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Barry Waterfront

Environmental Statement Chapter I

Ground Conditions and Contamination

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1.0 Ground Conditions and Contamination

Introduction

1.1 This chapter describes the existing ground conditions and contamination and considers how these will be affected by the proposed development during it's implementation and on completion. Strategies for mitigating the impacts are described. The section concentrates on the impact of the proposed development on human health, soil and geological resources arising from the prevailing ground conditions, particularly dealing with soil contamination, ground and radon gas.

1.2 The assessment summarises the legislation, guidance and planning policy and describes the assessment methodology used. The consultation undertaken with the Environment Agency and Vale of Glamorgan County Council is summarised. The baseline conditions are described, based on detailed desk study and ground investigations undertaken in the four distinct areas of the application site (Arno Quay, East Quay, West Pond and South Quay). This includes the ground contamination encountered in each area together with ground gas. Mitigation measures are proposed to reduce the impacts of ground conditions and contamination, residual effects are then considered.

1.3 Details on the impact of the proposed development to controlled water receptors (including risks associated with ground contamination) are found in Chapter H – Water Resources, Drainage and Flood Risk.

2.0 Planning Policy Context

Planning Context: Legislation and Guidance

2.1 Current UK legislation on contaminated land is principally contained in Part IIA of the Environmental Protection Act 1990 which was retrospectively enacted by Section 57 of the Environmental Act 1995. Pending publication of Statutory Guidance to Local Authorities, its principles are being widely adopted for assessment purposes. The legislation defines contaminated land as: -

2.2 "Land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that: -

- Significant harm is being caused or there is a significant possibility of such harm being caused, or
- Pollution of controlled water is being, or is likely to be caused."

2.3 The legislation requires that the identification of contaminated land is undertaken within a risk assessment framework. The Statutory Guidance describes a risk assessment methodology in terms of a source-pathway-target ("significant pollution linkage") model of the site, comprising: -

- the pollutant hazards associated with the site (the sources);
- the targets at risk from the identified hazards; and
- the existence, or absence, of plausible pathways between the identified hazards and targets.

2.4 For land to be identified as contaminated land all three elements of a "significant pollution linkage" must be present.

2.5 The contamination levels encountered on the site have been compared with appropriate guideline values in order to assess the degree of contamination at the site, and to identify Contaminants of Concern and/or the need for remediation with respect to human health and the environment (groundwater and surface waters).

2.6 In March 2002 the UK Environment Agency published guidance in the form of the Contaminated Land Exposure Assessment (CLEA) model, which included Soil Guideline Values (SGV's) for a variety of parameters. At present there are ten SGVs and they apply to four general land uses:

- residential with gardens/allotments and consumption of homegrown vegetables;
- residential with gardens but without consumption of homegrown vegetables;

- allotments;
- commercial/Industrial.

2.7 In the absence of additional SGVs, Land Quality Management Ltd have undertaken work to produce Generic Assessment Criteria (GAC), for contaminants that to date do not have SGVs, and Arup was part of the team inputting to this process. These LQM GACs have been published in the document "Generic Assessment Criteria for Human Health Risk Assessment" Although these LQM GACs are not, at present, authoritative they have been produced in line with current UK Guidance, including the protocol set out in the Environment Agency's documents CLR 9 and CLR10, and using the CLEA UK (beta) model. Toxicological and chemical property data were sourced from UK references where possible and if not then in line with the protocol set out in the EA documents.

2.8 National, regional and local planning policies that are applicable to this chapter and the Application Site include:

National Planning Policy

2.9 National planning policy is set out in Planning Policy Wales (PPW) (2002) and includes guidance on development on unstable and contaminated land. PPW also advises that Appendices A and B (Causes of Instability and Sources of Information) of PPG 14 Development on Unstable Land remain in force in Wales until Technical Advice Note has been published. PPW aims to ensure that development is suitable and that the physical constraints on land are taken into account at all stages of the planning process. Paragraph 13.7.2 of PPW notes that, where significant issues arise, a local planning authority will require a detailed site investigation and risk assessment. Where there are acceptable remedial measures, planning permission may be granted subject to conditions specifying the necessary measures.

Development Plan

2.10 The development plan for the area is the adopted Vale of Glamorgan UDP. Relevant policies include:

- Policy 2 favours proposals which encourage sustainable practices. Criterion (iii) of the policy refers to the reclamation of derelict or degraded land for appropriate beneficial use.

- Policy 25 refers to the regeneration of urban areas. It states that measures to improve the environmental quality of the urban fabric will be favoured and that particular attention will be given to the regeneration of derelict or degraded land, especially within the former dockland of Barry and Penarth.

- Contaminated and unstable land is covered by Policy 26. This policy states that proposals for the redevelopment of contaminated land and unstable land will be permitted where the contamination and/or instability will be removed or reduced to a level where there is no unacceptable risk to the health and safety of those living or working on the site or nearby, to flora and fauna, and to the quality of air and water.

- Policy 29 refers to protection of environmental quality. It states that development will not be permitted if it would be liable to have an unacceptable effect on either people's health and safety or the environment by:

  (iii) releasing pollutants into water, soil or air, either on or off site; or

  (iv) from smoke fumes, gases, dust, smell, noise, vibration, light or other polluting emissions.

Emerging Vale of Glamorgan Local Development Plan (LDP)

2.11 The Vale of Glamorgan Council is currently preparing a new LDP for the area. To date, a draft Preferred Strategy was published for public consultation in 2007. The draft strategy sets out the land use and settlement policy for the Vale of Glamorgan and strategic planning polices. The draft strategy does not include any specific policies on ground conditions, but does aim to protect the natural and built environment and states that development proposals should encompass the principles of sustainable development.

Consultation

2.12 Consultation has been undertaken with the Environment Agency (EA) and the Vale of Glamorgan (VoG) Local Planning Authority regarding the geo-environmental conditions at the site and the risks from ground contamination. A number of meetings took place in November and December 2007 to discuss the desk study and conceptual models for each site and agree the proposed site investigation. Following completion of the ground investigations for each area, the Geo-Environmental Reports were issued to the EA and VoG in June 2008, November 2008 and February 2009 containing the contamination risk assessments of each area. Consultation and discussions regarding the technical details within these reports is ongoing.

