partial collapse of walls and roofs of houses
0.21	3	Heavy machines (3,000lb) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations

5.3.7 Ammonia Vapour Dispersion End Points

The releases of ammonium hydroxide were modelled to determine the distance to reach the concentrations shown in the table below:

Table 10 Ammonia Vapour Dispersion End Points

Source	Parameter	Averaging Time[7]	Concentration (ppm)
AIHA	ERPG3	1 hour	750
AIHA	ERPG2	1 hour	150
AIHA	ERPG1	1 hour	25
Various	Odour Threshold	1 hour	Reported values vary widely; 0.6 to 53 ppm; geometric mean: 17 ppm (detection)

The parameters are defined as follows:

Table 11 Air Quality Parameter Definitions

Parameter	Meaning
ERPG3 (Emergency Response Planning Guidelines)	The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.
ERPG2	The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.
ERPG1	The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild, transient adverse health effects or without perceiving a clearly defined objectionable odour.
OT (Odour Threshold)	Concentration in air that can be (a) detected or (b) recognised by defined percentage of population

5.3.8 Results

The summary results for the various scenarios are outlined below. In all cases the worst case scenarios have been presented i.e. the weather conditions which produced the greatest downwind distances to specified thermal effects.

Modelling results are depicted graphically in Figures 6 – 13.

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[7] The Averaging Time is to take into account the effects of changes in the wind direction over the course of the release. These changes cause the plume to meander from side to side, and reduce the concentration experienced at a given point below the full, centreline concentration. The average concentration you received at a given point over, say, 5 minutes will be much less than the peak concentration; at the same location for 30 minutes, the average would be lower still. This factoring down of the peak concentration is carried out in the model by the Averaging Time Adjustment—the longer the time window, or Averaging Time, the lower the calculated average concentration will be.

Table 12 Distances to Incident Radiation Levels

Major Accident	Distances (m) to Specified Heat Levels		
	29.22 kW/m²	18.8 kW/m²	11.2 kW/m²
Diesel bund fire	9	16	24
Diesel unbunded fire	Not reached	52	60
LPG BLEVE	78	99	129

Table 13 Distances to Overpressures

Major Accident	Distances (m) to Specified Overpressures		
	0.0207 barG	0.14 barG	0.21 barG
Diesel bund fire	No hazard	No hazard	No hazard
Diesel unbunded fire	No hazard	No hazard	No hazard
LPG BLEVE	133	34	26

Table 14 Distances to Air Quality Parameter Concentrations

End Point	Distance (m) to Specified Concentrations	
	100% Ammonium Hydroxide Retained in Bund	68% Ammonium Hydroxide Overtops Bund
ERPG 3	668	585
ERPG 2	17,469	13,757
ERPG 1	>50,000	45,911
Odour Threshold	>50,000	>50,000

5.4 Bund Overtopping Modelling

Bunds are designed to contain a leakage of hazardous material from the primary containment unit. However, most bunds will not contain the entire tank inventory for a catastrophic loss of containment event. A number of correlations have been developed for the potential overtopping of the bund wall following the catastrophic rupture of a storage tank.

HSE CRR 324/2001[8], prepared by WS Atkins gives (Appendix E) correlations for calculating bund overtopping. The correlations imply overtopping in all cases where the height of the bund wall is less than the height of the tank:

$$Q = e^{-3.8898(h/H)}$$

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[8] HSE Contracts Research Report 324/2001

where:

Q - fraction of the tank contents that will overtop the bund wall

h = bund wall height

H = tank height.

Clark et al in HSE Research Report No 333 prepared by Liverpool John Moores University (LJMU)[9]

$Q_C = \exp[-p \times (h/H)]$

Where p = 3.89 for θ, bund angle = 90º

Thyer, Hirst & Jagger (2002)[10]

$Q = A + B \times \ln(h/H) + C \times \ln(r/H)$

Where A, B and C are: 0.044, -0.264 and –0.116 for θ, bund angle = 90º and r = bund radius

HSE Research Report 333

$Q = A \times \exp[-B \times (h/H)]$

With values for A and B depending on tank type and bund capacity.

LJMU performed a number of laboratory scale experiments on bund overtopping due to catastrophic tank failure. For the diesel tank h/H = 0.12. For the ammonium hydroxide tank h/H = 0.10. The results of the LJMU experiments for h/H = 0.10 and the overtopping fraction predicted for diesel and ammonium hydroxide tanks are as follows (110% nominal bund capacity):

Table 15 Predicted Bund Overtopping Fractions Using Published Correlations

	Q	Q_C	Q_H	Q_{WS}
LJMU	0.70	0.68	0.59	-
Diesel tank	-	0.63	0.63	0.63
Ammonium hydroxide tank	-	0.68	0.67	0.68

Q is the measured overtopping fraction. Q_C and Q_H are the overtopping fractions predicted using the correlations of Clark and Hirst respectively. Q_{WS} is the overtopping fraction predicted using $Q = e^{-3.8898(h/H)}$ (HSE CRR 324/2001).

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9 HSE (2005) *An experimental investigation of bund wall overtopping and dynamic pressures on the bund wall following catastrophic failure of a storage vessel*, Prepared by Liverpool John Moores University for the Health and Safety Executive 2005, Research Report No 333

10 Thyer, A.M., Hirst, I.L. & Jagger, S.F. (2002) *Bund overtopping - the consequence of catastrophic tank failure*, Journal of Loss Prevention in the Process Industries, vol. 15, no. 5, pp. 357-363 (7)

6. PREVENTION AND MITIGATION OF ACCIDENTS

6.1 Prevention Measures

6.1.1 Diesel Bund Fire

Diesel oil has a relatively high flash point (>52°C) i.e. a flammable air/vapour mixture would not be formed above the liquid surface at ambient temperatures.

All tanks at the facility will be designed to internationally recognised standards.

Transfer of diesel to the storage tanks will take place in the bund as per Standard Operating Procedure (SOP). Tank valves will be located within the bund. Regular visual inspection of the bund will take place for leaks.

The building drainage system is a closed or contained system. Therefore contamination of surface water from loss of containment of diesel will be prevented.

In the event of loss of containment, and failure of the bund, a spill of diesel oil would be contained within the building as the building and the isolated drainage system act as tertiary containment.

6.1.2 LPG BLEVE (Boiling Liquid Expanding Vapour Explosion)

The automatic fire suppression system would extinguish small fires, and engulfment of the LPG cylinders in a fire is highly unlikely.

The LPG cylinders will be deigned to internationally recognized standards. They will be protected by barriers from mechanical damage due to impact.

6.1.3 Failure of Flue Gas Treatment Equipment

Failure of the FGT treatment equipment will be prevented through the monitoring and maintenance programme, as well as a system of instrumentation and automatic response.

6.1.4 Loss of Containment of FGT Residues

FGT residues will be transported in sealed, road tanker wagons suitable for transport of such products.

FGT silos will be equipped with HEPA filters to prevent fugitive emissions.

6.1.5 Loss of Containment of Ammonium Hydroxide

Ammonium hydroxide storage tanks will be designed to internationally recognised standards. The tanks will be located in a bunded area. The bund would limit the surface area from which ammonia could evaporate.

6.1.6 Loss of Containment of Biocides

Biocide for cooling water treatment will be stored in a bulk container in the facility. The biocide bulk storage tank will be designed to internationally recognised standards. It will be located in a bund of capacity at least 110% of the tank volume. Small leaks and total loss of inventory will be retained by the bund wall.

