FLOOD RISK ASSESSMENT

FOR ENVIROPARKS HIRWAUN LTD

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Executive Summary

This report presents a flood risk assessment for a proposed development on land adjacent to Fifth Avenue, Hirwaun Industrial Estate, Hirwaun, Aberdare. The proposal is to develop the land into a waste recycling and energy producing facility.

The flood risk assessment has considered the likelihood of flooding at the site, and the potential impact on the site and surrounding area should flooding occur. The report concludes that the site has a low probability of flooding, both at the present time and with the potential effects of climate change. That said, the proposed development includes various water storage facilities which will provide water resources to the process, but which will also assist in controlling the rate and impact of site run-off. Additionally, the operator can take simple steps in the event that a flood event arises, to ensure than any risk of impact from the site operations is minimised.

CONTENTS

1. Introduction

When choosing a site for development consideration is naturally given to the supply and demand for the proposed operation in the area concerned. Planning policy is increasingly directing the development regime in order to protect the amenity and environment of towns, cities and the countryside in the public interest while promoting high quality, sustainable development. The increasing uncertainty in weather patterns, with meteorological conditions tending to become more intense and less predictable, result in a genuine need to consider the potential effects of more extreme conditions. With the current consideration that winter precipitation is likely to increase over coming decades, and that heavy winter precipitation is likely to become more frequent, the need to assess the flood risk associated with a site is increasing.

Enviroparks Hirwaun Ltd propose to develop a site on the Hirwaun Industrial Estate in Hirwaun, Aberdare. The company plans to operate a waste recycling and energy production plant using the concept of integrated technologies to extract the full recyclable value from the waste stream. The combination of technologies enables the residual fraction of material requiring disposal to be reduced to 2.5% of the original incoming waste.

The proposed development ensures maximum efficiency by sorting the waste materials that arrive at the site to extract recyclable materials, and preparing the feedstock for further processing. The site then employs five interlinked technologies to process this feedstock and recover energy resources.

The five main processing and energy production technologies are as follows:

- a 'Biomax' separator that extracts oil akin to a biodiesel from organic materials such as waste food, and other food industry products.
- anaerobic digestion, in which biomass waste is placed in sealed vessels and warmed and stirred in the absence of oxygen. This process removes most pathogens and odour from the waste and provides a useful energy source in the form of methane gas and a clean water effluent.
- pyrolysis, in which solid organic wastes are converted to a useful fuel gas under high temperatures and in the absence of oxygen.
- a plasma gasifier process in which any materials are converted to simple gases and an inert, glass-like solid material that can be used as an aggregate in construction.
- the liquid and gas-based fuels produced through these processes are then fed to a range of reciprocating engines to produce energy.

Some of the energy produced by the site will be used by a 'high energy user' – a manufacturing facility with high energy needs, occupying an industrial unit proposed in the northern part of the Enviroparks site.

The site is located within both the Rhondda Cynon Taf and Brecon Beacons National Park Authorities jurisdictions. The Rhondda Cynon Taf (Rhondda) Local Plan[1] includes Policy DCP5 which states that development in areas liable to flood risk will not normally be permitted unless in exceptional circumstances. Additionally, the Brecon Beacons National Park Authority includes several policies within the Local Unitary Development Plan[2] which consider flood risk:

Policy H2: Development and the Risk of Flooding
Development, including the raising of land, will not be permitted where that development would:

- be on land at high risk of flooding;
- result in an unacceptable risk of flooding either on or off site;
- adversely affect flood management or maintenance schemes;

- impede flood flows or result in changes in flow regime; or
- result in a net loss of flood-plain storage.

Where, exceptionally, development is allowed on land at high risk of flooding, such exceptional circumstances will be justified where it can be demonstrated that:-

- It needs to be located in a high risk area, or be part of a local strategy sustaining the settlement; or
- It is necessary to contribute to key employment objectives; and
- The proposal is on previously developed land; and
- The potential consequences of flooding have been considered and found to be acceptable.

Highly vulnerable development will not be permitted on land at high risk of flooding where that land is without significant flood risk infrastructure.

Policy H3: Reducing the Risk of Flooding
Development will only be permitted where:-

- It can be demonstrated that there is no increased risk of flooding locally or elsewhere due to additional surface run-off or changes in flow regime; or
- Where adequate mitigation works which are necessary to achieve such aims can be provided.

As the site is currently unused with all historical development removed, the modifications to the site surfacing and layout will be comprehensive. This will enable the developer to ensure minimal impact on the environment through a comprehensive system of protection and mitigation measures. However the development of a substantial plot of land will naturally alter the water flow routes across and from the site, and therefore the likelihood of any impact on flood risk must be assessed.

This flood risk assessment has been prepared in line with the requirements of the Welsh Assembly Government's Technical Advice Note (TAN) 15: Development and Flood Risk[3]. The methodology applied is therefore one of a staged assessment, with each requirement and the level of detail provided, being dictated by the previous level of enquiry. The overall aim of the flood risk assessment is to ensure that appropriate consideration is given to flooding issues by applying a precautionary approach.

Once the current baseline of flood risk has been described, the potential impact of the development as a whole will be considered. This will include assessment of the impacts on the development itself, and on downstream receptors in the local area, with consideration to the potential impact of flood water contributions to other locations from both normal site operations and site emergencies.