3.0 Assessment Methodology and Significance Criteria

Assessment Methodology

3.1 The assessment of effects on ground conditions and contaminated land has considered the current guidance on this subject. Potential environmental impacts have been assessed qualitatively by understanding the sensitivity of geological, hydrogeological, and hydrological conditions in the area, historical site uses and the general environmental setting of the site. The general approach has been to undertake a 'source-pathway-receptor' analysis of the potential effects.

3.2 There are very minor differences between the red line boundary submitted as part of the planning application and those which are shown within the appendices of this chapter. It is not considered that the differences between the drawings have any impact upon the assessment made nor on the conclusions drawn within this ES.

Significance Criteria

Assessing Impact Significance

3.3 The provisions for dealing with contaminated land are made under Part IIA of the Environmental Protection Act 1990 and the Environment Act 1995. The background to the contamination risk, in accordance with this legislation is defined in Section 2 of this chapter.

3.4 Guidance on the assessment of contamination risk advocates the use of a conceptual risk assessment model to establish connections between a hazardous source and a sensitive receptor through an exposure pathway. The principle is that there can be no significant contamination risk without all of the three elements (source, pathway and receptor). The presence of a contamination hazard at a particular site does not necessarily imply the existence of associated risks.

3.5 There are no published standard criteria for assessing the significance of the potential effects that may arise from land contamination. The significance of effect (where a contamination risk has been identified) has been determined from criteria developed from best practice techniques and professional judgement. Criteria describing the magnitude or scale of effect and the importance or sensitivity of the resource affected have also been used and are identified in the tables below.

3.6 This chapter assesses the impact of the proposed development to ground conditions and human health receptors on the application site during

Construction and operation. The impacts to controlled waters from the proposed development are assessed in Chapter H.

Valuation of the Receptor

Value	Criteria	Example Receptors
High	Resources/features which are unique and if lost cannot be replaced or relocated. Receptors of greatest sensitivity.	Human Health, including, that of construction and maintenance workers, future site users/occupants and third party neighbours Sites of Special Scientific Interest with geological features
Medium	Resources/features of important consideration at a regional or district scale. Receptors vulnerable to changes in land quality/contamination levels	Built development – business/residential Land use where contaminant uptake by plants used in food production may alter health risks: Agricultural land holdings Allotments and gardens Amenity/open green space areas
Low	Features important at a local scale. Receptors with a moderate sensitivity to changes in land quality/contamination levels	Other land uses where contaminant uptake by plants is unlikely to alter health risks: Woodland/forestry Derelict/vacant land
Negligible	Features of minor importance or with a low sensitivity to changes in land quality/contamination levels	

Table I.1 Criteria for Valuation of Receptors

Impact Magnitude (the extent of change i.e. deviation from the baseline)

3.7 Contamination has been assessed by the identified presence of specific potential sources of contamination, pathways and sensitive receptors. The categories below are used in assessing the impact magnitude.

Magnitude	Criteria
High	Loss of existing/creation of new resource; Extensive, long term deterioration/improvement in conditions or circumstances (either local or widespread), such as: Construction phase release of contaminants which causes a significant impact on identified receptors; Elimination and/or mitigation of existing large scale impacts upon identified receptors during the operational phase
Medium	Significant material (but not fundamental) change in conditions or circumstances, including long term impacts, such as: a. Minor release of contaminants during the construction phase; b. Elimination and/or mitigation of limited existing impacts upon identified receptors during the operational phase.
Low	Measurable (but not material) change in conditions or circumstances, generally in the short term, such as: a. Limited, temporary contaminant release associated with construction phase; b. Temporary creation/elimination of pollution pathways during the construction phase.
Negligible	No measurable or perceptible change in conditions or circumstances affecting identified receptors.

Table I.2 Criteria for Assessing Impact Magnitude

Impact Significance of Effects

3.8 The significance of the residual impact has been defined using the scale in the matrix below:

		Sensitivity of Receptor/Receiving Environment to Change/Effect			
		High	**Medium**	**Low**	**Negligible**
Magnitude of change/Effect	**High**	Major	Moderate to Major	Minor to Moderate	Negligible
	Medium	Moderate to Major	Moderate	Minor	Negligible
	Low	Minor to Moderate	Minor	Negligible to Minor	Negligible
	Negligible	Negligible	Negligible	Negligible	Negligible

Table I:3 Matrix for Determining the Significance of Effects

4.0 Baseline Conditions

4.1 The geology, history and ground conditions of the site are discussed in detail in separate desk study reports produced for Arno Quay, East Quay and West Pond/South Quay. In addition, geotechnical and contamination risk assessment reports have been produced for Arno Quay, West Pond, South Quay and East Quay (Appendices 4, 5, 6 and 7 respectively). The following sections summarise the geology, history and ground conditions for each area detailed in the following reports:

a Ove Arup & Partners (2008) Waterfront Barry – Arno Quay Desk Study, January 2008 (Appendix 1)

b Ove Arup & Partners (2008) Waterfront Barry – East Quay Desk Study, January 2008 (Appendix 2)

c Ove Arup & Partners (2008) Waterfront Barry – South Quay and West Pond Desk Study, February 2008 (Appendix 3)

d Ove Arup & Partners (2008) Waterfront Barry – Arno Quay, Geotechnical and Risk Assessment Report, June 2008 (Appendix 4)

e Ove Arup & Partners (2008) Waterfront Barry – West Pond, Geo-Environmental Site Investigation Report, September 2008 (Appendix 5)

f Ove Arup & Partners (2008) Waterfront Barry – South Geo-Environmental Site Investigation Report, November 2008 (Appendix 6)

g Ove Arup & Partners (2008) Waterfront Barry – East Quay, Geo-Environmental Site Investigation Report, November 2008 (Appendix 7)

4.2 There are Geological SSSI's located along the coastline over 400 metres from the site. It is considered that there are no likely significant effects of works on the application site, given the distance together with the presence of the existing Barry Island developments in between, and as such the SSSI's have not been assessed any further in this chapter.

Arno Quay

4.3 The published geological map shows that Arno Quay is underlain by made ground. See Fig ESI1. The made ground overlies alluvium - although this is absent in the northern area of Arno Quay. The underlying bedrock is the Penarth Group, with Blue Anchor Formation shown in the east.

