Accompanying Documents
99/02388/CIRC08

RIVERSIDE RESOURCE RECOVERY (ENERGY FROM WASTE) FACILITY, NORMAN ROAD, BELVEDERE - Report

SITE INVESTIGATION AND REMEDIATION PROPOSALS

Prepared for

RIVERSIDE RESOURCE RECOVERY LTD

by

Applied Environmental Research Centre Ltd

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APPENDICES:

1. INTRODUCTION

1.1 General

1.1.1 It is proposed to redevelop the site in Norman Road in Belvedere to an industrial end-use comprising an Energy from Waste (EfW) Facility which will involve the receipt, storage and incineration of waste, and generation of electricity. The site is currently owned by Cory Environmental Limited (CEL), which is a wholly owned subsidiary of Exel plc.

1.1.2 An application has been submitted by Riverside Resource Recovery Limited (RRRL) to the Secretary of State for Trade and Industry under Section 36 of the Electricity Act 1989 for consent to construct and operate the facility. The application was accompanied by a Consolidated Environmental Statement (June 2002) prepared in accordance with the Electricity and Pipe-Line Works (Assessment of Environmental Effects) Regulations 1990. The operation would also be regulated under the Pollution Prevention and Control Act 1999 and the Pollution Prevention and Control (England and Wales) Regulations 2000 (PPC Regulations) and a Pollution Prevention and Control Permit has been issued by the Environment Agency.

1.1.3 The site at Belvedere has been the subject of a number of site investigations (detailed in later sections) and the potential impacts of developments on site contamination have been addressed within the Consolidated Environmental Statement. In view of the presence of contaminants identified by these investigations within soil and groundwater, a decontamination and remediation programme will be required. This will form a condition in the consent and will be developed in consultation with the London Borough of Bexley and the Environment Agency.

1.1.4 In May 2003, Applied Environmental Research Centre Ltd (AERC) was commissioned by Riverside Resource Recovery Limited (RRRL) to prepare a Site Report[1] for submission to the Environment Agency. In May 2003, AERC was also commissioned by RRRL to prepare a Contamination Issues report[2] which reviewed existing information on the contamination status at the site and identified any issues relevant to the construction and development of the RRR facility. Subsequently in July 2003, AERC was commissioned to carry out a detailed site investigation. The objectives were to:

a) obtain sufficient information on which to determine an appropriate programme for decontamination and remediation of the site and;

b) refine the assessment of environmental impacts which would be predicted to arise from the development.

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1 Riverside Resource Recovery (Energy from Waste) Facility, Norman Road, Belvedere, Bexley. Site Report for IPPC Application. Prepared for Riverside Resource Recovery Ltd by Applied Environmental Research Centre Ltd. Ref: C3474/R1351/Final (1); June 2003

2 Riverside Resource Facility, Norman Road, Belvedere, Bexley. Contamination Issues Report. Prepared for Riverside Resource Recovery Ltd by Applied Environmental Research Centre Ltd. Ref: C3474/R1355/Final; June 2003.

1.2 Scope of Work

1.2.1 The site investigation has comprised the following:

- installation of groundwater monitoring boreholes into the River Terrace Gravels;
- monitoring of groundwater levels including tidal influence and groundwater quality; and
- further sampling and analysis of solids from the surface and deeper within the profile in order to:
  (1) confirm the types of contaminants present;
  (2) provide further evidence regarding the distribution of contaminants both vertically and horizontally;
  (3) obtain clarification of the nature of organic materials on-site and assess the leachability of contaminants.

1.2.2 The report is organised according to the following structure, accompanied by relevant maps and plans and chemical data:

Section 2	A description of the site
Section 3	A description of the proposed installation
Section 4	A review of previous site investigations
Section 5	A description of the recent site investigation
Section 6	A review of the chemical data and Conceptual Model
Section 7	A risk assessment
Section 8	Remediation Proposals
Section 9	Summary and Conclusions

2. THE SITE

2.1 Introduction

2.1.1 A brief appraisal of the site, its history and the geology is presented within this section. This has included a review of available historical maps, geological and hydrogeological maps, as well as information supplied by the client.

2.2 Location and Topography

2.2.1 The site, the centre of which may be located by National Grid Reference TQ 496 806, is situated in the Belvedere area of Erith on the south bank of the River Thames. The site covers an area totalling 21.95 ha, which is made up of the following components:

- Area within the River Thames 12.0ha
- Area of proposed EfW facility site 5.93ha
- Former Borax Residue Storage Area 2.58ha
- Norman Road and junction with Picardy Manorway 1.44ha

2.2.2 The area of land to be redeveloped is therefore 7.37ha in extent (being the area of the proposed EfW facility site and Norman Road and Junction with Picardy Manorway). The area of the proposed EfW is hereinafter referred to as the "main development site", and the former Borax Residue Storage Area as the "southern parcel of land".

2.2.3 The "main development site" is located approximately 750m to the north of the A2016 at the northern end of Norman Road, with the "southern parcel of land" to the west of Norman Road. Erith town centre is located approximately 3km to the south east of the site and the Dartford river crossing approximately 8km to the south east. The nearest residential development to the site is located approximately 1km to the south. A site location map is included within Appendix B (as Drawing No. C3474/R1351/01).

2.2.4 The site lies in a relatively flat low-lying area ranging from 1.5m to 2.5m above sea level. Erith Marshes is located approximately 1250m to the south west and on the opposite bank of the River Thames are the Hornchurch Marshes, approximately 2.5km to the north, Rainham Marshes, approximately 2km, and Wennington Marshes, approximately 3km, to the east. The site is situated on the south bank of the River Thames within Halfway Reach and the Thames Barrier at Woolwich is situated approximately 8km to the south west.

2.3 Geology, Hydrogeology and Hydrology

Geology

2.3.1 The records indicate that the following geological sequence is expected to underlie the site:

Formation	Lithology	Typical Thickness (m)
Made Ground	Brick/Concrete rubble	0.4 - 3.0
Alluvium	Clay and peat with occasional sandy layers at base	3.5 - 11.0
River Terrace Gravels	Medium dense, fine to coarse gravel	2.7 - 5.5
London Clay	Stiff, silty clay	>5.0
Blackheath Beds	Sandy clay to fine sand and gravels	approx. 12.0
Woolwich and Reading Beds	Mottled clay, silt and sand	approx. 13.0
Thanet Beds	Silty sands	approx. 17.7
Upper Chalk	Chalk with flints	50.0 - 150.0

2.3.2 Underneath the surface material, Made Ground is expected to lie across the entire "main development site". Underlying the Made Ground, alluvial deposits of varying thickness occur, which can be described as being highly variable in composition, but mainly consisting of clay, peat and sand. The River Terrace Gravels underlie the alluvial deposits at an average 3-4m in thickness and can be generally described as flint gravels with a sandy matrix grading to gravely sand. London Clay underlies the River Terrace Gravels, which in turn is underlain by the Blackheath Beds, that generally comprise sandy horizons.

Hydrogeology

2.3.3 The alluvial deposits, the Floodplain Gravels, the Blackheath Beds and the Thanet Beds are classified as minor aquifers. The Upper Chalk is classified as a major aquifer. It is possible that the Thanet Sands are in hydraulic continuity with the Upper Chalk and are confined by the clayey deposits of the Woolwich and Reading Beds and the London Clay which are both classified as non-aquifers.

2.3.4 The Floodplain Gravels are likely to represent a perched aquifer that is confined by the London Clay and are likely to be in hydraulic continuity with the River Thames. Shallow groundwater typically occurs within 1m of the surface, in the Made Ground and alluvial deposits.

2.3.5 The Groundwater Vulnerability Map indicates that the area of the site is underlain by soils of high leaching potential with little ability to attenuate diffuse source pollutants and in which non-adsorbed diffuse source pollutants and liquid discharges have the potential to move rapidly to underlying strata. The site does not lie within a currently defined groundwater Source Protection Zone and there are no current records of groundwater abstraction for potable supplies within a 3km radius of the site.

Hydrology

2.3.5 The River Thames forms the northernmost sector of the site in an area known as Halfway Reach. The water is brackish, although varies in salt content depending on freshwater flow and tidal conditions. The mean spring tidal range is 6.4m with 4.3m at mean neap tides. River quality data in the vicinity of the site indicate that quality was chemically fair (Grade D) in 2001.

2.3.6 There are several drainage ditches and dykes in the vicinity of the site. There is one unnamed ditch situated in the southern sector of the "main development site" which appears to flow southwards into the ditch on the western side of Norman Road. There is also a ditch on the eastern boundary of the "main development site" that generally flows southwards into the Norman Road Ditch (on the eastern side of Norman Road). The Norman Road Ditch and the ditch on the western side of Norman Road both flow towards the south and connect with the Horsehead Dyke which flows westwards into Great Breach Dyke. The drainage ditch to the south of the "main development site" and the ditches surrounding the "southern parcel of land" (the former Borax Residue Storage Area) flow eastwards into the ditch on the western side of Norman Road. There are two further ditches: one situated at the western edge of the "southern parcel of land" which flows towards the west and another flowing southwards from the southern boundary of the "southern parcel of land". The Great Breach Dyke flows generally northwards between the site and the Crossness Sewage Treatment Works to the west into the River Thames.

2.3.7 There is currently a licence to abstract surface water from the Great Breach Dyke at Crossness Nature Reserve located approximately 250m to the west of the "main development site". This is held by Thames Water Utilities Limited for "water supply".

2.4 Site History

2.4.1 Information on the history of the site has been obtained from review of historical maps summarised in Appendix B as Drawing no. C3477/R1384/02. Additional historical information has been obtained from a review prepared by ERM (1995; Appendix A).

2.4.2 In 1865, a 'Manure Works' occupied the north eastern sector of the "main development site" whilst residential properties were located in the southern sector and Norman Road is named as Picardy Manor Way. The remaining part of the site and surrounding area, including the "southern parcel of land" were occupied by agricultural fields with Powder Magazine Works located approximately 300m to the west of the Manure Works.

