FLOOD RISK ASSESSMENT

Cleator Mill,
Proposed Commercial Development,
Flood Risk Assessment.

Reference	RO/FRA/NEWCOM/13000.1
Date	April 2014
Version	2

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CONFIDENTIALITY STATEMENT

This report is addressed to and may be relied upon by the following:

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DOCUMENT HISTORY

VERSION	PURPOSE/DESCRIPTION	DATE
1	Draft Issue – for client comment	17.02.2014
2	Amended to suit latest data	03.04.2014

1.0 EXECUTIVE SUMMARY

This assessment has looked at the implications of the proposed new commercial development in relation to flood risk including overtopping and breach analysis.

The proposed development site is shown as being in Flood Zone 3a on the Environment Agency flood maps. Having undetraken a comparison between the existing flood defences and modelled flood levels, the site is actually protected to a minimum of the 1:100 + 20% climate change return period. However, as established in the independent condition survey report of the flood defences remedial works are recommended subject to Environment Agency agreement.

Flood defences should be improved to provide a minimum condition grade of 2, subject to Environment Agency agreement.

Based upon the proposed FFL's the new development is not at risk of flooding from a flooding incident for all events up to the 1:1000 year return, utilsing modelled node 1406.

Safe access and egress has been established via the new proposed access road onto the A5086.

The Environment Agency does not provide a Flood Warning Service for Cleator.

A Surface Water Management Plan (SWMP) has been identified including the levels of treatment requirement to ensure the River Ehen water quality remains protected.

Any potential impact of the development can be adequately addressed by good drainage design.

2.0 INTRODUCTION

RWO Associates Ltd (RWO) has been instructed by North Associates on behalf of their client to prepare a Flood Risk Assessment to support a planning application for a proposed new commercial development at Cleator in Cumbria. This report should be read in conjunction with RWO Associates report reference RO/Commercial/13000.1 Drainage Statement.

This site is covered by a Strategic Flood Risk Assessment commissioned by Copeland Borough Council. This, more detailed, site specific Flood Risk Assessment supplements the findings of the Strategic Flood Risk Assessment.

Mott MacDonald have been utilised to undertake Breach Analysis of the existing flood defences located on the North and Eastern boundaries.

The site is Brownfield and client wishes to convert the exitsing Mill into a commercial development; location plans are included in Appendix A.

3.0 THE SITE

The proposed development site is located to the east of Cleator, about 300m to the south of Cleator Moor and immediately to the west of the Lake Distract National Park, Figure 1 below shows the site location.

Figure 1 – Site Location (Red line indicates approxiamte extents)

The River Ehen forms the eastern and southern boundary, with residential dwellings located to the west and north. To the immediate north of the proposed development site is the former Kangol hat factory, with the building being from the 1960's. To the south and south east is the original Mill. The proposed development will consist 10,000 sqft of new commercial development. The A5086 is on the far extents of the western boundary of the proposed development site.

4.0 PROPOSED DEVELOPMENT

It is proposed to consider the site for conversion to commercial use consisting of circa 10,000sqft of commercial space. Based upon the Copeland Strategic Flood Risk Assessment, the development site is located in Flood Zone 3a, an extract of the map can be seen below in Figure 2 (area south east of the identified development area E8) with the full map included in Appendix B.

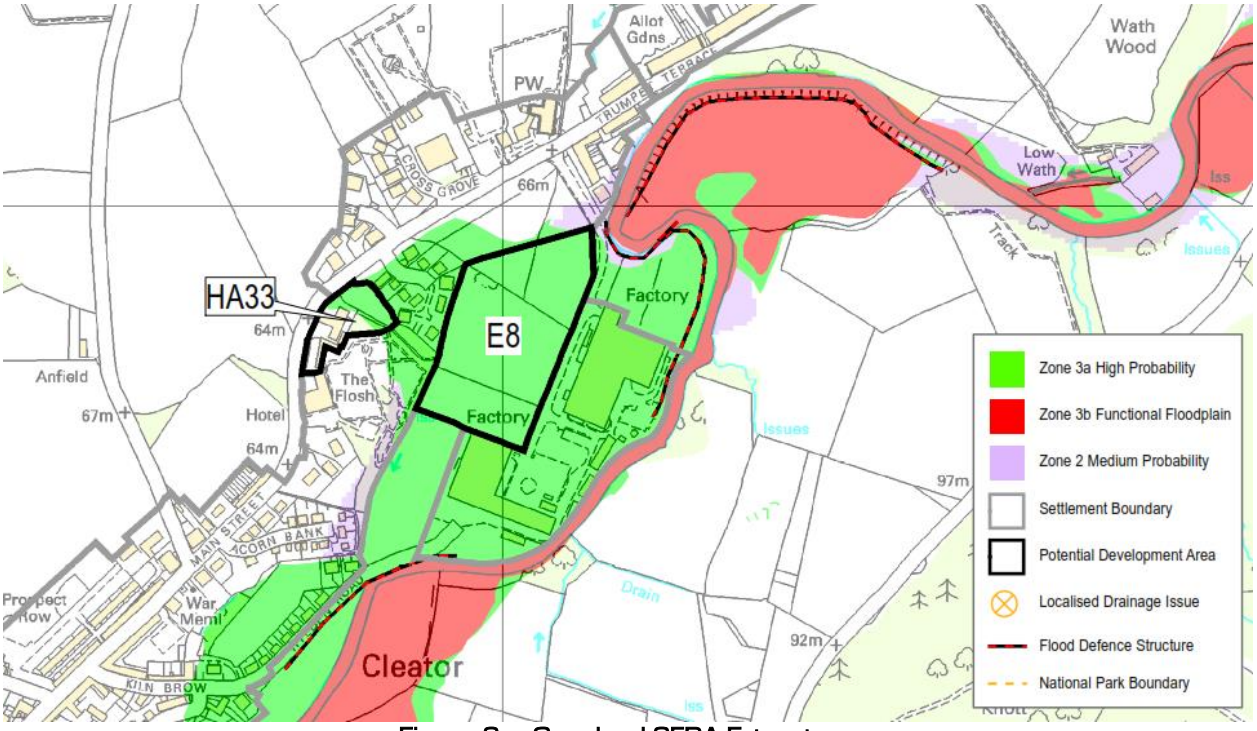


Figure 2 – Copeland SFRA Extract

As the development site is shown as being located in Flood Zone 3a with annual probability of flooding of greater than 1:100 years (>1%).

A proposed site layout is included in Appendix C.

5.0 FLOOD RISK

River Ehen

The site is located adjacent the River Ehen, to the west, within flood zone 3a as identified by the Copeland Strategic Flood Risk Assessment, map included in Appendix B. Predicted flood levels have previously been assessed by RAB Consultants as part of a former planning application. The Environment Agency modelled flood levels are included below in table 1.

Cross Section reference	5 Year	10 Year	25 Year	50 Year	75 Year	100 Year	200 Year
2006	63.96	64.09	64.28	64.38	64.43	64.47	64.54
1896	63.63	63.78	63.98	64.07	64.12	64.15	64.21
1726	62.34	62.44	62.60	62.67	62.71	63.08	63.14
1606	61.01	61.14	61.34	61.43	61.47	61.50	61.57
1502	59.90	60.02	60.26	60.40	60.49	60.54	60.97
1406	59.51	59.63	59.91	60.08	60.19	60.27	60.43
1299	59.04	59.14	59.33	59.45	59.51	59.54	59.62
1206	58.53	58.62	58.78	58.87	58.93	58.97	59.04

Table 1 – Modelled Flood Levels

Figure 3 below shows the positions of the modelled cross sections referenced above;

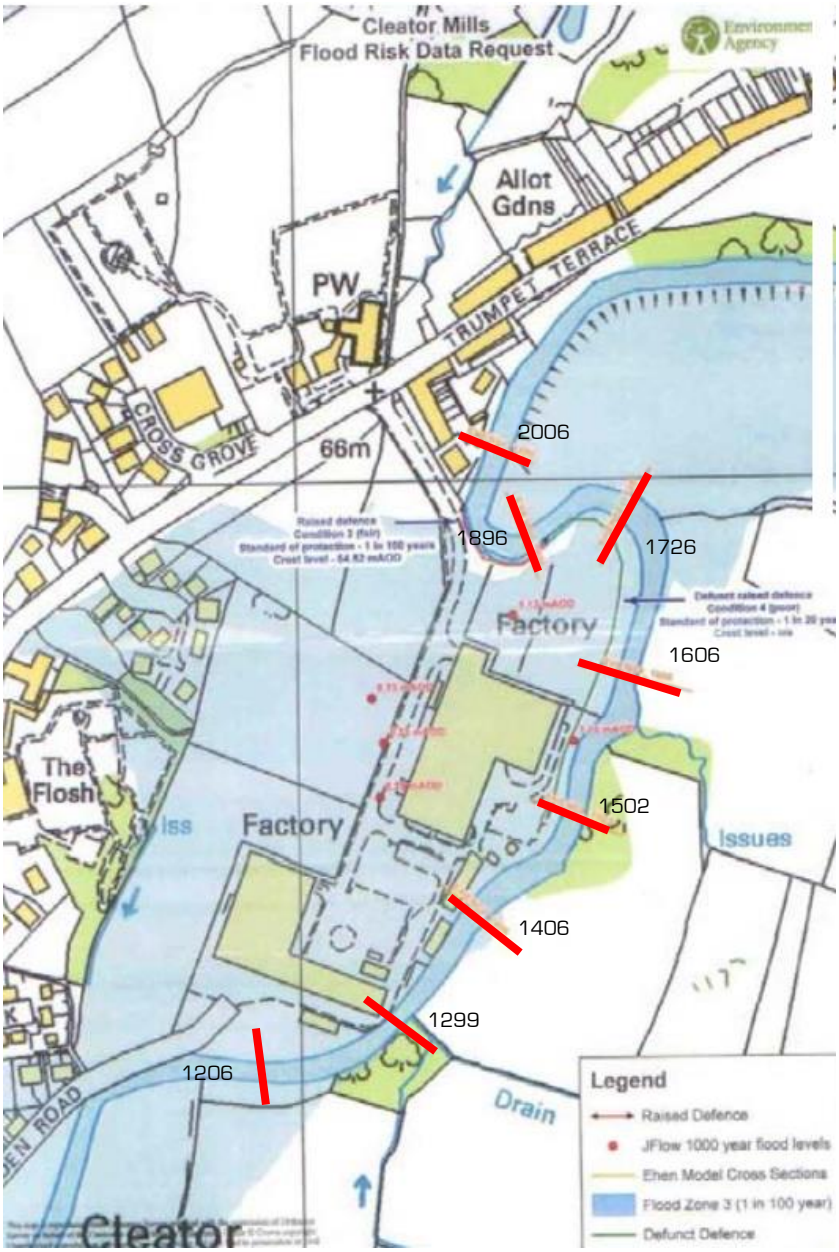


Figure 3 – Modelled Node Locations

A site walkover has been undertaken to review the flood defences and gain an understanding of the locations and risks associated with the defences. Flood protection is provided along the river reaches adjacent to the development site. At the most vulnerable point, on the northern boundary with the River Ehen hard defences are located on the right boundary located between modelled node points 1896 and 1726, as can be seen in Figure 3. The Environment Agency data shows these hard defences are at a 1:100 year standard. Photo 1 below of existing hard defences between 1896 and 1726 modelled nodes;

Photo 1 – Hard flood defences between 1896 & 1726

Downstream of the hard defences, soft earth defences exist continuing north to the extents of the Kangol Factory/premises. The Environment Agency notes these defences as being to the 1:25 year return period standard. The location of the modelled reference points has been cross-references against a topographical survey undertaken by Site Scan on behalf of North Associates; this is included in Appendix D.

An exercise of comparing modelled flood levels in table 1 with the levels from the topographical survey has been undertaken, included in Appendix D. Right bank crest levels have been interpolated, these are included in Table 2 below.

Cross Section Reference	Interpolated Right Bank Crest Level	Modelled 100 Year Flood Level	Modelled 100 Year + 20% Flood Level
2006	n/a	64.47	64.55
1896	64.45	64.15	64.22
1726	63.49	63.08	62.80
1606	62.65	61.50	61.58
1502	61.52	60.54	60.70
1406	60.54	60.27	60.45
1299	60.45	59.54	59.63
1206	59.48	58.97	59.05

Table 2 – Flood levels compared to Bank levels

Table 2 above demonstrates that the site is actually protected against the 1:100 + 20% climate change return period. As such the risk of flooding from the River Ehen is deemed low. Flood defence breach needs to be considered. It is noted that node reference 1406 is the most relevant for the proposed development site.