2. Assessing the Risk

Flood maps identify the likelihood of an area to suffer from flooding. TAN 15 considers five potential zones against which to apply the precautionary framework, as below:

Flood Zone Criteria

Zone	Description	Likely Uses
A	Considered to be at little or no risk of flooding	Any use, and no further justification for use is required
B	Areas known to have been flooded in the past	Apply a precautionary approach and check against the extreme flood level
C	Extreme flood outline, equal to or greater than 0.1 %	Flooding issues should be considered
C1	Areas of floodplain which are developed and served by significant infrastructure	Development can take place subject to the application of a justification test
C2	Areas of floodplain without significant flood defence infrastructure	Only for use with less vulnerable developments

Due to the proposed use of the site as a site which handles waste, the Enviroparks development is characterised as a "highly vulnerable development". As such the development should not be situated in areas of flood plain, or areas which are likely to suffer from extreme flooding events, i.e. equal to or greater than a 0.1 % chance of river, tidal or coastal flooding, without a full justification. The Environment Agency website has been consulted and the flood maps demonstrate that the site does not lie within a Zone C area, and thus is considered to have a less than 1 in 1,000 (0.1 %) annual probability of river or sea flooding in any year. Figure 1 presents the Flood Risk Map from the Environment Agency website.

Historical site investigation at the site denotes the presence of alluvium above boulder clay strata, and this suggests that the site may have flooded historically, leaving fluvial drift over the clay. Thus the site can be categorised as an area known to have been flooded in the past and is therefore located within a Zone B area. As such, the potential use of the site as an Enviropark can be considered suitable.

3. Sources of Site Water

The sources of site water which could contribute to flooding at the proposed site are:

Ground Water	From ground sources (contributions from precipitation and run-off)
Surface Water	From the stream or reservoir overtopping their banks
Rain Water	From precipitation
Other Run-Off	From the local landscape

Flooding is not thought to be an issue for the site presently. During re-grading works undertaken at the site in 1995, the low lying areas adjacent to the stream which passes through the site were raised to eliminate the risk of flooding from this source. Drainage maps from the time suggest that the surface water run off from the drainage channels incorporated onto the site were situated approximately 0.77 m above the stream bed (1995 levels). The bank then extends a further 1.7 m above the drainage discharge point.

Surface Water

Flood peak data is not recorded for the stream, or the River Camnant into which it flows, however both the River Mellte and the River Hepste are within the Hi Flows programme of flood data collection. Data from these two rivers has been included here due to their proximity to the site and the fact that the Camnant, Mellte and Hepste all ultimately join the same river. The aim is to provide information on river flows in the vicinity of the proposed development. Both the Mellte and the Hepste flow from the north and head west, the Camnant joining them via the River Sychryd prior to entering the River Neath. The River Neath is also included in the Hi Flows programme, and data of a gauging station located approximately 13 km to the west south west of the proposed development is provided here.

The Rivers Mellte, Hepste and Neath all have median annual maxima flood ratings below their bankfull (the river stage/elevation which represents the maximum safe water level that will not overflow the river banks or cause any significant damage within the river reach). The index of flood attenuation attributable to reservoirs and lakes, which is a fractional value identifying the attenuation occurring in a catchment due to upstream reservoirs and lakes, is 0.987 for the Neath , 0.975 for the Mellte and 1 for the Hepste. These values suggest that no or limited attenuation features are available, with 1 representing no attenuation, and the fractional value decreasing with increased effect.

The River Neath has had 397 occurrences of peak flows over the threshold (which has varied) between 1960 and 2006. The current Peak Over Threshold for this station is 113.26m^3/s**,** and the maximum peak has been 411.25 m^3/s. The two highest peaks were recorded in the 1960's, with the third highest experienced in October 1998. The River Mellte has had 280 occurrences of peak flows over the threshold of 51.82m^3/s flow since 1971, and an annual maximum of 176.12 m^3/s experienced in October 1998. The river's bankfull stage is 2.83 m. The River Hepste also experienced its highest annual maximum in October 1998, with a flow of 17.18 m^3/s, considering records from 1975 to 2005. The Hepste has had 187 occurrences of peaks over the threshold of 9.25 m^3/s (1975 – 2005), and five of these exceeded the bankfull level (0.8 m) possibly therefore being underestimated. The geology around the River Hepste is described as mostly Old Red Sandstone with carboniferous outcrops at southern limits. However peaty soils make it seasonally wet, and the standard percentage run off is considered to be 57.44 %. The study site has small, isolated areas of peat, however is located over boulder clay which can be estimated to have a standard percentage run off of 60 %. Although the data available does not relate directly to the water courses passing through or in the immediate vicinity of the study site, it does identify general trends in water flows and indicates that the highest flow rate over the last 37 years was probably experienced in October 1998, and was probably the result of relatively localised precipitation, i.e. that affecting the local catchment, including the rivers for which flow data is available.

Rain Water

Rainfall in Wales varies widely, with the highest average annual totals being recorded in the mountainous areas of Snowdonia and the Brecon Beacons. In the east, close to the border with England, annual totals are similar to those over much of the English Midlands. Snowdonia is the wettest part of Wales with average annual totals exceeding 3,000 mm, although the maximum rainfall in any one day was 211 mm at Rhondda on 11 November 1929. Throughout Wales, the months from October to January are significantly wetter than those between February and September.

The Hirwaun area would expect to receive between 1,691 and 4,577 mm per year (assessed as a 30 year average). The monthly average rainfall levels for South West England and Wales (assessed as a 30 year average) are as follows:

Monthly Average Rainfall Figures From a Thirty Year Period for the South West of England and Wales

Month	Rainfall (mm)	Days of Rainfall > 1mm
January	141.7	16.6
February	103.1	12.9
March	101.2	14.0
April	74.9	10.9
May	71.8	10.8
June	75.4	10.3
July	66.1	9.2
August	89.6	10.9
September	105.9	12.1
October	132.6	14.7
November	133.9	15.6
December	151.7	16.3
Total	**1247.9**	**154.4**

Average of 1971 – 2000 data.