2.4.3 By 1897, the "main development site" on the river front had been substantially developed with Thames Fish, Guano and Oil Works in the north western sector and Belvedere Mills (Bovril Disused) in the north eastern sector. A tavern, residential properties and open space occupied the remainder of the site. The "southern parcel of land" is occupied by agricultural land and Orient House on either side of a track running through the centre. The land to the south and west remains as agricultural fields. By 1909, Belvedere Mills were being used for borax refining and a spoil heap was situated in the northern sector of the "southern parcel of land". The surrounding area remained as agricultural with additional drainage ditches.

2.4.4 By 1958 the "main development site" comprises a Mill and fields in the north eastern sector, a Depot in the north western sector, a Works and some residential properties in the southern sector. The "southern parcel of land" is occupied by spoil heaps. Several more drainage ditches have been constructed within the area, whilst Works had been developed to the south of the "southern parcel of land". A Sewage Works comprising sludge lagoons, tanks *etc.* situated approximately 200m to the west was developed by 1984. Directly opposite the site on the north bank of the River Thames is the Dagenham Motor Works.

Other Historical Information

2.4.5 Borate refining on the "main development site" commenced in 1896 when Redwood Chemical Company Limited of Kennington purchased the land from Spencers Metal Manufacturing Company. An amalgamation of Redwood Chemical Company and Pacific Coast Borax led to the formation of Borax Consolidated Limited in 1899. Early processes at the site may have included borate refining, using crude calcium borate imported from North America, and Epsom Salt manufacture, using dolomite and sulphuric acid. A laboratory and calcium carbide store are believed to have been included in the Works.

2.4.6 In December 1988 the manufacture of borax-related chemicals ceased and in 1990/91 Cory Environmental Limited (CEL) purchased the site. In 1994/96 CEL commissioned the decontamination and demolition of all buildings to their concrete bases, except one situated in the western sector of the "main development site" which was used for the storage of building materials.

2.4.7 It is understood that the "southern parcel of land" has been used for the deposition of waste products arising from the Borax-related chemical plant located on the "main development site". Waste had been deposited from 1906 until the 1950s resulting in heaps of approximately 8m in height and primarily comprised a slurry consisting of gypsum, clay, calcium borate and boiler ash.

2.4.8 A year after the closure of the Borax-related chemical plant, the "southern parcel of land" was remediated by removing all waste materials down to the adjacent ground level. This involved the excavation of approximately 80,000m^3 of material between March and August 1990. The site of the Borax Residue Storage Area was subsequently sold to Ocean Group plc. (now Exel plc., CEL's parent company). It is estimated that approximately 38,500m^3 of waste remained below the existing ground level as a result of the consolidation and settlement of the underlying alluvial soils, and the site was subjected to remediation in 2001 by Knight Piesold (refer to Section 5 for further detail).

2.5 Existing Site Uses

2.5.1 A site walkover survey was carried out on 16 May 2003 by a representative from AERC. The site is currently vacant and inaccessible to traffic by means of a bund in the south eastern corner. The majority of the "main development site" is surrounded by a 2m high fence with four locked gates along the southern and eastern boundaries. The site generally comprises:

- two structures: one large side-less structure on a concrete base; and a single storey brick building for electricity;
- hardstanding, predominantly concrete, denoting footprints of demolished buildings, the majority of which are situated in the eastern sector, together with evidence of below ground structures;
- heaps of fly-tipped waste in certain locations on the site including lorry tyres, hardcore and rusty sheets of metal;
- where there is no hardstanding, vegetation appears to be typical of garden weeds and grass;

- the water within the drainage ditches on site is green in colour with little sign of aquatic life;
- deposits of a white soft fibrous mineral, possible gypsum was observed in the vicinity of the open-sided structure in the western sector of the site;
- a river flood defence embankment and walls on the river frontage; and
- public footpaths along the northern and eastern boundaries.

2.5.2 The "southern parcel of land" is mainly laid to grass which was reseeded following remediation in 2002, with a concrete road through the centre. To the south is the National Grid switching station and transformer, whilst areas of open, rough grazing land surround the "southern parcel of land".

2.5.3 The site is situated in a predominantly industrial area of Erith with commercial buildings to the east on the Isis Reach development and depots immediately to the south. Norman Road provides access to the "main development site" and the "southern parcel of land" and also to two industrial depots situated adjacent to the "main development site". The Crossness Sewage Treatment Works is located to the west of the site beyond the Ford Motor Company staff car park and open land. Generally, to the south west of the "main development site" is open, rough grazing land, used mainly by horses.

2.6 Potentially Contaminative Uses of the Site and its Environs

2.6.1 A detailed appraisal of potentially contaminative uses at the site and within its vicinity has been presented within AERC's Site Report for IPPC Application of June 2003 (Ref: C3474/R1351). This involved a review of the Sitescope environmental database and the Environment Agency web site and is summarised below.

2.6.2 There are six current discharge consents to controlled waters with a radius of 500-1000m of the site, two of which are located on the northern bank of the River Thames. The majority of the consents relate to the discharge of surface water from respective sites into the surrounding ditches or the River Thames.

2.6.3 One enforcement notice was served by the Environment Agency in 1996 for the unauthorised discharge of organic material into a sewer. However, this was located to the south west of the site at a distance of over 500m.

2.6.4 The nearest operational landfill site is the Cleanaway Rainham landfill site which is located 2.5km to the east, on the north bank of the River Thames, at Wennington Marshes. On the south bank of the River Thames, the Thamesmead Town landfill site at Tripcock Point is located approximately 3.5km to the west of the site.

2.6.5 There is one record of an IPPC Part A Authorisation relating to the site held by RRRL for the process of incineration under Authorisation Number AH8719 and Variation Number BH1484. The Authorisation was issued in May 1993 and a Variation Application was made in November 1999 and approved in March 2000 and, according to the records, is still in place. To the south east of the site, at a distance of between 500-1000m, there are two records of IPPC Part A Authorisations which involve the manufacture and use of organic chemicals, effective from January 2002 and processes involving halogens, effective from November 2001.

2.6.6 The Pollution Inventory provides details regarding the release of prescribed substances by major industrial installations authorised in accordance with IPPC. There are six entries in the Pollution Inventory within 1km of the site as listed below. The media potentially affected are air and water through the emission or discharge of substances such as hydrogen fluoride, nitrogen oxides, cadmium, mercury, hydrogen chloride, chlorine, sulphur oxides, phenols, toluene, dimethylamine, cresol, phenoxy acid, volatile organic compounds and chlorophenols.

Location to Site	Operator Name and Address	Authorisation No.	Process Type
500m to west	Thames Water Utilities Ltd., Crossness Sewage Treatment Works, Belvedere Road, Abbey Wood	AB4222	Incineration
500m to west	Thames Water, Crossness	CSSA.0362	Sewage Treatment Works
750m to south east	Henkel Ltd., Crabtree Manorway North, Belvedere	AG2987	Acid processes
750m to south east	Cray Valley Ltd., Crabtree Manorway South, Belvedere	AJ8044	manufacture and use of organic chemicals
750m to south east	Nufarm UK Ltd., Crabtree Manorway North, Belvedere	AK1312	manufacture and use of organic chemicals
750m to south east	Nufarm UK Ltd., Crabtree Manorway North, Belvedere	AL6018	processes involving halogens

2.6.7 Other sites subject to regulation are located predominantly to the south of the site. One site subject to IPC Part B Authorisation is located to the south east and relates to the manufacture of coatings and enamelling. There is one record of a site (Nufarm Limited) using dangerous substances situated in Crabtree Manorway, approximately 750m to the south east of the site. There are two sites requiring consents for the storage or presence of certain hazardous substances: one of which is located to the south east and stores/uses chlorine as a toxic substances and the other is situated to the west and stores/uses flammable substances such as gas or any mixture of gases. There are two sites regulated under the Notification of Installations Handling Hazardous Substances Regulations 1982, both located approximately 750m to the south east.

2.7 Potential for Historic Contamination

2.7.1 Borax is a mild alkali, with useful properties that make it valuable as a preservative, an essential component of optical glass, a rust preventative, a fire retardant material, a pH controller, a non-ferrous cleansing agent and of use in the manufacture of photographic supplies, artificial fertilisers and insecticides, although its main use is in detergents. Borax is often in combination with various other chemicals, particularly boric acid.

2.7.2 It is understood that raw materials used in historical borax production include calcium borate minerals, potash, calcium carbide and sulphuric acid. Some mineral ores used in borax production contain significant arsenic concentrations. Although strict limits on discharges from effluent ponds were applied in recent times, it is likely that less stringent limits were applied historically. It is further understood that weed killers were used on the site, but details of their use are not known.

2.7.3 The presence and likely spillage of acidic and alkaline chemicals during the long industrial history of the site may have affected the pH of the soil and shallow groundwater. Similarly, any spillages of sulphuric acid and weed killers may have contaminated soil and/or groundwater with potentially high concentrations of sulphate, sulphide and herbicides.

2.7.4 It is likely that other raw materials were also required at the site. If spilled, such materials may have also affected the soil and groundwater quality at the site.

3. DEVELOPMENT PROPOSALS

3.1 Introduction

3.1.1 RRRL proposes to construct and operate a Resource Recovery plant known as the Riverside Resource Recovery Facility (RRRF) on the "main development site". Subject to obtaining the necessary consents, construction is due to commence in 2004 and should take approximately 36 months and the RRRF would be operational in 2007. The RRRF would comprise an Energy from Waste (EfW) facility which would process an average 585,000 tonnes per annum of primarily Municipal Solid Waste (MSW) over an anticipated 30 years. Waste delivered to the RRRF would be incinerated and the resultant heat would be recovered to raise steam in high pressure boilers, the steam would be fed into a steam turbine to generate electricity and potentially heat for future district heating schemes. Air cooled condensers would re-circulate low pressure steam back to the boilers.