Climate Change

In making an assessment of the impact of climate change, NPPF Technical Guidance recommends 20% increase on the 1:100 (1%) year return period. As this has been modelled these figures have been utilised to establish the risk of flooding to the site based upon the flood defence levels.

Flood History

The fact flood defences have been formed along the boundary with the River Ehen suggest a historic flooding problem. It is understood the flood defences in their current form were constructed in 1978 by English Industrial Estates.

It is noted that the Copeland SFRA states there was some flooding form the River Ehen that caused damage to the factory in autumn of 2000. A previously prepared FRA noted that the site warden had been interviewed and could not recall any flooding in his 15 years, this was in March 2010. As such if any flooding did occur or to what extents it is unknown. It was noted during our site walkover that outfalls to the River Ehen did not have tidal flaps/non-return valves installed and as such is may have been possible for waters to back up the onsite drainage system

Having reviewed available data and previously prepared reports, it is understood during the extensive flooding in Cumbria during 2008 & 20009 this site was not affected.

Flood Defence Overtopping

There are flood defences affording the site protection from the risk of flooding. Table 2 has reviewed model flood levels. In order to ensure the level of protection afforded the site is maintained the condition of the flood defences must be maintained. The hard flood defences are substantial and appear to be in operational condition which is supported by the Environment Agencies grade 3 'fair', on the Environment Agencies asset condition criteria. The soft defences and the river bank do not appear to be adequately maintained to the required standard to ensure effective operation, the Environment Agency have graded these 4 'poor'.

A previous report assessing the condition of the embankment was commissioned by Hampton Investment Properties Ltd and undertaken by Dr John Chatterton, this is included in Appendix E. RWO Associates Ltd have undertaken a site walkover and note that the defences do not appear to have varied in condition since the survey in 2008.

The summary of the asset survey report are that "...the current condition of the flood defences is at best grade 3 but at worst grade 4. Therefore, priority remedial work is strongly recommended on the three NFCDD defence lengths".

It is recommended that at the locations identified within Dr John Chatterton's survey remedial works be undertaken either by the developer or by agreement with the Environment Agency involving a commuted sum. No development should be undertaken until the flood defences are improved.

The 1000 year modelled flood levels have been utilised to ascertain the level of protection the flood defences afford for the 1:1000 year return period, in table 3 below.

Cross Section Reference	Interpolated Right Bank Crest Level	Modelled 100 Year Flood Level	Modelled 100+20% Year Flood Level	Modelled 1000 Year level
2006	n/a	64.47	64.55	64.70
1896	64.45	64.15	64.22	64.39
1726	63.49	63.08	62.80	62.93
1606	62.65	61.50	61.58	61.73
1502	61.52	60.54	60.70	60.97
1406	60.55	60.27	60.45	60.68
1299	60.45	59.54	59.63	59.87
1206	59.48	58.97	59.05	59.25

Table 3 – 1000 year levels

Analysis of the risk to life from either overtopping or breach can be carried out utilising a 'simple assessment' methodology as outlined in Flood Risk Guidance for new development Technical Report FD2320/TR2.

Cross Section Reference	Distance from Defence	1000 Year Flood Level	Defence Height	Head Above Crest Level	Comment
1896	65	64.42	64.56	n/a	'very low hazard'
1726	100	62.94	63.27	n/a	'very low hazard'
1606	120	61.75	62.70	n/a	'very low hazard'
1406	90	60.71	60.55	0.16	'danger to some'

Table 4 – Risk of flood defence overtopping to people

The findings in Table 2 from overtopping scenario, shows that all but one of the cross sections have been classified as a 'very low hazard'. Cross section 1406 classifies the risk as 'danger to some', this includes children and elderly.

As the site is protected to the 1:100 + 20% year return period this risk could be reduced by raising of ground levels within the residential area to that greater than the estimated 1000 year flood level. No flood storage compensation would be required given the flood level is significantly greater than the 1:100 year return period.

Flood Defence Breaching

A detailed breach analysis has been prepared by Mott MacDonald based upon the historic requests of Gary Clark and utilising the latest data set. The purpose of the breach analysis was to determine flood extents, depths, velocities and hazard ratings for the site for the 1:100 year return period with 20% climate change as required under NPPF Technical Guidance. Figure 4 below shows the two breach locations which have been utilised and previously agreed with Gary Clark.

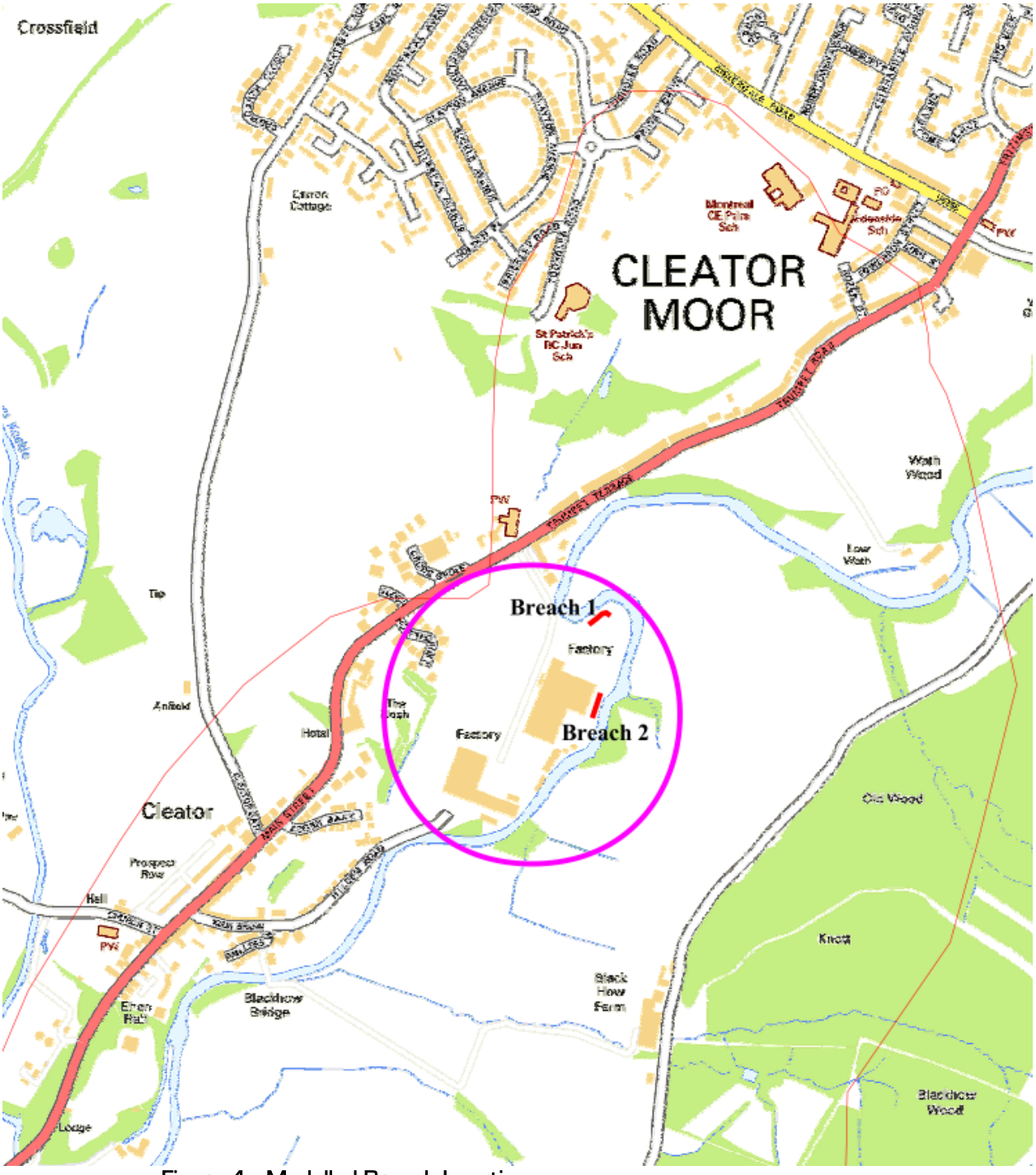


Figure 4 –Modelled Breach Locations

Breach 1

A breach in the gabion baskets north of the site has been considered for the 1:100 year plus climate change return period. The approximate lcoation of the breach event if indictaed in Figure 4 above. During the breach flood waters reach the site at the 1.5 hour mark, with the existing Kangol factory being flooded first and then flows head to the west reaching the propsoed residential development site. Mott Macdonald have identified the hazard rating as being generally low with a rating of between 0 to 0.75, with exception of the existing Kangol factory (1960's) which does not form part of this application. The flood waters which impact upon the development site have been classifed as low in terms of risk by Mott MacDonald.

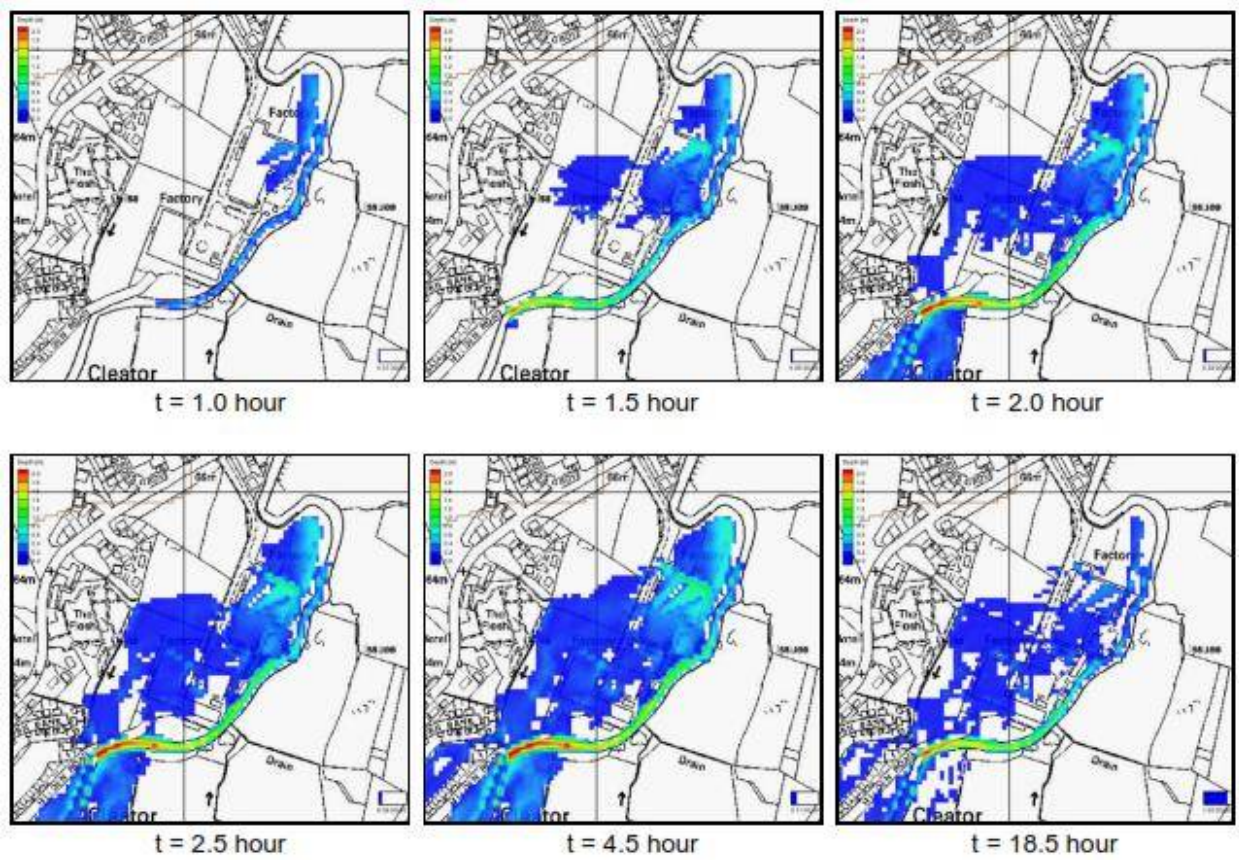


Figure 5 – Extract from Mott MacDonald of Breach 1

Breach 2

A breach in the earth embankment to the east of the site has been considered for the 1:100 year plus climate change return period. The approximate location of the breach event if indictated in Figure 4 above. During this breach event the only building impacted upon is the Kangol Factory which does not form part of this application. As such the risk of the site flooding from a breach at this location is deemed low.