The reported accumulation of rainfall is the sum of the amount of liquid precipitation plus the liquid equivalent of any solid precipitation (that is the liquid obtained by melting snow or ice that has fallen). A review of nine recent years worth of rainfall data from the St Athan meteorological station, which is situated approximately 36 km south of Hirwaun, along the South Wales coast, identified the peak rainfall intensity between 1999 and 2004 to be 18 mm per hour. This rainfall intensity was recorded during 1 hour only, with very little rain in the hours either side, and the next highest rainfall intensity over the 9 year period was 13.6 mm per hour. However, as rainfall near the south cost can be assumed to be substantially lower than that in the area of concern, further information has been obtained from the Met Office.

The Met Office provide site specific data calculated using the Flood Estimation Handbook method and, where appropriate the Flood Studies Report. The data obtained for the proposed development site suggests that, a one hour downpour of 18 mm per hour, as experienced at St Athan, is likely to have a probability of occurring 1 in 3 times in any given year. The information supplied by the Met Office is presented over page.

Climate change is predicted to increase the peak rainfall intensity by 5 % and peak river flow by 10 % between 1990 and 2025. Thus, the predicted peak rainfall intensity in the area up to 2025 has been calculated for various storm return rates. The return rates (T) indicate the probability of such a storm being experienced and amount to a 1 in T probability of the peak rainfall rate being experienced or exceeded in any given year.

Rainfall in Millimetres Corresponding to a Sliding Duration

		RETURN PERIOD (YEARS)												
SLIDING DURATION	TWICE A YEAR	1	2	5	10	20	50	100	200	500	1000	2000	5000	10000
15 MINS	5.2	6.5	8.2	10.7	13.8	17.5	23.8	30.0	37.9	51.3	64.6	81.3	110.2	138.7
30 MINS	7.6	9.5	11.8	15.2	19.2	24.0	32.1	40.0	49.7	66.1	82.2	102.0	135.8	168.7
60 MINS	11.3	13.8	16.9	21.4	26.7	33.0	43.3	53.1	65.1	85.3	104.5	128.0	167.4	205.1
120 MINS	16.6	20.1	24.3	30.3	37.2	45.2	58.4	70.7	85.5	109.9	132.8	160.6	206.3	249.5
180 MINS	20.8	25.0	30.0	37.0	45.1	54.4	69.5	83.5	100.2	127.4	152.9	183.4	233.2	279.7
240 MINS	24.5	29.2	34.8	42.7	51.7	62.1	78.7	94.0	112.1	141.6	168.9	201.5	254.3	303.3
360 MINS	30.7	36.3	43.0	52.3	62.7	74.7	93.7	111.0	131.4	164.3	194.4	230.0	287.4	340.1
480 MINS	36.1	42.4	49.9	60.3	72.0	85.2	106.1	124.9	147.1	182.5	214.8	252.7	313.4	368.8
12 HOURS	45.2	52.8	61.7	73.8	87.3	102.6	126.3	147.6	172.4	211.7	247.2	288.6	354.2	413.5
18 HOURS	55.0	63.7	73.8	87.5	102.6	119.5	145.7	168.9	195.8	237.8	275.5	319.1	387.6	449.0
24 HOURS	63.1	72.7	83.7	98.7	115.1	133.3	161.2	185.8	214.2	258.3	297.5	342.8	413.2	476.0
36 HOURS	76.7	87.6	100.2	117.0	135.2	155.3	185.9	212.6	243.1	290.2	331.6	379.1	452.3	516.9
48 HOURS	88.1	100.1	113.7	132.0	151.6	173.2	205.7	234.0	266.0	315.1	358.2	407.1	482.2	548.0
72 HOURS	103.9	117.1	132.1	151.9	173.0	195.9	230.3	259.9	293.2	343.7	387.6	437.1	512.3	577.7
96 HOURS	116.8	131.0	146.8	167.8	189.9	213.9	249.5	280.0	314.1	365.5	409.9	459.7	534.8	599.7
144 HOURS	137.8	153.3	170.5	193.0	216.7	242.0	279.4	311.0	346.2	398.7	443.6	493.5	568.2	632.2
192 HOURS	154.9	171.4	189.6	213.3	237.9	264.2	302.7	335.1	370.9	424.0	469.1	519.0	593.2	656.3

Other Run-Off

Information on the maintenance of the Penderyn reservoir suggest that when damp patches have appeared on the face of the embankment over the years, these have been dug out and replaced with stone in order to drain the areas through French drains, down into the stream which flows along side the site proposed for development. Discussion with the Revervoir's Supervising Engineer suggests that the dam is stable, despite being known to leak. Failure of the dam could have devastating effects on the proposed Enviroparks site. Welsh Water are understood to have considered the impact of such an event, although their findings are not available to the public. That said, the Reservoir's Supervising Engineer, has indicated that should the dam wall fail catastrophically, the proposed Enviroparks site would be inundated to a depth of 2m of water.

4. Current Water Flows and Flood Water Pathways

Although the site is not thought to flood presently, the presence of Boulder Clay across the site does result in marshy conditions in some areas, especially those not served by the drainage channels, as depicted in the photographs in Appendix 1. The drainage ditches run over approximately two thirds of the site area, and provide storm water drainage through 0.225 m diameter drainage pipes, discharging the collected surface water run-off to an un-named stream which runs along the western boundary of the site. This stream then joins the Camnant, approximately 50 m to the south west of the site, and would be the predominant predicted route of any flood water from the site in its current state. The site benefits from a small embankment around the boundaries with Fifth Avenue and Ninth Avenue, and the reservoir embankment to the north of the site. Thus any water from flood conditions at the current site would largely accumulate within the confines of these earth walls. The main access points through the embankment include the stream to the west of the site, into which the drainage channels discharge, and through the current road access onto Fifth Avenue.

Groundwater contour maps have been produced from data obtained from historical and recent site investigations, which are summarised in Chapter 11 of the Environmental Statement. These are presented in Appendix 2 and depict the groundwater movement in a general south westerly direction.

