BARRY ENERGY RECOVERY LTD

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FLOOD CONSEQUENCE ASSESSMENT

December 2008

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SECTION 1

INTRODUCTION

1 INTRODUCTION

1.1 Introduction

1.1.1 Parsons Brinckerhoff Ltd (PB) was commissioned by Barry Energy Recovery Ltd to undertake an Environmental Impact Assessment (EIA) in support of the planning application for an Energy Recovery Facility at Barry Docks, Barry, in the Vale of Glamorgan, South Wales.

1.1.2 The Environment Agency (EA) indicate in their Scoping Opinion that the site lies entirely within Zone C2, as defined by the development advice map (dam) referred to under Technical Advice Note 15 (TAN 15): Development and Flood Risk(1). The EA therefore requests that the risk of flooding be considered as part of the EIA and requests that a Flood Consequence Assessment (FCA) is submitted in accordance with TAN 15 to demonstrate that the consequences of flooding can be acceptably managed. This document has been prepared to address that request. The findings of this FCA are summarised in the Environmental Statement (ES) which reports on the findings of the Environmental Impact Assessment (EIA) prepared for the Scheme.

1.2 Site Location and Description

1.2.1 The site is situated on a level plot, approximately 1.6 hectares in size, at National Grid Reference 312810, 167260 on Atlantic Way, Barry Docks. The site is approximately 100 metres (m) south east of Eastern Dock Wharf, approximately 450 m east of the main dock gates, and approximately 370 m to the north of the Severn Estuary.

1.2.2 The site is currently disused and appears to comprise Made Ground. There is evidence of tipping of materials including inert waste. There are currently no buildings on site and there is no evidence of any previous buildings. The site is vegetated with a mixture of grasses, scrub, ruderal species and immature trees. The site is considered to be of low ecological value.

1.2.3 A topographical survey was provided by Encia Geomatics, Land and Engineering Surveyors, which covers the extent of the site. The topographical survey can be found in Figure 1.

1.3 Project Description

1.3.1 Vale of Glamorgan (VoG) Council is currently investigating a range of waste management solutions for waste generated within the county that will meet their future targets for increasing percentage of waste used to recover heat, power, or other energy (VoG Community Strategy 2003-2013)(2).

1.3.2 Barry Energy Recovery Ltd is owned by BioGen Power Ltd, which was established in 2005 to develop small to medium scale gasification facilities in the UK. The company provide local waste management solutions that process locally generated wastes, in accordance with the Government's proximity principle.

1.3.3 The proposed 80,000 tonnes of waste per annum Energy Recovery Facility will generate up to 7 megawatts (gross) electricity for export to the National Grid. The facility can utilise municipal solid waste and trade waste. The facility will use proven

gasification technology that has been operational in Europe for 10 years. A preliminary layout of the proposed facility is shown in Figure 2.

1.4 Adjacent Sites

1.4.1 The site lies within an industrial area on the Barry Docks. Surrounding land use comprises mixed industrial activities, including waste management activities (scrap yards, waste segregation, and landfill) and bulk materials storage and handling (including stockpiles of sand and other aggregates) and other small industrial units.

1.4.2 The Cadoxton River flows through the Atlantic Trading Estate via an open channel in a south-westerly direction before entering a tidal flap structure under Wimbourne Road, approximately 280 m east of the site. This structure marks the normal tide limit (NTL) of the Cadoxton River. The tidal flap provides a physical barrier to tidal influx. The river then flows through the Black Rocks where it discharges into the Severn Estuary.

1.4.3 The proposed development lies approximately 230 m and 485 m northwest of the Hayes Point to Bendrick Rocks Site of Special Scientific Interest (SSSI). The Barry Island (including Cosmeston Lakes) SSSI lies approximately 920 m southwest of the site.

1.4.4 Other surrounding water features include:

- East Breakwater Stream located approximately 250 m southeast of the site;
- Cross Breakwater Stream located approximately 300 m southwest of the site;
- Barry Dock No.2 located approximately 100 m to the west of the site;
- Barry Dock No.1 located approximately 450 m to the west of the site;
- Barry Dock No.3 located approximately 350 m southwest of the site; and
- The Severn Estuary located approximately 370 m to the south of the site.

1.5 Consultation with Relevant Bodies

1.5.1 The following consultations were undertaken by PB in relation to the FCA:

- Environment Agency Wales (flooding information);
- Vale of Glamorgan Council – Local Planning Authority (LPA);
- Associated British Ports (private drainage); and
- Dwr Cymru Welsh Water (public drainage).

1.5.2 The EA were consulted in April 2008 via a Scoping Opinion request. In response, the following comments and observations were made with respect to the proposed Scheme:

- The site lies entirely within Zone C2;

- A FCA is required for the proposed development in accordance with TAN 15 to demonstrate that the consequences of flooding can be acceptably managed;
- The risk of flooding is to be considered as part of the EIA; and
- There is no runoff restriction in place for the site due to its proximity to the Barry Docks.

1.5.3 Further consultation with the EA was undertaken in June 2008 when the following information was provided:

- The site lies partially within Flood Zone 2 and partially within Flood Zone 3;
- 1 in 200 year tidal flood levels;
- 1 in 1000 year tidal flood levels;
- Climate Change levels;
- Flood Zone Map;
- Flood warning information; and
- Water quality sampling data.

1.5.4 Additional consultation with the EA was undertaken in August 2008 when the following information was provided:

- Energy Recovery Facility is classified as a 'Highly Vulnerable Development';
- Critical tidal flood level is 1 in 200 year plus climate change of 20 years;
- Hydraulic modelling of the Cadoxton River is not required for project; and
- Results of Parsons Brinckerhoff's Bendrick Road, Barry Flood Study Report[3] should be incorporated in this FCA.

1.6 Potential Sources of Flooding

1.6.1 The potential sources of flooding at the site, which are considered in this assessment, are outlined below:

- Tidal flooding;
- Fluvial flooding from the Cadoxton River;
- Overland surface water flooding from adjacent sites;
- Site generated surface water runoff and sewers; and
- Groundwater flooding.

1.6.2 The impacts the above may have on the site are discussed in the following sections.

SECTION 2

FLOODING AND FLOOD RISK

2 FLOODING AND FLOOD RISK

2.1 Definition of Flood Risk

2.1.1 Flood frequency is identified in terms of the return period e.g. 1 in 100 year, 1 in 200 year, etc. In terms of probability, there is a 1 in 100 (1%) risk of one or more 100 year floods occurring in a given year. Similarly, there is a 1 in 200 (0.5%) risk of one or more 200 year floods occurring in a given year.