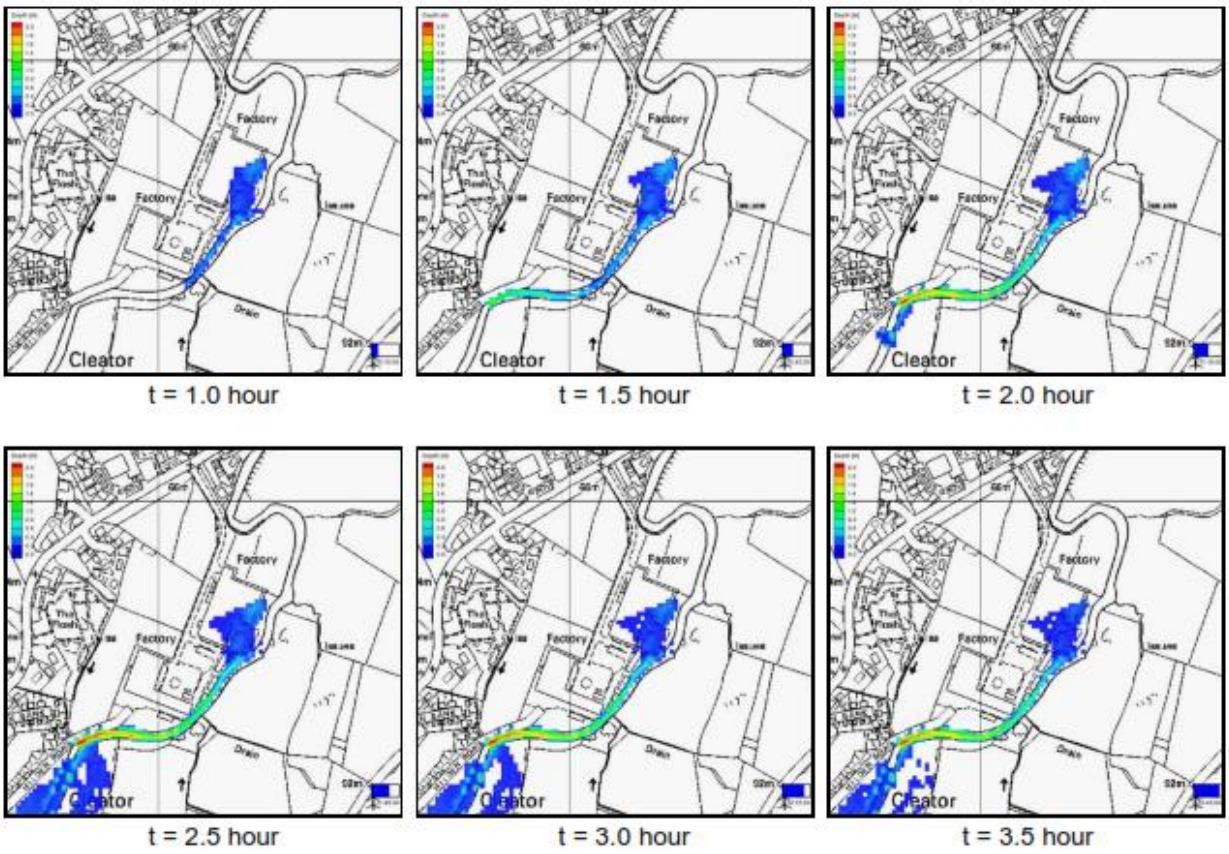


Figure 6 – Extract from Mott MacDonald of Breach 2

The Mott MacDonald report 'Updated Flood Risk Modelling – Cleator Mills Site' is included in Appendix F.

6.0 RECOMMENDED FINISHED FLOOR LEVELS

In order to afford future development a level of protection against future flooding it is our normal recommendation to increase Finished Floor Levels (FFL) by 600mm over the 1:100 year return period plus climate change. As there is no climate change information the 1:200 year flood level will be utilised for the appropriate modelled node in relation to the development site.

The most appropriate deemed model node point is 1406 which has a 1:200 year return period flood level of 60.37m AOD. Applying a 600mm freeboard to this modelled flood level gives a proposed minimum FFL of 60.97m AOD.

7.0 SAFE ACCESS AND EGRESS

As the proposed development site will be serviced by a new access onto the A5086 located to the west of the development site, safe access and egress will achievable at all times. In the event of a breach occurring in the northern flood defences the extents of flooding do no impact upon the proposed access.

Should a breach occur occupants should be evacuated from the building, it is the responsibility of the management company to ensure all occupants are aware of an evacuation plan. Buildings users could leave the building and safely evacuate to the A5086, taking into consideration the breach waters would take circa 2.0hrs to reach the Mill.

It is noted that the Environment Agency does not provide a Flood Warning service for the Cleator community. However, taking into consideration the access/egress location and the proposed FFL's the risk of access/egress being unachievable is deemed low.

The surface water management plan associated with this development site has been considered utilising the following documentation;

- Building Regulations Part H,
- Sewers for Adoption,
- CIRIA C697

8.0 SURFACE WATER RUNOFF

The proposed development site is currently Brownfield in nature and as such has limited discharge to watercourse. The drainage philosophy has been established in RWO Associates report reference RO/Commercial/13000.1, which is included in Appendix G. The Drainage Statement establishes a principle for utilising soil infiltration techniques in accordance with CIRIA C697.

9.0 CONCLUSIONS

This assessment has looked at the implications of the proposed new commercial development in relation to flood risk, including overtopping and breach analysis.

The proposed development site is shown as being in Flood Zone 3a on the Environment Agency flood maps. Having undetraken a comparison between the existing flood defences and modelled flood levels, the site is actually protected to a minimum of the 1:100 + 20% climate change return period. However, as established in the independent condition survey report of the flood defences remedial works are recommended subject to Environment Agency agreement.

Flood defences should be improved to provide a minimum condition grade of 2, subject to Environment Agency agreement.

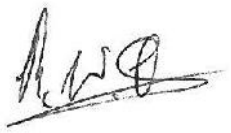
Based upon the proposed FFL's the new development is not at risk of flooding from a flooding incident for all events up to the 1:1000 year return, utilsing modelled node 1406.

Safe access and egress has been established via the new proposed access road onto the A5086.

The Environment Agency does not provide a Flood Warning Service for Cleator.

A Surface Water Management Plan (SWMP) has been identified including the levels of treatment requirement to ensure the River Ehen water quality remains protected.

Any potential impact of the development can be adequately addressed by good drainage design.

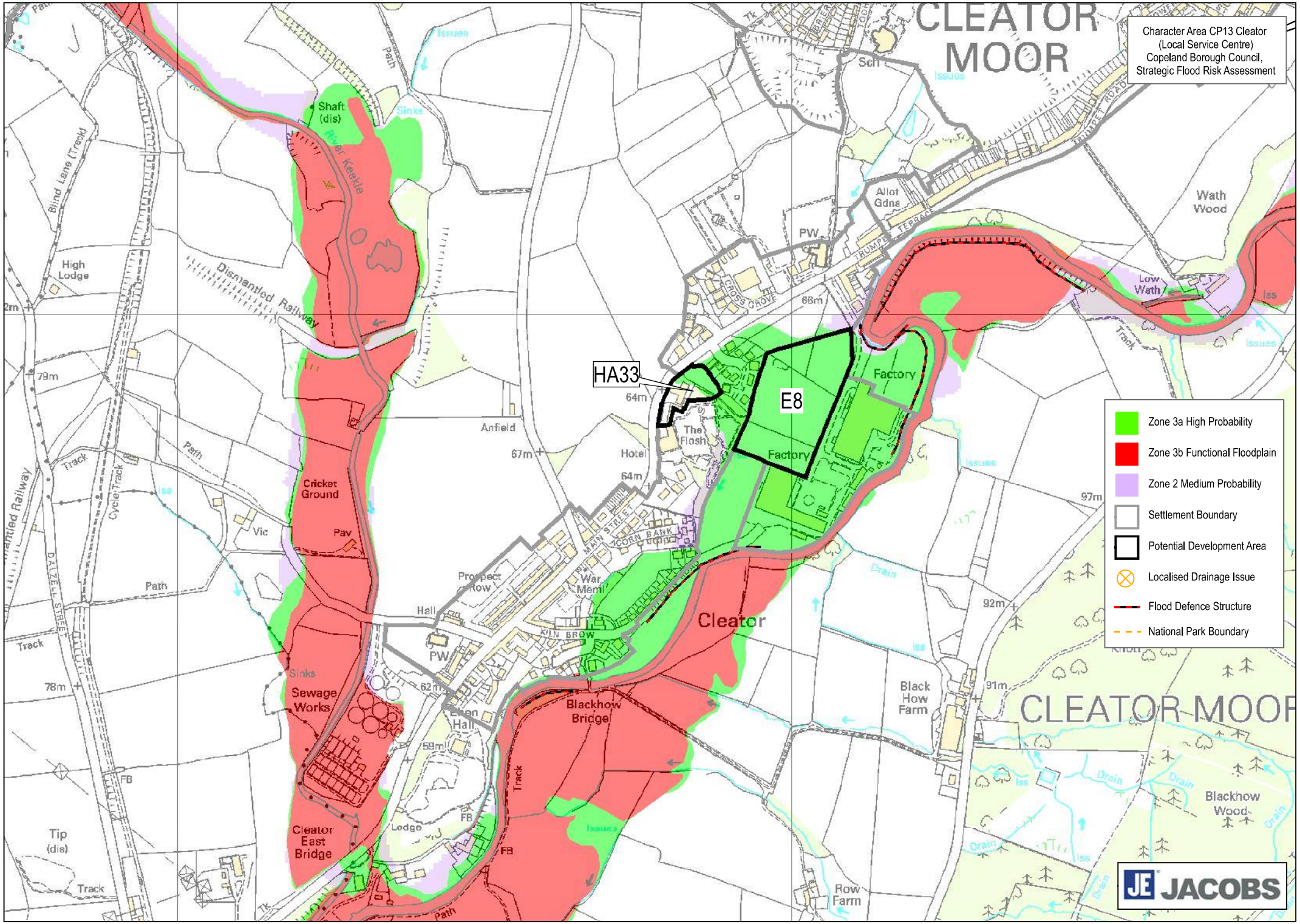


Ross Oakley
For and behalf of RWO Associates Limited
April 2014

Appendix A Site Location Plan

Location Map	
Site	Cleator Mill – Mill Conversion
Client	North Associates
Job Number	13000
Scale	NTS

Appendix B Flood Map



Appendix C Landscaped Site Layout

ART LINED TO FOOT PATH

FOOT PATH LINED ON CHIMNEY

CHIMNEY

BUILDING FRAMES VISTA OF CHIMNEY

0 25

CLEATOR MILLS — CLEATOR MILL

REFURBISHMENT OF DERELICT MILL BUILDINGS INTO GRADE A SPECULATIVE OFFICES

ALTERNATIVE SITE LAYOUT AS PROPOSED

NORTH ASSOCIATES

1:500 (A2) 22 JAN 2014

SK-02 GMcG

Appendix D Topographical Survey

MODELLED NODE 1206

MODELLED NODE 1299

MODELLED NODE 1406

MODELLED NODE 1502

MODELLED NODE 1606

MODELLED NODE 1726

MODELLED NODE 1896

MODELLED NODE 2006

Key

MH	Manhole
BT	British Telecom Manhole
IC	Inspection Cover
LP	Lamp Post
ST	Stop Top
SV	Stop Valve
G	Gully
TP	Telegraph Pole
FH	Fire Hydrant
WM	Water Meter
	Wall
	Fence – Post & Wire
	Fence – Post & Rail
	Fence – Metal Railings
	Kerbline – Channel
	Edge of Path/Track
	Top of Bank
	Bottom of Bank
	Gate
	Face of Hedge/Bushes

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File	E2532\Kang500	Client	Site Scan Ltd
Note	All levels and the plan grid are in metres and are both relative to the Ordnance Survey.	Project	Former Kangol Factory Site Cleator, West Cumbria
		Description	Topographic Survey
		Surveyed	04-08/11/2010
		Drawing Number	E2532/01/A
		Plotted	09-10/11/2010
		Scale	1:500

Appendix E Flood Defence Survey

Appendix E – Asset condition report

Asset Condition survey: River Ehen (right bank) Flood Defence at Cleator Mills

1. Introduction

The asset survey of the flood defences on the right bank of the River Ehen, protecting the site of the Cleator Moor proposed development, was conducted on 18th November 2008 in good weather conditions. (Appendix 1 catalogues the main physical features of the defences and associated outfall structures). The crest level of the earth embankments were modestly cut back for both survey purposes and visual condition assessment. Total vegetation management and sensitive vegetation removal would be a more prolonged exercise requiring the permission and supervision of the Environment Agency's (EA's) Fisheries, Recreation and Biodiversity officers.