5. Future Water Flows and Flood Water Pathways

The development will include the conversion of much of the site to hardstanding, with the current estimated area covering approximately 5.4 hectares. It is proposed that hardstanding will be impermeable across the operational areas of the site, and surface water from the building roofs will be collected and stored in tanks for use in the process. Surface water from the site surfaces will be directed into a sustainable drainage system holding pond which will be located along the southern boundary of the site, passing through interceptors en-route to remove any oils or grease collected from the site roadways. This will ensure protection of surface and ground water sources from any potential pollution impacts, and the purpose built drainage and treatment systems will control the release of any surface water run-off or effluent. The remainder of the land will be left as soft landscaping and therefore the impact on the water flows in these areas will be limited. Figure 2 depicts the proposed site layout, and denotes the building and roadway areas, the landscaping and the large SUDS pond.

The proposal will see a reduced contribution from the site area run-off to groundwater, with much of the run-off water being harvested for use in the process, and any remaining run-off discharging through a sustainable drainage system. Thus the site will have a reduced risk of flooding and potential impact on other downstream areas through the development of the site. Other contributions to groundwater which may lead to an increased risk of flooding are through precipitation (discussed below) and contributions from sources such as other local operations, however there are not understood to be any other proposed developments in the immediate vicinity which may impact on the groundwater levels of the site.

Surface Water

The proposed development will result in the diversion of the surface water passing through the site, and will modify the flow rate of surface water run-off from the site, from direct discharge into the stream, to collection and use within the process. The surface waters entering the stream will therefore reduce and will in turn reduce the chance of the stream being flooded. That said, effluent discharges from the site will pass via the sewage treatment works and will be discharged into the River Camnant, into which the site stream also flows. Thus the proposed development will re-direct the water and reduce the flow to the on-site stream, however the overall effect downstream of the sewage treatment works will be less pronounced.

The Penderyn Reservoir has almost no catchment area and is reliant on water being fed from up to five other sources. Each of the sources of water serving the Penderyn provides a relatively small quantity of water, and none are shown on the Environment Agency Flood Maps to suffer from flooding. The reservoir has a capacity of 600 million litres (600,000 m^3) and serves the Hirwaun Water Treatment Works, which is understood to take most of the supply. It is also understood that 75% of the demands of the Cynon area are supplied by sources outside of the valley. However in times of excessive water capacity, the use of outside sources would be minimised and local sources would be used in preference, where possible.

Rainfall

The area of the site is approximately 70,000 m^2, and approximately 54,000 m^2 of this will be developed as hard surfacing in the proposed development. That said, approximately 22,000 m^2 will comprise building roof area, and the surface water run off from roofs will be collected in storage tanks for use around the site. Surface water run off from other areas will be directed to the sustainable drainage holding pond, which has a total capacity of 3,110 m^3. The results of calculations applying the area rainfall figures to the impervious areas of the site are presented in Appendix 3. Applying the maximum precipitation rates for 15 minute and 1 hour periods, and accounting for increases in precipitation levels from climate change, a 1 in 100 year return period storm of peak intensity rainfall could be contained within the water holding pond.

This can be demonstrated by the following calculation:

15 minute
(30 mm rainfall x 1.05 (climate change increase) / 1000) x 53,792 m^2 = 1,695 m^3

60 minute
(53.1 mm rainfall x 1.05 (climate change increase) / 1000) x 53,792 m^2 = 3,000 m^3

If the storm were to maintain its peak intensity rainfall for two hours, then the 1 in 10 year return period storm could be contained, however a greater intensity or a longer heavy rainfall period, could lead to some site flooding. These calculations assume that all of the surface water run-off from the site is directed to the pond, i.e. no roof water is stored in tanks, and that the full capacity of the holding pond is available to contain the storm water.

Alternatively if we assume that the tanks are empty and thus all of the roof water is diverted from the pond, and that the pond is already half full, that is 1 m deep, with 1,555 m^3 available capacity, the peak intensity rainfall for a 15 minute or 1 hour period can be contained, with the exception of a 1 in 100 year return period storm lasting for an hour which would result in some flooding. The volume of water which would exceed the capacity of the holding pond in this instance, would be less than 220 m^3. With site roads and pathways accounting for 31,788 m^2 this equates to a potential flood depth across the site of less than 7 mm.

When considering the six month return period, storms of between 18 and 24 hours duration can be contained within the holding pond assuming its full capacity is available, or alternatively, where only half of the pond capacity is available for use, a six month return period storm of just over 12 hours duration could be contained.

Other Run-Off

There is no proposed modification to the routing of other surface run off.

The overall impact of the proposed development will be to reduce the likelihood of flooding. The individual impacts considered either have no overall effect on the release, or reduce the likelihood of flooding, when considering both the site itself and any down stream or down gradient receptors. The use of adequate drainage, storage and control techniques will result in less water entering surface and ground waters directly, and can control the release to sewer such that, although the loading on the treatment works will increase with this proposed additional source, the discharge can remain within its regulated limits.

6. Floodwater Receptors

Although the site is not expected to flood, any flood waters would initially be directed to the site holding pond which contains clean and treated surface water run off is used to provide process waters across the site. From there, any excess quantity of water would initially overflow to the stream which currently takes all of the undeveloped site drainage. Should the pond level continue to increase, this stored surface water run-off will reach a permeable layer in the pond liner and will pass to soak away. The use of the 3,110 m^3 holding pond and soakaway system, will ensure that any floodwaters from the site are directed to ground and surface water resources in a controlled manner, and will therefore afford some reduction in potential impact of flood waters on down gradient receptors, which include the Hirwaun Waste Water Treatment Works.

