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Redevelopment of the former Shell Haven refinery

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Abstract

It is proposed to redevelop the former Shell Haven Refinery in Stanford-le-Hope, Essex, England into a world class port and business centre creating up to 16,500 new jobs. The refinery closed at the end of 1999 and a series of site assessments and progressive remediation has been instigated to address areas of historical contamination.

A Quantitative Risk Assessment was undertaken to develop site specific risk based remediation goals which were accepted by the Environment Agency in England and the Local Authority, Thurrock Council. Shell adopted more stringent remediation targets based on addressing potential commercial and reputation concerns.

The result was a pragmatic, sustainable approach to soil and groundwater remediation focusing on: bioremediation of oil impacted soil; removal of free product; monitoring of natural attenuation processes; and off-site disposal of the more untreatable materials.

Phase I remediation activities are currently drawing to a close including the excavation of approximately 115,000m^3 of oil contaminated soil. Almost 80% of this material has been treated on site using licensed mixed biopiles, making this project what is believed to be the UK's largest on-site bioremediation project. The balance of untreatable material has been sent for licensed disposal using a dedicated rail loading facility installed for the purpose. Further works are currently being planned and it is anticipated that a Phase 1a contract will be let in May 2002

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1 Introduction

After over 80 years of operation, the Shell Haven Oil Refinery in Essex ceased production at the end of 1999. The 310 hectare site was developed on mud flats and marshes on the north bank of the River Thames and has comprised refinery, chemical works and oil storage operations.

Prior to closure, Shell commissioned a Land Use Study to advise on the pattern of land use likely to be established after refinery use ceases, with priority given to future employment opportunities.

Post closure, Shell initiated a programme of decommissioning, demolition and site remediation works, which in view of their sheer scale will run until 2003.

As part of these works Environmental Resources Management (ERM) was commissioned to undertake a phased site investigation and remedial plan development associated with the closure of the refinery and potential redevelopment as a container port and associated business centre.

2 Pre-Closure Assessment Activities

2.1 Previous investigation works undertaken by ERM

ERM was commissioned by Shell to undertake a Phase II Investigation of the site in September 1999. The purpose of the site investigation was to enable the development of a remedial strategy for the site and to provide appropriate estimation of likely remedial costs. To do this it was necessary to delineate the free phase product and contaminated soil on the site, and to confirm if contaminated water had impacted the shallow aquifer present beneath the site. The investigation built on previous investigative works, in particular, a RBCA Tier 1 risk assessment undertaken by Shell Global Solutions, in order to provide more complete information on the site.

The investigation was undertaken by ERM on-site between October and December 1999 and comprised over 330 intrusive exploratory holes into the shallow made ground and alluvium beneath the site. The holes were advanced as either soil bores (192) or trial pits (140), allowing continuous sample recovery from the shallow soil column to a maximum depth of 6.00m.

Additionally 10 wells were installed into the shallow aquifer in the sand and gravel beneath the alluvium. These boreholes were also utilised for limited Geotechnical assessment.

The exploratory holes and wells facilitated geological logging of the subsurface and the collection of samples for laboratory analysis.

In order to provide adequate data for a risk assessment, the leaching potential of soil contaminants was addressed through collection of site-specific soil leachate data. The volatilisation potential of soil contaminants was addressed through collection of site-specific gas data.

Field geological and laboratory analytical data were recorded onto an Earthsoft EQuIS database.

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2.2 Remediation strategy

A risk-based approach was adopted to develop a remediation strategy for the site which addressed human health and groundwater issues within recognised guidelines and applied Shell's stringent commercial and reputational criteria.

2.2.1 Quantitative risk assessment

ERM undertook a Quantitative Risk Assessment based upon the findings of the site investigation undertaken between October and December 1999. The QRA was based on Risk Based Corrective Action (RBCA) Tier 2 risk assessment methodologies. The RBCA methodology for chemical release sites was used in parallel with the Environment Agency methodology for protection of groundwater as a means of integrating the assessment of both human health and groundwater using recognised guidelines.

The results of the assessment for soils were considered consistent with both the nature of the chemical contamination observed to be present, namely low concentrations of BTEX and PAH and relatively higher concentrations of less toxic heavy aliphatic fractions (e.g. TPH), and the nature of the end uses under current and proposed future scenarios. The results indicated that under these conditions risk based concentrations of most of the contaminants in soil would not determine the degree of remediation undertaken.

For groundwater within the first major body, the river terrace deposits, the conceptual site model demonstrated that this aquifer was of low sensitivity. Furthermore, it was concluded that risks posed by it to the River Thames from discharge were low. Improvement in groundwater quality will be achieved by the implementation of source remediation.

2.2.2 Remediation rationale

In addition to the remediation requirement to be protective to human and environmental receptors provided by the quantitative risk assessment, other reputational and legal drivers were considered:

- Surface soil visually impacted with residual product, refinery hydrocarbon wastes in designated waste disposal and treatment areas, and areas of mobile free phase floating product were identified to represent the main areas of concern with respect to reputational liability.
- Remediation work would require licensing either through:
  - a site licence authorising the keeping, treatment or disposal of controlled waste on land; or
  - a mobile plant licence authorising the treatment or disposal of controlled waste.