2.1.2 Table 1 below provides a conversion between return periods and annual flood probabilities.

Table 1: Conversion Table

Return Period (Years)	2	5	10	20	25	50	100	200	1000
Annual Flood Probability (%)	50	20	10	5	4	2	1	0.5	0.1

2.2 Flood Zones

2.2.1 The EA identified the site as lying partially within Flood Zones 1, 2, and 3. References to such Flood Zones are not found in guidance documents for Wales (Technical Advice Note 15 [TAN 15]) they are however, identified in Planning Policy Statement 25 (PPS 25) – Development and Flood Risk[(4)] the guidance document for England.

2.2.2 The zones refer to the probability of river (fluvial) and sea (tidal) flooding, whilst ignoring the presence of defences. Table 2 below summarises the relationship between Flood Zone category and the identified flood risk.

Table 2: Flood Zones

Flood Risk Area	Identification	Annual Probability of River Flooding	Annual Probability of Sea Flooding
Flood Zone 1	Low Probability	<0.1%	<0.1%
Flood Zone 2	Medium Probability	1% – 0.1%	0.5% – 0.1%
Flood Zone 3a	High Probability	>1%	>0.5%
Flood Zone 3b	Functional Floodplain	>5%	>5%

2.3 Development Advice Zones

2.3.1 TAN 15 identifies development advice zones in relation to planning action. Table 3 below describes the composition and use of these zones to control and manage development.

Table 3: Development Advice Zones

Zone	Zone Description
Zone A	Considered to be at little or no risk of fluvial or tidal/coastal flooding
Zone B	Areas known to have been flooded in the past evidenced by sedimentary deposits
Zone C	Based on Environment Agency extreme flood outline, equal to or greater than 0.1% annual probability of flooding (river, tidal or coastal)
Zone C1	Areas of the floodplain which are developed and served by significant infrastructure, including flood defences
Zone C2	Areas of the floodplain without significant flood defence infrastructure

2.3.2 Consultation with EA has indicated that the site lies entirely within Zone C2, as defined by the development advice map (DAM) referred to under TAN 15.

2.4 Environment Agency's Indicative Floodplain Map

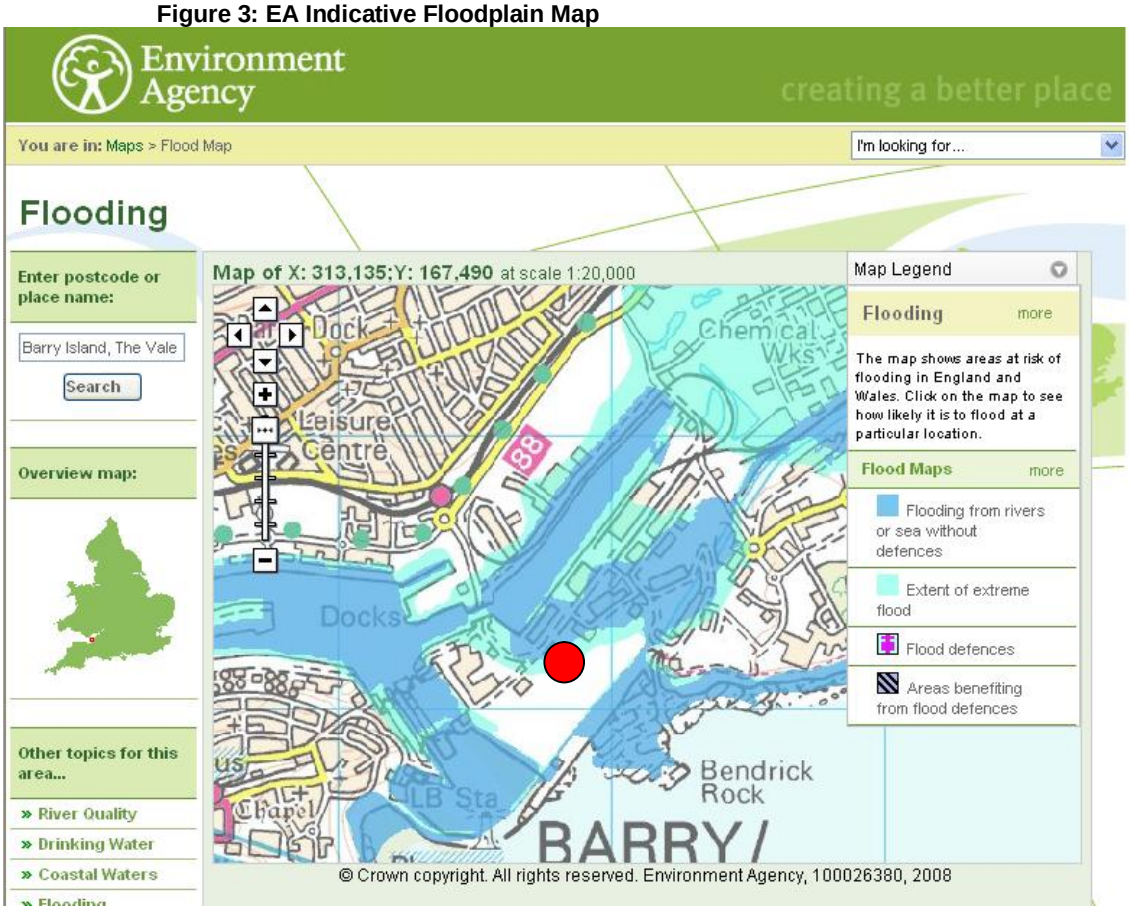
2.4.1 The EA produce indicative floodplain maps which highlight areas that are likely to flood from either tidal (sea) inundation or fluvial (river) flows.

2.4.2 The indicative floodplain map illustrates that the site could be affected by flooding, either from rivers or the sea, if there were no flood defences. The current EA indicative floodplain map indicates that the site lies partially within three different flood risk areas. For descriptive purposes, the site can be divided into three respective portions (northern, middle, and southern) to associate flood risk with the general site location. These portions are further described below:

- Northern Portion - area identified as having an annual probability of 0.5% or greater chance of sea flooding, or a 1% or greater chance of river flooding;
- Middle Portion - area likely to be affected by a major flood, from rivers or the sea, with up to a 0.1% chance of occurring each year; and
- Southern Portion – area outside the extent of extreme flooding and generally indicates that the likelihood of flooding each year from rivers or the sea is 0.1% or less.

2.4.3 Figure 3 below shows the indicative floodplain map for the study area:

Figure 3: EA Indicative Floodplain Map



Extract from Environment Agency Flood Mapping Website[5]

2.4.4 There are currently no flood defences (tidal or fluvial) within the vicinity of the site, operated or maintained by either the EA or VoG Council.