7. Management

The Enviroparks development intends to utilise as much surface water run-off within their process as possible, and thus will reduce the waters available to contribute to flooding. The site will incorporate a large holding pond and sustainable drainage system, as well as tanks which will collect clean surface water run-off for use in the process. It is not considered that any further specific flood management defences or precautions are required for the site as:

1) Despite some evidence to suggest that the site may have flooded historically, the site is considered to have a less than 1 in 1,000 (0.1 %) annual probability of river or sea flooding in any year.
2) Despite the major modifications to the site layout and impermeability by the proposed development, the water storage and use measures noted above will result in an overall reduction of water flow from the site area

Should a localised or wider flooding situation occur however, Enviroparks should make every effort to control the impact. It should be noted however that staff safety is a priority and where immediate evacuation of the site is required, this must take precedence over environmental control issues.

At the first sign of a flood risk, the site should be shut down. If vehicles are in the process of being loaded or unloaded, this should be completed where practical and the vehicle dispatched from site. The gates to the site should then be closed and locked to prevent unnecessary access. Other measures may include the securing of loose equipment or materials within buildings where possible to prevent their escape from site. Should any drums or containers of potentially polluting substances be located around the site, these shoudl be moved internally where possible and will be secured.

At the first sign of an emergency situation, i.e. flood waters beginning to rise, the site should be evacuated via the main entrance route on to Ninth Avenue.

8. Conclusion

The proposed development of the land adjacent Fifth and Ninth Avenues on the Hirwaun Industrial Estate for use as a waste recycling and energy production facility will entail major development of the site which is currently an open field. Despite the proposed conversion of 5.4 hectares of the 7 hectare site to impermeable hardstanding or buildings, it is considered that the development will not suffer from flood risk and will likely result in an overall reduced risk to down gradient receptors of flood waters. This is due to the proposed collection and use of a large quantity of surface water run-off, and the controlled discharge of excess run-off from that which is stored. The site is considered to have flooded historically, however the overall risk of flooding at the site is believed to be less than 0.1 %.

Should a flood event occur, the site may be impacted from local water sources, although the largest single contributor to potential flood waters at the site is considered to come from precipitation rather than ground or surface water sources.

Although there is little likelihood of the site flooding, simple, common sense actions by staff in the event of a flood would assist in limiting the impact of the site operations.

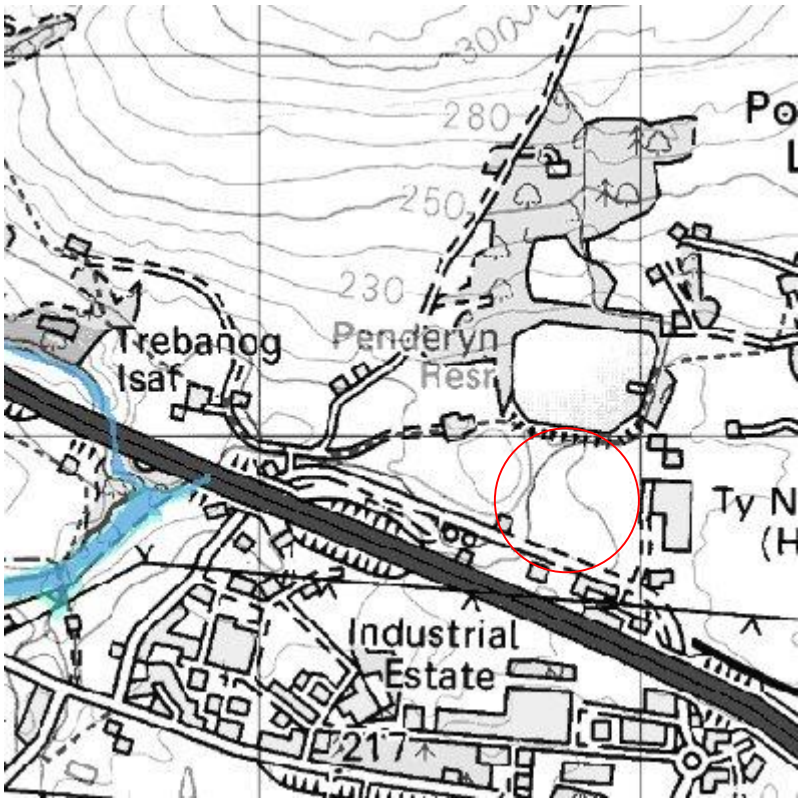
9. References

1. Rhondda Cynon Taff (Rhondda) Local Plan 1991 – 2006 (adopted 1998)

2. Brecon Beacons National Park Authority. Authority Approved Unitary Development Plan; March 2007

3. Planning Policy Wales Technical Advice Note 15: Development and Flood Risk. July 2004. Welsh Assembly Government. ISBN 0 7574 3501 1.