2.2.3 Remediation strategy

The following overall phased strategy was developed based upon the findings of the quantitative risk assessment and consideration of reputational drivers.

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Phase 1 – Works independent of redevelopment

The main liabilities have been identified as:

- Surface residual product (visual surface impact);
- Mobile free phase floating product; and
- 'Waste areas'.

The removal of these areas is a baseline policy requirement of Shell to meet its environmental management targets and to minimise legal and reputational risks and forms the minimum requirement for remediation. These works are considered independent of the current proposed end use for the site.

Phase 2 – Works dependent on the proposed development

The Phase 1 works are intended to remove the significant areas of contamination, but potentially further Phase 2 works may be required, dependant on the planned future use. Such works will be carried out during development and may include capping of selected remaining contaminated areas (residual saturated soils), provision of clean underground service corridors and disposal/treatment of contaminated material from roads, foundations, piles, etc.

Phase 3 – Post remediation monitoring

Continued environmental monitoring of the site is proposed following remediation, chiefly to enable assessment and demonstration of natural attenuation processes in the river terrace deposits.

2.3 Scope of the Phase 1 remediation activities

The Phase 1 remediation strategy included the following:

- The removal of surface residual hydrocarbon product, site wide, to either 0.50m below ground or the top of the water table, whichever is the shallower. Control of the excavation by visual assessment will be backed up by the application of a 10,000 mg/kg total petroleum hydrocarbons (TPH) criteria.
- The removal of on-site 'waste areas'. For the remediation strategy, waste areas have been defined as:
  - Sludge Land Farm – Manor Central North'
  - The identified Acid Tar Pit and Acid Tar Pockets, Industrial Site; and
  - Sludge Lagoons – Curry Marsh West; and

  All visually identified waste is to be removed from these identified waste disposal areas. To help control of the excavation, visual identification will be backed up by a target of 10,000 mg/kg TPH between surface and 0.50m below ground, and 50,000 mg/kg TPH below a depth of 0.50m. Both these

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numbers were lower than the >70,000 mg/kg TPH concentration identified as the risk based criteria.

- The removal of buried mobile free product. For the remediation strategy the following areas have been identified to contain mobile free product:
  - Reedham;
  - Rugward West; and
  - Homelight.

  The strategy recommended the adoption of pragmatic criteria for product recovery based upon the practical difficulties associated with recovery.

2.4 Procurement of Phase 1 remediation works

In December 2000, Shell decided to appoint an Environmental Consultant ('Contractor') to design, procure, manage, undertake and report on the remediation works required in the areas defined above. The Contractors role included:

- Detailed delineation of the defined areas;
- Extension of the remediation strategy into detailed remedial design;
- Support of Shell in appointing a Remediation Contractor;
- Management, employment and supervision of the Remediation Contractor;
- Regulatory liaison including assistance in application for site licences;
- Verification of remediation and closure reporting; and
- Provision of warranty covering assessment and remediation activities.

ERM was appointed by Shell to conduct these Phase 1 remediation works.

3 Redevelopment Proposals

3.1 Port and Business Centre

In parallel with the assessment activities, in the year 2000 Shell signed an agreement with P&O related to the development of a container port, and also a business centre comprising state-of-the-art associated storage and distribution facilities to be known as London Gateway.

The proposed port will take up to 75 hectares of the site and an additional 93 hectares of reclaimed land created from dredging the approach channel. This dredged material will raise the elevation of the river frontage section of the site by between 0.5m and 6m. It will provide container and roll-on, roll-off (Ro-Ro) berths plus a relocated oil jetty for existing Shell operations.

The business centre will accommodate up to one million square metres of new buildings that will attract occupiers from the manufacturing, industrial and distribution sectors. There will also be a range of smaller buildings able to accommodate high-tech, light industrial and distribution activities.

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3.2 Economic benefits

The benefits to the local economy are considerable including:

- Re-use of a 600 hectare brownfield site which can accommodate a mix of commercial uses whilst retaining green areas;
- The creation of 16,500 new jobs;
- Use of a 3km river frontage which has been used as a port since the 16th century;
- A population catchment of 3.2 million people within a one-hour drive;
- Good road access to central London and the motorway network; and
- An existing and expandable connection to the rail network.

3.3 Environmental benefits

Extensive and detailed environmental standards have been carried out to ensure the scheme is developed in a sustainable manner. These are integral to the planning and statutory applications submitted in early 2002.

The environmental benefits of the scheme include:

- The remediation and clean-up of contaminated industrial land;
- Maximising the use of on-site bioremediation (i.e. waste treatment rather than disposal);
- Minimising both the volume of waste taken off-site and associated traffic movements;
- Widespread landscaping across the site;
- Management of Greenfield land to encourage greater biodiversity;
- The use of energy-efficient construction materials;
- Improvement to the local footpath and bridleway; and
- Enhancement and improved management for nature conservation.