2.5 Environment Agency Flood Map

2.5.1 The EA has issued a current Flood Map (Figure 4), which covers the proposed Site. The Flood Map indicates that the Site lies almost entirely within Flood Zone 3, with a small portion within Flood Zone 2 (Table 2). These Flood Zones refer to PPS 25 terminology. Though PPS 25 is the guidance document used to assess flood risk in England (versus TAN 15 in Wales), the EA identified the Energy Recovery Facility with references to Flood Zones. In terms of TAN 15, the EA confirmed that the site is located in a Zone C2 area.

2.5.2 The EA indicates that the site is currently shown to be at risk from tidal flooding.

2.5.3 The EA has specified that there is an absence of detailed flood risk mapping in the vicinity of Barry, therefore, the EA Flood Map is based on generalised modelling that utilised a combination of projection and 2D tidal modelling.

2.6 Tidal Flood Levels

2.6.1 The EA do not hold specific local tidal level data for the Barry area. However, they provided predicted tidal levels at Cardiff Bay (approximate National Grid reference 318170, 174285) and Porthcawl (approximate National Grid reference 278544, 179401), which can be interpolated to estimate tidal levels for the Barry site. The Cardiff Bay and Porthcawl tidal levels are based on Dixon, M.J. and Tawn, J.A. (1997) "Extreme Sea Levels at the UK A Class Sites: Optimal Site by Site Analyses and Spatial Analyses", as well as Proudman Oceanographic Laboratory (POL) Internal Document No 112. The estimated tidal levels do not incorporate effects of climate change. Table 4 summarises the levels for the 1 in 200 year and 1 in 1000 year flood events, which are measured in metres Above Ordnance Datum (mAOD).

Table 4: Predicted Tidal Flood Levels in Vicinity of Site (for interpolation)

Node Description	1 in 200 year	1 in 1000 year
Cardiff Bay	8.17 mAOD	8.40 mAOD
Porthcawl	7.03 mAOD	7.25 mAOD

2.6.2 Table 5 below shows the tidal levels interpolated for the Barry site for the 1 in 200 year and 1 in 1000 year flood events, based on levels in Table 4, which do not account for climate change.

Table 5: Estimated Tidal Flood Levels for Barry Site without Climate Change

Node Description	1 in 200 year	1 in 1000 year
Barry	7.88 mAOD	8.10 mAOD

2.6.3 The EA also provided climate change values, measured in metres, which are relative to year 2000 levels in the vicinity of the site. Table 6 summarises the predicted levels of sea rise for several future time periods:

Table 6: Climate Change values near Barry site

Year	Rise in Sea Level
2025	0.125 m
2050	0.288 m
2075	0.463 m

2.6.4 Based on the estimated tidal levels (without effects of climate change) for the Site (Table 5) and predicted sea level rise (Table 6), the estimated tidal levels including the effects of climate change can be determined. These levels are summarised in Table 7 below:

Table 7: Estimated Tidal Flood Levels for Barry site with effects of Climate Change

Year	Rise in Sea Level	1 in 200 year	1 in 1000 year
2025	0.125 m	8.01 mAOD	8.23 mAOD
2050	0.288 m	8.17 mAOD	8.39 mAOD
2075	0.463 m	8.34 mAOD	8.56 mAOD

2.6.5 Further consultation with the EA indicates that the critical tidal flood level associated with the site is the 1 in 200 year tidal flood event plus the effects of climate change. The approximate design life of the Energy Recovery Facility is 25 years, thus the effects of climate change should be interpolated for the year 2033. Based on Table 7, the critical flood level must be interpolated between years 2025 and 2050. Table 8 below demonstrates the critical flood level associated with the Barry site:

Table 8: Estimated Critical Tidal Flood Level for Barry site with effects of Climate Change (25 years)

Year	Rise in Sea Level	1 in 200 year
2025	0.125 m	8.01 mAOD
2033	**0.177 m**	**8.06 mAOD**
2050	0.288 m	8.17 mAOD

2.6.6 Therefore, the critical tidal flood level for the site, which is used in this assessment, is 8.06 mAOD.

2.7 Fluvial Flood Levels

2.7.1 The EA indicates that the site is currently shown to be at risk from tidal flooding, therefore, no fluvial flood levels were provided.

2.8 Historical Flooding

2.8.1 The EA has confirmed that there is no historical flood data on record for the Cadoxton River or records of historical flooding in the vicinity of the site.

SECTION 3

JUSTIFICATION TEST

3 JUSTIFICATION TEST

3.1 Background

3.1.1 The EA indicates that the site is entirely located within a Zone C2 area, which describes an area of the floodplain that does not possess significant flood defence infrastructure. The EA also indicates that the Energy Recovery Facility is classified as a 'Highly Vulnerable Development', for its ability to generate and provide power.

3.1.2 TAN 15 indicates that 'Highly Vulnerable Development' should not be considered within a Zone C2 area. However, consultation with the EA indicates that the chosen location for the Energy Recovery Facility may be acceptable provided it meets the requirements of Section A1.15 of TAN 15.

3.1.3 TAN 15 indicates that new development should be directed away from Zone C and towards suitable land in Zone A, otherwise to Zone B, where river or coastal flooding will be less of an issue. In addition, if a development is located within a Zone C area, tests outlined in Section 6 (Justification Test) and Section 7 (Assessing Flooding Consequences) of TAN 15 must be applied.

3.2 Justification Test

3.2.1 Section 6 of TAN 15 describes that development will only be justified in Zone C if it can be demonstrated that:

Part A

i. *Its location in Zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement;* ***or***

ii. *Its location in Zone C is necessary to contribute to key employment objectives supported by the local authority, or other key partners, to sustain an existing settlement or region;*

and,

Part B

iii. *It concurs with the aims of Planning Policy Wales (PPW)*[6] *and meets the definition of previously developed land (PPW Fig 2.1);* ***and,***

iv. *The potential consequences of a flooding event for the particular type of development have been considered, and in terms of the criteria contained in Sections 5 and 7 and Appendix 1 found to be acceptable.*

3.3 Part A: ii - Section 6 of TAN 15

3.3.1 The Vale of Glamorgan (VoG) Council Local Development Plan (LDP) - Draft Preferred Strategy 2011-2026[7], indicates that a study was commissioned to examine

future employment land need within the Vale of Glamorgan. The study identified a need to overcome development constraints at key sites, such as Barry (Hayes Wood, Atlantic Trading Estate), and a need to provide serviced, freehold, development plots in Barry. The proposed development is located adjacent to the Atlantic Trading Estate, therefore, it is identified as an area benefiting from surmounted development constraints.

3.3.2 The results of the employment study suggest that Part A of the Justification Test can be satisfied.

3.4 Part B: iii - Section 6 of TAN 15

3.4.1 Part B of Section 6 of TAN 15 requires that the development meets the definition of previously developed land, as set forth in PPW Fig 2.1. The PPW document's definition of 'previously developed land' includes land used for waste disposal where provision for restoration has not been made through development control procedures.