Continuous dosing of biocide will be prevented by a stand-alone independent dosage monitoring system that will indicate an alarm if pre-set dosage limits are exceeded.

6.1.7 Fire in Waste Bunker

The plant will be designed by experienced and skilled staff (both Elsam staff and a local consultant) to internationally recognised design codes and standards. HAZOP studies will be undertaken of the facility's equipment and procedures.

6.2 Mitigation Measures

6.2.1 Diesel Bund Fire

The heat effects of a diesel bund fire on the surrounding environment would be mitigated by the fact that the bund will be enclosed in the building.

6.2.2 LPG BLEVE (Boiling Liquid Expanding Vapour Explosion)

The effects of explosion overpressure on the surrounding environment would be mitigated by the location of the tanks within the building. Explosions of the scale possible from an LPG cylinder battery would be partially attenuated by the building and directed to a safe location.

6.2.3 Loss of Containment of LPG Leading to a Fireball

Gas detection will be provided for the LPG battery. The area will be well ventilated to prevent the accumulation of vapours in the event of leakage.

6.2.4 Failure of Flue Gas Treatment Equipment

In the event of failure of flue gas treatment equipment an alarm would sound and the system shut down as fast as is consistent with safe practice.

6.2.5 Loss of Containment of FGT Residues

In the event of loss of containment of FGT residues, Workplace Safety Instructions would be followed. These Instructions provide the following information with regard to FGT residues:

- Composition/facts on constituents
- Risk identification
- First aid instructions
- Fire extinguishing
- Precautions by accidental discharge
- Handling and storage
- Exposure control/personal safety equipment
- General and chemical characteristics
- Stability and reactivity
- Toxicological information
- Environmental information
- Disposal
- Transport information
- Information concerning regulations
- General information/applications

6.2.6 Loss of Containment of Ammonium Hydroxide

Ammonium hydroxide will be isolated from surface waters by primary containment (storage tanks), secondary containment (bund) and tertiary containment (the facility's closed drainage system).

6.2.7 Loss of Containment of Biocides

In the event of failure of the bund wall, any spills will be retained in the storm water retention tank.

6.2.8 Fire in Waste Bunker

An "Emergency Procedure Strategy" or "EPS", incorporating the requirements identified in a Hazard and Operability (HAZOP) assessment for the facility, will be prepared. The EPS shall ensure that resources are available to respond to emergencies at all times during the operational period and that suitably qualified personnel will be available at all times to manage the response of the emergency services.

The waste storage bunker would provide capacity to store approximately 16,250 m³ of water and collapsed foam[11]. The storm water drainage system of the facility is connected to a storm water tank where the water is collected for reuse in the process. The storm water tank is, however, equipped with an overflow option, which will overflow to the waste bunker.

Adequate firewater retention capacity will be provided for at the facility by the storm water storage tank and waste bunker.

7. EMERGENCY RESPONSE

7.1 Emergency Plans

1. It will be ensured that:
   - the operator draws up an internal emergency plan for the measures to be taken inside the establishment
   - the operator supplies the competent authorities with the necessary information to enable it to draw up external emergency plans
2. The emergency plans will be established with the objectives of:
   - containing and controlling incidents so as to minimise the effects, and to limit damage to man, the environment and property,
   - implementing the measures necessary to protect man and the environment from the effects of major accidents,
   - communicating the necessary information to the public and to the services or authorities concerned in the area,
   - providing for the restoration and clean-up of the environment following a major accident.
3. The emergency plans will contain the information set out in Annex IV / Seveso II Directive.
4. Without prejudice to the obligations of the competent authorities, it will be ensured that the internal emergency plans provided for in this Directive are drawn up in consultation with personnel employed in the establishment.

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[11] 65,000 m^3 x 750kg/m^3 = 48,750,000 kg waste, leaving spare capacity for 16,250,000 kg (16,250 m^3) of firewater.

5. It will be ensured that internal and external emergency plans are reviewed, tested, and where necessary revised and updated by the operator at suitable intervals of no longer than three years. The review will take into account changes occurring in the establishments concerned or within the emergency services concerned, new technical knowledge and knowledge concerning the response to major accidents.
6. It will be ensured that the operator puts the emergency plans into effect without delay for this purpose:
   - when a major accident occurs, or
   - when an uncontrolled event occurs which by its nature could reasonably be expected to lead to a major accident.

7.2 Systems and Procedures

7.2.1 Emergency Services

Throughout the construction and operations period there will be a 24 hour per day, 7 day per week emergency service. This service will include immediate action in the case of e.g.:

a) Fire alarm

b) Accidents on site

c) Spillages

d) Malfunction of dewatering pumps during construction.

The services will be equipped with vehicles, radio communications, equipment and trained personnel so as to be able to deal effectively and promptly with any risk, threat or hazard to persons, livestock or property arising from the construction and operation phases.