FIGURE 1 FLOOD RISK MAP

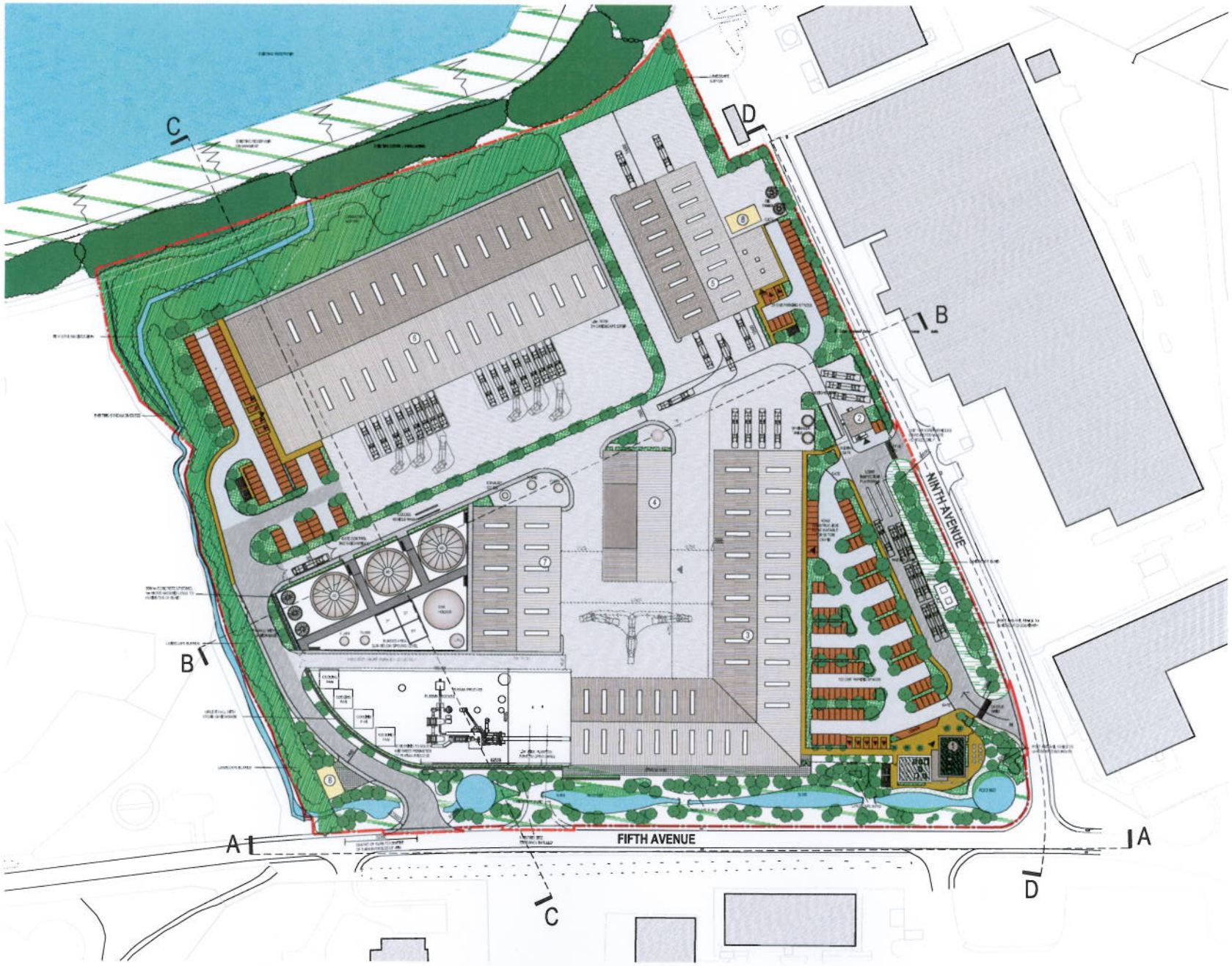


What's on the map?

- Flooding from rivers or sea without defences
- Extent of extreme flood
- Flood defences
- Areas benefiting from flood defences

Site location highlighted by red circle.

FIGURE 2 PROPOSED SITE LAYOUT PLAN


C
D
B
NINTH AVENUE
B
A
FIFTH AVENUE
A
C
D

APPENDIX 1 PHOTOGRAPHS

The Site Viewed From Fifth Avenue

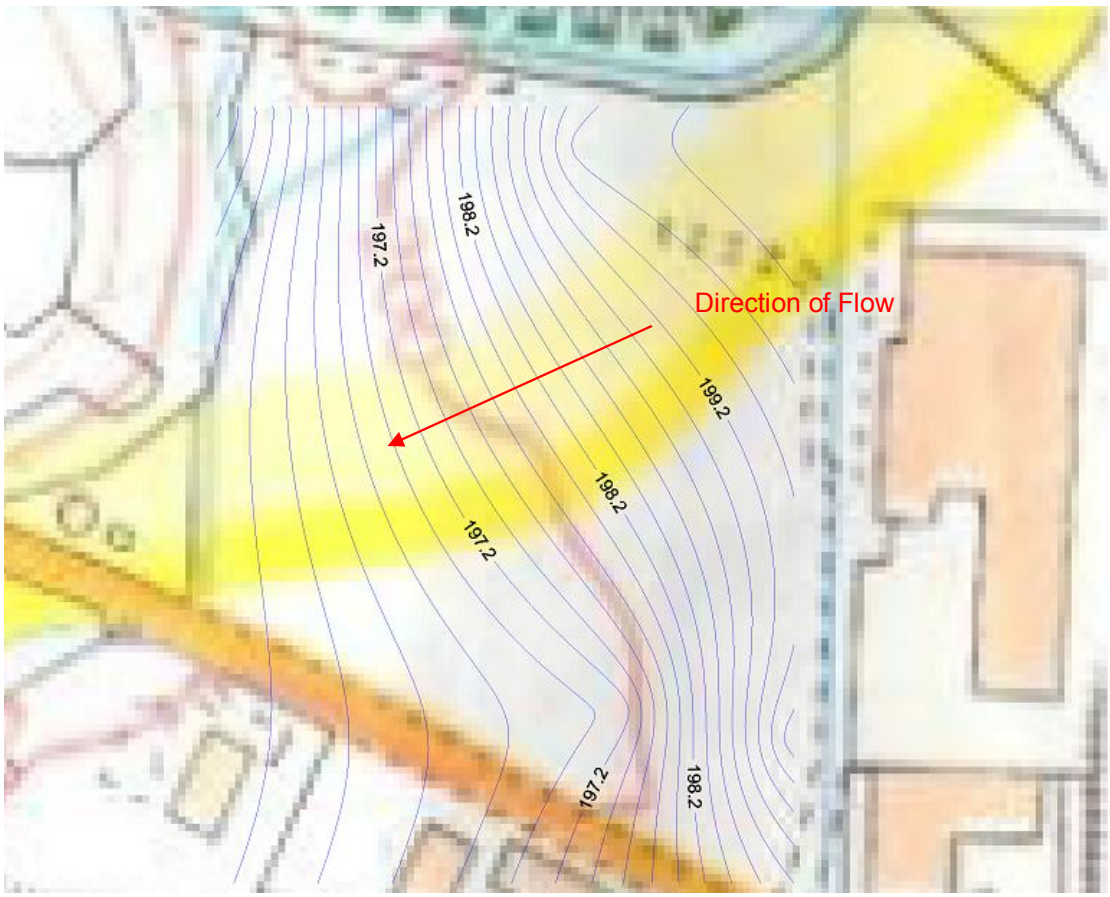
Water Logged Area to the South of the Site