3.4.2 The Envirocheck Report[8] prepared for the site indicates that a landfill area, licensed to BP Chemicals Ltd, is recorded as being operational on the site between 1945 and 1994. Wastes permitted for deposition included industrial wastes, Special Wastes, liquid sludge, commercial and household waste. Prior to this, the site is known to have been used as a railway sidings and coal store.

3.4.3 Section 7 of the ES: Ground Conditions indicates that in recent times, the on-site landfill and surrounding area has been subject to further tipping of construction and demolition waste in order to increase the height of the land. Section 7 also documents that the site has remained largely unchanged since 1994. Information collected to date concerning current and historic use of the site and the surrounding area indicates that the site remains unrestored.

3.4.4 Information supplied in the Envirocheck Report, as well as the Ground Conditions section of the ES, suggests that the proposed Energy Recovery Facility satisfies the definition of previously developed land.

3.5 Part B: iv - Section 6 of TAN 15

3.5.1 Part B of Section 6 of TAN 15 requires that the potential consequences of a flooding event for the particular type of development have been considered, and that criteria contained in the following sections are found to be acceptable:

- Section 5 of TAN 15 - Nature of Development or Land Use;
- Section 7 of TAN 15 - Assessing Flooding Consequences; and
- Appendix 1 of TAN 15 - Assessing Flooding Consequences.

<u>Section 5 of TAN 15</u>

3.5.2 Section 5 of TAN 15, indicates the Energy Recovery Facility is classified as a 'Highly Vulnerable Development', for its ability to generate and provide power. The EA have confirmed this classification.

3.5.3 TAN 15 describes 'Highly Vulnerable Development' as development where occupants have a limited ability to decide whether they wish to accept the risks to life and property associated with flooding, or be able to manage the consequences of such a risk.

3.5.4 Given the nature of the industrial facility, where energy is produced by processing commercial/residential wastes, the position and elevation of the Waste Reception Hall and Fuel Bunker are critical for their attendant risk to the public if the site should be inundated. Both features will contain 8 m deep bunkers. The critical tidal flood level at the site is 8.06 mAOD (Table 8). Preliminary design plans for the Energy Recovery Facility indicate that on-site hard standing/roadway/site egress is designed at elevation 8.50 mAOD, which will allow a 440 mm (minimum) height of protection. Building floor levels will be above this design level, adding further protection from the potential of tidal and fluvial flooding. In addition, the proposed on-site hard standing/roadway/site egress design level is approximately 100 mm above an extreme tidal flood event (1 in 1000 year), which is 8.39 mAOD for the year 2050 (Table 7).

Section 7 of TAN 15

3.5.5 Section 7 of TAN 15 specifies that if a development proposal meets the requirements of the Justification Test (see Section 3.2), it is understood that the development may flood, and therefore, associated consequences need to be assessed.

3.5.6 Section 7 of TAN 15 also specifies that site access and egress be considered. Section 4 of this FCA addresses site access/egress in terms of risk of flooding, as well as potential sources of flooding, and associated consequences at the site.

3.5.7 Section 7 of TAN 15 also specifies that factors of contamination and its affect on water quality be assessed should the site become inundated. Properly designed and sized oil separator(s) will be incorporated within the drainage designs for the Energy Recovery Facility to provide pollution control for runoff.

3.5.8 Preliminary design plans indicate that on-site hard standing/roadway/site egress is designed at an elevation of 8.50 mAOD, which is above the critical tidal flood level. Preliminary design plans also indicate that the only potentially low-lying area on-site will be the western side of the site. Based on the preliminary design plans, the lower-lying area may not be reached by inundation.

Appendix 1 of TAN 15

3.5.9 Appendix 1 of TAN 15 necessitates that this FCA address the nature of flooding, including the speed of inundation, velocity of floodwaters, depths of flooding, etc. Furthermore, Appendix A1.15 provides a table which provides indicative guidance on what are considered tolerable conditions for different types of developments. Given the nature of the proposed development, Table 9 lists parameters for an 'industrial' development only.

Table 9: Excerpt of Table listed in A1.15 of TAN 15

Type of Development	Maximum Depth of Flooding	Maximum Rate of Rise of Floodwaters	Maximum Speed of Inundation of Flood Risk Area	Maximum Velocity of Floodwaters
Industrial	1000 mm	0.3 m/hr	2 hrs	0.3 – 0.45 m/s

Note: mm = millimetres
m/hr = metres per hour
hrs = hours
m/s = metres per second

3.5.10 According to the preliminary design plans, the proposed Energy Recovery Facility is located approximately 100 mm above the extreme tidal flood event (1 in 1000 year), which includes the effects of climate change for the year 2050 (Table 7). The proposed development is designed above the extreme tidal flood level therefore the parameters outlined in Table 9 are not applicable to this site.

3.5.11 Appendix 1 of TAN 15 suggests that attention should be paid to impacts of the development on flood risk elsewhere in the floodplain. The topographical survey indicates that the existing on-site elevations range from 12.5 mAOD (southern end of site) to 7.5 mAOD (western side of site). By observation, approximately 20% of the existing site appears to lie below the critical tidal flood level (1 in 200 year tidal flood event plus climate change), which offers some storage for flood waters. Equally, preliminary design plans indicate that approximately 20% of the site will not be surfaced. The existing flood water storage characteristics of the site area, therefore, may not be significantly altered.

3.6 Mitigation Measures

3.6.1 Flood risk can be further managed by appropriately designed drainage infrastructure, as well as the incorporation of sustainable urban drainage systems (SUDS). SUDS drainage techniques may include soakaways, swale ditches, rainwater harvesting, and permeable paving. SUDS drainage techniques will be considered during the detailed design phase with a view to minimising on-site storage volume, controlling surface water runoff, as well as providing a degree of natural water treatment.

SECTION 4

ASSESSING FLOODING CONSEQUENCES

4 ASSESSING FLOODING CONSEQUENCES

4.1 Background

4.1.1 Part B of Section 6 of TAN 15 requires that the potential consequences of a flooding event for the particular type of development have been considered. In addition, the terms of the criteria contained in Section 7 (Assessing Flooding Consequences) and Appendix 1 of TAN 15 are to be found acceptable.

4.1.2 This section addresses site access/egress in terms of risk of flooding, as well as potential sources of flooding, and associated consequences impacting the site. Potential sources of flooding include the following:

- Risk of tidal flooding;
- Risk of fluvial flooding from the Cadoxton River;
- Risk of overland surface water flooding from adjacent sites;
- Risk of site generated surface water runoff and sewers; and
- Risk of groundwater flooding.