4.4 Prior to the development of Barry No 1 Dock, the area was an undeveloped sea inlet on the Cadoxton Estuary. The majority of the Arno Quay areas were part of the former mudflats, the northern area was agricultural land above the high water mark of ordinary tides. Barry Docks development commenced in 1884 and was opened in 1889. Coal Staiths and Railway Sidings were formed on the sites together with the projections into the dock for loading onto ships. By

the 1960's and 1970's coal export had declined and parts of the southern area were levelled for a car crushing plant and scrap yard. During the 1990's, the northern areas were remediated and the current landform shaped. These works included earthworks, removal of foundations and sub-surface structures from the upper 1m, removal of contamination hot spots and provision of a 600mm capping layer at the surface of the final ground level.

4.5 The ground investigation undertaken in December 2007 confirmed the presence of made ground overlying alluvium in the south, which in turn rests on Penarth Group bedrock. The thickness of made ground typically varies between 1.8m and 3.2m but thins to 0m on the bank and in the north the fill is deeper beneath the projections. The made ground typically comprises of firm sandy gravelly clay and medium dense clayey sand gravels, clayey gravelly cobbles and clayey gravelly sand. The underlying alluvium varies in thickness from 0m to the north to 3.5m in the south and consists of a soft to firm sandy gravelly clay. The underlying Penarth Group bedrock was found to consist of layers of stiff clay, very weak or weak mudstone and weak becoming strong siltstone with depth.

4.6 The chemical analysis undertaken on soil samples from Arno Quay showed in general low levels of inorganic and organic compounds. Benzo(a)pyrene levels slightly exceeded the initial assessment criteria at one location and a hotspot of 2,6-dinitrotoluene, antimony and cyanide were identified which required further assessment. The Site Specific Assessment Criteria in accordance with CLEA guidelines showed that the Benzo(a)pyrene, 2,6-dinitrotoluene and antimony concentrations are within the acceptable levels and no further measures were considered necessary. However, the elevated Benzo(a)pyrene concentration at TP14 should be excavated and removed from site, this area is shown on Figure ESI4. A cyanide hotspot is at a depth of 1.0m and may remain on site providing no excavation will take place at that location. No further soil remediation works are required on Arno Quay.

East Quay

4.7 The published geological map shows East Quay lies on made ground resting on alluvium, see Figure ESI2. The bedrock below the majority of the site is Mercia Mudstone Group, although Blue Anchor Formation is shown in the north-west corner of the site.

4.8 Prior to the development of Barry No 1, the area was an undeveloped sea inlet on the Cadoxton Estuary, with the Cadoxton River Channel passing through the centre of the site. Mudflats are shown either side of the line of the river, with the former cliff line shown along the northern boundary of the site. The docks were built in the 1880's and the northern graving dock and channel to a timber pond in the east were formed at the same time. Engineering works for ship repairs were constructed along the graving dock. In the late 1890's, the timber pond was relocated further east and the former channel became Graving Dock No 2.

4.9 Between the 1890's and 1920's various structures were built on the land between the two graving docks including engineering works, timber working shops, a pump-house and a boiler house. The land to the north, east and south of the graving docks were largely used as sidings. The graving docks became disused after the 1940's; however, dockside premises continued to be used for a variety of industrial processes including ship and vehicle repairs, joinery and warehousing. Isolated offices and dock storage buildings were developed in the southern and northern areas of the site; vehicle repair works were also present along the northwest boundary. The structures were demolished in the early 1990's. The majority of the site (apart from the area of land between the two graving docks) was then subject to a reclamation scheme. As part of this work, the northern graving dock (No 1) was in-filled with contaminated soils derived from the Phase 1 Barry Docks Reclamation Scheme under a Waste Management Licence (WML). Prior to infilling, the graving dock was de-watered, de-silted and lined with HDPE. After filling, the surface was capped and grassed over and the WML was surrendered in 2006. The northern, southern and eastern areas were remediated as part of the reclamation scheme - with obstructions and hot spots removed, surface re-profiled and a capping layer installed. Whilst no remediation or reclamation works was undertaken in the area of land between the graving docks, a 0.5m layer of clean soil/subsoil was placed over the area and seeded to improve its visual appearance.

4.10 The site investigations undertaken in 2008 indicated that the depth of fill and alluvium varies across the East Quay Site. In the north, the fill and alluvium are relatively shallow, typically up to 5.6m thick. The thickness of fill between the two graving docks deepens to between 3m and 8.2m, the alluvium also thickens to between 1.6m and 6.1m. Further east and south the fill thickness extends to up to 12.7m and the Estuarine Alluvium thickens to between 6.3m and 18.1m, the alluvium also contains a band of peat up to 0.9m thick. These superficial deposits are underlain by Mercia Mudstone in the central and southern areas and Blue Anchor Formation in the north. The fill is typically loose to medium dense clayey gravelly sand and firm silty gravelly clay. The Estuarine Alluvium is a very soft and soft organic silty clay with bands of silty sand/sandy silt. The Mercia Mudstone Bedrock is typically a very weak to weak becoming strong siltstone and mudstone. The Blue Anchor Formation is moderately weak to moderately strong mudstone.

4.11 The chemical analysis undertaken on soil samples from East Quay showed some elevated concentrations of organic and inorganic compounds including Benzo(a)pyrene, Dibenzo(a,h)anthracene, Arsenic, Copper, Mercury, Naphthalene, Zinc, Lead, Cadmium, Artimony, Aromatics and PCB and required further assessment. The Site Specific Assessment Criteria in accordance with CLEA guidelines showed that these levels were acceptable providing a minimum 0.7m thickness of clean cover would need to be provided across the site. Plot E13, the low lying area to the north of the Graving Dock requires a larger thickness of 1m to break viable exposure pathway from

elevated lead concentrations. No further soil remediation works are required for East Quay.

West Pond

4.12 The published geological map showed made ground across West Pond, the majority of the site is also underlain by Estuarine Alluvium, however the alluvium is absent in the south-eastern area, see Figure ESI3. The superficial deposits are underlain by the St Mary's Well Bay Formation and the Penarth Group.