Drainage Channel Running Close to the Southern Boundary to the Stream

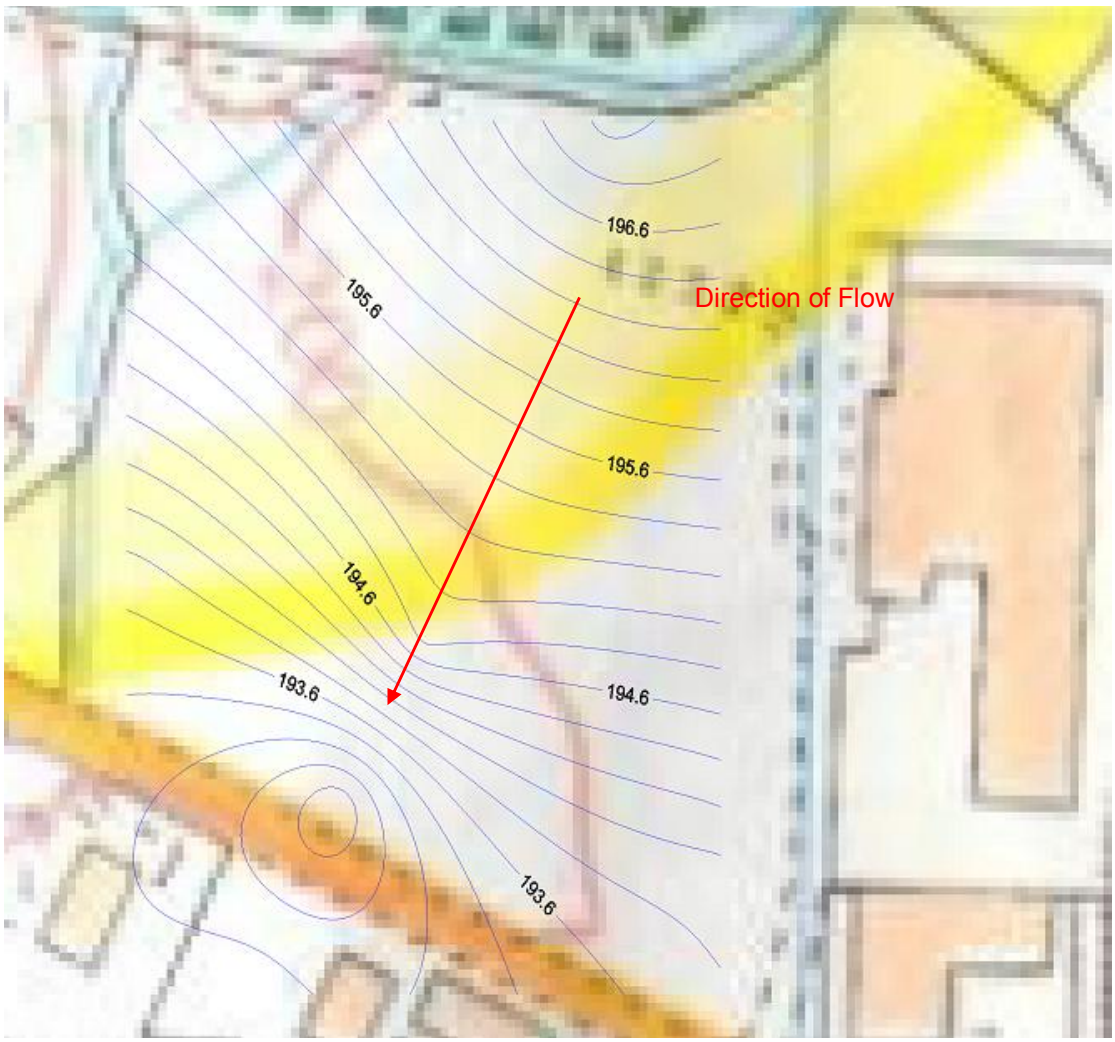
Further Evidence of Water Logging

APPENDIX 2 GROUNDWATER CONTOUR PLOTS

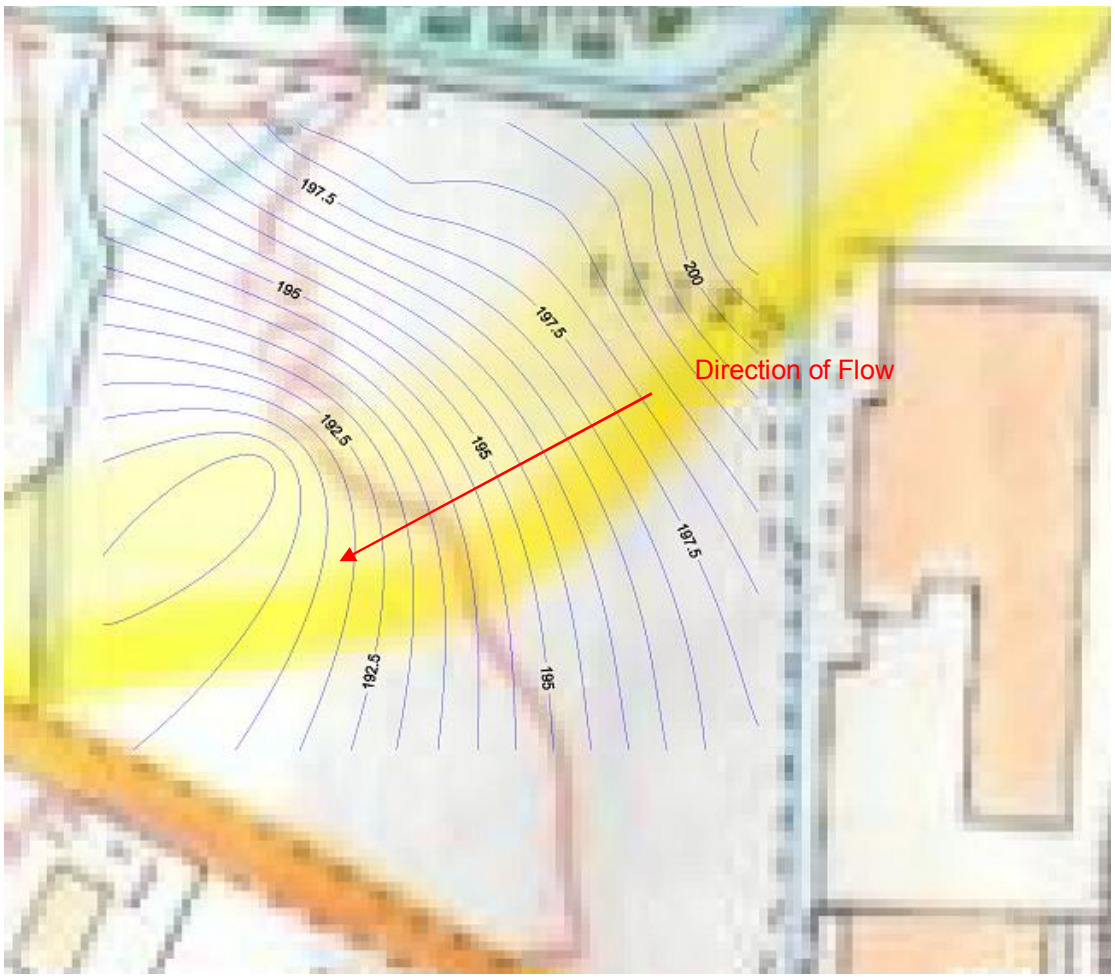
Groundwater Contour Plot from Levels Recorded in 1971



Groundwater Contour Plot from Levels Recorded in 1995



Groundwater Contour Plot from Levels Recorded in 2008



APPENDIX 3 SITE FLOOD FROM PRECIPITATION CALCULATIONS

Precipitation Data from the Met Office (FEH)
Data includes a 5 % increase for Climate Change.

	6 months	1 year	5 years	10 years	50 years	100 years	
15 Minutes	5.2	6.5	10.7	13.8	23.8	30	
Max Vol	**293.70**	**367.13**	**604.35**	**779.45**	**1344.26**	**1694.45**	m3
60 Minutes	11.3	13.8	21.4	26.7	43.3	53.1	
Max Vol	**638.24**	**779.45**	**1208.71**	**1508.06**	**2445.65**	**2999.17**	m3
2 Hours	16.6	20.1	30.3	37.2	58.4	70.7	
Max Vol	**937.59**	**1135.28**	**1711.39**	**2101.12**	**3298.53**	**3993.25**	m3
6 Hours	30.7	36.3	52.3	62.7	93.7	111	
Max Vol	**1733.99**	**2050.28**	**2953.99**	**3541.40**	**5292.33**	**6269.46**	m3
12 Hours	45.2	52.8	73.8	87.3	126.3	147.6	
Max Vol	**2552.97**	**2982.23**	**4168.34**	**4930.84**	**7133.63**	**8336.68**	m3
18 Hours	55	63.7	73.8	87.5	145.7	168.9	
Max Vol	**3106.49**	**3597.88**	**4168.34**	**4942.14**	**8229.37**	**9539.74**	m3
24 Hours	63.1	72.7	98.7	115.1	161.2	185.8	
Max Vol	**3563.99**	**4106.21**	**5574.73**	**6501.03**	**9104.83**	**10494.28**	m3