This report will comment on EA's allocated asset condition grades for this site, challenge their asset condition assessment where necessary (last inspection 5th June 2008) and suggest ways to improve the defences to achieve at least a grade 2 condition, along with very indicative 'ball park' costs.

2. The Condition Assessment Methodology

The process is visual and no intrusive testing is involved, other than clearing some vegetation, as necessary, to facilitate inspection of the floodbank. The inspection followed the EA's performance based visual condition survey approach, using their Condition Assessment Manual (CAM, introduced in November 2006). Broadly this breaks down the elements or components of the assets (Flood Crest, Inward or riverward face, etc) and allocates one of 5 grades between 1 (very good) and 5 (very poor) to each element. The overall condition of the asset is ascertained by weighting the importance or criticality of each element to the performance of the whole asset. Weights range from 1 to 9. Thus an asset element is given a weighting of 9 if the integrity of the asset is compromised immediately *should it fail.*; if the whole defence section will take more than a year to fail should the element fail, then a weighting of 5 or perhaps 6 is allocated. Overall condition is calculated by summing the product of each element grade and weight and dividing by the sum of the weights.

This overall grade is measured against a target grade (again 1 to 5 as before). Should the actual condition not meet the target then the defence is deemed to be inadequate or unfit for purpose and repairs or remedial work to bring the asset up to target are vital to maintain the structural integrity of the asset.

Understanding the difference between elements with a grade of 3 from those with a grade of 4 is very important as grade 3 ***could affect*** performance but grade 4 ***would significantly affect*** performance and increase the likelihood of defence failure. (Grade 2 **would not affect** performance). In January 2008, the EA's Chief Executive ruled that, except in extreme conditions, where the consequences of failure were dramatic affecting many people and their property, a target of 3 is sufficient. The right hand bank defences on the river

Ehen at Cleator Mills are allocated a target of 3 by the EA at present, as the consequences of failure are limited. Redeveloping the site may prompt a review of this target. So it is recommended that, where remedial work to the defences is required, the developer should promote improvement work to provide overall condition grade of each defence section to Grade 2

It is important to point out that remediation work, without increasing the original crest height, will be viewed more favourably by the EA as the status quo is being retained.

3. Results of visual assessment of asset condition

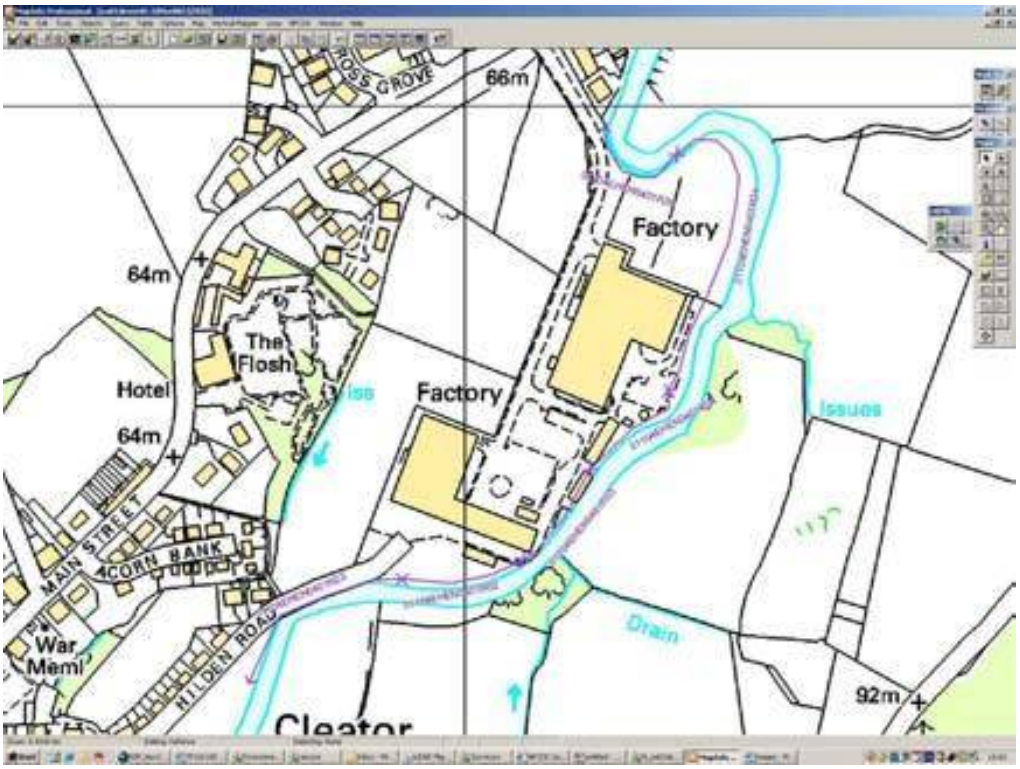


Figure 1 Environment Agency National Flood and Coastal Defence Management System map

The defences (see Figure 1) comprise:

- A 2 metre high (landward side to crest) hard defence section upstream of the site, referenced by EA as 0114EHEN0401R25, which comprises a Steel Pile retaining wall some 91.4 metres in length, a wide concrete berm (or horizontal ledge) giving protection to an approximately one metre high flood defence wall made of masonry in the upstream section and some 26 gabion baskets (each 1 metre in length, 1 metre wide and 1 metre deep) at the downstream end.
- An earth flood embankment some 253.5 metres in length, referenced by EA as 0114EHEN0401R24, which comprises an approximately 1.3 metre high earth embankment, choked with invasive, dense vegetation
- A lower earth embankment, some 92.8m in length, no higher than 0.5m referenced by EA as 01104EHEN0401R04, which is also choked with

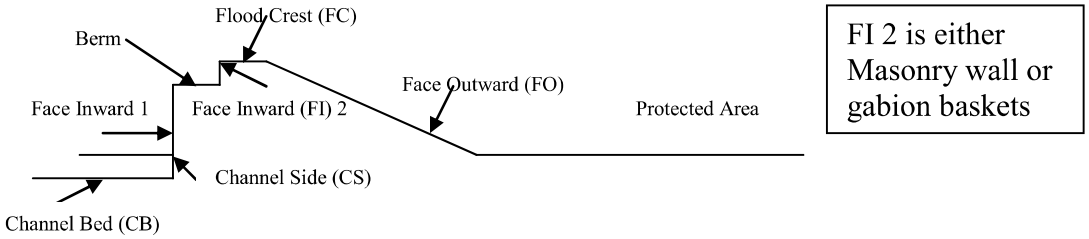
invasive, dense vegetation. The EA maps show this as no longer a formal embankment.

- Two downstream sections (adjacent to Cleator Mill) referenced by EA as 0114EHEN0401R02 and 0114EHEN0401R03, which are effectively 'high ground' adjacent to natural channel with no flood embankment at all.

3.1 Defence section 0114EHEN0401R25 (see Appendix 1.1)

NFCDD includes this defence section of 91.4 metres as one defence. This report splits the defence where the masonry Face Inward becomes a gabion basket section as the condition of the latter is far worse than the former.

3.1.1 U/S section (masonry flood wall)



Data from NFCDD

Assumed Standard of protection years (from Statutory Section 105 survey analysis)	1 in 100
Actual upstream crest level	64.52m
Actual downstream crest level	64.52m
Target standard to be achieved (from 09/11/07)	Grade 3
Overall Condition (EA) – both masonry wall and gabion elements	2.82 (rounded to 3)

Current Target achieved

Overall Condition (JCA) – masonry wall section only (see Appendix 2.1) 2.55 (rounded to 3)

Current Target achieved

3.1.2 U/S section (gabion basket section)

(see above cross section)

Data from NFCDD

Assumed Standard of protection years (from Statutory Section 105 survey analysis)	1 in 100
Actual upstream crest level	64.52m
Actual downstream crest level	64.52m
Target standard to be achieved (from 09/11/07)	Grade 3
Overall Condition (EA)	2.82 (rounded to 3)
Current Target achieved	
Overall Condition (JCA) – see Appendix 2.2	3.13 (rounded to 3)
Current Target NOT achieved	

Of the 26 baskets 7 are seriously if not totally depleted of stonework, wires cut (presumed stolen:

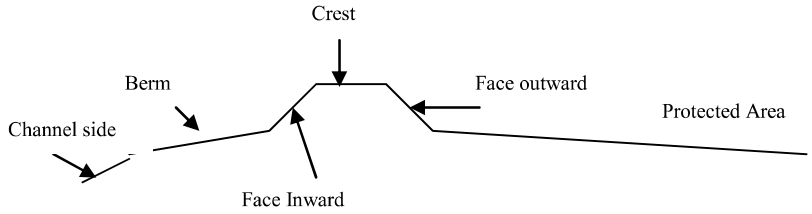
1 to 6 (upstream)	Fair to Good
7	Stonework seriously depleted
8-12	Fair to Good
13	Stonework seriously depleted
14-20	fair to Good
21-25	Majority of stonework stolen
26	Fair to Good

3.1.3 Conclusions

The CAM system works on the weakest link philosophy; in the gabion basket section of the defence, even though most of the baskets are in fair to good condition, the face inward can be assumed to have failed completely and it is likely that within a year the crest (and therefore the integrity of the whole defence) will erode away as the baskets further decay. The present target 3 has just failed. Failure of the defence is self evident and remedial work is very necessary. Along with the vegetation management and treatment of bare patches, at least 7 baskets need replacement (maybe more as the theft continues).

3.2 Defence section 0114EHEN0401R24 (see Appendix 1.2)

This section comprises some 253 .5 metre of raised embankment, with about a 1.3m protection (crest to Outward face toe) above a natural channel with an unacceptable levels of invasive vegetation covering most of the Inner and Outward faces and crest. The crest is too narrow and in parts the slopes are over-steep. The Inner or waterward face in particular is covered with mature trees and inflexible vegetation which will inhibit flood flow conveyance (increase flooding). There is little sign of vermin (moles) unlike in the adjacent defended grassland. Vegetation was cut back in parts of the bank and there were few signs of horizontal cracking or fissuring, with no evidence of seepage/piping. NFCDD identifies the standard of protection as 1 in 25 years. However the EA ISIS model results, when compared with ground levels from an earlier level survey, indicate a standard of protection much higher than this. Another map provided by the EA gives the standard of protection as 1 in 20 years.