4.2 Risk of Fluvial and Tidal Flooding

4.2.1 The Cadoxton River catchment covers an area of approximately 38 km^2 upstream of the site. The catchment is predominately urban with Dinas Powys located in the upper portion of the catchment, and Barry located in the lower portion. The Cadoxton River is classified by the Environment Agency as a 'main river', and is approximately 11.9 km in length from the source upstream of the Michaelston-le-Pit to the outfall to the Severn Estuary. The river channel is predominantly straight, with a silty riverbed and heavily vegetated embankments. The Cadoxton River discharges to the Severn Estuary through a tidal flap structure. The catchment contains 2 major lakes; one along the Cadoxton River above Michaelston-le-Pit and the other, Cosmeston Lakes, along the Sully Brook at Lower Penarth.

4.2.2 The Cadoxton River flows through the Atlantic Trading Estate via an open channel in a south-westerly direction before entering a tidal flap structure under Wimbourne Road, approximately 280 m east of the site. This structure marks the normal tide limit (NTL) of the Cadoxton River. Discharge through the tidal flap structure is influenced by tidal conditions in the Severn Estuary, with the tidal flap providing a physical barrier to tidal influx.

4.2.3 The tidal flap is housed in a bridge structure. The crest elevation of the bridge structure at this location is 8.5 mAOD. The immediate surrounding ground level on the left bank (looking downstream) is also at elevation 8.5 mAOD whilst the elevation of the downstream right bank is approximately 8.1 mAOD. The bridge is topped by a solid parapet wall with a top elevation of 10.4 mAOD.

4.2.4 By inspection of present day levels, the 1 in 200 year tide level (7.88 mAOD – Table 2.5), would not overtop the bridge structure or the right/left embankments at this location. When allowance is made for future climate change (8.06 mAOD –

Table 8), the 1 in 200 year tide level is still contained within the right/left embankments (8.1 mAOD), and does not overtop the bridge structure.

4.2.5 The EA indicated that the risk to the site is currently shown to be from tidal flooding. However, further consultation with EA, indicates that the site is at risk of fluvial flooding when the Cadoxton River becomes tide-locked for a period of several hours. Thus, fluvial flooding may occur when flows are not permitted to exit the tidal flap structure at the downstream end of the river, causing the Cadoxton River to back-up and spill over the river embankments. Tide-locking may occur whenever the tidal water level at the downstream side of the tidal flap is higher than the river water level at the upstream side of the flap.

4.2.6 As part of a separate flood study, PB recently studied the effects of tide-locking on the River Cadoxton (Appendix A). Results of this flood study were accepted by the EA in April 2008 (Appendix B), and, after further consultation with the EA, the results were permitted for use in this FCA. To demonstrate a worst case scenario, the study tested the effects of a 1 in 100 year fluvial flood event coupled with a 1 in 100 year tidal flood event. The study demonstrated that the River Cadoxton channel has sufficient capacity to store fluvial flood water during tide-locked periods. It should be noted that any flooding arising from the joint probability of a 100 year tidal flood event and a 100 year fluvial flood event is considerably greater than requirements considered under TAN 15.

4.2.7 On-site existing elevations range from approximately 12.5 mAOD (southern end of site) to 7.5 mAOD (western side of site). The eastern side of the site consists of elevations ranging between 8.55 mAOD to 8.97 mAOD. Given that the Cadoxton River lies east of the site, the on-site eastern 'bund' acts as a natural barrier to lower lying areas on the western side of the site.

4.2.8 As previously discussed, the preliminary design plans for the Energy Recovery Facility indicate that the concrete hardstanding/roadway is designed at elevation 8.50 mAOD. The critical tidal flood level (1 in 200 year plus climate change) for the site is 8.06 mAOD, giving a 440 mm height of protection. In addition, the proposed on-site hardstanding/roadway design level is approximately 100 mm above an extreme tidal flood event (1 in 1000 year plus climate change), which is 8.39 mAOD for the year 2050 (Table 7).

4.2.9 Given that the design level of the site is higher than the critical tidal flood level, the risk of tidal and fluvial flooding is considered to be low.

4.3 Risk of Overland Surface Water Flooding from Adjacent Sites

4.3.1 The westerly site boundary (running northeast to southwest), which lies adjacent to Atlantic Way, is bordered by an embankment. Both the embankment and Atlantic Way lie at an elevation consistently above the immediate surrounding ground elevation on the site. The embankment itself is approximately 0.1 m above the elevation of Atlantic Way, and approximately 0.5 m above the westerly edge of the site.

4.3.2 The northerly end of the site, which lies adjacent to a service road, is also bordered by an embankment. The embankment rises approximately 1.5 m to 2.5 m above the immediate surrounding ground elevation of the site. The service road generally lies at an elevation just above the immediate surrounding ground within the site.

4.3.3 The presence of the embankments along the westerly and northerly sides of the site effectively forms a barrier to overland surface water flood waters from entering the site.

4.3.4 The southerly end of the site consists of sand and gravel stockpiles, as well as dense, overgrown vegetation, which extends into the adjacent site. The stockpiles rise approximately 3 m to 4 m above the immediate surrounding ground on the site.

4.3.5 The easterly side of the site generally rises in elevation beyond the site boundary, to elevations ranging between 8.55 mAOD to 8.97 mAOD. These elevations are higher than the critical tidal flood level.

4.3.6 Overland flow generated further south and east of the site is captured by the Cadoxton River and the East Breakwater Stream. Overland flow generated further southwest of the site is captured by the Cross Breakwater Stream. Barry Dock No. 2 lies approximately 100 m west of the site, therefore, overland flow generated further west flows to the Dock.

4.3.7 Given limited evidence of historical flooding in the area, the risk of overland flooding onto the site is considered to be low.

4.4 Risk of Site Generated Surface Water Runoff and Sewers

4.4.1 The site is generally rectangular in shape and is situated in a northeast-southwest direction. Based on existing topography, surface water generally flows towards the centre of the site, and then exits in a north-westerly direction. On-site existing elevations range from approximately 12.5 mAOD (southern end of site) to 7.5 mAOD (western side of site).

4.4.2 The existing ground cover consists mainly of scrub and dense vegetation, with historical development records indicating this has been the case since approximately 1994.

4.4.3 The proposed development will increase the area of hard impermeable surfacing at the existing site, resulting in an increase in the proportion and rate of rainfall-runoff. This may cause a marginal increase in the risk of surface water flooding if the receiving drainage system does not contain sufficient capacity. As part of the detailed drainage design, the effects of surface water runoff and surcharges within the sewer system will be considered so as not to place existing or new development at risk from drainage flooding. Given the relatively small area of the site, consideration will be given to the use of permeable pavement systems.