Precipitation Data from the Met Office (FEH)
Data includes a 5 % increase for Climate Change.

	6 months	1 year	5 years	10 years	50 years	100 years	
15 Minutes	5.2	6.5	10.7	13.8	23.8	30	
Max Vol	**173.5625**	**216.9531**	**357.1382**	**460.6081**	**794.3821**	**1001.322**	m3
60 Minutes	11.3	13.8	21.4	26.7	43.3	53.1	
Max Vol	**377.1646**	**460.6081**	**714.2764**	**891.1766**	**1445.241**	**1772.34**	m3
2 Hours	16.6	20.1	30.3	37.2	58.4	70.7	
Max Vol	**554.0648**	**670.8857**	**1011.335**	**1241.639**	**1949.24**	**2359.782**	m3
6 Hours	30.7	36.3	52.3	62.7	93.7	111	
Max Vol	**1024.686**	**1211.6**	**1745.638**	**2092.763**	**3127.462**	**3704.891**	m3
12 Hours	45.2	52.8	73.8	87.3	126.3	147.6	
Max Vol	**1508.658**	**1762.327**	**2463.252**	**2913.847**	**4215.566**	**4926.504**	m3
18 Hours	55	63.7	73.8	87.5	145.7	168.9	
Max Vol	**1835.757**	**2126.14**	**2463.252**	**2920.523**	**4863.087**	**5637.443**	m3
24 Hours	63.1	72.7	98.7	115.1	161.2	185.8	
Max Vol	**2106.114**	**2426.537**	**3294.349**	**3841.739**	**5380.437**	**6201.521**	m3

Red text highlights volume which is below the capacity of the storage pond.

The first table calculates run-off from all impermeable areas, including site roofs. The available capacity in the pond is considered to be 100 % (3,110 m^3).

The second table calculates run-off from all roadways and pathways, but assumes the roof run-off is directed to site storage tanks. The available capacity in the pond is considered to be 50 % (1,555 m^3).