FIGURES

Figure 1 Site Location

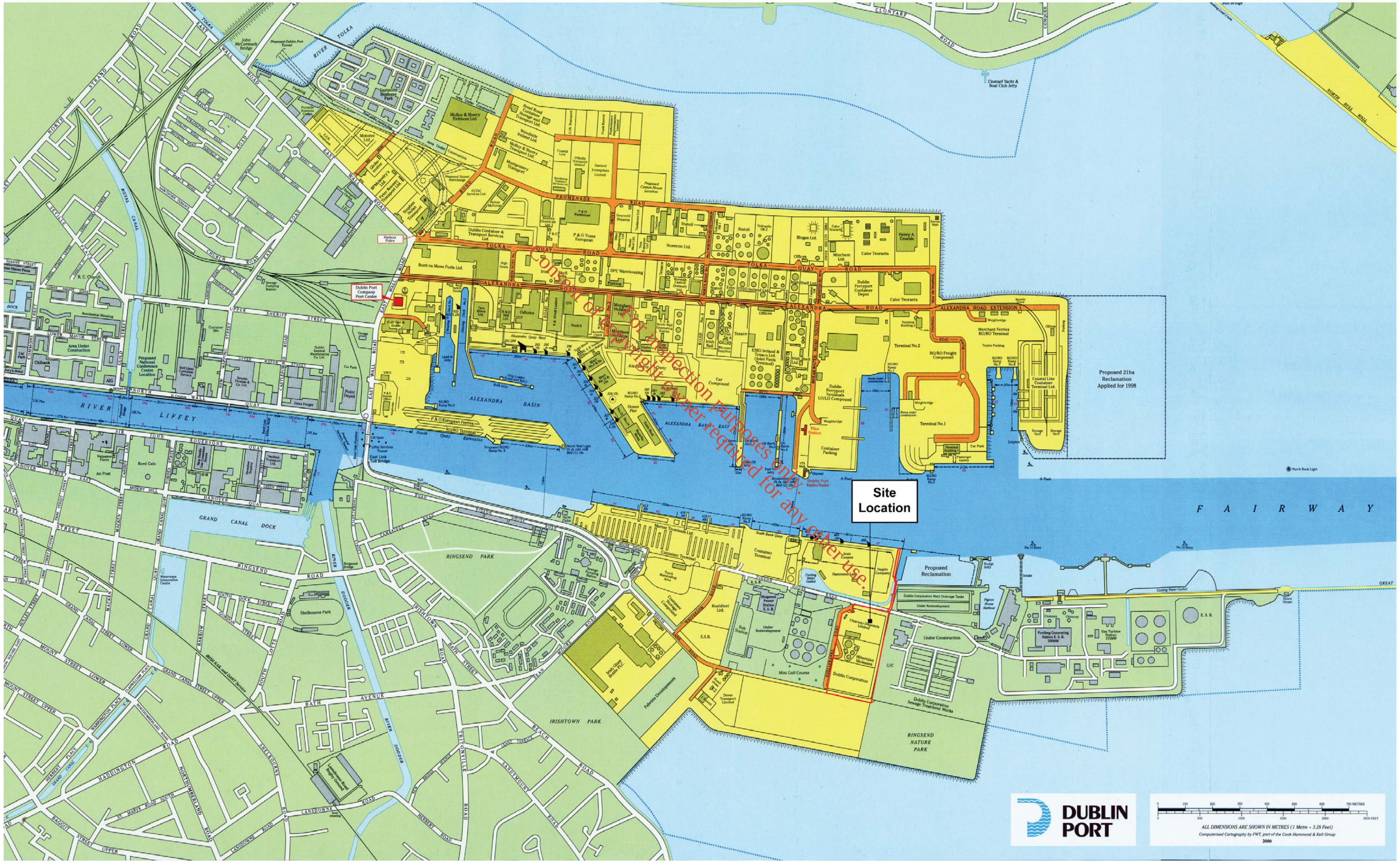

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Figure 2 Biotopes of the Western Section of the Irishtown Study Area. Littoral Core Samples C1, C2, C4 are shown as red dots

Figure 3 Biotopes of the Eastern Section of the Irishtown Study Area. Littoral Core Samples C3, C4 are shown as red dots

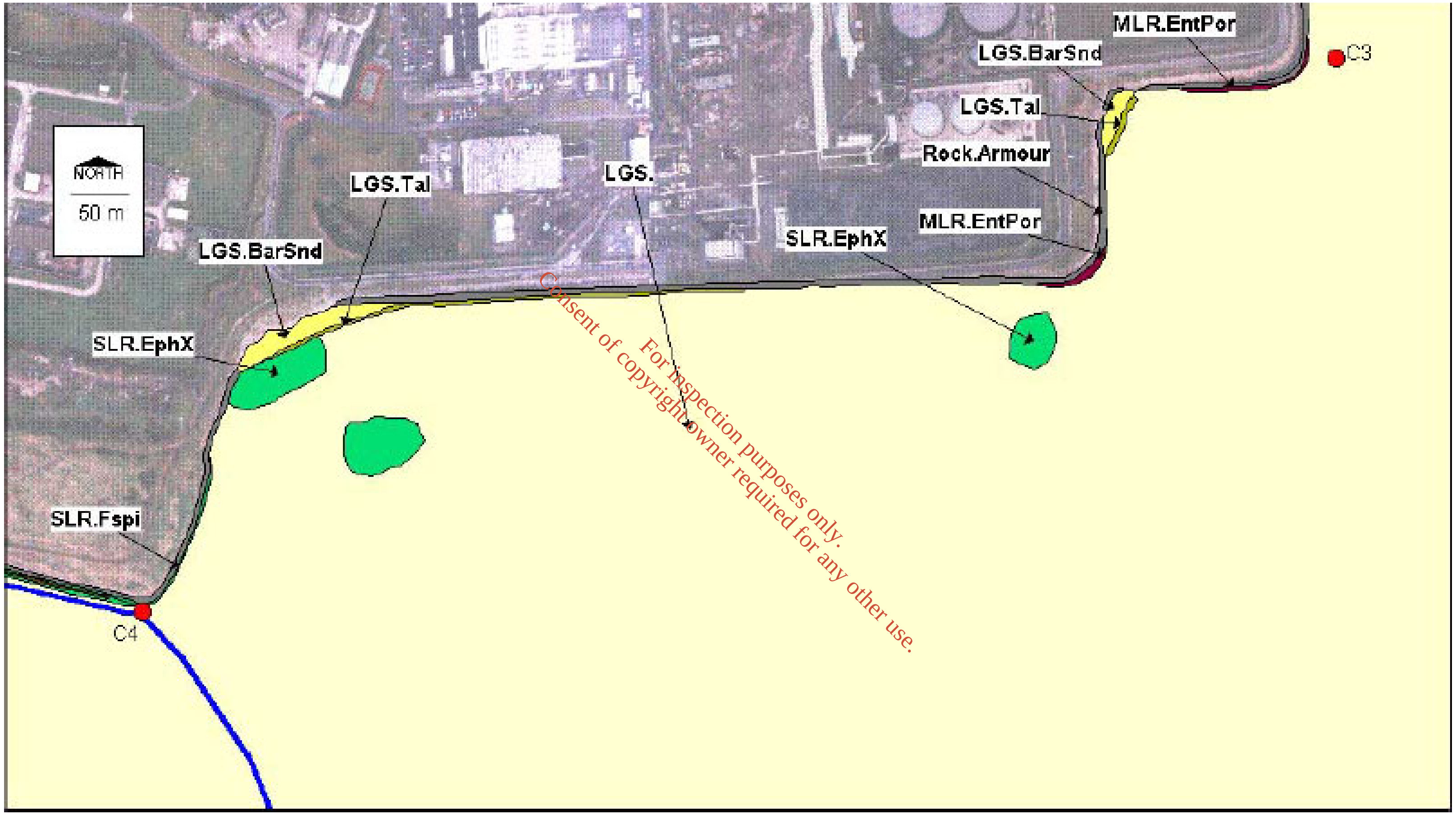

Figure 4A Close up of a Section of Biotopes Illustrating Typical Biotopes Present Along the Irishtown Study Area