4.4.4 The new surface water drainage system will be designed and sized in accordance with current best practice to ensure that no flooding out of manholes results from storms of 1 in 30 year return period. In addition, the new drainage systems will be simulated under a 1 in 100 year design storm to determine which parts of the drainage system are likely to flood in such a storm event, and finished levels will be arranged so as not to place buildings at risk of flooding.

4.4.5 The EA has stated that there is no runoff restriction in place at the Barry site, due to its proximity to the Barry Docks. It is understood that the on-site surface water drainage will discharge into the Barry Docks.

4.4.6 In addition, road levels and building floor levels on the site will be arranged in such a manner that essential buildings are not put at risk from site-generated surface water flooding, and that there will be no increase in risk of flooding to existing parts of the site, or outside the site.

4.4.7 An oil separator(s) will be added to provide pollution control of runoff from the process areas.

4.4.8 Given there is no runoff restriction to the Barry Docks, the risk of site generated surface water flooding is considered to be low.

4.4.9 Dwr Cymru Welsh Water (DCWW) indicates that no public foul sewers exist in the vicinity of the site. Associated British Ports (ABP) confirm that no private drainage exists in the vicinity of the site.

4.4.10 Foul drainage has not been designed at this time. There is preference to connect to a public sewer system. However, if this is impractical, foul drainage will discharge to cess pits. The cess pits will be operated by telemetry and outfitted with an alarm system designed to detect volumes near capacity. The cess pits will be designed in such a manner as not to adversely affect public health and the water environment.

4.5 Risk of Groundwater Flooding

4.5.1 Based on the British Geological Survey Maps[9,10] for the Barry area, the ground conditions beneath the site are likely to comprise of Mercia Mudstone Group (solid) overlain by Made Ground (drift).

4.5.2 A review of the Groundwater Vulnerability Map[11] indicates that the Energy Recovery Facility site is underlain by a designated Minor Aquifer with variable permeability. Such features may comprise of fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability including unconsolidated deposits. Although these types of aquifers do not produce large quantities of water for abstraction, such aquifers can be important for both local supplies and supplying base flow to rivers.

4.5.3 Local groundwater flow is likely to be influenced by the topographic slope in the area. In the vicinity of the Site the flow may be in a generally southerly direction toward the Severn Estuary, which represents the natural outflow of the groundwater system.

4.5.4 The likelihood of groundwater flooding is considered to be low.

4.6 Site Access/Egress

4.6.1 The site entrance to the Energy Recovery Facility is proposed to be off Atlantic Way. The approximate road levels on Atlantic Way near the proposed entrance to the site range from 8.11 mAOD to 8.16 mAOD. The topographical survey of the site indicates that the road levels generally increase north of the site entrance, and generally decrease south of the site entrance. The site entrance levels are above the 1 in 200 year tidal flood level (8.06 mAOD), which includes effects of climate change. In addition, the preliminary design of the Energy Recovery Facility indicates that the concrete hard standing is designed at 8.50 mAOD. This enables a safe exit to be made from the site.

SECTION 5

CONCLUSIONS

5 CONCLUSIONS

5.1 Conclusions

5.1.1 The proposed development is designed above the critical tidal flood level (1 in 200 year flood event plus 25 years of climate change).

5.1.2 The tidal flap control structure at the downstream end of the Cadoxton River (located approximately 280 m east of the site) provides a physical barrier to tidal influx. Providing that the integrity of the structure is maintained, and flood defence levels are maintained at least to the present levels, the proposed development site is not at risk from tidal inundation during the 1 in 200 year tidal flood event (plus climate change).

5.1.3 The risk of overland surface water flooding from adjacent sites, site generated surface water runoff, and groundwater flooding is considered to be low.

5.1.4 Appropriately designed drainage infrastructure, as well as the incorporation of SUDS can reduce flood risk and other environmental damage, as well as minimise on-site storage volume, control surface water runoff, as well as provide natural water treatment.

5.1.5 The preliminary design of the Energy Recovery Facility indicates that site egress is designed at 8.50 mAOD. This is approximately 440 mm above the critical tidal flood level and will enable a safe exit to be made from the site.

5.2 References

(1) Welsh Assembly Government, *Planning Policy Wales Technical Advice Note 15: Development and Flood Risk*, July 2004.

(2) Vale of Glamorgan Council, *Community Strategy 2003-2013*, 2003.

(3) Parsons Brinckerhoff, *Bendrick Road, Barry, Flood Study Report and Assessment of Flooding Consequences*, August 2007.

(4) The Stationary Office, *Planning Policy Statement 25: Development and Flood Risk*, December 2006.

(5) Environment Agency Flood Mapping, www.environment-agency.gov.uk/maps/info/floodmaps/?lang=_e

(6) Welsh Assembly Government, *Planning Policy Wales*, March 2002.

(7) Vale of Glamorgan Council, *Local Development Plan – Draft Preferred Strategy 2011 – 2026*, December 2007.

(8) Landmark Envirocheck® Report No. 25314547_1_1 and historical plans, May 2008.

(9) Geological Survey Map of Great Britain, Geological Map Sheet 263 – Cardiff, Drift Edition, 1946.

(10) British Geological Survey, 1:50:000 Series, England and Wales Sheet 263 – Cardiff, Solid Geology Edition, 1986.

(11) Environment Agency Policy and Practice for the Protection of Groundwater, Groundwater Vulnerability Map Sheet 36 - Gwent, South & Mid Glamorgan, 1996.

FIGURE 1

TOPOGRAPHICAL SURVEY

167400mN

312700mE

312800mE

312900mE

167400mN

167300mN

167300mN

167200mN

167200mN

312700mE

312800mE

312900mE

SURVEY STATIONS			
Name	Easting	Northing	Height
BARRY REF	312796.760	167330.696	8.152
B1	312815.623	167366.213	8.332
B2	312771.467	167306.639	8.170
B3	312716.358	167231.695	8.259

LEGEND

- Borehole
- Benchmark
- Bollard
- Bus Stop
- Electric Box
- Electricity Pole
- Fence Post
- Gas Stop Valve
- Gate Post
- Gas Marker
- Gully
- Gas Well
- Kerb Outlet
- Litter Bin
- Leachate Chamber
- Lamp Post
- Manhole Point
- MH Triangular
- Wooden Peg
- Ground Marker
- Marker Post
- Pylon
- Rodding Eye
- Sample Point
- Sign Post
- Spot Height
- Eave Level
- Ridge Level
- Stile
- Survey Station
- Traffic Camera
- Telephone Box
- Trial Pit
- Telegraph Pole
- Deciduous Tree
- Road Sign
- Valve
- Vent
- Water Meter
- Letter Box
- MH Circular
- Knockout Pot