3.1.2 After satisfying its own power needs, the RRRF would export approximately 66 megawatts of electricity sufficient to supply 66,000 residential properties. The majority of waste would be MSW with a smaller proportion originating from industrial and commercial properties. The great majority of waste (85% or more) would be delivered to the RRRF by river utilising the new jetty and pier, whereas delivery of waste by road would be from the Bexley area (approximately 85,000 tonnes per annum).

3.1.3 The proposed RRRF installation, as shown on Drawing No. C3477/R1384/03, comprises the following main components:

- the main RRR plant building which would contain the waste reception hall, waste storage bunker, waste combustion grates, gas cleaning equipment, turbine house and chimney stack;
- the air cooled condensers;
- a jetty and pier equipped with two container cranes to handle containerised riverborne waste and co-mingled bottom ash and metal containers;
- internal site roads, ramp, weighbridge, gatehouse, car parks for staff and visitors and an ash container storage area;
- two site access points;
- improvements to Norman Road; and
- the temporary use of the "southern parcel of land" as a construction compound.

3.2 The "Main Development Site"

3.2.1 A brief description of the RRR Facility is presented in this section. Further details are available within the IPPC Permit Application[3].

The RRRF Plant

3.2.2 The total area to be covered by the RRRF main plant footprint is anticipated to be approximately 1.2ha, which equates to approximately 20% of the "main development site".

Jetty and Pier

3.2.3 The proposed jetty would be a single pier construction, extending 170m from the bank into the River Thames. The proposed jetty is 270m long by 12m wide (3,240m^2) which is wide enough to enable two-way HGV traffic and able to accommodate eight barges alongside.

Ash Container Storage Park

3.2.4 Containers containing bottom ash would be stored in a rectangular area of 119m by 26m (3,094m^2) covered with hardstanding and located within the western sector of the site.

Site Drainage

3.2.5 Surface water from the site is to be collected by a gully system and discharged into the Norman Road Ditch after passing through oil interceptors, silt traps and flow attenuation tanks. Oil and sludge recovered from the interceptors is to be transported off–site in sealed containers for disposal. In any areas where this is a risk of contamination from spillages, the water will drain via a sump which allows for containment and sampling before discharge.

Vehicular Movement

3.2.6 Vehicular access to the "main development site" is from the A2016 (located approximately 700m to the south) along Norman Road. It is proposed to provide two points of access to the "main development site". The first is an ingress only and is located to the south east of the "main development site" and would be used by vehicles delivering consumables (including lime, fuel oil and carbon), maintenance vehicles, cars *etc.* The second and main access to the RRRF is on the southern boundary of the "main development site" and will be for the exit of all vehicles and the only vehicles entering the site at this point will be those carrying waste from the Bexley area.

3.2.7 It is intended that traffic movement would be in an anti-clockwise direction around the RRRF plant along the eastern, northern and western perimeter roads. Riverborne waste deliveries via the jetty would be transported by container vehicles to and from the

[3] Riverside Resource Recovery Limited. *Riverside Resource Recovery Facility - Application for an Authorisation under Integrated Pollution Prevention and Control.* November 2002.

waste reception hall. Car parks for staff and visitors would be situated adjacent to the ash container storage area and immediately west of the RRRF respectively.

Chimney Stack

3.2.8 A three-flue chimney stack would be provided into which flue gases will be discharged from the induced draft fans. The stack has a proposed height of 90m, established as optimal by atmospheric dispersion modelling.

3.3 The "Southern Parcel of Land"

3.3.1 The "southern parcel of land" is the former borax residue storage area which has been subject to remediation and completed with a temporary grass finish in 2002. It is anticipated that the future use of this area will be as a construction compound whilst the RRRF is being developed and is intended to be developed for employment use after clean-up.

3.4 Additional Areas of the Site

3.4.1 An additional area of land situated to the east of the "main development site" is also included within the entire site. This area is not intended to be developed as part of the RRRF, but has been set aside for landscape and ecological purposes comprising shrub, grassland and swamp habitats.

3.4.2 Other areas of landscaping/ecological enhancement are included within the "main development site", as shown on Drawing C3477/R1384/03, and described in greater detail within Chapters 12 and 13 of the Consolidated Environmental Statement (June 2002).

3.4.3 Notably these include an area of proposed shingle/pebble habitat to the west of the "main development site" to provide a refuge for reptiles etc. Areas of grassland and shrub/tree planting are located to the north, south and east and also alongside the access roads and the main building. A new water body is to be constructed along the eastern boundary of the "main development site".

3.5 Construction Issues

3.5.1 The Construction Method Statement will be confirmed by the appointed Design and Build Contractor. However, it is known that excavation will be required in relation to the following:

- excavation of the ash bunker (Number 33 on the Installation Drawing, No. C3477/R1384) to a maximum depth of approximately 6 metres) and
- piling beneath the boiler house (Number 6 on the Installation Drawing) and the chimney (Number 16 on the Installation Drawing).

4. PREVIOUS INVESTIGATIONS

4.1 General

4.1.1 At least seven intrusive site investigations have been carried out on the Belvedere site. These, together, have involved the drilling of 20 boreholes and the excavation of 41 exploratory holes. Each site investigation is summarised in this section, with the full reports being available in Volume II of the IPPC Permit Application, with the exception of the reports relating to the "southern parcel of land". Sampling locations from the previous site investigations carried out are shown on Drawing No. C3477/R1384/04.

4.1.2 There are four reports relating to site investigations carried out at the "main development site" which were subsequently reviewed by Environmental Resources Management in May 1995. These reports are as follows:

- *Site Investigation Report at Norman Road, Belvedere*: prepared for Greenham Construction Materials Ltd by Terresearch Foundation Engineers, 1989
- *Report on Site Investigation at Waste to Energy Incineration Plant, Belvedere*: prepared for CEL by Wilkinson Associates, October 1992 (Ref. 87-01-01)
- *Report on Contamination Investigation at Chitty Site, Waste to Energy Incineration Plant, Belvedere*: prepared for CEL by Wilkinson Associates, December 1992 (Ref. 87-01-03)
- *Report on Contamination Investigation at Greenham Site, Waste to Energy Incineration Plant, Belvedere*: prepared for CEL by Wilkinson Associates, December 1992 (Ref. 87-01-02)
- *Environmental Assessment of Thameside Energy from Waste Power Station - Geology, Hydrogeology & Ground Contamination*: prepared for PowerGen CHP Ltd by Environmental Resources Management, May 1995

4.1.3 At least three intrusive site investigations have been carried out on the "southern parcel of land" previously used for the deposition of waste arising from the boric acid production facility. Wilkinson Associates carried out a site investigation in 1992, whereas Knight Piesold carried out further intrusive site investigations and subsequent remedial works. The site investigations and the remediation works carried out are detailed in the following reports:

- *Former Waste Heaps Site Remedation, Belvedere, Kent - Method Statement*: prepared for Borax Europe Limited by Knight Piesold Limited, January 2000
- *Contamination Investigation Off Site, Waste to Energy Incineration Plant, Belvedere*: prepared for CEL by Wilkinson Associates, September 1992 (Ref. 87-01-01)
- *Former Waste Heaps Site Remediation, Belvedere, Kent - Contamination Risk Assessment Survey (Appendix 1)*: prepared for Borax Europe Limited by Knight Piesold Limited, January 2000

- *Former Waste Heaps Site Remediation, Belvedere, Kent - Construction Completion Report*: prepared for Borax Europe Limited by Knight Piesold Limited, August 2001

- *Former Waste Heaps Site Remediation, Belvedere, Kent - Post Completion Monitoring Report (Draft)*: prepared for Borax Europe Limited by Knight Piesold Limited, December 2002

4.2 The "Main Development Site"

4.2.1 Four site investigations have been carried out on various sections of the "main development site" by Terresearch and Wilkinson Associates in 1989 and 1992 respectively. These involved the drilling of 14 boreholes and the excavation of 35 exploratory holes, with contamination testing on 74 solid samples from 31 locations and 12 liquid samples for a range of determinands.

Terresearch Site Investigation, 1989 (prepared for Greenham Construction Materials)

4.2.2 Terresearch's primary objective for its investigation was geotechnical and involved the drilling of eight boreholes and 11 trial pits across the "main development site". A total of 30 solid samples were collected from throughout the soil profile within seven trial pits, together with five liquid samples from five locations. The solid samples were analysed for a range of metals, inorganic compounds, toluene extractable matter (TEM) and phenols. The data are summarised below, with the full data set presented within Appendix C.