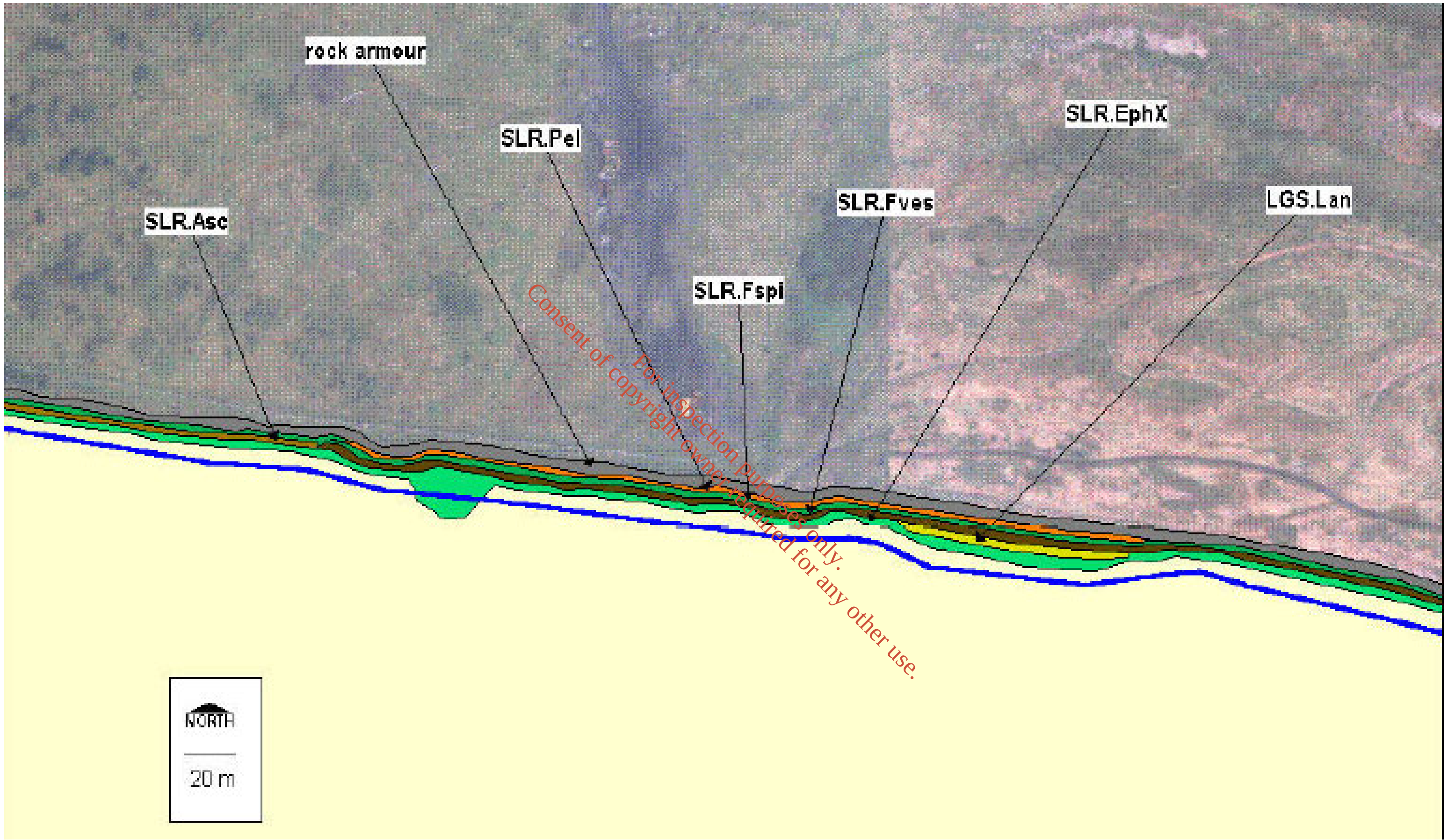

Figure 5Consultation Distances of Seveso Sites in Dublin Port

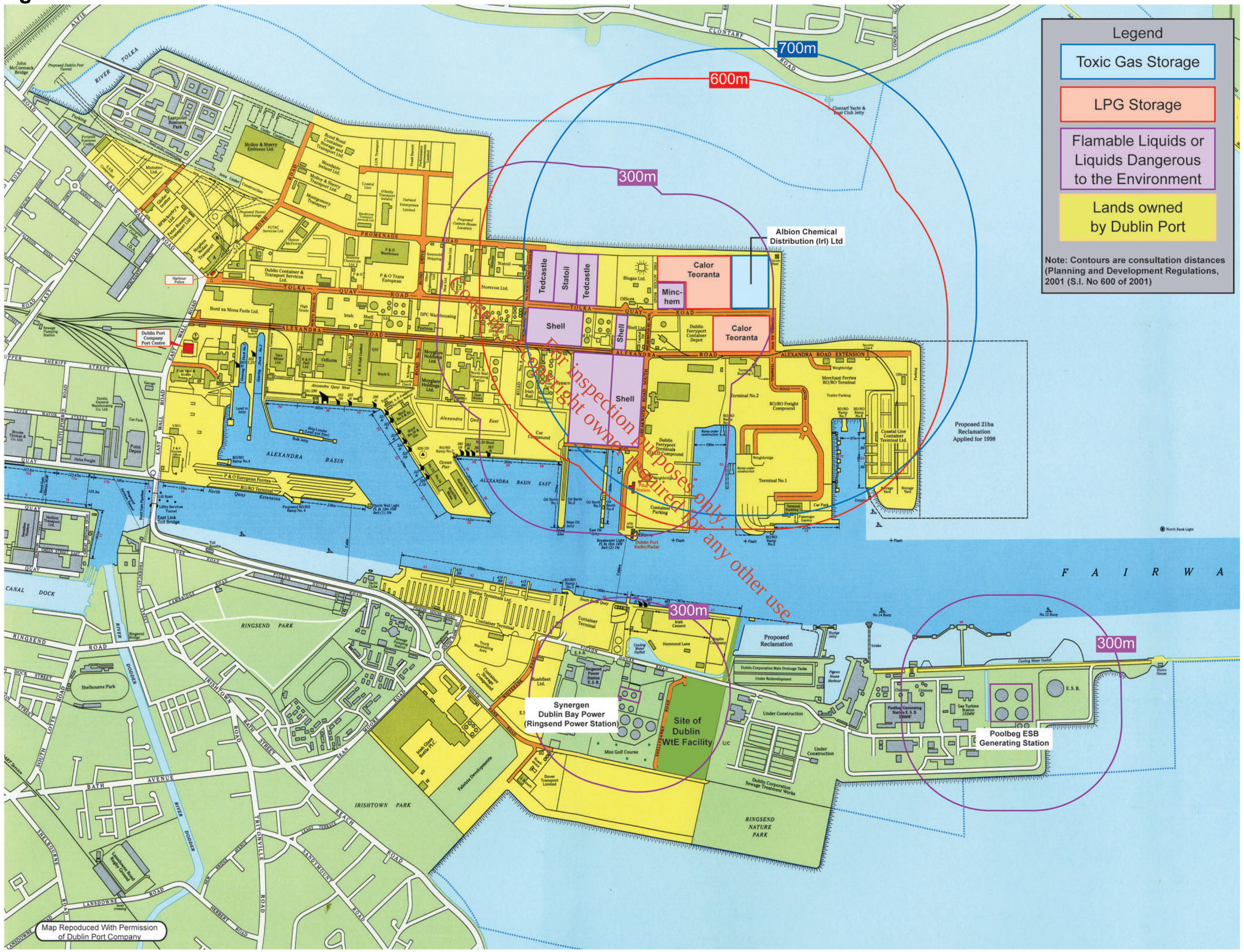

Figure 6 Diesel Bund Fire, Maximum Distances to Incident Radiation Levels

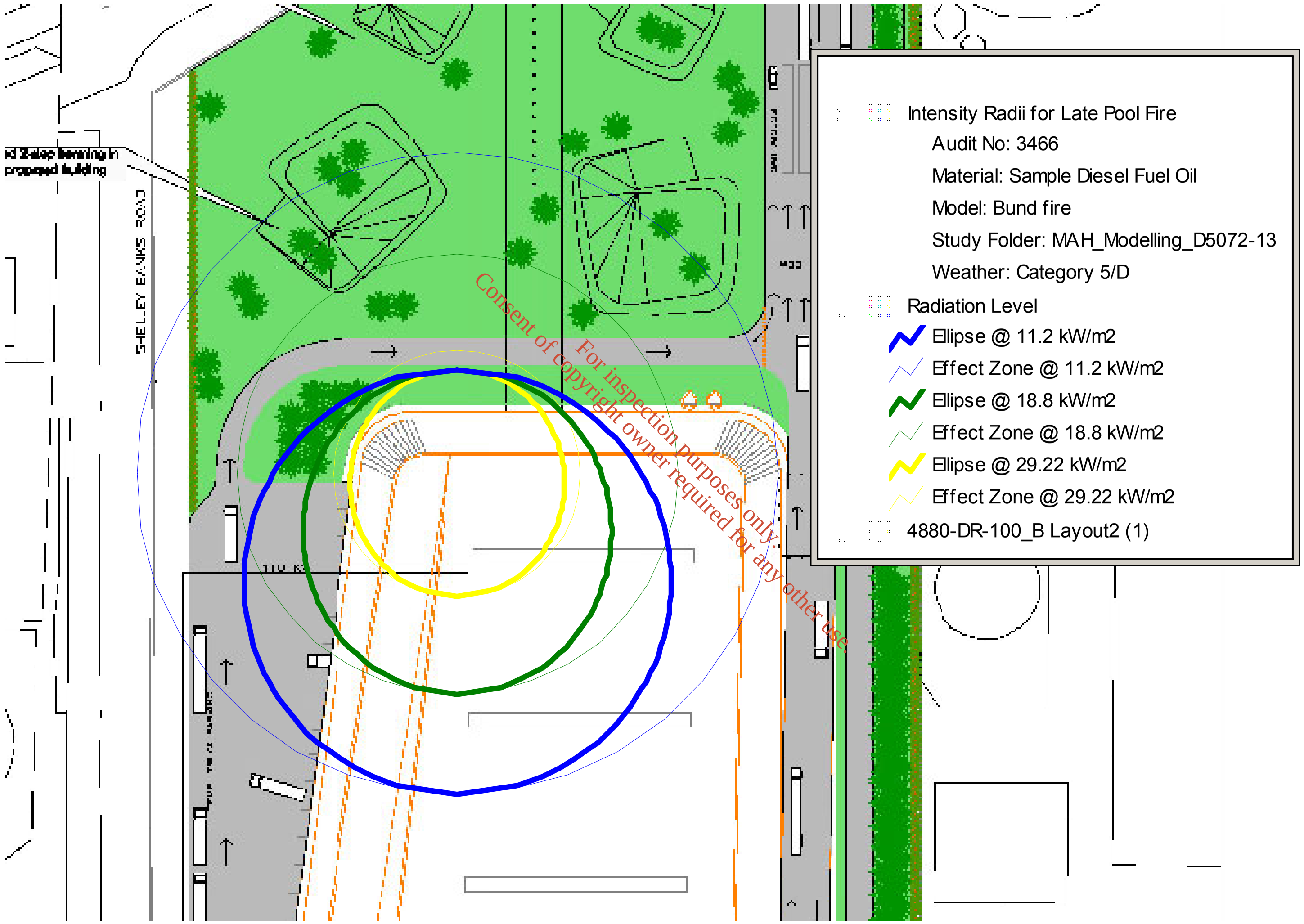

