Eco2 Ltd

Brigg Renewable Energy Plant

Flood Risk Assessment

March 2009

FINAL REPORT

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REVISION HISTORY

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CONTRACT

This report describes work commissioned by Eco2 Ltd under email instruction dated 1 September 2008. Eco2 Ltd representative for the contract was Gary Bird. Chris Wright of JBA Consulting carried out the work.

This version (Final v2.0) has been produced with changes to the proposed layout to accommodate issues raised by the Environment Agency.

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PURPOSE

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EXECUTIVE SUMMARY

Background

Eco2 Ltd is proposing to construct a renewable energy plant on part of the site of the former sugar factory at Brigg.

The development site lies partly within Flood Zone 3a as defined in PPS 25 and therefore a flood risk assessment is required as support to the planning application.

The site lies within the area of the Ancholme Internal Drainage Board and close to the River Ancholme.

The report describes the requirement for a flood risk assessment as detailed in PPS 25.

Description of the Area and Site

Drainage of the area and the site is described.

The area drains to Scawby Beck which is maintained by the Ancholme IDB. Scawby Beck discharges to the River Ancholme by gravity.

The site currently drains surface water to the River Humber via on site pumps and a pipeline which follows the west bank of the River Ancholme to Ferriby.

Consultations

The results of consultations are described as follows:-

- Environment Agency – flood risk from the Ancholme and loss of floodplain volume
- Ancholme IDB – flood risk from Scawby Beck, loss of floodplain volume and impact of discharge of surface water to Scawby Beck
- Centrica Energy – history of flooding in June 2007
- Previous studies – flood risk assessment by Stirling Maynard and a contamination study by Eco2

Flood Risk

The risk of flooding is considered from the following sources:-

- River Ancholme – predicted 1 in 100 year plus an allowance for climate change flood level is 2.68m AOD
- Scawby Beck - predicted 1 in 100 year plus an allowance for climate change flood level is 3.58m AOD
- Groundwater – site investigation boreholes in the contamination report indicate groundwater was struck at between -0.7 and +0.5m AOD and rose to between 0.5 and 1.4m AOD
- On site drainage systems – an outline design of storm water storage is described resulting in a storage pond of approximate area at ground level of 2800m^2.

Impact of the Development on Flood Risk

The design of floodplain compensation is described. The areas to be excavated are shown where ground levels are to be lowered on land currently outside the floodplain, in order to bring it into the floodplain as compensation for volume lost to proposed buildings and roads.

The route of flood water from and back to Scawby Beck will be impeded by the development and a diversionary route is shown with culverts under proposed roads linking areas of floodplain compensation.

Conclusions

- Proposed mitigation works:-
- New building floor levels are to be set at 4.0m AOD, to be above the 1 in 100 year plus climate change flood levels from:-

  The River Ancholme (2.68m AOD)

  Scawby Beck (3.58m AOD)

- Surface water discharge is to be to Scawby Beck at 7.3l/s maximum flow rate
- Open pond storage of surface water run off with an approximate area at bank top level of 2840m^3
- Storage volume in 1 in 100 year rainfall event plus climate change = 1390m^3
- Storage pond base level 1.2m AOD, top 1 in 100 year water level 2.1m AOD
- Discharge to Scawby Beck to be by pump. A water level detector in Scawby Beck at the outfall to the River Ancholme will be connected to the pump control to switch off the pump when the water level at the detector is at 1.5m AOD or higher.
- Floodplain compensation excavations will compensate for floodplain volume lost due to the development resulting in an increase in floodplain volume available. Compensation is calculated in 0.2m thick bands. The compensation excavation also provides a flood route through the site at the same level as the existing flood route.

Recommendations

It is recommended that:-

- Development site including access roads and working areas to be set at 4.0m AOD
- Straw barns to have floor levels at 4.0m AOD but land level beneath the barns and land between to be lowered to 3.2m.
- Land to west and north of the straw barns excluding the surface water storage pond to be lowered to 2.2m AOD
- Details of the design and operation of the surface water discharge pump is submitted to the Ancholme IDB for approval, including the arrangement for switching the pump off during times of high water levels in the River Ancholme as described in the report
- Agreement in principle is sought from the Environment Agency for the surface water discharge cut off arrangement described in the report.