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Solid Samples ($mgkg^{-1}$)					
Arsenic	30	5	5600	341	1041
Cadmium	30	0.5	5.4	1.4	1.3
Chromium	30	8	60	26	16
Lead	30	5	980	132	221
Mercury	30	0.1	4	0.4	0.9
Selenium	5	1.4	1.7	1.6	0.1
Copper	30	2	290	50	67
Nickel	30	2	290	50	67
Zinc	30	32	3564	451	881
pH (units)	30	6.1	12.2	8.4	1.2
Water soluble boron	30	9.8	>50	~28	~11.6
Phenols	30	1	5.4	1.2	0.8
Total cyanide	30	0.1	2.4	0.2	0.4
Toluene extractable matter	30	100	20500	2370	3873
Sulphate	30	100	226700	33863	57596
Chloride	26	500	2556	636	422
Sulphide	27	0.6	18.4	6.1	6

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Liquid Samples (mgl^{-1})					
Arsenic	5	0.05	0.31	0.1	0.12
Cadmium	5	0.05	0.05	0.05	0
Chromium	5	0.1	0.1	0.1	0
Lead	5	0.5	0.5	0.5	0
Mercury	5	0.02	0.02	0.02	0
Copper	5	0.1	0.1	0.1	0
Nickel	5	0.1	0.1	0.1	0
Zinc	5	0.1	0.1	0.1	0
pH	5	4.2	8.2	6.9	1.6
Water soluble boron	5	24	>30	~24	~0.7
Phenols	5	0.1	0.1	0.1	0
Total cyanide	5	0.02	0.02	0.02	0
Chloride	5	71	895	278	350

Wilkinson Associates Site Investigation, 1992 (prepared for CEL)

4.2.3 Wilkinson Associates carried out a site investigation predominantly within the western sector of the site (known as the ex-Greenham site at the time). Eight trial pits were excavated with a mechanical excavator to depths ranging 0.9m to 1.5m below ground level (bgl) and a total of 18 solid samples and two liquid samples analysed for a range of determinands such as metals and inorganic compounds as follows:

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Solid Samples ($mgkg^{-1}$)					
pH	18	8.2	10.3	8.8	0.5
Arsenic	18	<5	800	246	289
Cadmium	18	0.6	8.5	1.7	2.4
Chromium	18	10	30	21.1	7
Copper	18	6	120	42	30
Lead	18	25	1200	429	371
Mercury	18	<0.5	2.1	1.1	0.6
Nickel	18	6	50	27	14
Selenium	18	0.5	1	0.6	0.2
Zinc	18	35	8500	908	1978
Water soluble boron	18	110	4700	1207	1471
Sulphate (gl^{-1})	18	0.25	2.75	1.5	0.6
Sulphate	18	2000	340000	34472	78240
Sulphide	18	100	2000	206	448

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Liquid Samples (mgl^{-1})					
pH	2	8.1	8.3		
Arsenic	2	2	1.6		
Cadmium	2	0.01			
Chromium	2	<0.05			
Copper	2	<0.05			
Lead	2	<0.05	0.1		
Mercury	2	<0.001			
Nickel	2	<0.05	0.07		
Selenium	2	<0.05			
Zinc	2	<0.05			
Boron	2	190	240		
Sulphate	2	500	1200		
Sulphide	2	<0.02			

Wilkinson Associates Site Investigation (ex-Borax), 1992 (prepared for CEL)

4.2.4 Wilkinson Associates carried out a site investigation predominantly within the north eastern sector of the site. Ten trial pits were excavated with a mechanical excavator to depths ranging 1.2m to 3.2m and six boreholes were drilled using cable percussive techniques to a maximum depth of 29.8m bgl. A total of 21 solid samples were collected from all trial pits and one borehole, together with liquid samples from three trial pits and two boreholes. A range of determinands, including metals, inorganic compounds and TEM were analysed for and the data are summarised below.

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Solid Samples ($mgkg^{-1}$)					
pH	21	5	11.5	7.7	1.7
Arsenic	21	8	2000	161	426
Cadmium	21	0.5	8	1.3	1.7
Chromium	21	5	40	14	9
Copper	21	5	360	82	88
Lead	21	6	7400	791	1578
Mercury	21	0.5	13.7	2.0	3.1
Nickel	21	6	170	40	33
Selenium	21	0.5	1	0.5	0.1
Zinc	21	30	2400	591	652
Water soluble boron	21	6	160000	106003	34990
Sulphate	21	1500	175000	310771	427523
Sulphide	21	100	100	100	0
Chloride	21	100	900	190	184
Toluene extractable matter	21	500	14000	1933	3126

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Liquid Samples (mgl^{-1})					
pH	5	6.1	9.1	7.3	1.2
Arsenic	5	0.05	0.1	0.1	0
Cadmium	5	0.01	0.12	0.1	0.1
Chromium	5	0.05	0.5	0.2	0.2
Copper	5	0.05	0.35	0.1	0.1
Lead	5	0.11	0.7	0.3	0.2
Mercury	5	0.001			
Nickel	5	0.05	5.2	1.5	2.2
Selenium	5	0.001	0.05	0	0
Zinc	5	0.05	12.4	2.9	5.4
Boron	5	13	3400	1075	1498
Sulphate	5	520	16100	5874	6639
Sulphide	5	0.02			
Chloride	5	20	290	134	112
Cyclohexane extractable matter	5	1	10	5	3

Wilkinson Associates Site Investigation (Chitty), 1992 (prepared for CEL)

4.2.5 Wilkinson Associates carried out a site investigation within the south central sector of the site, that had previously been owned by Chitty. Six exploratory holes were excavated using a drive-in sampler to depths ranging 1.6m to 2.5m, from which five samples were collected. These were analysed for a range of determinands including metals, inorganic compounds and TEM and the resulting data are summarised below.

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Solid Samples ($mgkg^{-1}$)					
pH	3	8.3	10.8	9.67	1.27
Arsenic	5	5	40	22	18
Cadmium	3	0.5	1.6	1.1	0.6
Chromium	3	10	15	13	3
Copper	3	50	220	157	93
Lead	3	280	580	387	168
Mercury	3	0.7	1.6	1.2	0.5
Nickel	3	45	50	47	3
Selenium	3	0.5	0.6	0.53	0.06
Zinc	3	180	410	257	133
Water soluble boron	5	1.6	25	14	9
Sulphate	5	500	5500	2100	2302
Sulphide	3	100			
Chloride	3	100			
Toluene extractable matter	3	1000	2000	1667	577

4.3 "Southern Parcel of Land"

4.3.1 In August 1992 Wilkinson Associates carried out a site investigation to assess the extent, nature and degree of contamination at the site, which involved the excavation of four trial pits to a maximum depth of 3.2m. A total of 16 solid samples were analysed for a range of determinands including metals, inorganic compounds and TEM. The data are summarised in the table below with the full data set provided within Appendix C.

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Solid Samples ($mgkg^{-1}$)					
pH (units)	16	8.3	9.3	8.9	0.3
Arsenic	16	5	400	91	104
Cadmium	16	0.5	1.6	0.6	0.3
Chromium	16	5	25	12	5
Copper	16	5	50	15	11
Lead	16	15	320	76	7
Mercury	16	0.5	2	0.8	0.5
Nickel	16	0	30	15	8
Selenium	16	0.5	0.5	0.5	0
Zinc	16	10	120	40	27
Water soluble boron	16	2200	33000	11337	9139
Sulphate	16	800	139000	71019	60554
Sulphide	16	100	200	106	25
Chloride	16	100	900	337	178
Toluene extractable matter	16	500	2800	669	577

4.3.2 In July 1997 Knight Piesold carried out an additional site investigation to quantify the amount and impact of the remaining waste materials on the surrounding environment. This involved the excavation of 60 auger holes and the analyses of 27 solid samples of the waste materials. The analyses revealed concentrations of water soluble boron between 913 $mgkg^{-1}$ and 7936 $mgkg^{-1}$; arsenic between 55 $mgkg^{-1}$ and 3283 $mgkg^{-1}$; antimony ranging from 3 $mgkg^{-1}$ to 95 $mgkg^{-1}$ and sulphate up to 3.2%.

4.3.3 In May 1999 a second site investigation was carried out by Knight Piesold which involved the excavation of six trial pits to an average depth of 3.2m below ground level, the drilling of six boreholes using a cable percussive rig to a maximum depth of 10.0m at locations surrounding the site and the collection of surface water samples from four locations. A dust monitoring programme was also carried out. A total of 15 solid samples were collected from the trial pits and analysed for arsenic, boron and sulphate. Leaching tests were also carried out on the same samples for the same determinands. Liquid samples were collected from the boreholes and surface water locations on four separate occasions and analysed for the presence of pH, arsenic, boron, sulphate and electrical conductivity. The results are summarised below, with the full data set provided within Appendix C.

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Solid Samples ($mgkg^{-1}$)					
Arsenic	15	12.4	565.9	127.6	167.5
Boron	15	803	29131	5728	7748
Sulphate	15	200	128800	13807	32237
Leaching Tests on Solid Samples (μgl^{-1})					
Arsenic	15	20	2086	276	552
Boron (mgl^{-1})	15	56	734	308	247
Sulphate (mgl^{-1})	15	94	1904	850	536

Determinand	No. of samples	Min	Max	Mean	Standard Deviation
Liquid Samples (μgl^{-1})					
Aluminium	5	41	192	124	60
Antimony	5	20			
Arsenic	31	7.5	99	25.6	15.7
Mercury	5	0.2	1	0.5	0.3
Boron	31	232	58100	8623	12671
pH (units)	31	6.7	8	7.1	0.3
Sulphate (mgl^{-1})	31	47	825	220	196
Electrical conductivity ($\mu s\ cm^{-1}$)	31	790	19100	5509	4226

4.3.4 Remediation was considered necessary in order to discharge a condition of a planning consent granted on 31st May 1990. Remedial works were carried out between October 2000 and July 2001 and involved the excavation of 37,119m^3 of waste materials to an approximate average depth of 2.0m below the existing ground level. The excavations involved the removal of gypsum wastes which were of a distinct white colour, whereas the underlying alluvial material was of a darker colour. The excavations were subsequently backfilled with imported 'clean' material. The site has been seeded with an amenity grassland mix as a temporary grass finish.

4.3.5 An estimate of the mass of boron removed from the site can be made based on the volume (37,000m^3), equivalent to 66,600 tonnes, and the mean concentration (5700$mgkg^{-1}$). This provides an approximate mass of 370 tonnes.

4.4 Conclusions

4.4.1 It is agreed that the conclusions reached in the Consolidated Environmental Statement with respect to contamination are representative of site conditions, as described in previous site investigation reports. The data show that the principal potential contaminants identified in these surveys are: arsenic, lead, water soluble boron, sulphate and TEM (as an indicator for the presence of organic substances). Other determinands identified at elevated concentrations are cadmium, mercury, copper, nickel and zinc. There is some indication from the data that contaminants are associated with the Made Ground and that, where data are available, they decrease in concentration with depth.

5. AERC SITE INVESTIGATION, 2003

5.1 Introduction

5.1.1 The objective of the site investigation is to provide a basis for developing an appropriate programme for decontamination and remediation of the site.