Figure 7 Diesel Fire, 63% Overtopping of Bund, Maximum Distances to Incident Radiation Levels

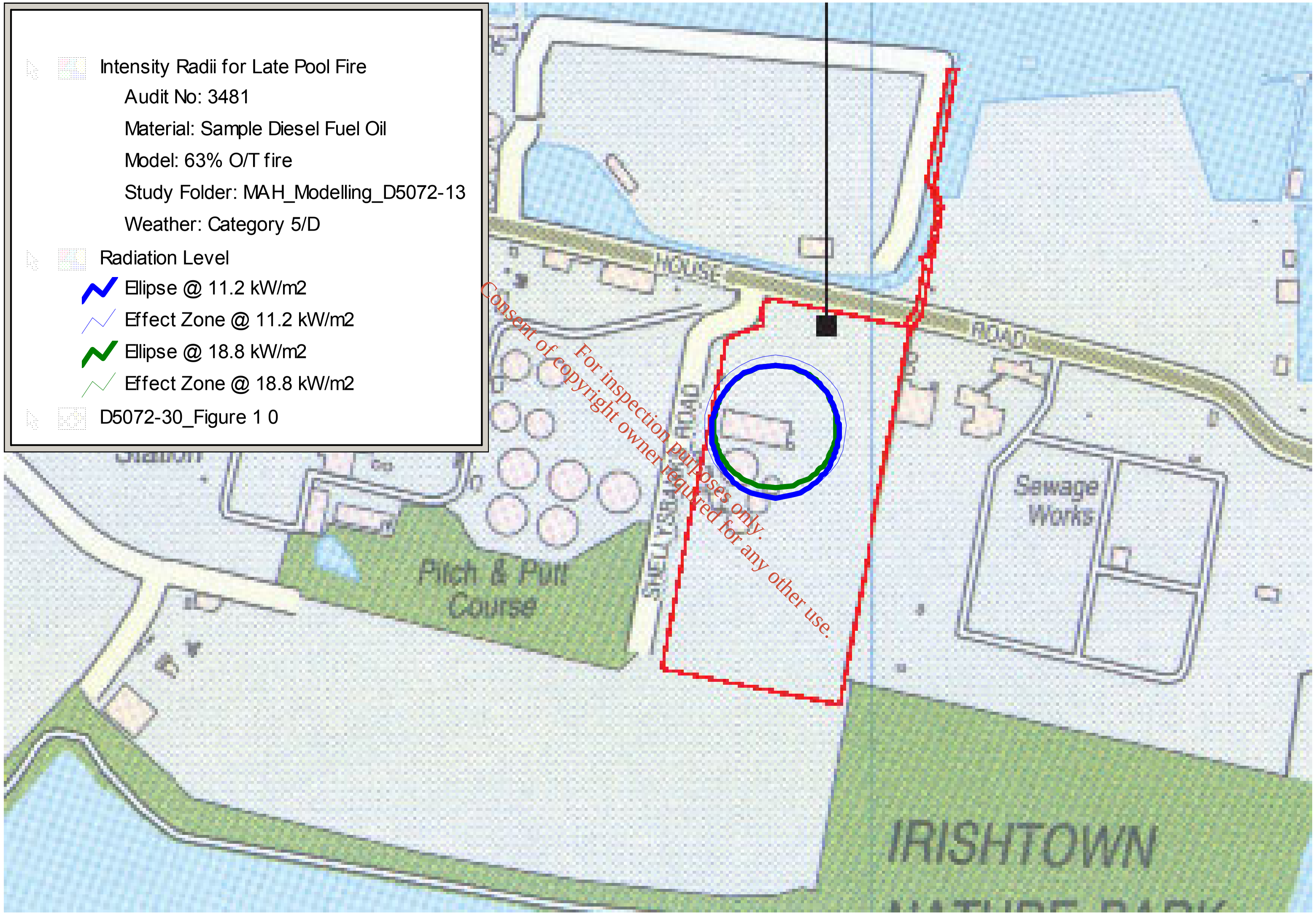

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Figure 8 BLEVE, Maximum Distances to Specified Overpressures