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APPENDICES:

LIST OF TABLES

ABBREVIATIONS

IDB	Internal Drainage Board
PPS 25	Planning and Policy Statement 25 Development and Flood Risk
AOD	Above Ordnance Datum

1 BACKGROUND

1.1 Development Proposals

Eco2 Ltd is proposing to construct a straw burning power station at Brigg on part of the site of the former sugar factory to the south of Brigg, North Lincolnshire. The development will include straw storage barns and access roads.

The site location is shown on Appendix A. and a draft development layout is shown on Appendix B.

The site lies within the Ancholme Internal Drainage Board (IDB) area and in the geological flood plain of the River Ancholme, the river being approximately 420m from the eastern boundary of the site.

1.2 Requirement for a Flood Risk Assessment

Guidance on the assessment of flood risk is provided in the Planning & Policy Statement 25 Development & Flood Risk (PPS25) published by the Department for Communities and Local Government in October 2006.

A Practice Guide Companion to PPS25 was published in June 2008 by the Department for Communities and Local Government (PPS25 Practice Guide).

All development sites should have flood risk assessed to Level 1 as defined in the PPS25 Practice Guide. This is to identify if there are any flooding or surface water management issues related to the development. If there are such issues, then a Level 2 Scoping Study and/or a Level 3 Detailed Study will be required.

In this case, a Level 3 study has been carried out as it was clear from the initial responses from Ancholme IDB and the Environment Agency that there is a potential risk of flooding from adjacent watercourses and the River Ancholme and that the development will impact on the floodplains of local watercourses and the River Ancholme.

PPS25 defines flood zones as follows:-

- Zone 1 – Low Probability – less than 1 in 1000 annual probability (< 0.1%) of river or sea flooding in any year
- Zone 2 – Medium Probability – between a 1 in 100 and 1 in 1000 annual probability (1% - 0.1%) of river flooding or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5%-0.1%) in any year
- Zone 3a – High Probability – 1 in 100 or greater annual probability (> 1%) of river flooding or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year
- Zone 3b – Functional Floodplain – 1 in 20 or greater annual probability (5%) of river flooding in any year. This is land on which water has to flow or be stored in times of flood.

A Flood Risk Assessment is required for sites in excess of 1ha within Zone 1 and all sites within Zones 2 and 3.

The majority of the site lies in Flood Zone 3a with small areas in Flood Zones 2 and 1, as shown on the flood map supplied by the Environment Agency and shown at Appendix D.

This report makes recommendations for the mitigation of flood risk to and as a result of the development as well as proposals for disposal of surface water.

PPS25 recommends that a risk based sequential test should be applied at all stages of planning particularly where the proposed development lies within Flood Zone 3a. Electricity generating power stations are designated as ‘Essential Infrastructure’ and PPS 25 recommends that an exception test should be carried out for proposed essential infrastructure in Flood Zone 3a.

1.3 Consultations

Consultations have been carried out with the following

- Environment Agency
- Ancholme IDB
- Centrica Power Station Staff
- Previous studies

1.4 Brief

Eco2 Ltd. has engaged JBA Consulting to carry out the flood risk and drainage impact assessment to support the promotion of development of the site.

2 GENERAL DESCRIPTION OF THE AREA

2.1 General

The site lies on the western side of the Ancholme valley and on the south western edge of the developed area of Brigg.

To the north and south outside the urban area, land is generally under agricultural use. A gas fired power station operated by Centrica Energy lies immediately to the south of the development site.

To the west, ground rises out of the valley to the watershed where the ground level is approximately 60m AOD. In the area of the site, natural ground levels are between 2 and 6m AOD.

The sugar factory closed in 1991 with demolition of the majority of the buildings taking place in 1995.

2.2 Drainage of the Area

Natural surface water drainage of the area is via Scawby Beck which rises in Scawby village approximately 4km to the west. Scawby Beck discharges to the River Ancholme by gravity. Discharge is restricted when water levels in the River Ancholme are high.

The former sugar factory site drained surface water via pumping stations to the River Humber approximately 15km to the north. This system remains in use for the surviving buildings and paved areas on the sugar factory site.

2.3 Soil Map of Great Britain

The Soil Map of Great Britain shows the site to be underlain by soil type 813f, designated the Wallasea 1 Series. This series is described as marine alluvium, non-calcareous and calcareous clayey soils with groundwater controlled by ditches and pumps. This description would suggest that infiltration drainage will not be a feasible method of surface water disposal.