5.2 Field Work

5.2.1 The field work was carried out between 23 July 2003 and 15 September 2003 in accordance with the guidelines given in BS 5930[4] and BS 10175[5], where applicable and involved: the excavation of trial holes; installation of boreholes; sampling of solids and waters; and a water level survey.

5.2.2 The positions and depths of the exploratory holes were determined and set out on site by AERC and are shown on Drawing No. C3474/R1384/05. The site was initially divided into a 40m grid to provide trial pit locations. These were marked out on site and each one scanned using a cable avoidance tool. The only service found on site was an electricity cable, however, this did not interfere with the locations. As the majority of the site was covered in concrete, a second JCB fitted with a hydraulic jackhammer was used to break out each location for both trial pits and boreholes. In the south east and north east corners of the site, concrete and brick footings were encountered at depths of between 0.7m and 1.4m which proved impenetrable.

5.2.3 The depths of the exploratory holes, the description of the strata encountered and comments on groundwater conditions are given on the exploratory hole records presented within Appendix D. The description of the soils encountered are generally in accordance with BS 5930.

Exploratory Holes

5.2.4 A total of 50 trial pits were excavated by JCB 3CX Backhoe Loader across the site, ranging in depth from 1.6m to 3.0m. Excavation of trial pits 01-42 was carried out in the period 23 July to 30 July 2003 on the "main development site", with an additional two trial pits excavated on 20 August 2003 in the area to the east of the site (it is understood that this has been referred to as the "blue land"). Six exploratory holes were excavated on the "southern parcel of land" between 20-21 August 2003. Three hand auger holes were excavated from the verge on the western side of Norman Road on 29 August 2003.

5.2.5 Ten boreholes were sunk by cable percussion techniques in the period between 31 July and 15 August 2003 on the "main development site". Each location was broken out using a JCB 3CX Backhoe Loader to the depth of natural ground in order to remove any obstruction which may have otherwise been encountered whilst drilling. Groundwater monitoring standpipes were placed in all boreholes and comprised a 50mm diameter slotted pipe with gravel pack in the response zone (the Floodplain Gravels), overlain by plain pipe of the same diameter. Bentonite seals were placed at the boundary of each

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4 BS 5930: Code of Practice for Site Investigations. British Standards Institution, 1999.

5 BS 10175: Code of Practice for the Investigation of Potentially Contaminative Land. British Standards Institution, 2001.

strata to prevent creation of a pathway for contaminant migration. All the installations were concreted in place to ground level and fitted with a gas tap and a lockable stopcock cover.

Sampling

5.2.6 Disturbed solid samples from all exploratory holes were collected at depths throughout the profile, shown on the exploratory hole records. All samples were despatched to Applied Environmental Services' Laboratories for examination and testing.

5.2.7 Groundwater samples were collected on two occasions. On the first occasion (20-21 August 2003) samples were collected from nine of the boreholes within the "main development site". The second sampling round (28-29 August 2003) included 8 samples from the "main development site" and 4 of the previously existing boreholes located to the north, west and south of the remediated area within the "southern parcel of land". On completion of purging approximately three well volumes, a 3.5l liquid sample was collected from 13 boreholes and despatched to the laboratory in Colchester for examination and testing.

5.2.8 Surface water samples were collected on 20 August 2003 from three locations. One sample (SW1) was collected from a drainage ditch situated within the north western sector of the "main development site", whilst the other two (SW2 and SW3) were from the drainage ditches along the northern and western perimeters of the "southern parcel of land".

5.2.9 Additional surface water samples were collected on 15 September from equivalent locations to SW2 and SW3 (SW4 and SW5 respectively), from Belvedere ditch which drains into the Norman Road ditch (SW6) and from Horsehead Dyke (SW7) downstream of the site.

Surveying

5.2.10 A groundwater level survey was carried out on 2 September 2003 in the boreholes on the "main development site". This was implemented over an eight hour period to cover both high and low tide on the River Thames in order to evaluate tidal influence on groundwater level and flow direction at a local level.

5.2.11 Exploratory holes on the "main development site" and the "southern parcel of land" were surveyed to an Ordnance Datum on 28 August 2003 and are shown on the exploratory hole records.

5.3 Laboratory Testing

5.3.1 Chemical analysis were carried out on 95 solid samples for some or all of the following determinands:

- Arsenic
- chromium
- mercury
- copper
- cadmium
- lead
- boron
- nickel

- zinc
- sulphate
- polycyclic aromatic hydrocarbons (PAH)
- benzene
- ethylbenzene
- chlorinated hydrocarbons
- sulphide
- total phenols
- total petroleum hydrocarbons
- toluene
- xylene
- asbestos

5.3.2 Surface and ground water samples were analysed for similar determinands as those selected for solid analysis, as follows:

- arsenic
- chromium
- mercury
- copper
- zinc
- sulphate
- polycyclic aromatic hydrocarbons (PAH)
- total organic carbon
- volatile compounds
- cadmium
- lead
- boron
- nickel
- sulphide
- total phenols
- total petroleum hydrocarbons
- semi-volatile compounds

5.3.3 The analytical suite for both solids and waters was selected on the basis of the history of the site and analytical data available from previous investigations and includes potentially phytotoxic and zootoxic elements, together with determinands which represent the dominant indicators of organic contamination.

5.3.4 In order to gain further information regarding the potential mobility of certain determinands within the solids, leaching tests were carried out on 19 samples, in accordance with the Environment Agency draft methodology[6]. Samples were selected to include representatives containing elevated concentrations of particular determinands.

[6] National Rivers Authority: Leaching Tests for Assessment of Contaminated Land - Interim NRA Guidance. R&D Note 301, Environment Agency, 1994.

6. RESULTS AND CONCEPTUAL MODEL

6.1 Summary of Ground Conditions

6.1.1 The results of the site investigation show slightly different ground conditions than those predicted in the conceptual model. However, the sequence of materials found was identical i.e.; Made Ground, Alluvium, River Terrace Gravels and London Clay with a surface covering of concrete over most of the site.

6.1.2 Made Ground was present in all the exploratory holes with thicknesses varying between 0.60m and 4.00m, in boreholes BH5 and BH10, respectively. On average the thickness was 1.49m compared to 3m in the conceptual model. This deposit typically comprised silty clays with varying amounts of brick, concrete and chalk fill present. It should be noted that a band of white silty sand was encountered within a number of trial pits which may have been a product of the former borax works.

6.1.3 Underlying the Made Ground was a substantial deposit of soft to firm green-grey silty clay, occasionally with peaty lenses, believed to part of the Alluvium. This was present to depths of between 4.00m, in borehole BH5, and 9.30m, in borehole BH4 where it was also at its thickest. The thickness of the deposit decreased towards the north-west of the site where only 2.00m of Alluvium was recorded in borehole BH10. Overall, the average thickness of the Alluvium was 4.25m compared to 8m in the previous conceptual model. Substantial deposits of peat were encountered within the Alluvium with the greatest thickness of 3.15m in borehole BH4. The main deposits of peat were encountered as follows:

- BH2 Between 2.80m and 4.05m
- BH4 Between 2.75m and 5.90m
- BH5 Between 2.70m and 4.00m
- BH7 Between 2.90m and 4.80m
- BH8 Between 3.80m and 5.80m
- BH9 Between 3.70m and 6.10m
- BH10 Between 4.00m and 6.00m

6.1.4 The River Terrace Gravels were then encountered in all the boreholes. This deposit consisted of predominantly sandy gravels although towards the top of the stratum, it tended to be a gravelly sand. The River Terrace Gravels were present to depths between 13.40m, in boreholes BH7 and BH8, and 16.55m, in borehole BH2. Thickness varied between 5.30m and 12.05m with the maximum thicknesses measured to the east of the site in boreholes BH2 and BH3.

6.1.5 All the boreholes were terminated at depths between 14.00m and 17.00m within the London Clay. This typically comprised a stiff grey-brown silty clay.

6.2 Groundwater

6.2.1 Groundwater was encountered within all the boreholes, and in a number of trial pits, predominantly in the north-east of the site. From the water strikes it is probable that two distinct water tables are present in the near surface deposits. The first water body is within the Made Ground or at the top of the Alluvium and was encountered at depths between 0.20m and 4.90m. After first encounter, the water level only rose by a few centimetres.

6.2.2 The second water body was noted within the River Terrace Gravels and generally rose by a few metres after first encounter.

6.2.3 The water within the Made Ground/Alluvium appears to be ephemeral. Standpipes were inserted into the Made Ground but no water was recorded. It is believed that the water within the Made Ground is a result of recent rainfall and that it rapidly dissipates into on site water courses. The relative inpermeability of the underlying Alluvium acts as an aquiclude between the Made Ground and River Terrace Gravels.

6.2.4 Indeed, the Alluvium also limits the influence of the adjacent River Thames with the near surface deposits. At high tide, the level of water within the Thames is up to 3.50m OD (some 2m higher than average ground levels across the site) with no effect on the Made Ground or Alluvium.

6.2.5 The underlying River Terrace Gravels, however, do show a marked influence relating to the tidal activities of the Thames. Water levels within the gravels can vary by approximately 2.50m over a tidal cycle. Therefore, it is reasonable to suggest that the River Terrace Gravels are in hydraulic continuity with the Thames. Groundwater flow is generally toward the Thames although the direction slews from north at high tide to north-west at low tide. Plots of groundwater levels at high and low tides are given in Appendix D.

6.3 Chemical Data

Introduction

6.3.1 Chemical data are included in Appendix E and summarised in Tables 1-4 at the end of this document. These have been evaluated in the context of the Assessment Framework described in Appendix F and are described in the following sections.

Solids

6.3.2 There are no mandatory standards in the United Kingdom for assessing the level of contamination on a site. However, DEFRA and the Environment Agency have proposed a set of guidelines known as The Contaminated Land Exposure Assessment Model (CLEA)[7] which provide a site specific risk based assessment framework for a limited number of contaminants. For those contaminants not yet covered by CLEA, AERC has compiled a set of Risk Assessment Values (RAVs) which is based on available guidance,

[7] The Contaminated Land Exposure Assessment Model (CLEA): Technical basis and algorithms. R&D Publication CLR10. DEFRA, Environment Agency (2002).

such as the Environment Agency and the Netherlands Test Tables AERC's RAVs should be considered as representative of a screening level above which risk should be considered.