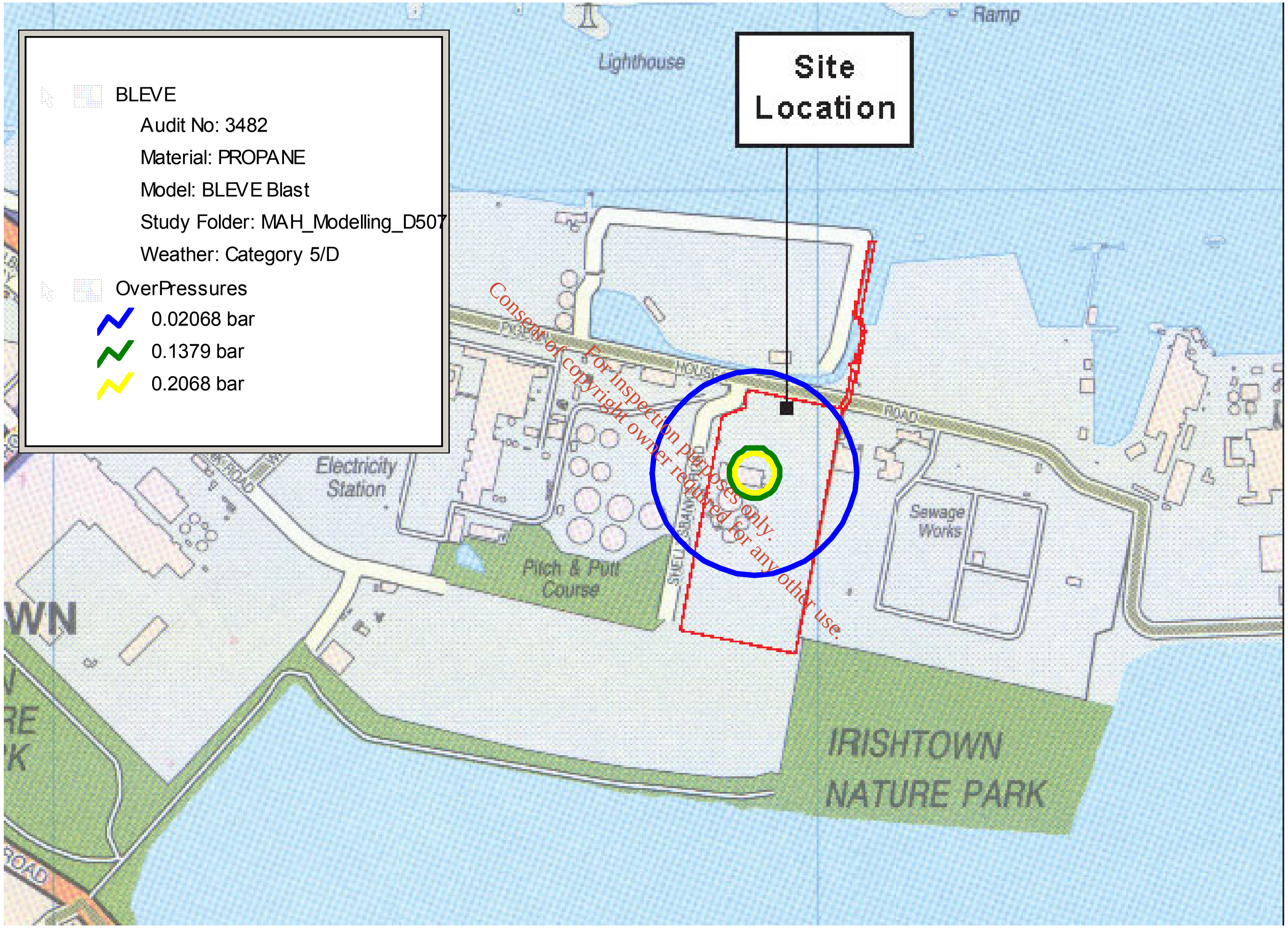

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Figure 9 BLEVE Fireball, Maximum Distance to 29.22 kW/m²