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3 DESCRIPTION OF THE SITE

3.1 General

The site is bordered to the north by Scawby Beck, to the west by agricultural land, to the south by the gas fired power station and to the east by the remainder of the former sugar factory site.

The site forms the western part of the former sugar factory, mainly taken up by warehouse buildings, offices and paved yards. The existing buildings can be seen on the plan at Appendix C

The total site area is 5.20ha of which approximately 95% was covered by buildings and paved areas.

Ground levels on the site vary between 2.0m and 6.0m AOD. The majority of the open area lies between 3.0 and 4.0m AOD. There is a small raised area in the north east corner rising to 6.0m AOD and a larger raised area in the south west part of the site also rising to 6.0m AOD.

The gas fired power station immediately south of the development has ground levels generally lower than the development site. Site levels obtained from Centrica Energy are generally between 2.5 and 3.0m AOD.

3.2 Drainage of the Site

Surface water drainage of the site pre-development is into the former sugar factory system from which it is pumped to the River Humber. The owner of the remainder of the sugar factory site intends to abandon this pumped system as the site is developed with surface water being discharged to Scawby Beck.

The Environment Agency will only allow discharge of surface water to the River Ancholme if compensatory storage is provided by the developer on the river upstream of the development site. This is not feasible due in part to land ownership issues.

Discharge to Scawby Beck will require the consent of the Ancholme IDB under the Land Drainage Act 1991. This has been proposed before with reference to the development of the whole sugar factory site. The Board's requirements were that discharge would be restricted to 1.4l/s/ha of development site area and that discharge would be permitted only when the water level in the River Ancholme and therefore Scawby Beck was at or below a level to be agreed. This was to ensure that in times of high water level in the River Ancholme, the pumped discharge from the re-developed sugar factory site would not result in increased water levels in Scawby Beck. It will therefore be necessary to provide on site storage and flow restriction with a facility to stop discharge to Scawby Beck. This is described in more detail below.

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4 CONSULTATIONS

4.1 Environment Agency

A meeting was held with the Environment Agency Development Control Officers on 16 October 2008.

The requirements for this assessment were discussed including the following:-

- Use of the new River Ancholme model results
- Flood levels for the River Ancholme and Scawby Beck to be assessed for the 1 in 100 year flood events, including an allowance for future climate change
- Impact of the development on adjacent power station site is to be considered and mitigation included in the development proposals
- The risk of flooding from the River Ancholme, Scawby Beck and groundwater are to be considered
- Flood plain compensation needs to be provided at the same level as the flood storage which has been lost

Predicted flood levels in the River Ancholme have been obtained from the Environment Agency. The results are shown at Appendix D.

Further consultation resulted from submission of a draft report to the Environment Agency. Issues raised have been addressed in this revised version of the report.

4.2 Ancholme Internal Drainage Board

A report to the Board dated August 2005 described the potential impact of the re-development of the whole sugar factory site on Scawby Beck. Hydrological modelling produced predicted 1 in 100 year flood levels and outline surface water storage volumes.

The principles for accommodating the development were as follows:-

- Surface water discharge to Scawby Beck would be permitted but the discharge rate would not exceed 1.4l/s/ha of the development site and would not be permitted when the water level in Scawby Beck measured at the outfall to the River Ancholme was above 1.5m AOD. This level would be detected and transmitted to the discharge control structure where a penstock actuator would be operated. This operation would be monitored by the Board's telemetry system and the Board's operator would have the facility of closing the discharge if the automatic system failed. If levels were such that surface water was to be pumped into Scawby Beck, the same arrangement would apply with the flow control being provided by the pump capacity.
- Any floodplain volume lost to the development relevant to Scawby Beck would require the provision of compensatory floodplain volume.

The Board maintains Scawby Beck. This consists of annual bank mowing and mechanical aquatic vegetation clearance. The Board has powers of access to carry out this work. In addition, any works affecting a watercourse or within 9m of the bank top of the watercourse requires the prior consent of the Board. In this case, once the Board has approved the method and details of the discharge of surface water, the Board's consent for the discharge would be applied for.