3.2.1 Data from NFCDD

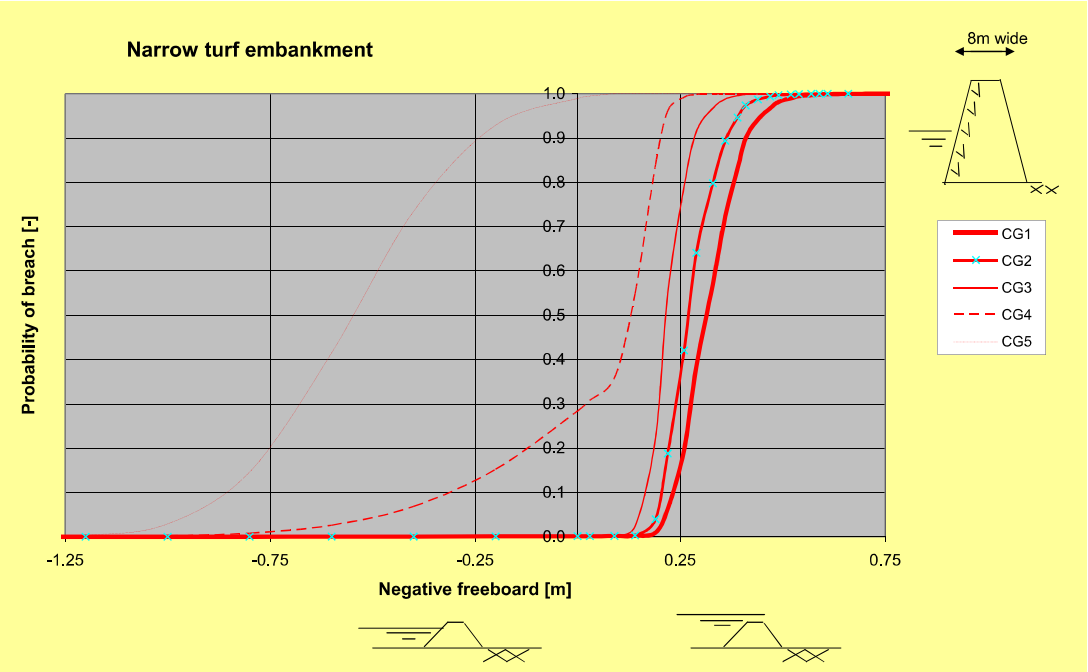
Assumed Standard of protection years (from Statutory Section 105 survey analysis)	1 in 25
Actual upstream crest level	63.40m
Actual downstream crest level	62.49m
Target standard to be achieved (from 09/11/07)	Grade 3
Overall Condition (EA)	3.58 (rounded to 4)
Current Target NOT achieved	
Overall Condition (JCA) - see Appendix 2.3	3.76 (rounded to 4)
Current Target NOT achieved	

3.2.2 Conclusion

The defence fails to meet target 3 as currently set and wholescale vegetation clearance is required along the whole length of defence, with selective vegetation management in co-operation with EA's Fisheries, Recreation and Biodiversity team on the berm and channel side. The rock revetment at the toe of the channel side is helping to prevent undercutting of the berm and strategic repair might be appropriate.

Once vegetation has been cleared the entire bank requires re-shaping to reduce its current fragility.

Research by HR Wallingford on behalf of EA indicates that a narrow earth/turf flood embankment like this in grade 4 condition would have a 70 per cent chance of failure if water levels (flood) reached 0.25 metres above crest level and about a 30 percent chance of failure should flood water should reach crest level (see diagram below). Remedial work on vegetation management and re-profiling the embankment without improving its standard of protection would reduce this fragility significantly. A Grade 2 or even 3 embankment is unlikely to fail at all until flood levels achieved are at least 0.2metres above the crest level.



3.3 Defence section 0114EHEN0401R04 (see Appendix 1.3)

EA have changed the asset type for this defence section from ***Fluvial raised defence*** (embankment) to ***maintained channel***, though evidence suggests it is a natural channel adjacent to 'high ground'. NFCDD identifies the standard of protection as 1 in 25 years. However the EA ISIS model results, when compared with ground levels from an earlier level survey, indicate a standard of protection much higher than this. The defence length is adjacent to the Kangol factory and the accurate level of this High Ground is crucial within the context of this flood risk assessment.

The profile is however similar to the R24 section only with, at most, a 0.5m defended height.

3.3.1 Data from NFCDD

Assumed Standard of protection years (no source for this assumption)	1 in 25
Actual upstream crest level	60.64m
Actual downstream crest level	60.64m
Target standard to be achieved (from 09/11/07)	Grade 4
Overall Condition (EA)	2.0 (but recorded 3)
Current Target achieved	
Overall Condition (JCA) – see Appendix 2.4	3.76 (rounded to 4)
Current Target achieved	

3.3.2 Conclusions

The findings of this recent survey do not agree with the EA data. However both gradings indicate that the defence is meeting the prescribed target (4). (Though one section of the asset inspection sheet suggests overall grade 3 and another overall grade 2). The target is confusing as all defences have to work

together to prevent inundation of the site. It is likely that, as this defence reach is downstream of the Kangol business units, then flooding from this section would only be local.

3.4 Defence sections 0114EHEN0401R02 and R03 (see Appendix 1.4)

Adjacent to Cleator the River Ehen is a natural channel rising directly to the road and Mill. NFCDD records that the Standard of Protection afforded by the Natural channel (R03) i.e. the channel capacity has been changed to 1 in 100 years on the basis of survey levels versus the Section 105 survey. The channel is clear with no major build up of gravel with some natural erosion and slippage to the channel side.

In summary the channel conveyance is not likely to be impeded by vegetation growth in the channel or debris/siltation.

NFCDD suggests that the downstream defence section (R02) has a 1 in 20 year standard of protection but existing topographic survey provides a discrepancy in the standard of protection between defence lengths R02 and R03 is valid.

In these two reaches there are 2 clay 18" pipes which outfall to the Ehen. It appears that they flow free and it is assumed that they emanate as drainage conduits from the Kangol factory. Some 3no. 6" iron pipes also protrude into the river taking surface water and water from down pipes to the river.

A masonry wall stands on top of the river bank but this has no flood defence function

3.4.1 Conclusions

No maintenance, other than riparian ground maintenance, is required, though a survey of the outfall pipes may be required to ascertain their purpose and source. The inspection chamber suggests the clay pipes take surface water drainage from the Kangol factory. These pipes have no flaps to prevent ingress of flood water to the lower parts of the site.

4. Recommendations

The EA have a target grade for the defences of Grade 3 as the defences 'protect' only the Kangol site and rough grazing. The asset survey has concluded that the current condition of the flood defence is at best grade 3 but at worst grade 4. Therefore, priority remedial work is strongly recommended on the three NFCDD defence lengths, as follows (see site map above):

4.1 0114EHEN0401R25

Vegetation management of Face Outward and Flood Crest, some pointing to masonry wall; reseeding bare patches and fencing with an approximate cost of circ £3,000. Maintenance to retain target condition requires superficial vegetation management and regular inspection to monitor any deterioration.

- Vegetation management and re-profiling of Outward face £3,000
- Replacement of 7 gabion baskets £10,000

4.2 0114EHEN0401R24

- Total but sensitive vegetation management over the whole length
  £10,000
- Re-profiling the earth embankment to existing levels
  £125,000

4.3 0114EHEN0401R04

- Total but sensitive vegetation management over the whole length
  £2,000
- Re-profiling the earth embankment to existing levels
  £10,000

4.4 0114EHEN0401R02 and 0114EHEN0401R03

- Following construction of the development the clay pipes or their replacements should be fitted with flaps to prevent ingress of flood water.

4.5 Summary

The total cost of bringing the flood defence up to an appropriate standard would therefore be in the order of £150,000.

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20th November 2008

Appendix 1: Defence photographs

1. 01104EHEN0401R25 (Hard Raised embankment)

Flood crest Upstream (rutting)

Outward face and Flood crest (heavy poaching)

Steel pile retaining wall with concrete berm

Heavily overgrown Flood crest

Heavily overgrown flood crest

Inward face (masonry) and flood crest

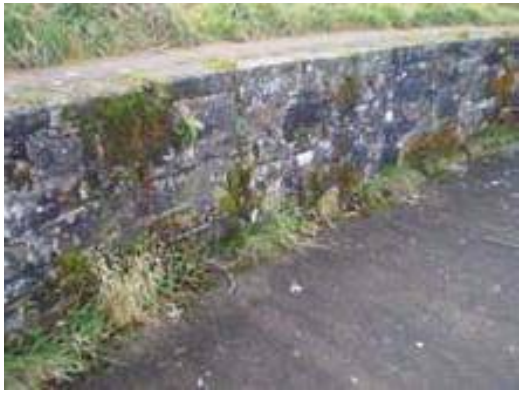
Gabions in Good condition (Grade 2)

Gabions in Very Poor condition (Grade 5)

Heavily eroded outward face

D/S gabion baskets in failed condition

Sheet pile FI showing minor distortion
But flood wall well protected by concrete berm



Minor grass growth in masonry wall joints

2. 01104EHEN0401R24 (Raised earth embankment)

Crest heavily vegetated with rutting

Outward Face with vegetation cleared

Invasive vegetation on whole bank

Mature Trees on Inward face

Invasive vegetation on outward face

Outward Face and protected area

3. 01104EHEN0401R04 (Raised earth embankment)

Trees on „crest" of defence

Invasive vegetation on whole embankment

Trees on Channel Side

"Embankment at rear of Kangol

Stone revetment on channel side

4. 01104EHEN0401R02/R03 (Natural Channel)

U/S broken 18" clay pipe

D/S 18" clay pipe flowing clear #1

D/S 18" clay pipe #2

6" iron pipe #1

6" iron pipe #2

Channel side showing wrack from flooding

Appendix 2 Condition Grading - Element Charts

1. Defence section 0114EHEN0401R25 (concrete wall)

		EA		JCA		JCA Comments
Type	**Sub type**	**condition**	**weighting**	**condition**	**weighting**	
CB	Natural	2	1	2	2	Limited shoaling not affecting conveyance
CS	Pile	3	3	2	4	Some minor displacement
FI1	Pile	did not grade		2	4	Some minor displacement
Berm	Concrete	2	3	2	4	3m wide protecting flood wall
FI2	Wall	3	5	2	6	Minor defects with slight lateral displacement
Crest	Embank	3	5	4	6	Concrete front protection; heavily rutted and overgrown
FO	Embank	3	5	3	5	Heavily overgrown with extensive bare patches and churning by machinery

2. Defence section 0114EHEN0401R25 (Gabion wall)

		EA (masonry and gabions)		JCA		JCA Comments
Type	**Sub type**	**condition**	**weighting**	**condition**	**weighting**	
CB	Natural	2	1	2	2	Limited shoaling not affecting conveyance
CS	Pile	3	3	2	4	Some minor displacement
FI1	Pile	did not grade		2	4	Some minor displacement
Berm	Concrete	2	3	2	4	3m wide protecting flood wall
FI2	Gabion	3	5	5	6	Stonework stolen from 7 metre cubed baskets
Crest	Embank	3	5	4	6	Concrete front protection; heavily rutted and overgrown
FO	Embank	3	5	3	5	Heavily overgrown with extensive bare patches and churning by machinery

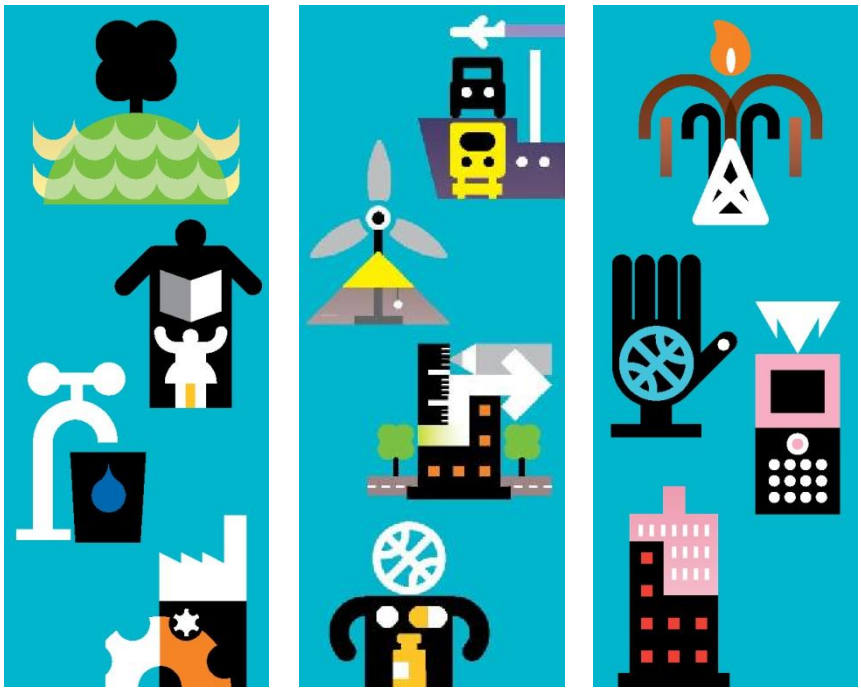
3. Defence section 0114EHEN0401R24

		EA		JCA		JCA Comments
Type	**Sub type**	**condition**	**weighting**	**condition**	**weighting**	
CB	Natural	2	1	2	2	Limited shoaling not affecting conveyance
CS	Natural	2	1	3	2	Overgrown; signs of undercutting of berm; Partial rock revetment
Berm	Natural	2	2	4	3	1m to 6m wide covered with mature trees and inflexible vegetation
FI	Embank	4	5	4	6	Over steep and infested with vegetation
FC	Embank	4	5	4	6	Invasive vegetation, uneven and significant rutting
FO	Embank	4	5	4	6	Infested with vegetation, cannot see embankment

4. Defence section 0114EHEN0401R04

		EA		JCA		JCA Comments
Type	**Sub type**	**condition**	**weighting**	**condition**	**weighting**	
CB	Natural	2	1	2	2	No build up of debis
CS	Natural	2	1	3	2	Signs of slippage and undercutting
Berm	Natural	Did Not Grade		4	3	1m to 6m wide covered with mature trees and inflexible vegetation
FI	Embank	Did Not Grade		4	6	Totally unmanaged
FC	Embank	Did Not Grade		4	6	Narrow 'crest' and wholly uneven crest line
FO	Embank	Did Not Grade		4	6	Serious vegetation management required

Appendix F Mott MacDonald Breach Analysis



Updated Flood Risk Modelling - Cleator Mills Site

Modelling Report

October 2013

RWO Associates

Updated Flood Risk Modelling - Cleator Mills Site

Modelling Report

October 2013

RWO Associates

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description	Standard
A	23/10/2013	Istvan Galambos	Richard Gamble	Richard Gamble	First Issue	

Contents

1 Introduction

1.1 Background and Objectives

Mott MacDonald has been commissioned by RWO Associates to undertake a flood defence breach analysis in the River Ehen catchment, near the Cleator Mills site at Cleator in Cumbria. This work follows on from the previous breach analysis work, which Mott MacDonald carried out for a proposed redevelopment of land on the Cleator Mills site in 2010.