LEGEND

- Bridge
- Bottom of Bank
- Building
- Canopy Edge
- Concrete Edge
- Ditch
- Drop Kerb
- Overhead Cable
- Fence
- Gate
- Kerb
- Path
- Pipe Line
- River
- Railway Line
- Road Centre Line
- Tarmac Edge
- Top of Bank
- Track
- Wall
- Verge
- Flagstone Paving
- Stone
- Hedgeline
- Grass Edge

ABBREVIATIONS

LP.	Lamp Post
TP.	Telegraph Pole
EP.	Electricity Pole
SP.	Sign Post
TS.	Terrific Sign
BS.	Bus Stop
GM.	Gas Marker Monument
MH.	Manhole
GU.	Gully
FH.	Fire Hydrant
CATV.	Cable Television Point
WM.	Water Meter
WSV.	Water Stop Valve
GSV.	Gas Stop Valve
RE.	Rodding Eye

SURVEY IS ORIENTED TO ORDNANCE SURVEY NATIONAL GRID. GPS ACTIVE NETWORK USED TO FIX CENTRAL POINT, FLAT PLANE WITH SF=1.00. LEVELS TO OSGM02.

THIS SURVEY SHOWS PHYSICAL SITE BOUNDARIES ONLY. CONFIRMATION OF LEGAL OWNERSHIP BOUNDARIES SHOULD BE OBTAINED BY REFERENCE TO THE H.M. LAND REGISTRY TITLE PLAN

THE PLAN SCALE IS FOR GUIDANCE ONLY. DO NOT SCALE DIRECTLY. IF IN DOUBT, CONSULT ENCIA GEOMATICS

REV.	DESCRIPTION	DATE

ENCIA GROUP LIMITED

ENCIA GEOMATICS
LAND AND ENGINEERING SURVEYORS
Yorkshire Office Tel :01937 589955
North East Office Tel :01642 809088
North West Office Tel :01942 824026
Web : www.enciagroup.co.uk
email : geomatics@enciagroup.co.uk

RICS

CLIENT

JOB TITLE

LAND AT BARRY DOCKS

DRAWING TITLE

DETAILED TOPOGRAPHIC SURVEY

DRAWN	SIGNATURE	DATE	STATUS
M.W		11/06/08	FOR COMMENT ☐
APPROVED	SIGNATURE	DATE	FOR APPROVAL ☐
XXXX		XXXXXX	DRAFT ☐
			FINAL ☐

SCALE	SHEET	DRAWING NO.	REVISION
1:500	A1	TBC	–

FIGURE 2

PRELIMINARY SITE LAYOUT

KEY PLAN

REV	DESCRIPTION	DATE	DRN	CHK	APP
X1	ISSUED FOR CLIENTS APPROVAL	18.07.08	TCJ	KC	MD

DWG. REVISION STATUS – APPROVED DWG. – A,B ETC
– PRELIMINARY DWG – P1,P2 ETC

CAD DRAWING – MUST NOT BE MODIFIED MANUALLY

BioGen

6 Croft Court,
Plumpton close,
Whitehills Business Park,
Blackpool,
Lancashire,
FY4 5PR

Birse Waste

Alexander House
4, Station Road
Cheadle Hulme
Cheshire SK8 5AE
Telephone: 0161 486 9191

SCALE	DWG. TITLE
1:500	PLOT PLAN

PROJECT TITLE
BARRY ENERGY FROM WASTE PLANT

CLIENT/SITE
BIOGEN

DATE	CAD REF	DRAWN BY	CHECKED BY	APPROVED BY
17.07.08		TCJ		

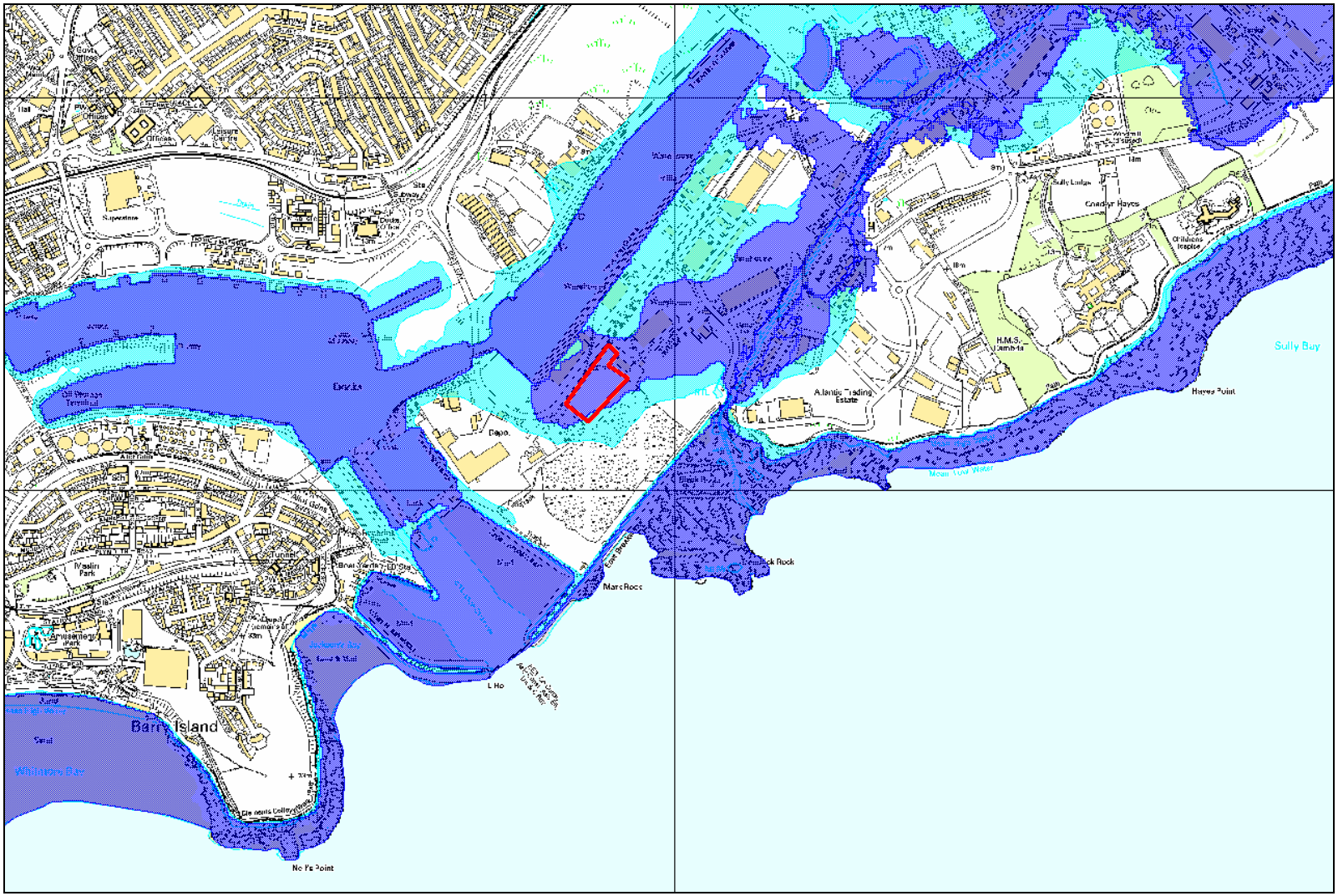
DRAWING No	REV
P3706–BARRY–SK001	X1

FIGURE 4

ENVIRONMENT AGENCY FLOOD ZONE MAP

Figure 4: Flood Map and location of site

E 312800 N 167250



Key

Dark Blue area : Flooding from rivers or sea without defences
Light Blue area : Extent of extreme flood
Red Polygon : Location of Site