The Board meeting held on 14 January 2009 agreed to the following which is taken from the Board's minutes:-

> ***British Sugar Site, Brigg -*** The flood risk assessment had been completed. The Clerk and Engineer had described the Board's requirement that surface water discharge would be allowed into Scawby Beck on condition that the discharge rate is limited to 1.4l/s/ha and that the discharge would be shut off when the Scawby Beck upstream of the outfall into the River Ancholme reached

a level to be confirmed but likely to be 1.5m AOD and that no discharge would be permitted until the Scawby Beck level returned to below 1.5m AOD.

4.3 Centrica Energy

Discussions with the Engineer at the power station confirmed that existing ground levels at the power station on the northern boundary are between 2.5 and 3.0m AOD. Flooding of the site was experienced in June 2007 with water flowing from Scawby Beck on the northern boundary and from the River Ancholme on the eastern boundary.

4.4 Previous Studies

Stirling Maynard and Partners produced a flood risk assessment for development of the whole sugar factory site in February 2006. Ground level survey information and site investigation results have been taken from that report.

A contamination study has been carried out by Eco2 and reference has been made to the results in assessing flood risk from groundwater. The borehole location plan from the report is included at Appendix G with a summary of ground water levels.

5 FLOOD RISK

5.1 Flood Risk Mechanisms

The following flood risk mechanisms have been considered:-

- Overtopping and breach from River Ancholme
- Overtopping from Scawby Beck
- Groundwater
- On site drainage systems

The level of protection expected by the Environment Agency for new development is as follows:-

- Against flooding from tidal rivers – 0.5% annual probability
- Against flooding from non tidal rivers and watercourses – 1% annual probability with a check on the effect of climate change, usually taken as an increase in peak flow of 20%.

5.2 River Ancholme

The River Ancholme is 420m from the eastern boundary of the development site.

The predicted 1 in 100 year flood level taken from the most recent completed study by the Environment Agency which includes a 20% increase in flow rate to allow for the effects of future climate change is 2.68m AOD (see Appendix D).

The flood bank on the west side of the river has a top level of approximately 3.0m AOD which is above the 1 in 100 year flood level including the allowance for climate change and therefore, the risk of the bank being overtopped is very low.

We understand that the existing flood banks are not all maintained by the Environment Agency and therefore the risk of a breach occurring needs to be considered.

The Environment Agency flood zone map is attached at Appendix D. It indicates the area which would be affected by flooding if the flood bank failed.

From the flood zone map and the predicted flood level, it can be seen that part of the development site will be flooded if a breach occurred during the 1 in 100 year flood event on the River Ancholme. Cross sections have been drawn using existing ground levels to show the potential flood route from the River Ancholme. These sections are shown on Appendix E and their locations are shown on Appendix C.

The main part of the development will be raised with a floor level of 4.0m AOD which will prevent flood water entering the buildings. The straw barns will have a floor level of 4.0m AOD. However, they will be raised above the proposed ground level of 3.2m AOD which will allow floodplain compensation as described below. The majority of the unpaved land will also be lowered to provide sufficient floodplain compensation. The access road will be at 4.0m AOD to provide safe access and egress.

5.3 Scawby Beck

A hydrological model of Scawby Beck created for previous assessments of flood risk for the development of the whole sugar factory site has been modified and re-run.

Alterations have been made to the cross sections within the development site boundary to include actual site levels and existing buildings. The sections have been extended to the southern site boundary. The locations of the sections are shown on Appendix C.

The results of the modelling are provided in Appendix F. The table below provides a summary of the 1 in 100 year flood levels at the cross section locations shown on Appendix C**.** The maximum water level adjacent to the site is 3.58m AOD. The model has used a downstream water level in the River Ancholme equal to the 1 in 100 year plus climate change peak flood level of 2.68m AOD.

Table 5-1: Scawby Beck Predicted 1 in 100 year plus Climate Change Flood Levels

Cross Section	Peak Water Level m AOD
951	3.58
946	3.58
921	3.54
821	3.54
721	3.54
716	3.54
641	3.54

The above flood levels compare with a proposed floor level for the buildings on the development of 4.0m AOD.

The risk of flooding of the proposed buildings from Scawby Beck is therefore low.

5.4 Groundwater

The contamination report includes site investigation borehole results and the location plan and summary of ground water levels are included at Appendix G.

The summary shows that in most cases, groundwater was encountered at between -0.7 and +0.5m AOD and that it rose to between 0.5 to 1.4m AOD. The main exception was BH 11 situated on the higher part of the site in the south west corner where the water level rose to 1.8m AOD compared to a ground level of 5.8m AOD in this area.