The main objectives of the new study are:

- Set up and run a two-dimensional TUFLOW model with new ground survey now available;
- To map the spatial variation of depth, velocity and hazard rating across the floodplain resulting from failure of defences in two alternative locations for a fluvial flood with a return period of 100 year plus climate change.

This report describes the methodology and results of two-dimensional modelling and mapping of the River Ehen breach scenarios.

1.2 Study Area and Model Extent

The breach analyses cover an area situated to the south-east of Cleator Village, adjacent to the River Ehen. The location is shown on the map included in Appendix A. The River Ehen is located to the north and east of the Cleator Mills site. The site is divided into three sections, including the existing Kangol premises, a disused Kangol factory and a car park area.

1.3 Scope of Work

The scope of work for this study is summarised below:

- Use of the existing 2D model of the Cleator Mills site which was developed by Mott MacDonald in 2010;
- Update the model with new topographic survey information provided by RWO Associates;
- Use breach hydrographs as developed for the 2010 modelling and apply these at the same locations as for the 2010 modelling;
- Prediction of the flooding extent, flood depth, velocities and hazard ratings for the 1 in 100 year plus climate change fluvial event;
- Reporting.

2 Breach Analysis

The initial locations of defence breaches to be assessed were agreed with the Environment Agency in March 2010. Output from the existing ISIS model, developed by JBA in 2004, was used by Mott MacDonald in the 2010 study to generate breach scenario hydrographs. Hydrology and boundary inputs that form the basis of this assessment are based on the 2010 study.

2.1 Breach Constraints and Inputs

The following breach locations were used in the 2010 study:

Table 2.1: Breach Locations and Details

Breach	Location	Defence Type	Breach Width (m)	Point X	Point Y	Elevation (mAOD)	Bank
Breach 1	North of the site	Combination of gabion lined baskets and earth embankment	40	302196	513947	64.52	Right bank
Breach 2	East of the site	Earth embankment	40	302202	513840	62.49	Right bank

The following additional requirements were also agreed with the Environment Agency at the time:

- One design event to be considered: 1 in 100 year plus climate change return period;
- All of the breach locations are on a fluvial river, and therefore the following breach width and time to closure details were to be used:

  Earth bank: 40m width; 36 hours to closure.

  Combination of hard defence and earth bank: 40m width; 36 hours to closure.
- The start of the breach is the bank-full condition or at the peak water level if lower.

2.2 Breach Methodology

The following gives details of the method used in 2010 to model the breach hydrographs in the 1D ISIS model.

- The existing hydraulic model covers the entire reach of River Ehen, including the breaches identified in Table 2.1. The objective of the assessment was to determine a flow hydrograph through each of the breach locations. These hydrographs identified the flows leaving the main channel at these points and was then used as an input to a 2D model of the surrounding area to establish a flood extent and rate of inundation from the breach event.
- In the existing ISIS model of River Ehen, floodplains were represented by ISIS RESERVOIR units which model the rate of water accumulation in a storage pond/lake and made the assumption of a water level surface in the storage. Exchange of flow between river channel and flood cells was characterised by SPILL units representing side weir flow over the river banks.

- The breach locations were identified on the model network. Where necessary an interpolated channel cross-section was added 40m downstream to ensure the breach width of 40m was maintained. The interpolated channel cross-sections were also connected to the RESERVOIR units to ensure any excess water was spilled from the main channel onto the flood cells. This prevented any downstream water level increase, any backwater effect through the breach and also stabilised free flow conditions.

- The breaches were assumed to be formed over a single one second time step in the model runs. The breaches were assumed to form to the full extent of 40m width, thereby providing a 'worst-case' assessment for the development of the breach. The breach was taken as occurring through the full height of the embankment to the level of the surrounding land. This was represented by lowering the elevation of the right bank spill from embankment level to the elevation of the surrounding floodplain. This lower level was obtained from the LiDAR data available for the catchment (See Table 2.2).

Table 2.2: Embankment and Floodplain Levels

Breach Nr.	Embankment Elevation (mAOD)	Floodplain Elevation (mAOD)
Breach 1	64.52	62.5
Breach 2	62.49	61.0

3 2D Hydrodynamic Modelling

3.1 Introduction

The main purpose of this study was to assess the flood extent in the event of flood defence breach for the 100 year plus climate change fluvial event.

The approach to hydraulic modelling has comprised the following stages:

Step 1: constructing a two-dimensional hydraulic model incorporating the new topographic data made available by RWO Associates;

Step 2: breach analysis using the breach hydrographs generated in 2010 study;

Step 3: predicting flood extent for the specified fluvial return period (1 in 100 year plus climate change);

Step 4: producing flood extent, depth, velocity and hazard maps.

3.2 Model Build

The proposed development site is located to the south-east of the village of Cleator adjacent to the River Ehen. The extent of the model was estimated so that the model would include a sufficient length of the River Ehen within the model, whilst also including the Cleator Mills site that has a theoretical chance of flooding. Two breach locations are identified in the study area, as described in Table 2.1.

3.2.1 Digital Terrain Model

The Digital Terrain Model (DTM) for the Cleator Mills area was produced using 1m resolution LiDAR and ground based topographic survey data. In order to ensure that channel volume was not available to flood waters (since during a breach scenario channels are assumed to be full to bank-top) the DTM along channel lengths was raised to bank-top levels.

The topographic survey (North Associates - Kangol Factory,Cleater_topo.dwg) was provided by RWO Associates. The survey data was recorded in local coordinate system, therefore the first step was to transform it to the national coordinate system. After the transformation the 2d_zsh feature of TUFLOW was used to incorporate the survey into the DTM.

The TUFLOW model comprises of a grid of the Cleator Mills area, with grid points (z points) assigned elevations from the above mentioned sources. Details of the grid used for modelling the River Ehen at Cleator Mills are summarised in Table 3.1 below.

Table 3.1: Cleator Mills TUFLOW Model Grid Details

Grid Information	
Grid size (spacing)	7m
Origin	301,135N, 512,883E (British National Grid)
Orientation	0 degrees
Width of grid (in the east direction)	2.16km
Height of grid (in the north direction)	2.15km

A grid size of 7m was used as this is of sufficient detail for flood mapping, whilst not being so small as to result in unacceptably long model run times.

3.2.2 Boundary Conditions

The upstream boundary of the model is a flow-time boundary condition. Breach hydrographs were extracted at SPILL units connected to the model river cross-sections at each breach location for the 100 year plus climate change fluvial event. The breach hydrographs were developed in the 2010 modelling study and have been used in this updated study without modification. The breach hydrographs are shown on Figure 3.1

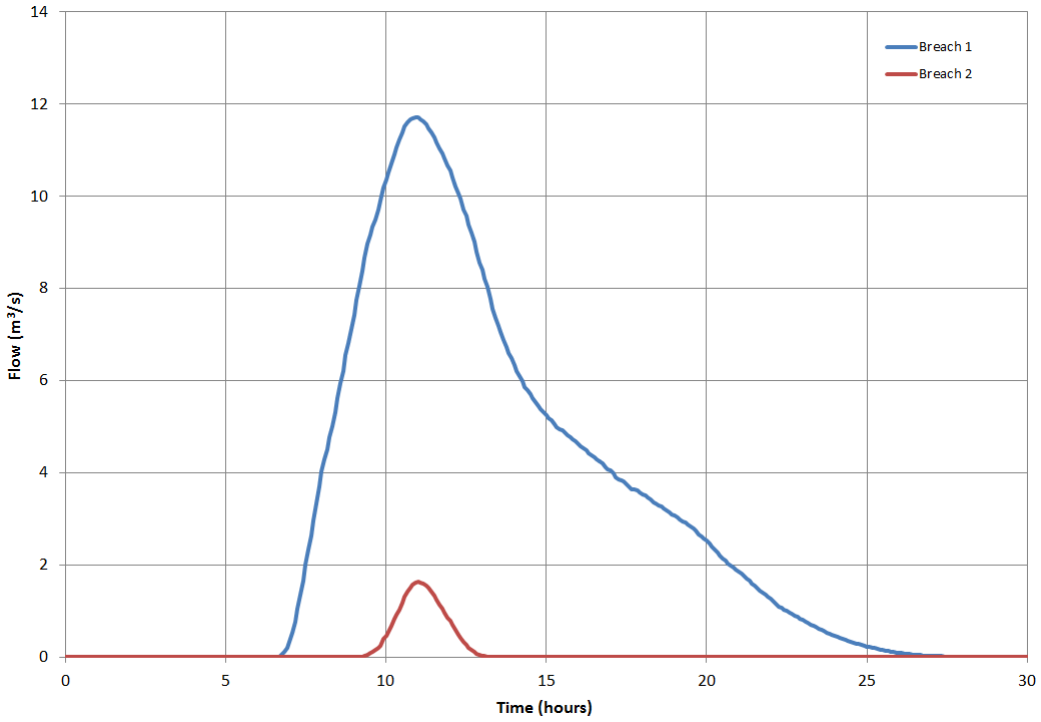


Figure 3.1 – Breach hydrographs

3.2.3 Manning's n

Land classification within the TUFLOW model determines the roughness values (Manning's n) of each land type, and therefore the resistance that is provided by the land to the flood water. For this study, a detailed land classification was used, as outlined in Table 3.2.

Table 3.2: Summary of Manning's n Values Used in the Model

Terrain Type	Roughness
Water	0.035
Grassed floodplain	0.055
Buildings	0.300
Woodland	0.120
Roads and railways	0.020

3.3 Flood Hazard Classification

Hazard rating has been defined in the *Supplementary Note on Flood Hazard ratings and Thresholds for Development Planning and Control Purpose – Classification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1* (Defra 2008). Hazard rating is calculated from depth, velocity and a debris factor at each time step in the model using the following equation:

$$HR = d (v + 0.5) + DF$$

where, HR = (flood) hazard rating;

d = depth of flooding (m);

v = velocity of floodwaters (m/s); and

DF = debris factor (0, 0.5, 1 depending on probability that debris will lead to a hazard).

The debris factor was based on the conservative land use classification. It varies with depth and velocity of flooding as shown in Table 3.3.

Table 3.3: Guidance on debris factors for different flood depths, velocities and dominant land use (from Table 4.2 in Flood Risks to People)

Depth (d)/Velocity (v)	Debris Factor based on Conservative Land Use
d = 0 to 0.25m	0.5
d = 0.25 to 0.75m	1.0
d > 0.75 and/or v > 2m/s	1.0

Hazard rating has been classified into four categories in the *Supplementary Note on Flood Hazard ratings and Thresholds for Development Planning and Control Purpose – Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1* (Defra, 2008) for emergency planning purposes.

Table 3.4 summarises the four categories. This classification has been used in the description of the results.