Figure 10 BLEVE Fireball, Maximum Distance to 18.8 kW/m^2

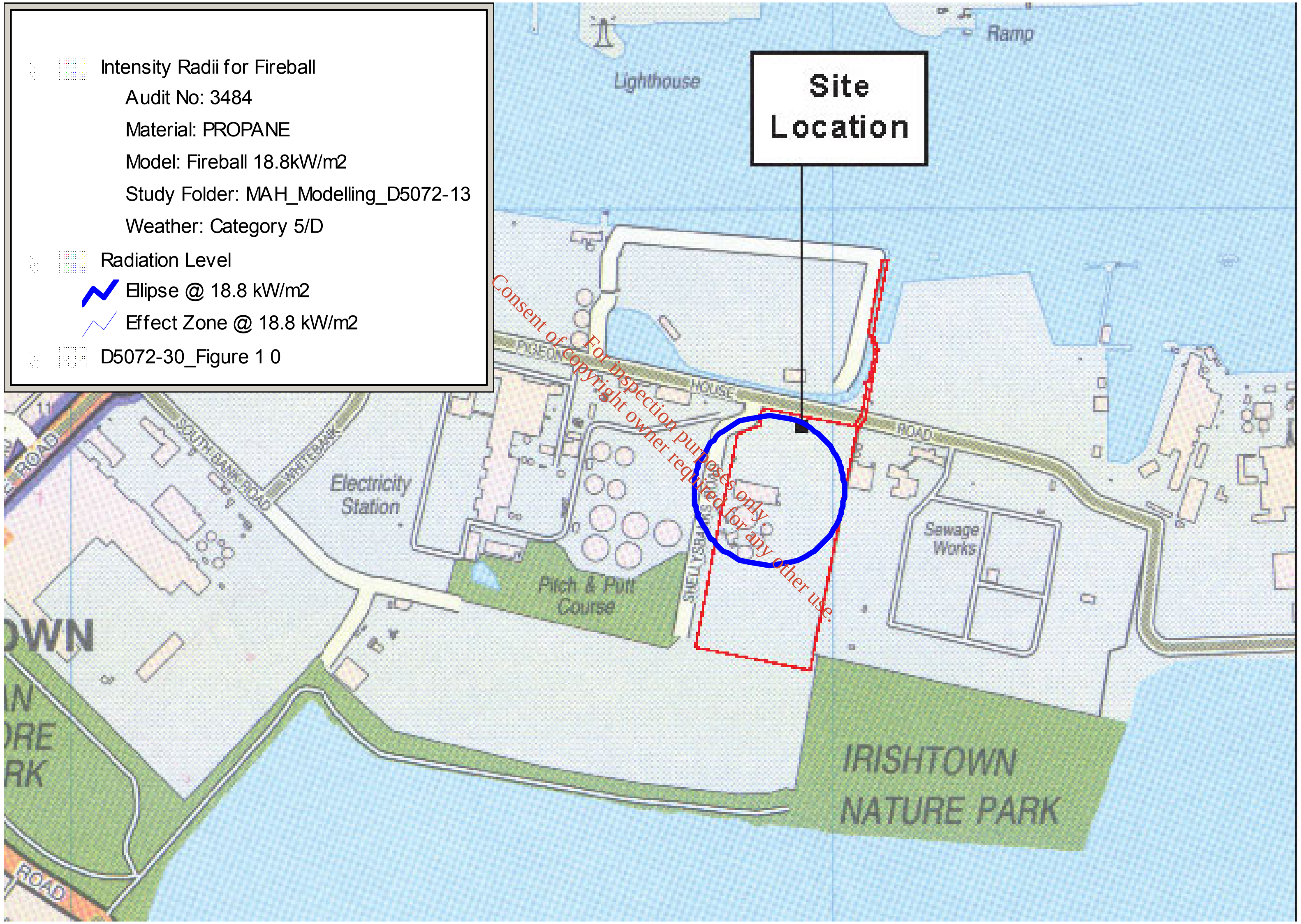

Figure 11 BLEVE Fireball, Maximum Distance to 11.2 kW/m²

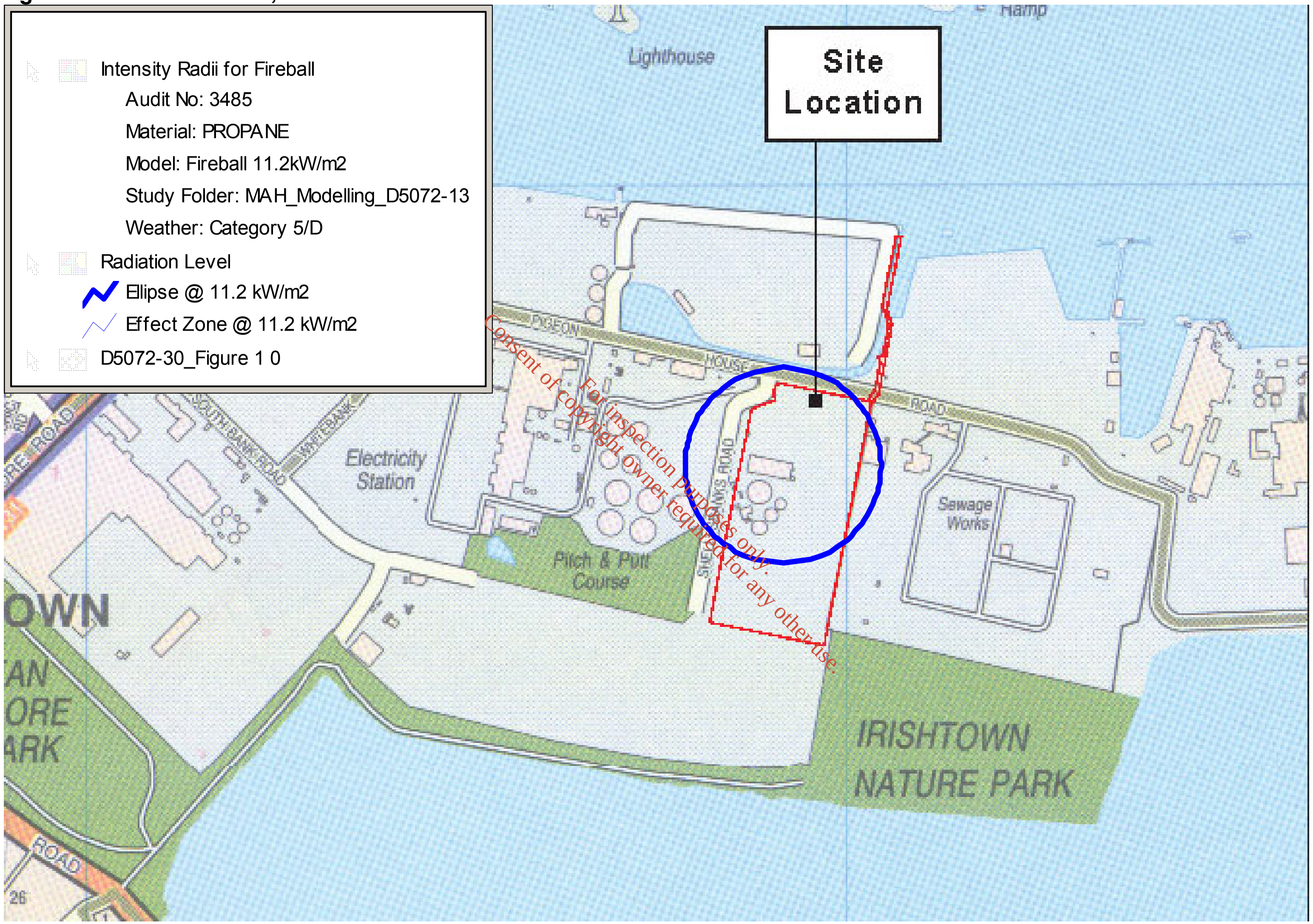

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Figure 12 Release of Ammonia Vapour from Ammonium Hydroxide Liquid Surface in Bund, Maximum Distance to ERPG3