The risk of flooding from groundwater is therefore considered to be low.

5.5 On Site Drainage Systems

The pre-development surface water drainage system discharges via pumps to the River Humber. As the current site owners are proposing to abandon this system, it will be necessary to obtain the consent of the Ancholme IDB to discharge surface water to Scawby Beck.

As described above, the Ancholme IDB will require the surface water discharge rate to be restricted to 1.4l/s/ha of the development site. The total site area is 5.2ha so the maximum discharge rate is 1.4 x 5.2 = 7.3l/s. Discharge will only be permitted when the water level in Scawby Beck as detected at the upstream side of the outfall to the River Ancholme is at or below 1.5m AOD. This is to ensure that discharge only takes place when there is capacity available in the River Ancholme. This will need to be confirmed by the Environment Agency.

The principle to be used for management of surface water run off is to provide an open storage pond within the site boundary which is not situated in the existing flood plains of Scawby Beck and the River Ancholme during the 1 in 100 year flood event.

The draft development plan at Appendix B shows the total roof and paved area of 1.91ha. The area of the storage pond is approximately 2,800m^2 and this has been added to the impermeable area to give a total of 2.19ha.

The storage volume required has been calculated using Micro Drainage POND software. The effect of future climate change has been allowed for by increasing the rainfall depth by 20%. The software calculates storage volumes for a range of storm durations up to 1800 minutes from which the critical duration resulting in the maximum storage volume can be assessed. The outputs are summarised below.

Table 5-2: Surface Water Storage Volumes

Return period 1 in X years	Storm duration minutes	Peak water depth m	Peak storage volume m^3
2	600	0.29	402
	720	**0.29**	**402**
	960	0.29	397
	1800	0.28	364
30	600	0.56	802
	720	**0.56**	**803**
	960	0.55	791
	1800	0.52	739
100	600	0.72	1069
	720	**0.72**	**1075**
	960	0.72	1069
	1800	0.68	998

The critical duration is 720 minutes.

The storage capacity to be provided needs to include the volume which would discharge at the restricted rate throughout the storm duration in order to allow for the discharge being prevented due to high water level in Scawby Beck.

The critical storm duration for drainage of the site (the duration producing the maximum volume) is 720 minutes.

The feasibility of gravity discharge of surface water to Scawby Beck was investigated. The normal water level in Scawby Beck is between 2.1m and 2.5m AOD. An outfall invert level of 2.5m AOD would require a pond base level of say 2.8m AOD.

Table 5-3: Storage Pond (Assumed Base Level = 2.8m AOD) – Gravity Discharge

Return Period 1 in X years	POND Storage Volume m^3	Additional Volume if Discharge is Stopped m^3	Total Storage Volume m^3	Maximum Water Level m AOD
2	402	315	717	3.3
30	803	315	1118	3.5
100	1075	315	1390	3.7

The proposed buildings will have floor levels at 4.0m AOD and the safe access route and working areas will be at the same level. As the 1 in 2 year water level in the storage pond would be within 0.7m of the site ground levels, it can be seen that gravity discharge into Scawby Beck will not be feasible without significantly increasing the size of the storage pond. This would result in reduction of the available floodplain volume.

It is therefore proposed that discharge from the storage pond is pumped into Scawby Beck. The restrictions to discharge will be as described above. The pond can be excavated to a lower level to provide freeboard to the existing site levels where they are not to be raised. A base level of 1.2m AOD has been chosen.

Table 5-4: Storage Pond (Assumed Base Level = 1.2m AOD) – Pumped Discharge

Return Period 1 in X years	POND Storage Volume m^3	Additional Volume if Discharge is Stopped m^3	Total Storage Volume m^3	Maximum Water Level m AOD
2	402	315	717	1.7
30	803	315	1118	1.9
100	1075	315	1390	2.1

The top water level in the 1 in 100 year event would be 2.1m AOD and the base level would be 1.2m AOD. From site investigation provided with the contamination report, it appears the base of the pond would be in a layer of stiff clay which it is anticipated will retain water. It will be necessary for in situ tests to be carried out. If the clay is permeable, a waterproof membrane will be required.

From the same report, ground water is retained in the sand and gravel below the clay at a level of between 0.0 and 0.3m AOD, i.e. at least 0.9m below the pond base.

The high level detector in Scawby Beck will stop the operation of the pumps rather than closing a penstock.