Table 3.4: Hazard to People as a Function of Velocity and Depth

Hazard Rating	Degree of Flood Hazard	Elevation (m AOD) Bank
<0.75	Low	Caution "Flood zone with shallow flowing water or deep standing water"
0.75 – 1.25	Moderate	Dangerous for some (e.g. children) "Danger: Flood zone with deep or fast flowing water"
1.25 – 2.0	Significant	Dangerous for most people "Danger: flood zone with deep fast flowing water"
>2.0	Extreme	Dangerous for all "Extreme danger: flood zone with deep fast flowing water"

3.4 Scenarios Modelled

Two scenarios using the above methodology have been modelled for the 1 in 100 year plus climate change event. These scenarios are listed in Table 3.5 below:

Table 3.5: Scenarios Modelled

Breach Nr.	Design Event
Breach 1	100 year plus climate change
Breach 2	100 year plus climate change

Appendix A shows the location of breaches.

4 Results

4.1 Breach 1

A breach in the gabion lined baskets north of the site has been considered for the 1 in 100 year plus climate change event. The approximate location of the breached defence is indicated on the Appendix A. A breach of the flood defence was assumed to occur when the river was at bank-full downstream. During a breach for the 100 year plus climate change event, floodwaters flow onto the floodplain (see Figure 4.1), flooding the existing premises, car park area and the disused factory building downstream of the site. Some of the floodwaters flow back into the River Ehen near the downstream end of the existing Kangol premises. Flood depths in the vicinity of the breach are fairly significant reaching up to 0.90 m near this building.

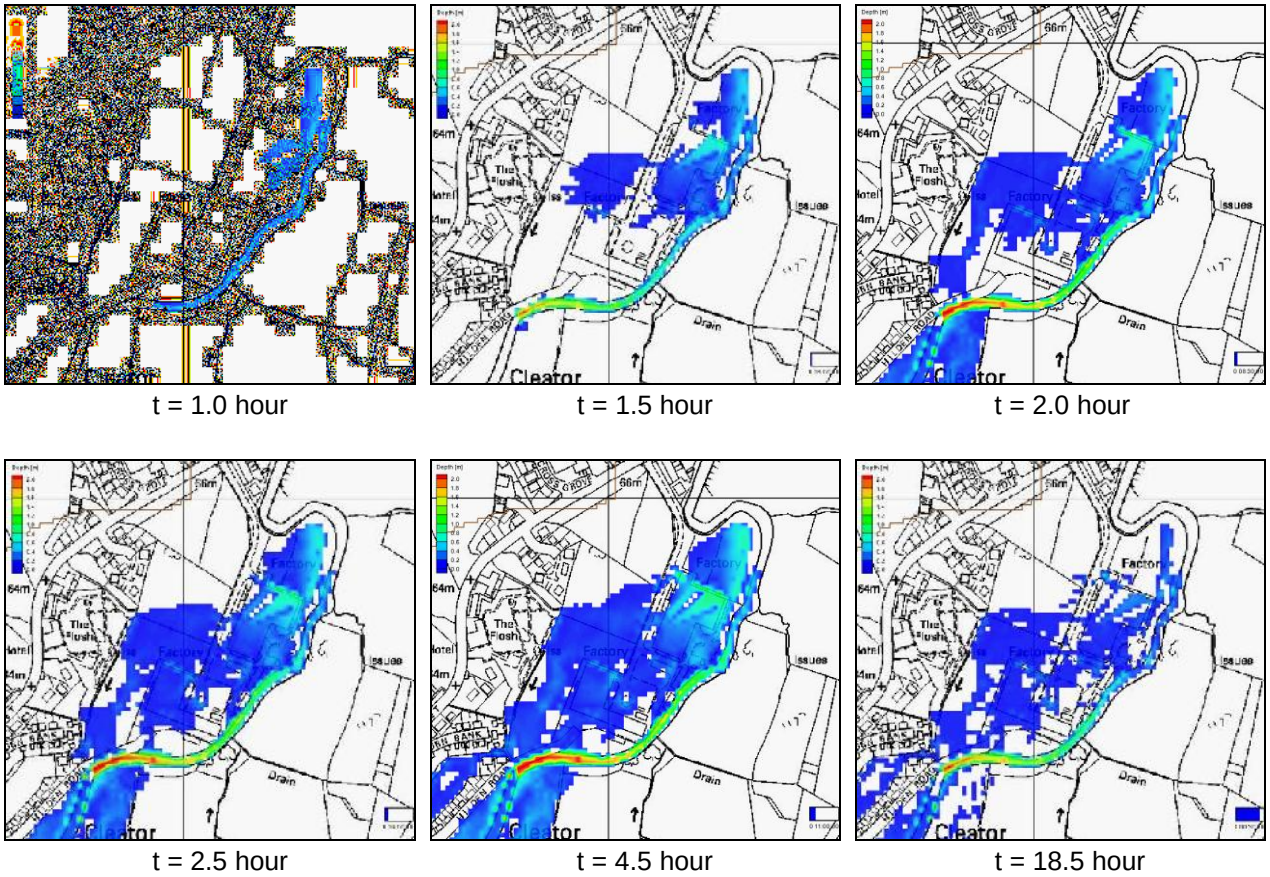


Figure 4.1 – Progress of flood wave from Breach 1

The hazard rating was generally low (0 to 0.75) throughout the site, although this was observed to be greater in the areas of deeper waters. There are areas, in the vicinity of the Kangol Building where the hazard rating is significant (1.25 to 2) implying that it is dangerous for most people.

4.2 Breach 2

A breach in the earth flood embankment east of the site was considered for the 100 year plus climate change event. The approximate location of the breached flood embankment is shown on Appendix A. For this analysis it has been assumed that the River Ehen was bank-full downstream of the breached

embankment. During a breach, floodwaters spread onto the floodplain (see Figure 4.2), inundating the Kangol premises, and then flow through parts of the car park area and the disused factory building. Flood depths generally remain low (0 to 0.25m) through the site, although there are small areas in the vicinity of the Kangol building where there is deeper flooding of up to 0.5m. The flood hazard rating of the breach floodwaters is low (0 to 0.75) as the depth of flooding is shallow (less than 0.25m) and the velocities are low (less than 0.3m/s) with the exception of a few areas in the vicinity of the existing building (0.8m/s).

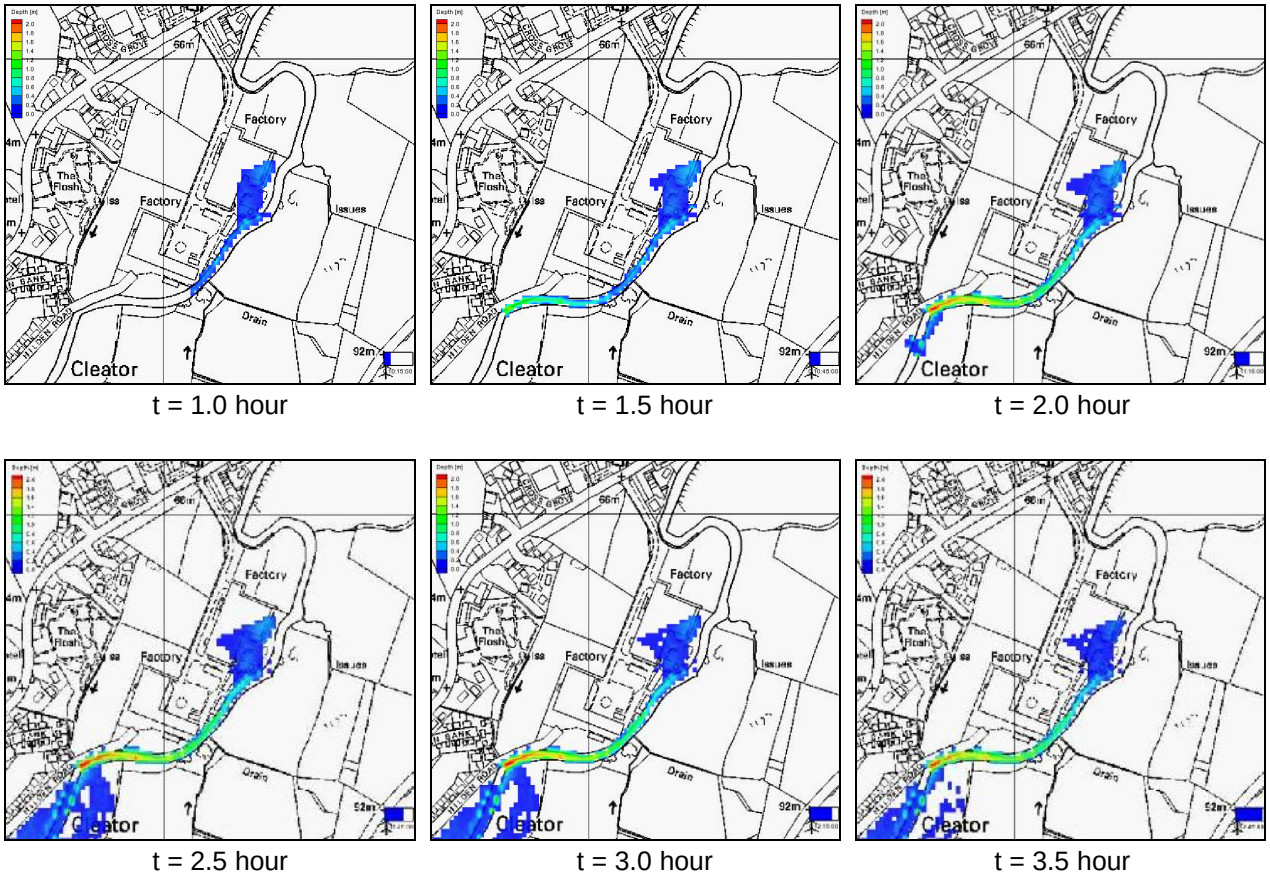


Figure 4.2 – Progress of flood wave from Breach 2

5 Flood Mapping

Flood maps have been produced from the outputs of the 2D modelling. The maps show maximum water level, flood depth, velocities and hazard rating for all of the scenarios which have been modelled. Table 5.1 summarises the flood maps located in Appendix B and discussed in Section 4.

Table 5.1: Summary of Flood Maps

Drawing No.	Parameter Shown	Breach Location	Return Period
1.01	Depth	Breach 1	100 year + 20%
2.01	Velocity	Breach 1	100 year + 20%
3.01	Water Level	Breach 1	100 year + 20%
4.01	Hazard Rating	Breach 1	100 year + 20%
1.03	Depth	Breach 2	100 year + 20%
2.03	Velocity	Breach 2	100 year + 20%
3.03	Water Level	Breach 2	100 year + 20%
4.03	Hazard Rating	Breach 2	100 year + 20%

6 Assumptions and Limitations

The model and input data are based on the following assumptions:

- River channel is bank-full downstream of breach locations.
- Flood defences and embankment levels used in the existing ISIS model are correctly representing the study area.
- The ISIS model accounts for surface runoff in the study area.

The model has several limitations which should be understood before applying the findings of this report:

- Models are not calibrated or verified, owing to lack of observed historic data.
- LiDAR data has verified accuracy of +/- 150mm.

7 Conclusions

The outputs from the updated Cleator Mills FRA Breach Analysis facilitate the assessment of extent and severity of flooding in the event of breaches in the fluvial defences. The breach hydrographs used were those produced in the previous breach analysis (2010) and are for the 100 year plus climate change event, based on best available data at the time.

Breach hydrographs were input as flow-time boundary conditions into the 2D TUFLOW model. The 2D model covered areas adequate to model the full extent of flood waters, using a grid size of 7m.