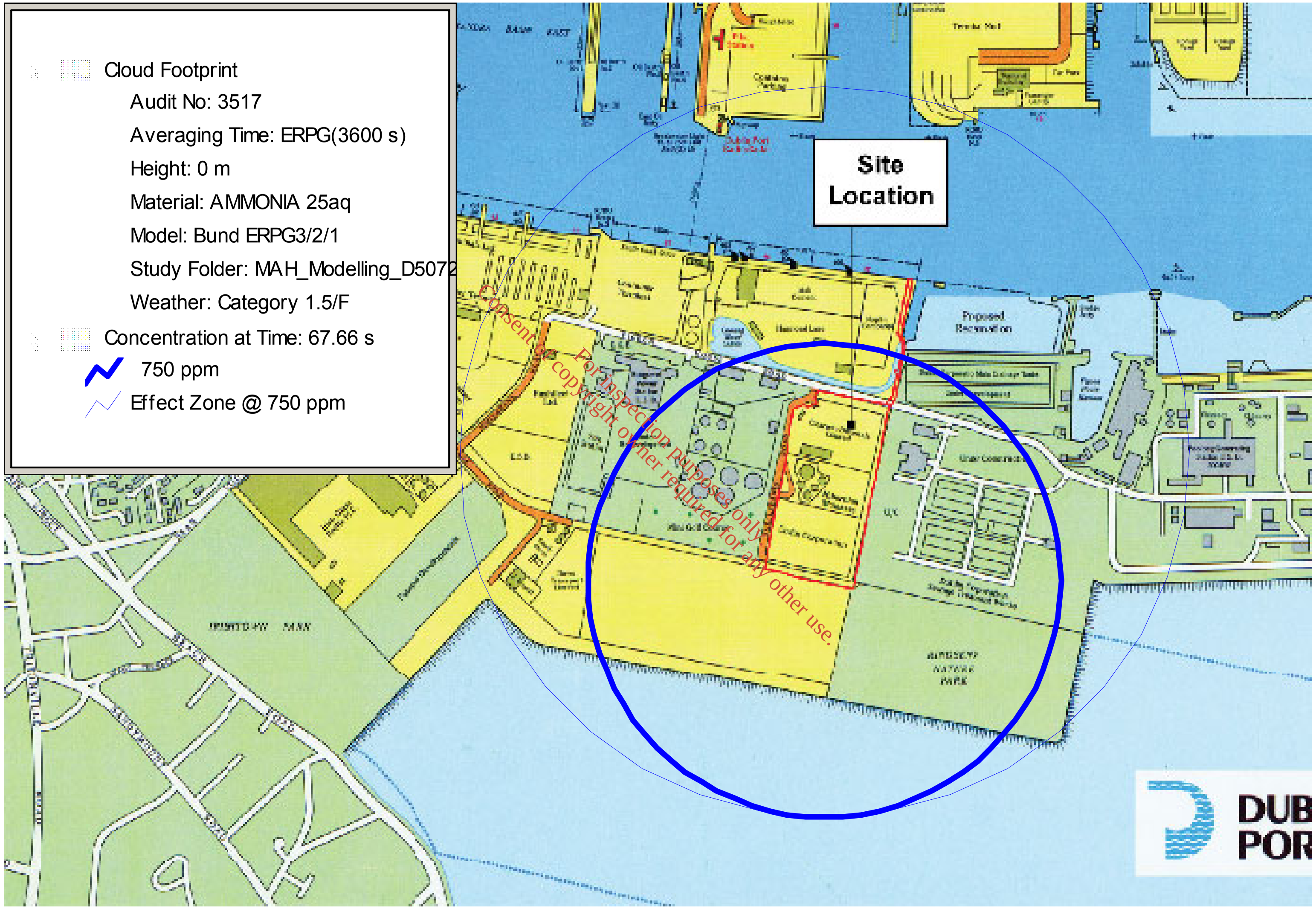

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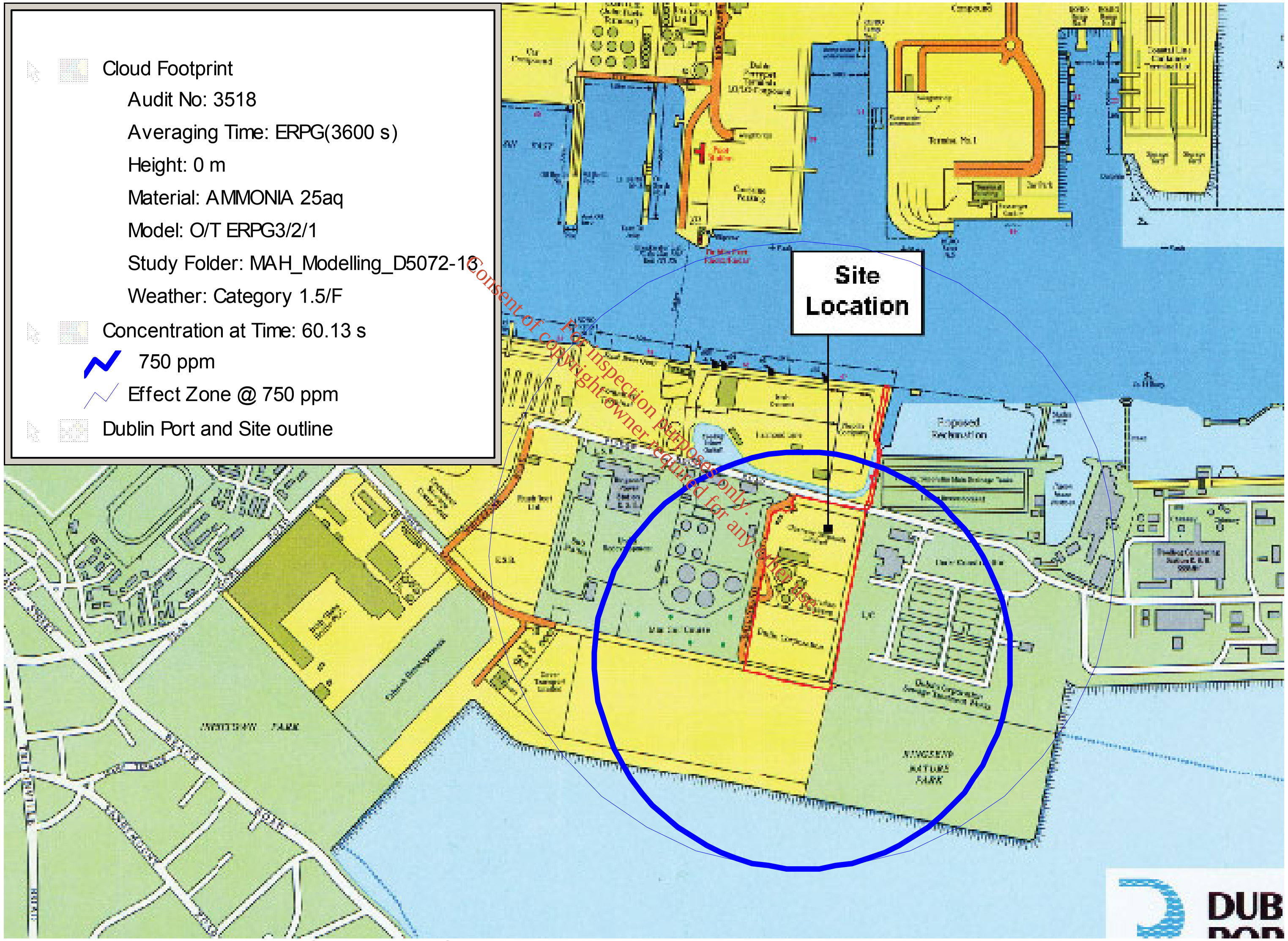
Figure 13 **Release of Ammonia Vapour from Ammonium Hydroxide from Unbunded Liquid Surface (68% Overtopping), Maximum Distance to ERPG3**



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APPENDIX A

DWtE Facility Dangerous Substances Inventory

A1. DANGEROUS SUBSTANCES INVENTORY

Tank No	Substance	CAS No	Risk Phrases	Classification	Physical Form	Contents of Container	Units	Litre/tonne	Maximum Quantity in Storage (tonnes)
Named Substances									
	LPG (propane)	74-98-6	R12	F+	Liquid/Gas	2	tonnes	1	2
	Diesel oil	68334-30-5	R40, R65, R66, R51/53	Xn, N	Liquid	100	tonnes	1	100
Dangerous to the Aquatic Environment - N - R 50/53									
	Ammonia (25% w/w NH_4OH)	1336-21-6	R34, R50	N, C	Liquid	100	tonnes	1	100
	Ammonia (25% w/w NH_4OH	1336-21-6	R34, R50	C, N	Liquid	80	tonnes	1	80
	Total								180
Dangerous to the Aquatic Environment - N - R 51/53									
	Taski Bruco Accel Z94 (12706.17)	64425-86-1; 107-98-2; 67-63-0; 1310-58-3	R38, R41, R51	Xi, N	Liquid	0.005	tonnes	1	0.005
	APC residues	301-04-2	R33, R61, R62, R48/22, R51/53	N, Xn	Powder	500	tonnes	1	500
	Total								500
Flammable (R10)									
	Total								
Highly Flammable (R11)									
	Acetone (8804.00)	67-64-1	R11, R36, R66, R67	F	Liquid	0.005	tonnes	1	0.005

Tank No	Substance	CAS No	Risk Phrases	Classification	Physical Form	Contents of Container	Units	Litre/tonne	Maximum Quantity in Storage (tonnes)
	Mistral Spray, dark/grey 650 °C	64742-95-6; 67-64-1; 123-86-4; 74-98-6; 106-97-8	R11, R36, R52/53	F, Xi, N	Liquid	0.005	tonnes	1	0.005
	Tangit Reiniger	109-99-9; 67-64-1	R11, R19, R36, R66, R67	F, Xi	Liquid	0.005	tonnes	1	0.005
	Plastmo PVC-glue 2966	108-94-1; 109-99-9	R11, R19, R36/37	F, Xi	Liquid	0.005	tonnes	1	0.005
	Total								0.02
Extremely Flammable (R12)									
	Polymer	106-97-8; 74-98-6	R12	F+	Liquid	0.1	tonnes	1	0.1
	Acetylene	74-86-2; 67-64-1	R5, R6, R12	F+	Gas	0.025	tonnes	1	0.025
	Kema GM-12 Lubrication	74-98-6; 106-97-8; 110-54-3	R12, R52/53	F+, N	Liquid	0.005	tonnes	1	0.005
	Total								0.13
Oxidising (R7, R8, R9)									
	Oxygen, gasform	7782-44-7	R8	O	Compressed Gas	0.025	tonnes	1	0.025
	Total								0.03