The Environment Agency has indicated that the critical duration for the peak flood level in the River Ancholme is 48 hours. Although the POND software maximum duration is 1800 minutes (30 hours) it can be seen from Table 5.2 that the POND storage volume will be no greater than $1000m^3$. The additional volume if discharge is stopped will be 48 x 60 x 60 x 7.3/1000 = $1261m^3$. The total volume will be 1000 + 1261 = $2261m^3$. This volume would produce a depth in the proposed pond of 1.32m and a water level of 2.52m AOD which is significantly below the development level of 4.0m AOD.

5.6 June 2007 Flood Event

Flooding of the development site occurred in June 2007. The cause was overtopping of the right bank of Scawby Beck. A maximum water level was recorded on the wall of the existing warehouse building and this has been surveyed. The level to Ordnance Datum is 2.987m AOD.

This level confirms the report of flooding extending across the sugar factory site to the power station.

At this flood level, up to 3.0m AOD, table 6.3 below shows that there will be a significant increase in floodplain volume provided by the development resulting in a decrease in flood levels due to such an event.

5.7 Sequential and Exception Tests

The proposed development is described in PPS 25 as essential infrastructure and PPS 25 recommends that for such a development to be carried out in Flood Zone 3a, an exception test is required.

The development is on previously developed land and this flood risk assessment shows that the development will be safe from flooding and will not increase the flood risk elsewhere.

The third requirement for passing the exception test is that the development should provide wider sustainability benefits to the community. This question is to be addressed elsewhere in the planning application.

6 IMPACT OF DEVELOPMENT ON FLOOD RISK

6.1 Floodplain Compensation

A significant part of the development site lies within the 1 in 100 year plus climate change floodplain. The relevant flood level for Scawby Beck is 3.58m AOD and that for the River Ancholme is 2.68m AOD.

It is therefore proposed to provide floodplain compensation for the floodplain lost due to the development up to 3.6m AOD.

At Appendix H is drawing 2008s3591-005. This is based on the proposed site layout drawing at Appendix B. It shows:-

- existing ground level contours and the outline of the existing buildings. Existing ground levels are between 2.2 and 6.0m AOD. Contours are shown of existing ground levels between 2.2 and 3.6m AOD in 0.2m intervals.
- proposed ground level contours and the outline of the development features which will be above 3.6m AOD. This includes the surface water storage pond. Contours are shown at proposed ground levels between 2.2 and 3.6m AOD. Some of the contours are not shown for clarity as they would be close together on the proposed slopes.

The existing building footprint is excluded from the existing floodplain. However, it is proposed that ground levels in the existing building footprint will be lowered as part of the floodplain compensation.

6.1.1 Floodplain Volume to be Lost

The area between contours is measured by planimeter and summed to give the area enclosed by each contour. The volume between each contour is the average area of the two contours multiplied by the depth (0.2m). This gives the volumes to be compensated for.

It is taken that where there are existing buildings in the floodplain; the footprints of the buildings are excluded from the floodplain.

Table 6-1: Floodplain Volumes Lost

Contour m AOD	Area between contours m^2	Area of Contour m^2	Volume between Contours m^3
2.2	433	433	
2.2-2.4	2930	3363	380
2.4-2.6	152+98+393=643	4006	737
2.6-2.8	545+30=575	4581	859
2.8-3.0	732+843+230=1805	6386	1097
3.0-3.2	7985+195=8180	14566	2095
3.2-3.4	180+3180=3360	17926	3249
3.4-3.6	478+575=1053	18979	3691

6.1.2 Floodplain Volume to be Provided

In effect, the area of each contour of the proposed ground profile is measured in those areas where the ground level is to be lowered. This includes the area of the existing building. It is currently excluded from the floodplain but the land in its footprint will be lowered to either 3.2 or 2.2m AOD.

Where contours would be close together, the areas of selected contours are measured and the areas for contours between are interpolated. This is only done where contours arte close together.