4.13 Prior to the 1880's, the majority of the West Pond area was tidal mudflats of the Cadoxton Estuary. The Cadoxton River Channel crossed the central part of the site and a tributary ran from the East Barry settlement in the north. The former cliff line of Barry Island was present in the south with open fields present to the south of this line. Barry Docks was built in the 1880s, with development and filling only occurring in the east; the western area remained as part of the estuary mudflats. The causeway situated at the current location of Harbour Road was formed in 1898, with a lake to the east known as West Pond. Infilling of the pond took place in phases between the 1900's and 1950's. The eastern area of West Pond was initially used as railway sidings and coal staiths. A tank farm to facilitate storage of fuel and other substances was then developed in the eastern area in 1938. Warehouse buildings were subsequently built in the southern area of the site, the central area was used to dismantle railway wagons and store railway engines. During the 1990's, the old tank farm was demolished and a reclamation scheme took place across the majority of the site. The works included removal of slabs, foundations, shallow services and general debris together with isolated area of contamination including asbestos. A capping layer was placed across some of the areas, however due to the shortage of material, capping was not installed across all areas. The south and south-eastern areas were not remediated, the derelict building in this area remains present.

4.14 The ground investigation undertaken in 2008 indicates that the southern area of West Pond consists of 0.4-1.1m of fill overlying bedrock. The thickness of fill in the central area increases to between 4.8m and 11.6m, overlain by between 10.4m and 21.4m of alluvium. Further north, the fill thickness reduces to between 6.2m and 7.7m, the alluvium thickness also reduces to between 0m and 7.6m. The fill material is typically a loose to medium silty, ashy, coaly sand and gravel including slag fragments. The alluvium is typically very soft to soft silty clay/sand clayey site with occasional sand layers and traces of peat. The bedrock consists of limestone and siltstone.

4.15 The chemical analysis undertaken on soil samples from West Pond showed some elevated concentrations of organic and inorganic compounds including Benzo(a)pyrene, Copper, Artimony, Lead, Zinc, Total Petroleum Hydrocarbons, Naphthalene, Dibenzo(a,h)anthracane, Bis(2-ethlylhexyl)phthalate, Arsenic, Nickel, Mercury, Cadmium and required further assessment. The Site Specific

Assessment Criteria developed as part of the Human Health Risk Assessment, in accordance with CLEA guidelines showed that a 0.6m thickness of clean cover would need to be provided in residential areas. The proposed educational area in the north partly contains an existing cap and a further clean cover is not required in this area, with the exception of the northern end where no such capping exists. The Risk Assessment also showed that the area where commercial development is proposed is suitable for use without a further cover material, although in practice this area will need to be raised for flood protection and provision of construction thicknesses beneath the building, roads and car park areas.

4.16 Hydrocarbon groundwater contamination has been encountered, the majority of which is located in the former tank farm area in the east. Remediation measures, consisting of source removal will be required at these location, see Figure ESI4. The free product recovered will need to be disposed at a suitable landfill site accepting hazardous waste.

4.17 The western and southern areas have not been subject to previous reclamation works. Surface obstructions are also present in these areas and these will need to be broken up and removed.

South Quay

4.18 The published geological plan shows that the northern and eastern part of the site is underlain by the Penarth Group, see Figure ESI3. The south-western part of the site overlies the St Mary's Well Bay Formation and the south-west corner by the Lavernock Shales formation. The solid strata lies below made ground with Estuarine Alluvium in the northern part of the site.

4.19 Prior to the 1880's, the southern half of the site was open fields with the old shoreline running through the centre of the site. The northern area was tidal mudflats of the Cadoxton Estuary; an old quarry and limekiln were present in the west and a further limekiln was shown in the east. Barry Docks was developed in the 1880's - the quay wall was formed to the north and the cliff face cut back to the south; the mud flats between the quay wall and original shoreline were filled over. Railway sidings were then developed across the quayside. The South Quay area continued in use for coal transportation until the 1960's when the area was redeveloped as a tank farm and associated buildings to handle the storage of fuel and other hydrocarbons (e.g. diesel oil, jet fuel, kerosene, lube oil, mineral oils, carbon tetrachloride, phenol, benzene, solvents) and other chemical substances (e.g. sodium hydroxide solutions, methanol, silicone). A structure was built in the eastern area, this was used by Natural Environment Research Council (NERC). By the early 2000's all the tanks had been demolished and the NERC building had become disused.

4.20 The ground investigation undertaken in 2008 indicates that the ground conditions beneath the southern area of the South Quay consist of 0.1-2.9m of made ground overlying limestone and siltstone bedrock. In the north, the fill

thickness increased to up to 15.6m, above a layer of alluvium up to 9.4m thick. The alluvium is predominately cohesive although sand layers are present in places. The alluvium overlies a 0.3-2.0m layer of clayey gravel above limestone and siltstone bedrock.

4.21 South Quay has not been subject to any previous remediation. The chemical analysis undertaken on soil samples from South Quay clearly indicates that the site is impacted by hydrocarbon contamination resulting from previous land use. Elevated organic and inorganic concentrations were encountered including Copper, Zinc, Total Petroleum Hydrocarbons, Benzo(a)pyrene, Vinyl Chloride, BTEX substances, 1,2-dichloroethane, Antimony, Chromium, Mercury, Nickel, Naphthalene, Zinc, Dibenzo(a,h)anthracene. The Site Specific Assessment Criteria developed as part of the Human Health Risk Assessment, in accordance with CLEA guidelines showed that the site could be protected by the provision of a 0.6m clean cover. However, detailed risk assessment of the potential risk of hydrocarbon vapour inhalation, some Total Petroleum Hydrocarbons are present at concentrations posing a significant risk to future site users. Therefore, further remedial action is required. In association with the groundwater remediation discussed in chapter H, excavation and remediation of soils exceeding the adopted remedial targets will be required. The site investigation indicates that bio-remediation will be required in the areas shown on Figure ESI4. The bioremediation should reduce the majority of contamination to an acceptable level below the adopted remedial targets. A quantity of material will be grossly contaminated and Bioremediation will not reduce contamination to the acceptable level; this material will need to be removed to a landfill site licensed to accept this waste. The placement of a minimum thickness of 0.6m clean cover will also be required across South Quay, to break the dermal and ingestion pathways for contamination encountered on the site

4.22 The site has not previously been subject to any reclamation works, surface obstructions are present across the whole area, these will need to be broken up and removed.