4 Phase 1 Remediation

4.1 Introduction

The Environment Agency and Local Authority accepted the proposed remediation plan in April 2001. A cost benefit study conducted by ERM identified that considerable savings could be achieved if on-site bioremediation could be used. Accordingly a bioremediation trial was undertaken in May/June 2001 on 1,000m^3 of oil contaminated soil accumulated from across the site. This demonstrated that the material was amenable to biodegradation and a tender was prepared for the main works.
In July 2001, Bilfinger and Berger was appointed by ERM to undertake the Phase 1 remediation contract comprising:

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- Removal of free product including the bulk excavation of approximately 115,000m^3 of contaminated soils exceeding the site specific target levels;
- Biotreatment of as much of the oil contaminated soil, as was technically possible to minimise the cost of off-site disposal; and
- Installation of monitored natural attenuation wells.

Following a further cost benefit analysis and subsequent tender, Shanks was appointed to conduct the transport and off-site disposal of untreatable materials, such as oil saturated soils, acid tars etc. The transport method for the disposal of this material, approximately 25,000m^3 in volume, was via rail, achieved by constructing a new rail siding. Using this approach, the trains could travel direct to the landfill site in Bedfordshire avoiding the need for unnecessary lorry movements.

4.2 Clean-up goals

As previously described Shell adopted post remediation target criteria that were more stringent than those required through the development of the Quantitative Risk Assessment. For example the criteria for TPH was 5,000 mg/kg, benzene was 1 mg/kg and visual and odour assessment criteria were adopted. Compliance to these criteria was maintained by ERM as the works progressed.

4.3 Progress to date

Work in July 2001 and the Phase 1 remediation works are currently drawing to a close, on the scheduled contract completion day of 31 May 2002. During this time the following has been achieved:

- In seven accessible areas of the site, principally in the former Oil Movements areas over 115,000m^3 of contaminated soils have been excavated for treatment or off-site disposal.
- The excavation works ranged from shallow surface scrapes of near surface oil saturated soils, principally in former tank farm areas, to excavation down to a maximum depth of 4m. This work has been co-ordinated with the progressive demolition of many of these storage facilities.
- Bioremediation has been successfully employed to treat over 91,000m^3 of oil contaminated soils. The bioremediation was conducted in licensed conditions on prepared impermeable concrete bases within three treatment areas, in accordance with the Contractor's Mobile Plant Licence (Waste Management Licensing Regulations 1994).
- The oil contaminated soils were piled in 3m wide and 2m high windrows and processed using two soil turning machines which moved through the piles to promote oxygen transfer and contaminant accessibility. The source of the material in each windrow was logged as was the treatment time and final location of treated material. Treatment times varied between 5 and 9 weeks dependant on the source of the material.

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- Where possible recycling measures were adopted. For example, bitsand material was removed from the top of many of the tank bases. This was screened and over 1000 tonnes of suitable material were sent to a local bitumen road base producer. In addition a considerable volume of subsurface concrete, former foundations, were recovered and crushed on-site. Much of this will be used on site during the future redevelopment works.
- Despite the on-site treatment and recycling measures adopted there was still almost 25,000m^3 of untreatable material that required off-site disposal. This included some acid tars and oil saturated/bituminous material that was recovered during the surface scrape activities. The construction of the rail siding was successfully completed. By the end of 2001 31 trains, each carrying approximately 1450 tonnes of waste, were loaded and transported the material to landfill for licensed disposal.
- All these works were conducted under the Construction, Design and Management Regulations, in accordance with Shell's permit-to-work system. To date no injuries or lost time accidents have occurred and works have remained on schedule.

4.4 Cost benefit

The Phase 1 works will be completed for approximately €6.5 million, which through incentive mechanisms to maximise the degree of bioremediation, the use of train transport for off-site disposal of wastes and the recycling measures adopted is well below the target price of €7.5 million set at the time of the Phase 1 contract award in July 2001.

5 Phase 1a remediation

At the time of preparing this paper (April 2002) Shell is finalising proposals for further works to address some further areas requiring remediation before redevelopment can commence. These include areas that have only become available as demolition works have latterly been completed and the works are anticipated to comprise between 64,000 to 85,000m^3 of oil contaminated soil the majority of which will be bioremediated.

At least one further phase of Phase 1 works is anticipated. Once that is completed, probably in 2003, any further remediation works will be dependant on the specific nature of future site redevelopment. For example, measures may be necessary to address any contamination identified during the construction of building foundations or during the installation of service corridors.

6 Conclusions

The Phase 1 remediation works necessary to prepare the site of the former Shell Haven refinery for redevelopment as a container port and business centre is proceeding on schedule.

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The remedial targets were developed by the use of site specific risk based goals and supplemented by more stringent commercial and reputational criteria adopted by Shell. Works were discussed with the regulatory authorities, who accepted the remedial strategy proposed by ERM and Shell.

The use of these site specific, risk based targets, the application of on-site bioremediation, recycling of suitable materials and the use of freight train transport for off-site waste disposal all have contributed to the fact that the first stage of the Phase 1 remediation works will be completed on time and well under the target price, despite the fact that additional material was identified.