Table 6-2: Floodplain Volumes to be Provided

Contour m AOD	Area of Contour m²	Area of existing buildings where GL is to be reduced to 2.2m AOD m²	Area between contours where existing GL is 3.6m AOD or less which is to be reduced to 2.2m AOD m²	Area of contours where existing GL is 3.6m AOD or less which is to be reduced to 2.2m AOD m²	Total area of each contour m²	Volume between each contour m³
2.2	7040	2260			9300	
2.4	7464	2260			9724	1902
2.6	7888	2260			10148	1987
2.8	8312	2260			10572	2072
3.0	8736	2260			10996	2157
3.2	9160 + 7270*	2260	217	217	11637 + 18907	2263
3.4	16292	2260	263	480	19032	3794
3.6	15083	2260	385	865	18208	3724

Notes:- * area to be level at 3.2m AOD

The area of excavated land which is to be finished at 3.2m AOD in the area of the straw barns is separated in the table so that a more accurate calculation can be done to provide the volumes between contours.

Table 6-3: Comparison Between Floodplain Volumes lost and Provided in Compensation

Contour m AOD	Volume lost m³	Volume Provided m³	Increase m³
2.2-2.4	380	1902	1522
2.4-2.6	737	1987	1250
2.6-2.8	859	2072	1213
2.8-3.0	1097	2157	1060
3.0-3.2	2095	2263	168
3.2-3.4	3249	3794	545
3.4-3.6	3691	3724	33
Total	**12108**	**17899**	**5791**

The tables show that there will be a significant increase in flood plain storage volume due to the development. This will reduce flood levels on adjacent land including the existing power station. The calculations show that there is an increase in floodplain volumes at all levels.

The existing flood water route to and from Scawby Beck across the site will be obstructed by the raising on the development to 4.0m AOD. Therefore a series of culverts will link areas to be lowered to 2.2m AOD around the raised area to restore the flood route. These culverts will have invert levels of 2.2m AOD.

Provision of the floodplain compensation volumes as described above will result in there being no increase in flood levels within the development site and in adjacent land. Provision of the flood route including culverts will ensure that flood water is not trapped on adjacent land and will flow back to Scawby Beck.

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7 CONCLUSIONS & RECOMMENDATIONS

7.1 Conclusions

Proposed mitigation works:-

- New building floor levels are to be set at 4.0m AOD, to be above the 1 in 100 year plus climate change flood levels from:-

  The River Ancholme (2.68m AOD)

  Scawby Beck (3.58m AOD)
- Surface water discharge is to be to Scawby Beck at 7.3l/s maximum flow rate
- Open pond storage of surface water run off with an approximate area at bank top level of 2840m3
- Storage volume in 1 in 100 year rainfall event plus climate change = 1390m^3
- Storage pond base level 1.2m AOD, top 1 in 100 year water level 2.1m AOD
- Discharge to Scawby Beck to be by pump. A water level detector in Scawby Beck at the outfall to the River Ancholme will be connected to the pump control to switch off the pump when the water level at the detector is at 1.5m AOD or higher.
- Floodplain compensation excavations will compensate for floodplain volume lost due to the development resulting in an increase in floodplain volume available. Compensation is calculated in 0.2m thick bands. The compensation excavation also provides a flood route through the site at the same level as the existing flood route.

7.2 Recommendations

It is recommended that:-

- Development site including access roads and working areas to be set at 4.0m AOD
- Straw barns to have floor levels at 4.0m AOD but land level beneath the barns and land between to be lowered to 3.2m.
- Land to west of the straw barns excluding the surface water storage pond to be lowered to 2.2m AOD
- Details of the design and operation of the surface water discharge pump is submitted to the Ancholme IDB for approval, including the arrangement for switching the pump off during times of high water levels in the River Ancholme as described in the report
- Agreement in principle is sought from the Environment Agency for the surface water discharge cut off arrangement described in the report.

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APPENDICES

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Appendix A: - Location Map

Drawing 2008s3591-03A

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Appendix B: - Draft Development Layout Plan

RPS Drawing 15674/A1/0101F – Site Layout

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Appendix C: - Existing Site Survey

JBA Drawing 2008s3591-002

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Appendix D: - Information from Environment Agency

Letter from EA dated 28 November 2008
Flood Zone Map
Predicted Flood Levels River Ancholme

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Appendix E: - Floodplain Sections

JBA Drawing 2008s3591-001

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Appendix F: - Scawby Beck HEC-RAS Modelling

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Appendix G: - Site Investigation Borehole Locations & Ground Water Levels

Geotechnics plan Geo-PC073193-001(1)
Spreadsheet showing ground water levels

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Appendix H: - Draft Development Plan Showing Floodplain Compensation Areas

Drawing 2008s3591-005

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