Ground Gas

4.23 Gas standpipes were installed across Arno Quay and monitored for a period of 10 weeks between January and March 2008. Methane concentrations ranged between 0% and 1.7% and Carbon Dioxide readings varied between 0.4% to 0.6%, low flow rates were monitored throughout. The gas assessment indicated the site may be characterised as Characteristic Situation 1 in accordance with CIRCA guidelines, although there was a small number of marginal exceedances above the 1% methane and 5% carbon dioxide threshold values of Gas Characteristic Situation 1. Taking into account the low flow rate and that the gas levels are typically below this threshold, the site may be considered to meet Characteristics Situation 1 and no gas protection measures are necessary.

4.24 Gas standpipes were installed across East Quay and monitored on six occasions between May and July 2008. Methane concentrations ranged between 0.1% and 2.2%, Carbon Dioxides ranged between 0.01% and 1.3%. Flow rates were generally found to be very low, although unusually higher flow rates were encountered on two occasions. The gas assessment indicated that the Situation B applies for low rise residential development and characteristic Situation 1 for other residential development. The measures include a gas membrane together with passive venting measures beneath the slab. All joints and penetrations would need to be sealed.

4.25 Gas standpipes were installed across West Pond and monitored on six occasions between May and July 2008. Methane concentrations varies between 0.0% and 18.8%, carbon dioxide levels ranged between 0.0% and 12%. Flow rates measurements indicated that generally low ground gas flow was encountered in the majority of boreholes with a maximum flow rate of 5.7 l/hr. The gas assessment undertaken on site showed that Characteristic Situation 2 applies and that structures will require a gas membrane and passive venting measures. All joints and penetrations would need to be sealed.

4.26 Gas standpipes were installed across South Quay and monitored on six occasions between May and July 2008. Methane concentrations were generally 0% - 0.3% although one concentration was 5.2%. Carbon dioxide concentrations ranged between 0.0% and 9.9%. Flow rate measurements indicted generally low ground gas flow in the majority of boreholes, although one unusually high flow rate was encountered on a single occasion. The gas assessment undertaken shows that the site may be classified as meeting Gas Situation B. Gas mitigation measures, consisting of a membrane and ventilated sub-floor void is required.

Radon Gas

4.27 Radon is a naturally occurring radioactive gas produced by the radioactive decay of radium (which, in turn, is derived from the radioactive decay of Uranium). Uranium is found in small quantities in all soils and rocks, although the amount varies from place to place. Radon released from rocks and soils is quickly diluted in the atmosphere. Concentrations in the open air are normally very low and do not present a hazard. However, Radon entering enclosed spaces such as some buildings (particularly basements), caves, mines, and tunnels may reach elevated concentrations in some circumstances. Construction methods and degree of building ventilation will influence radon levels in individual structures. A person's exposure to radon will also vary according to how particular buildings and spaces are used. Inhalation of the radioactive decay products of radon gas increases the chance of developing lung cancer; if individuals are exposed to high concentrations for significant periods of time, there may be cause for concern. In order to limit the risk to individuals, the Government has adopted an Action Level for radon in homes of 200 becquerels per cubic metre (Bq m-3). The Government advises

householders that, where the radon level exceeds the Action Level, measures should be taken to reduce the concentration.

4.28 Advice on Radon protection is detailed in 'BR211 Radon: Guidance on protective measures for new buildings (2007 edition)' which also provides guidance on what to do if the result indicates that protective measures are required.

4.29 BR211 Radon Reports for the application site have been received from the British Geological Survey. These indicate that basic Radon protective measures are required for the application site.

Development and Construction Methodology

4.30 The development of Waterfront, Barry will be undertaken in phases as set out in Chapter C, commencing at West Pond and subsequently extending into South Quay, East Quay and Arno Quay over approximately 10 years. The development will need to include the following activities:-

- Site Clearance – works including vegetation strip, demolition of a small number of remaining buildings and the break-up and removal of concrete slabs and in-ground obstructions.

- Earthworks – consisting of importation of granular fill for use as up-fill for flood protection, clean cover material across contamination and surcharging in specific areas of West Pond. Some existing on-site material will also be excavated and re-distributed across the site. The imported and site in-fill used for surcharging will initially be placed in West Pond for a period of around 6 months and subsequently excavated and transported to make up levels in South Quay and East Quay during later phases of the works.

- Installation of Drainage – the main drainage runs will be placed within the proposed road footprint, also formed in phases as development proceeds, see Figure ESH8 (Chapter H). The surface water will transmit flows by gravity and ultimately discharge into the dock via flap valved outfalls. The foul drainage will connect into the existing foul drainage network, the majority of flows will be transmitted by gravity, however two pumping stations will be required to transmit flows from parts of South Quay and East Quay. The drainage will be installed after site clearance and earthworks and before the roads are developed.

- Formation of Roads – the main road network around the site will also be formed in phases as the development proceeds. This will allow the development sites to be fully serviced.

- Plot development – the plots will be developed by the individual housebuilders, once the site in each phase has been cleared, the

earthworks undertaken and main roads and drainage installed. The works will include provision of foundations, super-structure works together with local access roads, hardstandings and gardens. Piled foundations will be used for the majority of the development, raft foundations will be possible in parts of Arno Quay, West Pond and South Quay. Topsoil and sub-soil will need to be imported for gardens and landscaped areas, with minimum thicknesses in accordance with the remediation strategy.

Earthworks and Foundations

4.31 The site will be raised to protect the site from flooding and to provide clean cover as part of the remediation works, see Chapter H for details. Alternative options of raising only the areas along the dock sides are feasible, however there are a number of disadvantages associated with this option including additional drainage costs. To raise the site, a volume of material will need to be imported onto site, this is estimated to be around 40,000m^3. An alternative option of gaining this material from excavation of the cliff face to the south of South Quay has been considered. However, such work will result in additional environmental and visual impacts and this option has not been taken forward. The majority of imported material will be brought in as part of the initial phase of development and used for surcharging on West Pond for a period of up to 6 months. Once the surcharging is complete, the material will be moved onto subsequent development phases in South Quay and East Quay. An option for accelerating surcharging has been considered by using band drains. However, this has the disadvantage of connecting groundwater bodies and has been rejected on the grounds of potential environmental impact on the underlying aquifer.