6.3.3 The CLEA model provides default guideline values (Soil Guideline Values; SGV) representing potential risk to human receptors for four possible afteruses: residential with vegetable intake; residential without vegetable intake; allotments and commercial/industrial.

6.3.4 The proposed development comprises commercial/industrial usage with areas of hardstanding and landscaping. Consequently data have been compared with the SGV for commercial use. The SGVs for residential with vegetable uptake are more stringent, reflecting the increased exposure anticipated in the domestic environment. However, these values are closer to 'typical' concentrations which may be found in uncontaminated soils and hence provide an indicator of whether a particular determinand occurs on the site at elevated concentration, in which case it may be a risk to other receptors.

6.3.5 Data are summarised in Tables 1a ("main development site") and 1b (adjacent to Norman Road) with respect to the range and proportion of samples exceeding a defined comparitor.

"Main Development Site"

6.3.6 Concentrations of cadmium and chromium are all below the CLEA SGV for both residential and commercial end use.

6.3.7 Concentrations of mercury and nickel were found to be lower than the CLEA SGV for a commercial end use in all samples.

6.3.8 The maximum concentration of lead recorded in solid samples was 2175 $mgkg^{-1}$ and 8 samples exceeded the commercial CLEA SGV of 750 $mgkg^{-1}$. However, the CLEA guidelines require comparison of the 'geometric' mean of the population with the SGV. The geometric mean concentration for lead was determined as 181 $mgkg^{-1}$ which is below both the CLEA SGV for domestic and commercial enduses. The 95%ile of the population is 223 $mgkg^{-1}$. The maximum value test was used to assess the presence of outliers, but none of the values were identified as being potential 'hotspots'.

6.3.9 In the majority of samples arsenic was present at a concentration in excess of the SGV for residential with vegetable uptake and a small number of samples (2) contained arsenic at a concentration in excess of the CLEA SGV for commercial use. Statistical analysis has indicated that these two values are outliers from the population and consequently represent 'hotspots' of contamination. Analysis of the remaining 90 points provides a 95%ile of 68$mgkg^{-1}$ for comparison with the SGV (500$mgkg^{-1}$) indicating that the commercial end use SGV was not exceeded.

6.3.10 Copper, zinc and boron are generally considered to be a potential risk to plants rather than human health. No CLEA SGV values have been derived. Data from the site have

been compared with the Environment Agency Lower Threshold Concentrations (LTC)[8] which represent levels at which 'soils' can be used for uses leading to crop growth for human or animal consumption.

6.3.11 Copper and zinc exceeded the LTC in 23% and 46% of samples respectively. The concentration of water soluble boron ranged between 4mgkg^{-1} and 96mgkg^{-1} and exceeded the LTC in all samples.

6.3.12 The horizontal distribution of arsenic and boron are depicted in drawings C3477/R1384/06 and C3477/R1348/07, where values lower than the mean have been indicated as green and concentrations in excess of the mean marked as red[9]. The highest concentrations of arsenic were located to the west, north and east of the 'main development site'. Boron concentrations were relatively high to the west of the 'main development site'.

6.3.13 Comparison of the mean concentrations of arsenic and boron in Made Ground, and the underlying alluvium indicate a decline for arsenic from 121mgkg^{-1} to 41mgkg^{-1}. There is no difference in the boron concentration recorded in these two strata (Made Ground – 43mgkg^{-1}; alluvium – 42mgkg^{-1}). Other metals occur only rarely at elevated concentrations within the alluvium.

6.3.14 The maximum concentration of PAH detected on site was 145 mgkg^{-1} which is below the upper RAV derived by AERC. CLEA guideline values have been published for one PAH: (benzo (a) pyrene). Concentrations detected on site ranged between 0.3 mgkg^{-1} – 14.6 mgkg^{-1}, compared with the CLEA SGV[10] for a commercial use of 37mgkg^{-1} All values were below this level.

6.3.15 There are no UK guidelines for benzene, toluene, ethylbenzene and xylene (BTEX) and chlorinated solvents. Data for BTEX and key solvents (trichloroethene and tetrachloroethene) have been compared with the relevant Netherlands Intervention Values (NIV). Concentrations in all samples were below the NIV.

6.3.16 There was evidence for the presence of hydrocarbons (TPH) at concentrations in excess of a screening level of 500 mgkg^{-1} in a third of the samples, but the NIV was not exceeded in any sample.

6.3.17 Phenols were not present at detectable levels in any sample.

6.3.18 The maximum concentration of water soluble sulphate detected was 2.9gl^{-1} and 36 % of samples contained sulphate at a concentration in excess of 1.2 gl^{-1} advised by the BRE as indicative of the need to use resistant cement in concrete.

6.3.19 A small number of samples contained sulphide at a concentration greater than the RAV, the maximum concentration being 503 mgkg^{-1}, compared with a RAV of 250 mgkg^{-1}.

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8 Environment Agency : Guidance on the Disposal of Contaminated Soils. Version 3, April 2001

9 For arsenic the mean has been calculated without the 2 highest concentrations, assumed to be outliers.

10 CLEA SGV based on soil pH of 8; organic matter content of 2% and a sandy texture

6.3.20 Asbestos determinations were carried out on 32 samples. Chrysotile fibres were observed in one sample (TP23, 0.8m) at a concentration range between 0.01% - 2%. No asbestos was identified in any of the other samples.

Adjacent to Norman Road

6.3.21 The concentrations of determinands detected were in a similar range to those identified in the "main development site" but pH values were below 8.2.

Water Quality

6.3.22 Data for groundwater and surface water are summarised in Tables 2 and 3, respectively.

6.3.23 Groundwater has been assessed against the UK Drinking Water Standards (DWS). Where there are no standards present recourse has been made to the European Community Drinking Water Standards. Groundwater samples were taken from each of the borehole standpipes installed into the River Terrace Gravels with the exception of Borehole BH6 which had been vandalised. Of the remaining 9 samples collected on the first round of samples (Table 2a), only nickel arsenic, boron and sulphate were found to exceed the relevant DWS as detailed below;

- Nickel BH4 at 66µg/l, BH8 at 48µg/l, & BH9 at 34µg/l (DWS of 20µg/l).
- Arsenic BH3 at 66µg/l, BH5 at 28µg/l, BH7 at 2285µg/l, & BH10 at 869µg/l (DWS of 10µg/l).
- Boron All samples within the range from 13mg/l to 15mg/l (DWS of 1mg/l)
- Sulphate All samples within the range from 387mg/l to 1545mg/l (DWS of 250mg/l)

6.3.24 This distribution of arsenic in groundwater appears to be positively related to pH, as shown in Drawing C3477/R1384/08.

6.3.25 Data for the second round of sampling (Table 2b) show a similar trend but include data for boreholes located around the site of the former borax storage area. Generally water quality with respect to arsenic, boron and TPH was improved in this area when compared with the "main development site".

6.3.26 Surface water quality may be assessed using two parameters: Environmental Quality Standard (EQS) for freshwater and Environmental Quality Standard for saline waters. For the purpose of this assessment the EQS for freshwater has been adopted as the onsite ditches are not directly connected to the River Thames.

6.3.27 Three samples of surface water were taken from ditches on and around the site as shown on the site location plan. For the majority of the determinands, the levels recorded on site do not exceed the relevant EQS. However, for arsenic and boron all samples obtained exceeded the relevant EQS; 50µg/l and 2mg/l, respectively. In addition, one sample showed an elevated level of sulphide, compared to an EQS of 0.25g/l, and one sample showed an elevated level of sulphate, compared to an EQS of 250mg/l.

6.3.28 Data for four additional surface waters collected from the site and surrounding watercourses are provided below:

Determinand	SW4 (adj. To Norman Road ditch)	SW5 (adj. To remediated "southern parcel of land")	SW6 Belvedere ditch	SW7 Horsehead ditch
pH (units)	7.66	8.58	72	7.06
Electrical conductivity (μScm^{-1})	901	2190	1177	878
Arsenic (μgl^{-1})	44	580	7.1	9.0
Boron (mgl^{-1})	10	14	3	0.6

6.3.28 With respect to arsenic and boron the quality of water downstream of the site (SW7) is similar to, or better than, the sample from an inflowing watercourse (SW6).

Leaching Tests

6.3.29 The data from the leaching tests are included in Table 4 which also provides the total concentration within the solid sample.

6.3.30 The samples were selected to include some of the highest solid values. Data indicate that cadmium, lead, mercury, copper, nickel, zinc and sulphide are not mobile and that PAH have a low mobility.

6.3.31 Arsenic was observed to be mobile in some samples. Further evaluation of the data indicates that the solubility relative to the total concentration is related to soil pH. At soil pH values of 8.3 and below the arsenic is relatively immobile but its mobility increases significantly at pH values 8.4 or greater.

6.3.32 The data for TPH indicate relatively high mobility within the leachate.

6.4 Conceptual Model

6.4.1 The conceptual model, presented in Appendix B, has been revised in the light of the recent ground investigation. The main changes are;

- Thickness of Made Ground is not as great as originally thought.
- Thickness of the Alluvium is not as great as originally thought.
- The perched water table within the Made Ground is not extensive and appears to be influenced by rainfall.
- The Alluvium is acting as an aquiclude to the extent that it prevents water from the River Thames from penetrating the Made Ground.
- The extent of contamination, with the exception of arsenic and boron, is not as great as shown in the original model for either the ground, groundwater or surface waters.
- Groundwater flow within the Made Ground is towards the onsite drainage ditches and not the River Thames.
- Groundwater flow within the River Terrace Gravels minor aquifer is towards the River Thames.