APPENDIX A

PARSONS BRINCKERHOFF LETTER TO ENVIRONMENT AGENCY WALES

Miss Kayna Tregay
Planning Liaison Officer
Environment Agency Wales
St Mellons Business Park
Fortran Road
St Mellons
Cardiff
CF03 0EY

28 March 2008

Our Ref: FSE96821A

Your Ref: SE/2007/103575/01-LC

Dear Miss Tregay

FLOOD STUDY REPORT AND ASSESSMENT OF FLOODING CONSEQUENCES, PROPOSED RESIDENTIAL DEVELOPMENT AT BENDRICK ROAD, BARRY

Further to your letter dated 15th February 2008, we have re-examined the flood risk at the above location in the context of your comments. Essentially, we have followed the principle of a volumetric storage calculation during the tide-locked period that we discussed with your Development Control Officer, Johnathan Austin, and which you outlined in the above letter. The results are presented below.

The effect of tide-lock may occur whenever the tidal water level at the downstream side of the tidal flap is higher than the river water level at the upstream side of the flap. We have considered two scenarios: firstly, when the water level at which the river is tide locked is at the half of the flap height and, secondly, when the water level causing a tide lock is at the top level of the flap. Details of both calculations are shown below.

General Parameters Used:
T100 = 7.75mAOD
Q_{Med} = 17.85 m^3/s
Q100 = 32.09 m^3/s

Using the ReFH software we have used a storm duration of 8 hours 15 minutes with 15 minutes time steps to calculate the tide-locked storage volumes for the two scenarios.

1. *Water level at half of the tidal flap height*

The water level at which the river becomes tide-locked is 1.85mAOD.

Using the tide curve extracted from the Admiralty Tide Tables for United Kingdom and Ireland, the estimated duration of the tide-lock is 5 hours 30 minutes, and over this duration we have estimated the volume of water which needs to be stored within the river channel when the tidal flap is locked.

Interaction		Storage Volume (m^3)
T100	Q_{MED}	58,905
T100	Q100	105,930

It should be noted that any flooding arising from the joint probability of the coincidence of T100 and Q100 is considerable greater than anything required to be considered under TAN15.

2. *Water level at the top of the flap gate*

The water level at which the river becomes tide-locked is 3.48m.
Estimated duration of tide lock is 4 hours 30 minutes.

Interaction		Volume (m^3)
T100	Q_{MED}	39,447
T100	Q100	70,875

Available Storage:

The available storage volumes within the river channel have been calculated from the cross section data within the river model for a range of water elevations.

Water Elevation (mAOD)	Storage Volume (m^3)
1.85	2,650
3.48	18,050
5.00	36,190
6.00	50,700
7.00	66,170*

*It is not considered worth extending the elevation-storage relationship any further than a level of about 7.00m AOD since this is roughly the point at which overtopping of the banks of the channel would occur.

These volumes are conservative because the cross sections in the hydraulic model only extend to chainage 1390 along the river. At this location, the river bed level is 2.09mAOD, so an additional storage volume is clearly available beyond chainage 1390.

Ground level at the proposed development is approximately 7.1mAOD, whilst the top of bank level of the channel at the nearest cross section is about 7.2mAOD on the left bank and 8.2mAOD on the right bank. By inspection, the channel has the capacity to store fluvial flood water during tide-locked periods. Taking into consideration that additional storage not calculated above is also available upstream of chainage 1390 in the river model, it seems likely that fluvial flood flows of 1 in 100 year magnitude could easily be accommodated within the storage channel.

It has been described previously that the control structure at the downstream end of the Cadoxton River provides a physical barrier to tidal influx. Providing that the integrity of the structure is maintained (it is understood that the structure is operated and maintained by Dow Corning) and flood defence levels are maintained to at least the present levels, the proposed development site is not at risk from tidal inundation.

Given the degree of protection that appears to be afforded to the site by existing features, it is considered that the site is sufficiently well protected from both fluvial and tidal flooding and that the proposed residential development satisfies the principle objectives and conditions outlined by TAN15.

In conjunction with the previous submissions, we trust the above information is now sufficient to enable you to evaluate the assessment.

Yours sincerely
Parsons Brinckerhoff

pp **JONATHAN PRICE**
Senior Civil Engineer

APPENDIX B

ENVIRONMENT AGENCY WALES LETTER TO PARSONS BRINCKERHOFF

creu lle gwell
creating a better place

Asiantaeth yr Amgylchedd Cymru
Environment Agency Wales

RECEIVED 09 APR 2008

Mr Elizbieta Szostak - Environmental Engineer
Parsons Brinckerhoff
Queen Victoria House Redland Hill
Redland
Bristol
BS6 6US

Our ref: SE/2007/103575/02-L02
Your ref: FSE96821A

Date: 08 April 2008

Dear Mr Szostak

FLOOD STUDY REPORT AND ASSESSMENT OF FLOODING CONSEQUENCES, BENDRICK ROAD, BARRY

Thank you for your letter dated 28 March 2008, we would comment as follows:-

We have considered the Flood Consequences Assessment (Ref: FSE96821a/01/1 dated 28 August 2007) and additional supporting documentation from yourselves (letters dated 28 January 2008 and 28 March 2008) in support of the pre-development enquiry.

Based upon the information submitted, the assessment has taken into account in detail the probabilities of flooding to the site and shown that the risks and consequences of flooding could be acceptably managed in accordance with criteria set out in Technical Advice Note (TAN15).

If you have any queries, please do not hesitate to contact me.

Yours sincerely

S. Wilkes

Mrs SARA WILKES
Planning Liaison Officer

Direct dial 029 20245091
Direct fax 029 20362920
Direct e-mail wilkes.Cardiff2.WLS@environment-agency.wales.gov.uk