4.32 The fill thicknesses are deep across the majority of the site, whilst the majority of West Pond and parts of East Quay are underlain by soft, highly compressible Estuarine Alluvium. Piled foundations will be required across the majority of the site, driven and bored piling options have been considered. Conventional bored or Continuous Flight Auger (CFA) piles have the disadvantage of producing spoil which will need to be deposited in other areas. There are also concerns regarding pathways being developed around the bore sides that could connect groundwater bodies; this is discussed further in Chapter H. Driven piles are therefore being considered as these do not generate spoil and the presence of soft alluvium seals the bore sides during/after pile driving and prevents pathways from being developed. The final method of piling is however to be agreed with the regulators in due course.

5.0 Potential Impacts

Introduction

5.1 The source-pathway-receptor linkage model has been used to identify the potential impacts with respect to ground conditions and contamination during construction and after the completion of the proposed development.

5.2 Impacts to groundwater and surface water receptors are detailed in Chapter H – Water Resource, Drainage and Flooding.

Impacts during Construction

Impact to the health of construction workers and the general public from contaminated soils and materials

5.3 The site investigations undertaken on the site have identified a range of contamination across site areas, these are described in Section 4 of this Chapter.

5.4 Excavation of potentially contaminated soils may pose a health risk to site workers through dermal contact (ie direct skin contact with contaminated soils), ingestion (ie via the transfer of contaminated soils from unwashed hands during eating) and inhalation (ie breathing in contaminated dusts, vapours and fibres generated by excavation activities).

5.5 Excavation of potentially contaminated soils may also pose a health risk to the general public in the immediate vicinity of the site through inhalation of contaminated dusts and particulate matter/fibres generated by excavation activities.

5.6 The impact of contaminated soils and materials on construction workers and the general public is considered to be of major adverse significance prior to the implementation of mitigation measures. The valuation of the receptor is high and the impact magnitude is considered to be high due to the nature and extent of contamination identified.

Impact on neighbouring sites from disturbance/mobilisation of contaminated materials.

5.7 Construction activities, eg excavation of soils and movement of vehicles, may lead to the mobilisation of the identified contaminants within soils to adjacent neighbouring sites.

5.8 Contaminated soil may be transported via vehicles and wind blown dusts generated by construction activities and excavation of soils also have a

potential to directly impact neighbouring sites, particularly during periods of dry, windy weather; further details are provided within Chapter K - Air Quality.

5.9 The impact on soils from the disturbance or mobilisation of contaminated materials is likely to be of **minor to moderate adverse significance** prior to the implementation of mitigation measures due to the high valuation of the receptor and low magnitude of the impact.

Impact to the health of construction workers and the general public from ground gas

5.10 Slightly elevated methane and carbon dioxide gas have been identified within the site. A CIRIA Characteristic Situation 1 and 2 classification has been assigned to this part of the site based on data collected to date.

5.11 Construction workers working in confined and semi-confined spaces on the development site are at risk of being exposed to elevated levels of gas which could lead to a risk of explosion and/or asphyxiation.

5.12 Excavation and disturbance of fill and alluvial material during construction may release odours which could affect the construction workers and the general public; these issues are considered in more detail in Chapter K – Air Quality.

5.13 The impact on construction workers and other human health receptors from the effect of ground gases is likely to be of **minor to moderate adverse** significance prior to the implementation of mitigation measures due to the high valuation of the receptor and low magnitude of the impact.

Impacts After Completion

Impact to the health of future site workers and occupants from contaminated soils and materials

5.14 The intrusive site investigations undertaken on the site have identified hydrocarbon contamination. Ground remediation is proposed to treat and remove contaminated soil and groundwater.

5.15 There remains a potential for residual contamination to remain on-site following development of this land.

5.16 Potentially contaminated soils can pose a direct health risk to maintenance workers through dermal contact (i.e. direct skin contact with contaminated soils), ingestion (i.e. via the transfer of contaminated soils from unwashed hands during eating) and inhalation (i.e. the breathing in of contaminated dusts, vapours and particulate matter/fibres generated by excavation activities) should the need for maintenance work involving the excavation of ground, e.g. maintenance of underground services, arise.

5.17 Without mitigation measures, there is a clear risk to future site occupants/users. Whilst the presence of hard standing, building footprints will offer some protection, there remains significant risk to site users without mitigation measures. There are also potential risks exist associated with the permeation of water supply pipes by organic contaminants.

5.18 The impact on future site users from contaminated soils and materials is likely to be of **major adverse** significance, prior to the implementation of mitigation measures due to the high valuation of the receptor and high magnitude of the impact.

Impact to the health of site occupants and maintenance workers from ground gas

5.19 Post completion, fill and alluvial material remaining on the site has the potential to release ground gas which could have the potential to accumulate in confined spaces within the development and within confined service trenches.

5.20 The impact on human health receptors from the effect of landfill gases remaining after development is likely to be of **moderate to major adverse** significance prior to the implementation of mitigation measures due to the high valuation of the receptor and medium magnitude of the impact.

Impacts on the health of site occupants from radon gas

5.21 Natural emissions of radon gas may accumulate within properties in those areas of the site where a risk has been identified based on BGS data; prolonged exposure to high levels of radon (i.e. within residential dwellings) can result in an increased incidence of lung cancer.

5.22 The impact on human health receptors from radon gas is considered to be of **moderate to major adverse** significance prior to the implementation of mitigation measures due to the high valuation of the receptor and medium magnitude of the impact.

Impact on neighbouring sites from future contaminated material

5.23 Post development, contaminated soil may be transported via vehicles and wind blown dusts and have a potential to directly impact neighbouring sites, particularly during periods of dry, windy weather; further details are provided within Chapter K - Air Quality.

5.24 The impact on soils from the disturbance or mobilisation of contaminated materials is likely to be of minor to moderate adverse significance prior to the implementation of mitigation measures due to the high valuation of the receptor and low magnitude of the impact.