7. RISK ASSESSMENT

7.1 Introduction

7.1.1 When assessing the potential hazards and liabilities relating to land contamination the following issues must be addressed:

- Does the site present a threat to the public, controlled waters, sites of importance for nature conservation or buildings in its current state?
- Will the contaminants present a hazard to site operatives or the surrounding environment during redevelopment?
- Will there be a threat to end-users of the site? And
- Is there a potential for future liabilities die to off-site migration of contaminants.

7.1.2 Current good practice requires evaluation of risk from contamination according to the source-pathway-receptor model. A key component of this is the development of a Conceptual Model which is a representation of environmental processes on a site and in its vicinity. Its purpose is to identify potential contaminants, pathways and receptors with a view to identifying potentially significant pollutant linkages.

7.1.3 Within this section each component of the Conceptual Model is described as a basis for the risk assessment.

7.2 Potential Contaminants

7.2.1 Chemical data from the investigation carried out by AERC are included in Appendix E and have been described relative to a range of risk assessment guideline values in Section 7.

7.2.2 The data indicate elevations of the following determinands within solids:

Metals:	arsenic, lead, mercury, copper, nickel
Non-metals:	boron, water soluble sulphate and sulphide
Organics:	TPH and PAH
Others:	Asbestos

7.2.3 The range of substances detected at elevated concentration is consistent with the determinands detected at elevated concentration in other investigations carried out at the site and summarised in Section 4 of this report.

7.2.4 Elevations of lead, mercury, copper, nickel, TPH, PAH, sulphide and asbestos are relatively localised, with zinc occurring at an elevated concentration in approximately half the samples. Arsenic and boron are the most widely distributed contaminants.

7.2.5 Whereas the mean concentration of boron is similar in the Made Ground and the underlying alluvium, there is evidence that the concentration of arsenic and other metals within the alluvium is lower than the Made Ground.

7.2.6 Data on water quality have shown that a number of the metals are not detectable within ground or surface waters. These are: cadmium, chromium, lead, mercury, copper and zinc. There is some mobility of nickel and sulphide and high mobility of arsenic, boron and sulphate.

7.2.7 There is no evidence from the data for the presence of BTEX or chlorinated solvents within ground or surface waters. Data for PAH show the majority of samples at a concentration below the drinking water standard. Some mobility of TPH is indicated.

7.2.8 Leaching test data have provided further confirmation of the low mobility of cadmium, lead, mercury, copper, nickel, and sulphide but have shown some mobility of TPH and of arsenic in high pH soils.

7.3 Receptors

7.3.1 In the context of Part IIA of the Environmental Protection Act, 1990 (EPA 1990) which defines the term 'contaminated' for the purposes of the legislative framework the relevant targets are: humans; controlled waters; an ecological system of specified conservation interest and property, provided they are likely to suffer harm from the contaminant. Planning guidance for site redevelopment requires 'at the minimum' a 'suitable for use' approach which takes into account the actual or intended use of the site.

7.3.2 Consequently potential receptors requiring consideration at the site are:

- Current users of the site
- Future site occupiers
- Surface waters
- Ground waters
- Structures and Services
- Site construction workers
- Adjacent land owners during construction
- Future areas of landscaping

Current Site Users

7.3.3 Currently the site is not generally accessible to the general public. It is also covered predominantly by hardstanding. Consequently there are limited pathways for migration of contaminated soils towards human receptors and the site presents a low risk to human health.

Future Human Occupiers

7.3.4 The site is to be used for a commercial/industrial end-use and would be constantly occupied by humans on a shift system. As the majority of the application site is to be covered with hardstanding there would be little potential for contact between humans and the underlying soils.

7.3.5 Data for metals (arsenic, cadmium, chromium, lead, mercury and nickel) have been compared with the relevant CLEA SGV default value for a commercial/industrial end-use. The only determinand to exceed the SGV was arsenic in 2% of samples. Given the low numbers of samples in excess of the SGV it is concluded that there is no risk to human health from these determinands.

7.3.6 Copper, zinc and boron were detected at elevated concentration in a proportion of samples (copper and zinc) and nearly all samples (boron). Guidance on potential receptors for inorganic contaminants have been published by DEFRA and the Environment Agency[11]. Humans have not been identified as being a potential receptor to any of there elements and therefore their presence in the ground is unlikely to present a risk to human health.

7.3.7 Further information has been obtained from this investigation on the distribution of organic substances across the site. There is no evidence for elevated concentrations of phenols, BTEX and chlorinated solvents. A general screen of other volatile substances did not identify other determinands at elevated concentration.

7.3.8 There is a CLEA SGV default value for a key PAH species, benzo (a) pyrene. The concentration for a commercial/residential end-use, assuming a low organic matter content (2%) and a sandy soil at a pH of 8, is 37 $mgkg^{-1}$. The maximum concentration detected on site was 13 $mgkg^{-1}$. It is concluded that there is no risk to human health from the presence of PAH in the ground.

7.3.9 The highest TPH concentration detected in solids was 2193 $mgkg^{-1}$. There is currently no UK guidance on the risks to human health associated with TPH although this is currently under review. The Netherlands has an intervention value, i.e. a concentration above which remediation is required, of 5000 $mgkg^{-1}$, over twice the maximum value recorded. It is concluded that the risk to human health from the presence of mineral oils is negligible.

7.3.10 There was no visual evidence for the presence of asbestos on the site. A total of 32 samples were screened for asbestos fibres and chrysotile, white asbestos, was identified at low concentration in one sample. There is no indication that asbestos is distributed widely across the site and consequently there should be no risk to the health of future site occupiers. However, in the event that asbestos is observed during construction, further tests should be made and appropriate measures taken to protect the health of site workers and to ensure that future site occupiers will not be adversely affected.

7.3.11 On the basis of the data acquired in the AERC site investigation, and taking into consideration data from previous investigations, it is concluded that the there will be no risk to future site occupiers when developed to a commercial/industrial use.

Surface Waters

7.3.12 The drainage ditches on site eventually drain into the River Thames. The main source of contamination which will affect the surface waters is the contamination contained

[11] DEFRA/Environment Agency R&D Publication CLR 8: Potential Contaminants for the Assessment of Land

within the main ground. As identified above, only arsenic and boron have been recorded within the surface water samples at concentrations in excess of the EQS with the exception of sulphate in 1 sample. Both arsenic and boron have been found to be relatively mobile and can be leached out of the ground. However, it has been shown within the Knight Piesold report that although there are elevated levels of both arsenic and boron within the onsite drainage ditches, dilution of the surface water decreases the levels of contamination by the time the surface waters reach Horsehead Dyke at the entrance to the site.

7.3.13 Data obtained from this investigation have shown broadly equivalent concentrations of arsenic in a ditch upstream of the site (Belvedere ditch), compared with Horsehead Dyke. Concentrations of boron were higher upstream than downstream.

7.3.14 The data indicate that there is no adverse impact of contaminants on surface water quality outside the site boundary, although there are localised elevations within the site. Water quality at the perimeter of the "main development site" has not been measured because of the ephemeral nature of the peripheral ditches.

7.3.15 A significant mass of boron has been removed from the "southern parcel of land" (approximately 375 tonnes), and concentrations remaining within the "main development site" are significantly lower than those which were detected in the "southern parcel of land" before remedial works were carried out (mean = 42mgkg^{-1} compared with 5700mgkg^{-1}). Boron concentrations in surface water ditches would be expected to decline further as a consequence of the removal of the source.

7.3.16 There appear to be localised elevations of arsenic in surface water on site. Data from the leaching tests indicate that arsenic mobility is related strongly to soil pH, and that mobility is enhanced at soil pH of 8.4 or greater. Below this pH, the arsenic is relatively immobile. Within the Made Ground, there are significant areas with pH greater than 8.4 and therefore there is a risk, albeit relatively low, of ongoing arsenic migration into surface water courses on the site.

Groundwater

7.3.17 As shown in the conceptual model, there is no direct pathway between the soils on site and the minor aquifer within the River Terrace Gravels. However, the few elevated levels of arsenic, nickel and boron are not considered significant as the groundwater at this point is highly influenced by the tidal River Thames with flow towards the river. Therefore, any contamination present will be diluted by the Thames and present a negligible risk.

Structures and Services

7.3.18 Water soluble sulphate levels have been found to be in the range from 0.11g/l to 2.98g/l with a mean value of 0.90g/l within the soil. This is allied with generally alkaline pH values of up to 10.5. This would entail that all buried concrete be designed to Design Sulphate Class DS3 to prevent sulphate attack.

7.3.19 Sulphate within the groundwater has been measured at levels between 0.38g/l and 1.55g/l which again entails that all buried concrete is designed to DS3 conditions.

7.3.20 No other determinand is present on site in concentrations which would affect foundation design. However, Thames Water may dictate the specification of pipe works installed in the ground for potable water due to the localised elevated levels of TPH recorded.

Site Construction Workers

7.3.21 Although elevated concentrations of metals, non-metals and organic materials have been identified there should be no risk to the health of site construction workers provided that appropriate health and safety precautions are taken by all site workers in accordance with guidance from the Health and Safety Executive[12].

7.3.22 There is no evidence for widespread occurrence of asbestos on the site. However, in the event that asbestos is observed during site works, further tests should be made and appropriate measures taken to protect the health of the workers and to ensure that future site occupiers will not be adversely affected (*cf* 7.3.10).

Adjacent Land Owners

7.3.23 The principal risk to adjacent land owners would be during development of the site as a consequence of the liberation of dusts consequent on construction activities. The nearest areas of public residency are 1 km from the southern boundary of the 'main development site' at North Road. In addition two footpaths abut the site, one along the northern and the other along the eastern boundary.

7.3.24 Recent Environment Agency guidance[13] relating to the dispersion of dust around waste management facilities provides some indication of the anticipated dispersal relative to particle size; particles with diameter >30μm being deposited within 100m of the source and smaller particles travelling a distance of up to 1km from the source.