6.0 Mitigation Measures

Introduction

6.1 A number of adverse impacts have been identified, associated with both the construction and operational phases of the scheme. These can be managed through the implementation of appropriate mitigation measures as detailed below.

Impacts During Construction

6.2 The risks posed to the health and safety of site workers during the site preparation and construction phases may be mitigated by the following measures:

- The provision and use of suitable Personal Protective Equipment (PPE)
- Dust suppression measures and wheel washing facilities
- The provision of health and safety training and warning signs

6.3 Method statements and working plans will be prepared in accordance with good site practices to avoid/minimise the likely significant effects at source, will be discussed and agreed with the appropriate Regulatory Authorities and included within the Construction Environmental Management Plan (CEMP) and Site Waste Management Plan and enforced throughout the construction phase.

Impact to the health of construction workers and the general public from contaminated soils and materials

6.4 The effects to the health of construction workers and the general public from potentially contaminated soils and materials will be controlled under the Construction (Design & Management) Regulations 2007, Construction Phase Management Plan. Method statements and risk assessments will need to be prepared and remediation will be subjected to environmental permitting. These will ensure the protection of workers and the general public during the construction phases and specify appropriate safe working practices. Personal protective equipment (PPE) will be specified and used, particularly during ground works. Other protective measures will be incorporated to mitigate impacts posed to the general public.

6.5 All persons engaged in site redevelopment will be made aware of the findings of the geo-environmental site investigation. For the identified contamination, the associated hazards of handling potentially contaminated materials will be conveyed to all site workers and all works will be conducted in accordance with the Health and Safety Executive publication entitled Protection of Workers and the General Public during the Development of Contaminated Land', 1991.

Impact on neighbouring sites from the disturbance/mobilisation of contaminated materials

6.6 A variety of good environmental site practices shall be implemented whilst undertaking construction activities, in order to avoid or minimise impacts at the source. There are likely to be a number of contractors operating on different parts of the site during construction, detailed mitigation measures will be developed as part of the construction plan in accordance with appropriate best practice.

6.7 A site Construction and Environmental Management Plan (CEMP) will be developed including a site environmental and health and safety management policy to mitigate construction risks. The position and extent of working areas shall reflect surrounding areas and works being carried out. The contractor shall appraise the suitability of such working areas in this respect as part of working method statements.

6.8 Best practice recommendations for the prevention of contamination will be outlined in the detailed Construction Environment Management Plan (CEMP) and Site Waste Management Plan (SWMP) both of which will be developed and discussed with the Local Authority and Environment Agency, prior to commencing construction.

Impacts After Completion

Impact to the health of future site occupants from contaminated soils and materials

6.9 The risks to future site occupants will be mitigated by the remediation scheme which includes bio-remediation of soils and the removal of grossly contaminated soils and free product groundwater together with the provision of a minimum of 600mm cover across much of the site. The use of upgraded water supply pipes (i.e. wrapped polyethylene or ductile iron) in areas of significant organic contamination may be necessary.

Impact to the health of site occupants and maintenance workers from ground gas

6.10 The mitigation measures specified during the construction phase applies to any maintenance work that involves below ground excavation and/or entry into a confined space.

6.11 Passive venting measures should be incorporated into the development, measures associated with CIRIA Characteristic Situation 2 are considered appropriate for East Quay, West Pond and South Quay, these involve the provision of a gas membrane and passive venting measures, all joints and penetrations would need to be sealed. No measures are required for Arno Quay as this area is classified as CIRIA Characteristic Situation 1 .

Impact to the health of site occupants from radon gas

6.12 Where present, risks to human health associated with radon gas can be mitigated by the incorporation of radon gas protection measures within the proposed building design in line with BRE publication 211 (Radon: Guidance on protective measures for new buildings, 2007), as appropriate. The need for basic measures containing a synthetic membrane has been identified for this site.

Impact on neighbouring sites from future contamination of soils

6.13 Providing the remediation measures are undertaken including the provision of the appropriate cover, the risk of contamination of soils migrating to adjacent areas will be effectively mitigated.

7.0 Residual Impact Assessment

Introduction

7.1 Following the implementation of the mitigation measures, the source-pathway receptor linkage model has been reapplied to identify potential impacts with respect to ground conditions and contamination and the significance reassessed. The effects of contamination and the impact of construction and the operational use of the site on ground conditions, mitigation measures and the residual effects of these impacts are summarised below.

Environmental Topic	Description of Impact		Description of Mitigation Measure	Description of Residual Impact	
	Description	Significance		Description	Significance
Ground Conditions and Contamination: Construction	Health of construction workers and the general public affected by contaminated soils	Major Adverse Direct Temporary Medium-term	Mitigation measures to be developed in line with published guidance and best practice. Use of generic safe working practices and Construction Phase Management Plan.	Health of construction workers and the general public affected by contaminated soils	Minor to moderate Adverse Direct Temporary Medium-term
	Impacts on soils and neighbouring sites from contaminated soils and materials	Minor to moderate Adverse Direct Temporary Medium-term	Mitigation measures to be developed in line with published guidance and best practice. Use of good environmental site practices and adoption for pollution prevention guidelines.	Impact on soils and neighbouring sites from residual contamination soils and materials.	Negligible Direct Adverse Temporary Medium-term
	Impact of health of construction workers and	Minor to moderate Adverse	Mitigation measures to be developed in line with published	Impact to health of construction workers and	Negligible Direct Adverse

Environmental Topic	Description of Impact		Description of Mitigation Measure	Description of Residual Impact	
	Description	Significance		Description	Significance
	general public from ground gas	Direct Temporary Medium-term	guidance (CIRIA) and best practice, if required. Use of generic safe working practices and confined spaces procedures.	general public from landfill gas.	Temporary Medium-term
Ground Conditions and Contamination: Operation	Impact on human health from residual contaminated soils and materials	Major Adverse Direct Permanent Long-term	Mitigation measures implemented during construction including remediation and cover material Consideration of upgraded waste supply pipes.	Impact on human health from residual contaminated soils and materials	Negligible Direct Adverse Permanent Long-Term
	Impact to health of site occupants and maintenance workers from ground gas	Moderate to Major Adverse Direct Permanent Long-term	Mitigation measures implemented during design and construction to include gas membrane and passive venting measures.	Impact to health of site occupants and maintenance workers from landfill gas	Negligible Direct Adverse Permanent Long-term
	Impact to health of site occupants from radon gas	Moderate to Major Adverse Direct Permanent Long-term	Mitigation measures implemented during design and construction to include appropriate radon protection measures within new dwellings.	Impact to health of site occupants from radon gas	Negligible Direct Permanent Long-term

Environmental Topic	Description of Impact		Description of Mitigation Measure	Description of Residual Impact	
	Description	Significance		Description	Significance
	Impact on soils and neighbouring sites from future contaminated materials	Negligible Direct Adverse Permanent Long-term	Mitigation measures within development design including hardstanding and appropriate drainage infrastructure	Impact on soils and neighbouring sites from future contaminated materials	Negligible Direct Adverse Permanent Long-term

Table I4 - Summary of Residual Effects of the Proposal together with Mitigation Measures

8.0 Summary and Conclusions

8.1 The Application Site comprises of four distinct parcels of land at the Waterfront in Barry: Arno Quay; East Quay; West Pond and; South Quay. The sites have been subject to previous dockside development including land filling, railway sidings, tank farms, ship and engine repair works, warehousing.

8.2 The geology of the area typically comprises made ground over Estuarine Alluvium, which in turn rests on Penarth Group, Blue Anchor Formation, St Mary's Well Bay Formation and Lavernock Shale rocks. In places, the made ground is shallow and Estuarine Alluvium is absent.

8.3 Elevated hydrocarbon contamination has been identified within the made ground and ground/groundwater remediation will be required. A risk exists for human health receptors through dermal contact, inhalation and ingestion. Slightly elevated gas concentrations have also been encountered and the site has been classified as CIRIA characteristic Situation 1 and 2, with passive venting measures required.

8.4 The main impacts with respect to ground conditions and contamination during construction of the development are:

- Health of construction workers affected by contamination and ground gas
- Neighbouring sites from contaminated soils
- Health of future site users from contamination and ground gas together with Radon

8.5 Mitigation measures to be implemented through the construction process include the use of safe working procedures and good environmental practices in accordance with Construction (Design and Management) Regulations and Pollution Prevention Guidelines.

8.6 The remediation measures including treatment and re-use of soil together with removal of grossly contaminated soil and free-product groundwater together with the provision of a clean cover and membranes/passive venting should be implemented to mitigate impacts during operation of the development.

8.7 Following the implementation of mitigation measures it is considered that a minor to moderate adverse impact remains for the health and safety of construction workers from soil contamination, other impacts are considered negligible following mitigation.

9.0 Abbreviations

- BGS – British Geological Survey
- BRE – Building Research Establishment
- CIRIA – Construction Industry Research and Information Association
- EA – Environment Agency
- HDPE – High Density Polyethelyne
- m – metres
- mm - millimetres
- PPE – Personal Protection Equipment
- VoG – Vale of Glamorgan

10.0 References

Relevant Legislation

- Environment Protection Act 1990
- The Water Resources Act (1991)
- The Environment Act (1995)
- Groundwater Regulations 1998
- The Land drainage Act (1999)
- The Water Environment (Water Framework Directive) (England and Wales) Regulations (2003)
- The Water Act (2003)
- The Private Water Supplies Regulations (1991)
- UK Water Supply (Water Quality) Regulations 2000 and 2001
- Water Resources (Environmental Impact Assessment) Regulations 2003
- Water Resources (Abstraction and Impounding) Regulations 2006
- Pollution Prevention and Control Act 1999
- Environmental Impact Assessment (Land Drainage Improvement Works) Regulations 1999
- Land Drainage Act 1991
- Public Health Act 1848
- Control of Pollution Act 1974
- Control of Pollution Regulations 1996
- Pollution Prevention and Control (England and Wales) Regulations 2000
- Anti Pollution Works Regulations 1999
- EC Dangerous Substances Directive (76/464/EEC)

Relevant codes of practice:

- BS5930: 1990 Code of Practice for site investigations
- BS EN 1997 Eurocode 7 Geotechnical Design
- BS EN 1997-1:2004: General rules
- BS EN 1997-2:2007: Ground investigation and testing
- BS1377-9 (1990) Standard methods of laboratory testing for civil engineering purposes
- ISRM (1985) Rock characterisation methods
- BS6031: 1981 Code of Practice for earthworks
- BS8004: 1986 Code of Practice for foundations
- Policy and Practice for the Protection of Groundwater, 1992, Environment Agency.

Relevant guidance documents:

- Environment Agency Pollution Prevention Guidance Notes (PPG series)
- Good Practice Guide for Handling Soils (MAFF 2000)
- CIRIA 113 Control of Groundwater for Temporary Works,1988
- CIRIA 630 Sustainable water management in land use planning, 2006
- Environmental Good Practice on Site, CIRIA

- Wilson, S; Oliver, S; Mallet, H; Hutchings, H; Card, G (2006), 'CIRIA C659 – Assessing Risks Posed by Hazardous Ground Gases to Buildings', UK,
- BRE 211 (2007), Radon, Guidance on Protective Measure for New Buildings, UK.

Planning Policy

- Planning Policy Wales (PPW) (2002)
- Technical Advice Note (TAN):15 Development and Flood Risk. (2004)
- Adopted Vale of Glamorgan Unitary Development Plan (UDP) 1996-2011

Reports

- Ove Arup and Partners (2008) Waterfront Barry – Arno Quay, Geotechnical and Risk Assessment Report, June 2008 (Appendix 4).
- Ove Arup and Partners (2008) Waterfront Barry – West Pond, Geo-Environmental Site Investigation: Report, September 2008 (Appendix 5).
- Ove Arup and Partners (2008) Waterfront Barry – South Quay, Geo-Environmental Site Investigation Report, November 2008 (Appendix 6).
- Ove Arup and Partners (2008) Waterfront Barry – East Quay, Geo-Environmental Site Investigation Report, November 2008 (Appendix 7).
- Ove Arup and Partners (2009). Waterfront Barry Strategic Earthworks, Highways and Drainage Report, January 2009.