7.3.25 The nearest population centre is located beyond the anticipated distance for dust dispersal. Any use of the footpaths would be transitory, with little potential for exposure. Consequently it is concluded that there would be no risk to human health from dust emissions arising from construction activities.

End-users: Plants

7.3.26 Areas of landscaping are to be incorporated into the development area and also adjacent to the north eastern boundary.

7.3.27 Of the inorganic parameters reported at elevated concentration the following are considered by DEFRA/Environment Agency to represent a potential risk to the health of vegetation: boron, copper, lead, mercury, nickel and zinc. The leaching test data indicate a low mobility for copper, lead, mercury, nickel and zinc and it is concluded

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12 Health and Safety Executive: Protection of Workers and the General Public during the Development of Contaminated Land. HMSO, London1991.

13 Environment Agency Technical Guidance Document (Monitoring) M17 Waste Facilities. Version 3.0, February 2003.

that these would present a low risk to plant health. Boron is widely distributed at concentrations an order of magnitude greater than typical soil levels and is likely to present a moderate risk to plant health.

7.3.28 Other determinands which DEFRA/Environment Agency cite as being potential contaminants of concern for plant health are: sulphate, sulphide, pH and fuel hydrocarbons.

7.3.29 The presence of sulphate at elevated concentration, combined with pH levels at up to a maximum of 10.5 units, would be likely to support a specific type of plant community which is adapted to these conditions. Other species which are more tolerant of neutral pH and normal sulphate levels would be unlikely to survive in some parts of the site.

7.3.30 Mineral oils will be degraded with time and can provide a nutrient source to plants, dependent at concentration.

7.3.31 The principal risks to plant health on the site are likely to be related to the wide distribution of boron, sulphate, and high pH.

7.4 Summary

7.4.1 The magnitude of potential risks arising from the presence of existing ground contamination and in the absence of mitigation measures, are summarised in Table 5. This identifies the following potential risk factors.

a) Risk of contaminant migration into on-site ditches and dykes, particularly during construction. This could potentially arise following the disturbance of soils removed from site, *e.g.* from excavation of the ash bunker, and from piling. In addition, in the absence of a structure over the site, there would be potential for ongoing leaching of certain contaminants *e.g.* arsenic, from the Made Ground.

Once the construction is formed the risk will be reduced, partly because formation of the structure would remove a pathway for over 50-60% of the site. Any residual risk would be attributable to migration from exposed Made Ground.

b) Risk to health of construction workers. This will be minimised providing appropriate health and safety measures are used.

c) Risk to structures and services. This will be minimised by the design of all buried concrete to DS3 conditions. In addition, agreement will be required with Thames Water regarding the specification of pipe works installed into the ground for potable supply.

d) The potential contaminants of principal concern with respect to plant health are boron and sulphate. In addition the high pH of the Made Ground would limit the range of plant species suitable for planting.

7.4.2 On the basis of the above analysis remedial works will be required to:

a) reduce the potential for leaching of metals, particularly arsenic, into surface water bodies;
b) provide a 'clean' seed bed for areas of planting.

Table 5 Summary of Risks

Target	Construction Score	Operational Score
Human occupiers	N/A	1
Surface water		
R. Thames	1	1
On-site ditches/dykes (existing)	3	2
New water bodies	3	2
Off-site ditches	2	1
Groundwater		
Alluvial gravels	2	1
Aquifer	1	1
Structures and services	3	2
Site construction workers	3	3
Adjacent land users	1	1
Plants	N/A	3

Risk Scoring

1 - negligible
2 - low
3 - moderate
4 - high

8. REMEDIATION PROPOSALS

8.1 Introduction

8.1.1 The following remediation proposals have been designed to reduce the risks identified to a low level and are focused on the following three areas within the "main development site":

- Area to the east of the "main development site" (Zone 1)
- Area to the south and west of the "main development site" alongside existing water courses (Zone 2)
- Other areas of planting (Zone 3).

8.1.2 These proposals comply with the objectives of the mitigation measures detailed in Chapter 15 of the Consolidated Environmental Statement.

8.2 Zone 1

8.2.1 This encompasses the area to the east of the "main development site" and the area of land currently outside the development area. This zone is to be developed to a combination of planting, swamp areas and a new water body. The depth of Made Ground across this area is in the region of 1m. High concentrations of arsenic have been detected in the Made Ground at high pH.

8.2.2 It is proposed that all Made Ground is excavated from the area and removed from site. This should be replaced with clean infill with a hydraulic conductivity of 1×10^{-6}m/s or lower. The depth should be a minimum of 0.5m, of which a minimum of 0.3m should be soil suitable for forming a seed bed. The depth of cover may be deeper dependent on the invert levels required to ensure drainage into adjacent water bodies.

8.2.3 The hydraulic conductivity of the material to be emplaced in this area has been based on use of the Ogata Banks model and Environment Agency methodology[14] to determine the distance which arsenic would be expected to migrate, over a timescale of 1,000 years.

8.2.4 Assuming an initial concentration at the source of $1mgl^{-1}$ (twice the maximum concentration detected in a leaching test), the pore water would be equivalent to an EQS of $25\mu gl^{-1}$ at a distance of approximately 4.3m from the source, after a period of 1,000 years (Appendix G). Consequently it is concluded that there would be limited migration of arsenic from on-site sources into existing and new water bodies to the east of the site.

8.3 Zone 2

8.3 To the south and west, alongside the existing watercourses. Made Ground should be removed to a distance of 5m from the water course, on the development side, and replaced with clean material with a minimum hydraulic conductivity of 1×10^{-6}m/s.

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[14] Environment Agency R & D Publication 20. Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources (1999).

Any area of planting should have a minimum cover depth of 0.5m, of which a minimum of 0.3m should be soil suitable for forming a seed bed. The depth of clean soil in areas of tree planting should be thickened locally to a depth of 1.0m.

8.4 Zone 3

8.4.1 In other areas of planting a minimum cover depth of 0.5m of clean material should be provided of which a minimum of 0.3m should be soil suitable for forming a seed bed. The depth of soil in areas of tree planting should be thickened locally to a depth of 1.0m. These areas may be raised over existing ground, if required.

8.5 Use of materials on-site

8.5.1 Excavated materials, *e.g.* from piling, excavation of the ash bunker, or relocated from areas of planting may be used on-site to raise levels under areas of hardstanding subject to approval of the Environment Agency.

8.6 Off-site disposal

8.6.1 All materials for off-site disposal should be disposed to an appropriately licensed facility in accordance with the requirements of the Environmental Protection Act, 1990 (EPA, 1990) and the Waste Management Licensing Regulations 1994, as amended.

8.7 Health and Safety

8.7.1 Measures are required to protect the Health and Safety of Workers on site. These should comply with the Health and Safety Executive Guidance (1991).

8.7.2 Dust suppression measures should be used to ensure that dust levels do not exceed the Occupational Exposure levels.

8.7.3 In the event that further deposits of asbestos are identified these should be investigated by a suitably qualified organisation and appropriate remedial measures carried out.

9. SUMMARY AND RECOMMENDATIONS

9.1 The Application Site has been the subject of a number of potentially contaminative uses, the principal one being the manufacture of borax related chemicals, which commenced in the late 19th century and ceased in 1988. Remedial works have been carried out in the 'southern parcel of land' involving the removal of over 35 000m^3 of contaminated soil.

9.2 Site investigations carried out between 1989 and 1992 have identified the presence of contamination within solids, principally comprising: inorganics, particularly arsenic, boron and sulphate.

9.3 Chapter 15 of the Consolidated Environmental Statement considers the potential '*Geo-Environmental Impacts*' of the development, and the mitigation measures required.

9.4 In July 2003 AERC was commissioned by RRRL to carry out more detailed investigation of the site in order to provide confirmation of the spatial distribution of contaminants and the hydrogeological regime as a basis for refining the Conceptual Model.

9.5 The investigations have confirmed the general nature of the contamination present within solids on site. They have also provided the following information which is relevant to the Conceptual Model and risk assessment:

- The thickness of the Made Ground is on average 1.50m
- The thickness of the Alluvium is on average 4.50m.
- The perched water table within the Made Ground is not extensive and appears to be influenced by rainfall.
- The Alluvium is acting as an aquiclude to the extent that it prevents water from the River Thames from penetrating the Made Ground.
- Groundwater flow within the Made Ground is towards the on site drainage ditches and not the River Thames.
- Groundwater flow within the River Terrace Gravels minor aquifer is towards the River Thames.

9.6 The solubility of arsenic in solids on site is governed by soil pH, with solubility higher at a pH of 8.4 and above.

9.7 It is concluded from the risk assessment that limited remedial works are required and that these should include:

- removal of Made Ground to the east of the development (Zone 1) and replacement with clean material of hydraulic permeability 1 x 10^{-6} m/s or less;
- removal of Made Ground to a distance of 5m from existing water courses to the south and west of the "main development area" and replacement with clean material of hydraulic permeability 1 x 10^{-6}m/s or less;
- provision of a minimum of 0.5m of 'clean' material (minimum of 1 m in areas of tree planting) in other areas of landscaping.

9.8 Construction arisings, for example from piling or the ash bunker, could be relocated and used for raising areas of hardstanding, subject to approval of the Environment Agency.

9.9 All works should be carried out using relevant Health and Safety procedures for contaminated sites and construction materials will require specific design in order to protect against attack from sulphate in the ground.

9.10 The potential impacts associated with the activities proposed have been discussed within Chapter 15 of the Consolidated Environmental Statement and mitigation measures identified. It is concluded that the remedial proposals identified herein fall within the scope of activities considered in the Environmental Statement, and that the site can be developed to the proposed afteruse with little adverse impact on sensitive receptors, and indeed provides an opportunity for improving ground conditions and water quality.

9.11 The proposed remedial works should be agreed with the Local Authority and the Environment Agency prior to preparation of a detailed Remediation Strategy in consultation with these organisations and the Main Developer.