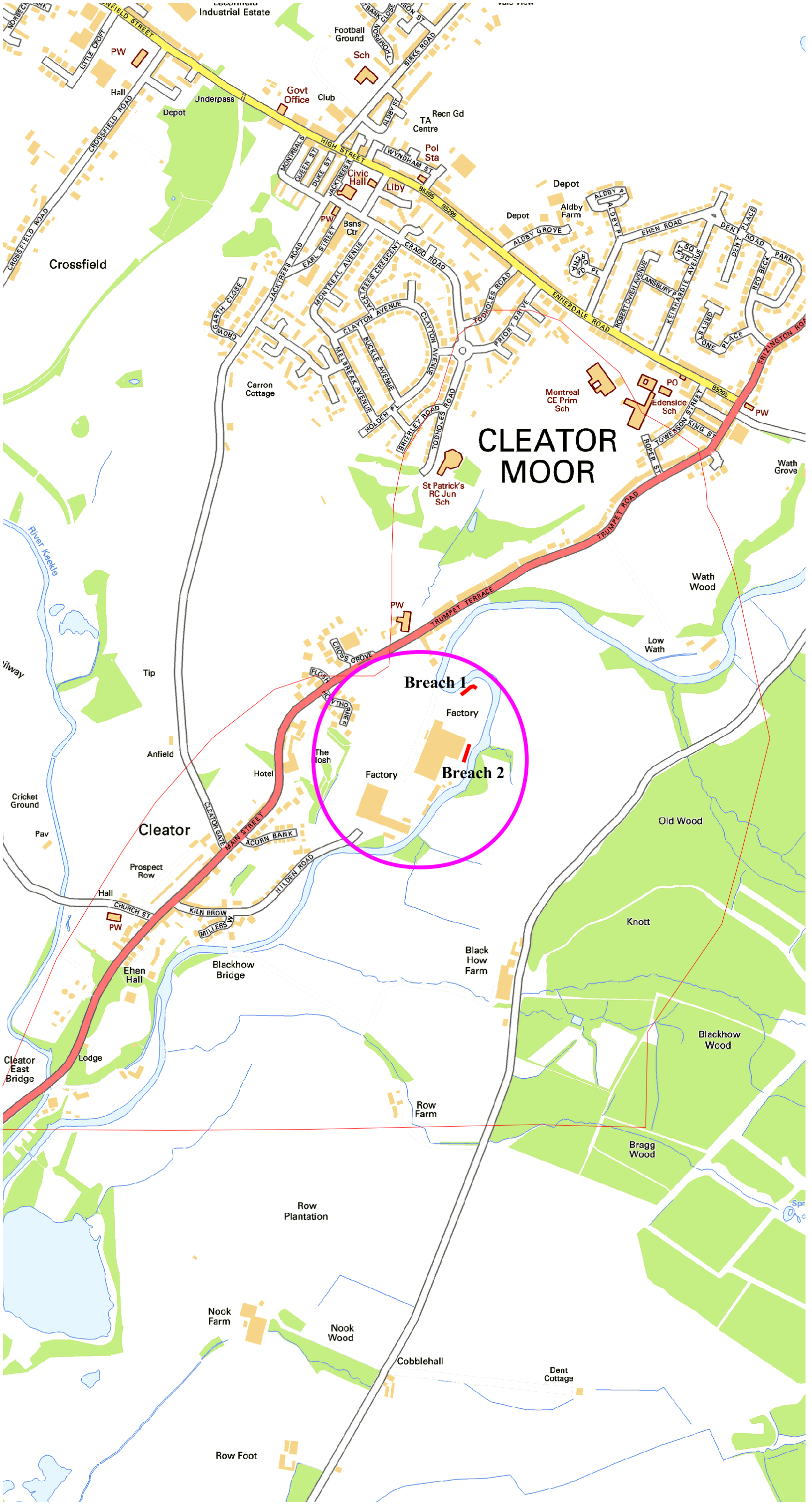
It was observed that the extent of flooding south of the breached gabion lined baskets (Breach 1) was significant. Areas affected were mainly near the existing Kangol premises, car park area and the disused factory building downstream of the site. Hazard rating was generally low through the site, with the exception of a few areas in the vicinity of the existing building. Flood waters were observed to be deeper in these areas (up to 0.9 m), and the hazard rating was identified to be significant (1.25 to 2) implying that it is dangerous for most people.

During a breach in the earth embankment east of the site (Breach 2), floodwaters covered the existing building and parts of the car park area. Flood depths generally remained low (0 to 0.25m) through the site, although there were small areas in the vicinity of the factory building where there was deeper flooding of up to 0.5m. The flood hazard rating of the breach floodwaters was low (0 to 0.75) as the depth of flooding was shallow (less than 0.25m) and the velocities were low (less than 0.3m/s) with the exception of a few areas in the vicinity of the existing building (0.8m/s).

The extent and severity of flooding predicted for both breaches is very similar to that predicted in the 2010 study. The additional ground based topographic data now available indicates that the area to north-west of the existing factory are lower than given by LiDAR data used in 2010. This results in greater flood extent in this area. However maximum values of flood depth, velocity and hazard around the site has not significantly changed.

Appendices

Appendix A. Study Area



KEY PLAN

LEGEND

Extent of 2D Domain

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Project Title

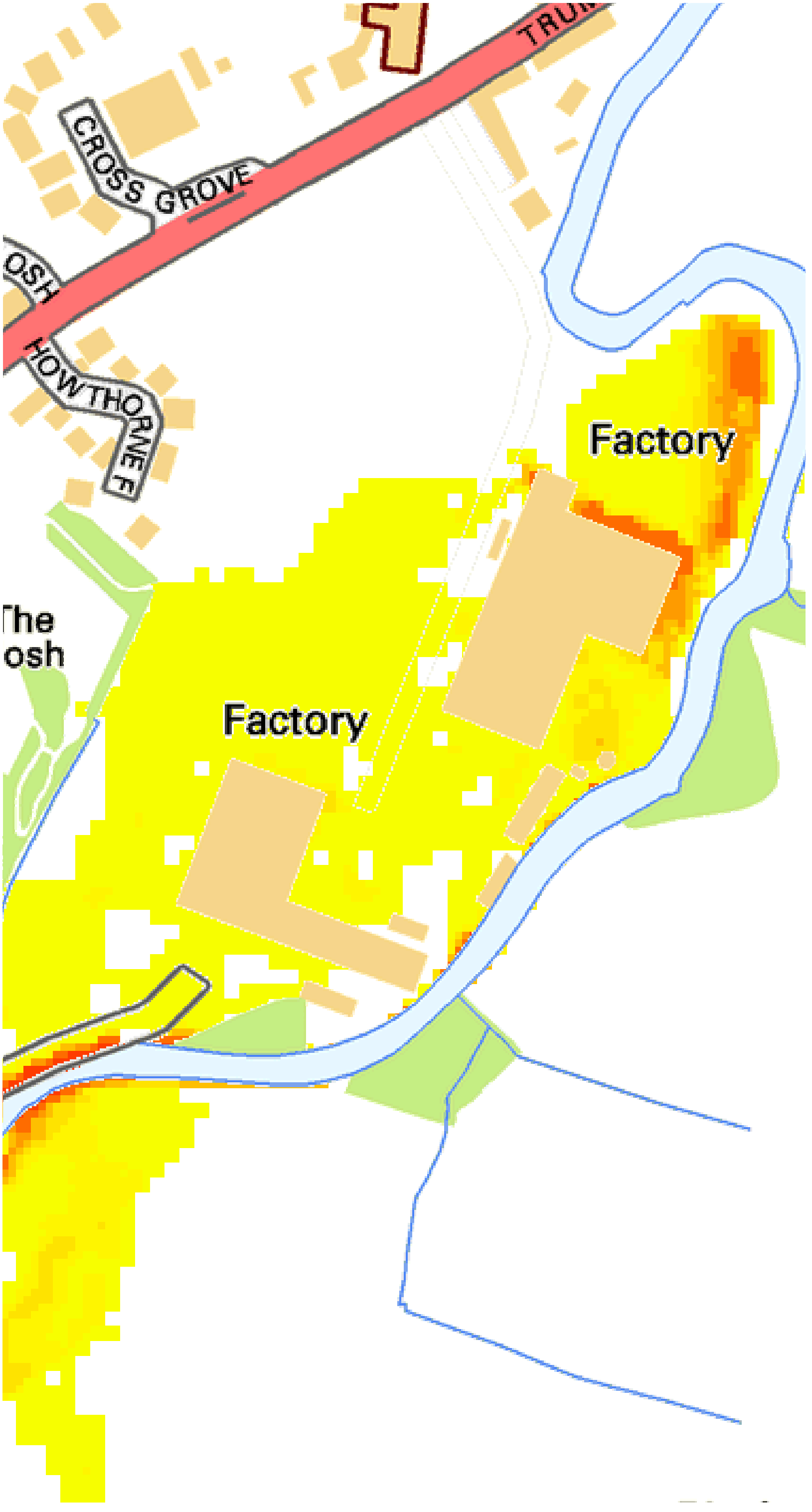
Flood Risk Modelling - Cleator Mill Site

Map Title

2D Model Extent

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	0.01
Drawing Scale at A3	1:5000

Appendix B. Flood Maps



KEY PLAN

LEGEND

Depth [m]

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0

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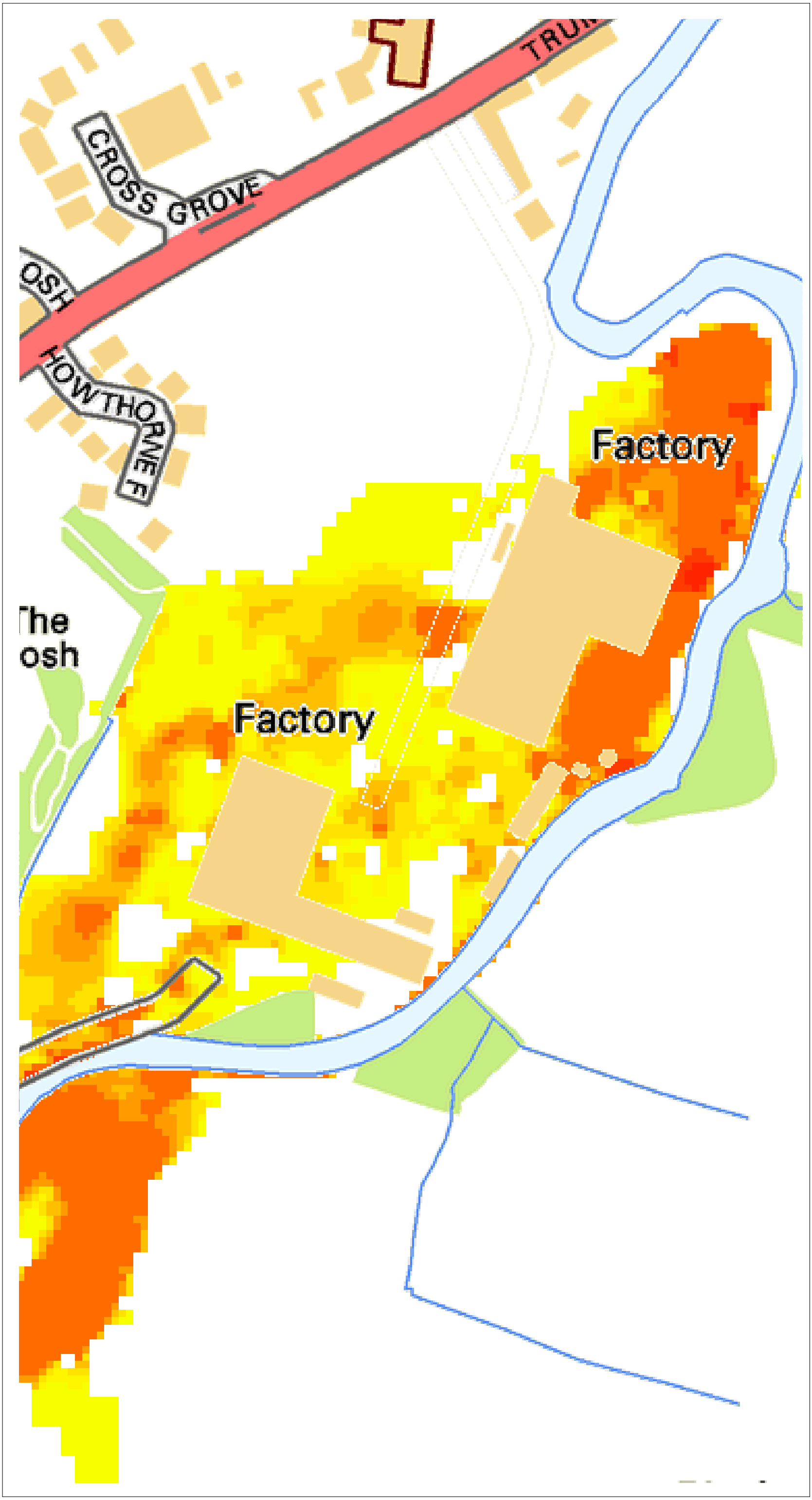
Project Title

Flood Risk Modelling - Cleator Mill Site

Map Title

Maximum flood depth for breach 1 (DTM 2013)

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	1.01
Drawing Scale at A3	1:1100



KEY PLAN

LEGEND

Velocity [m/s]

- 0.00 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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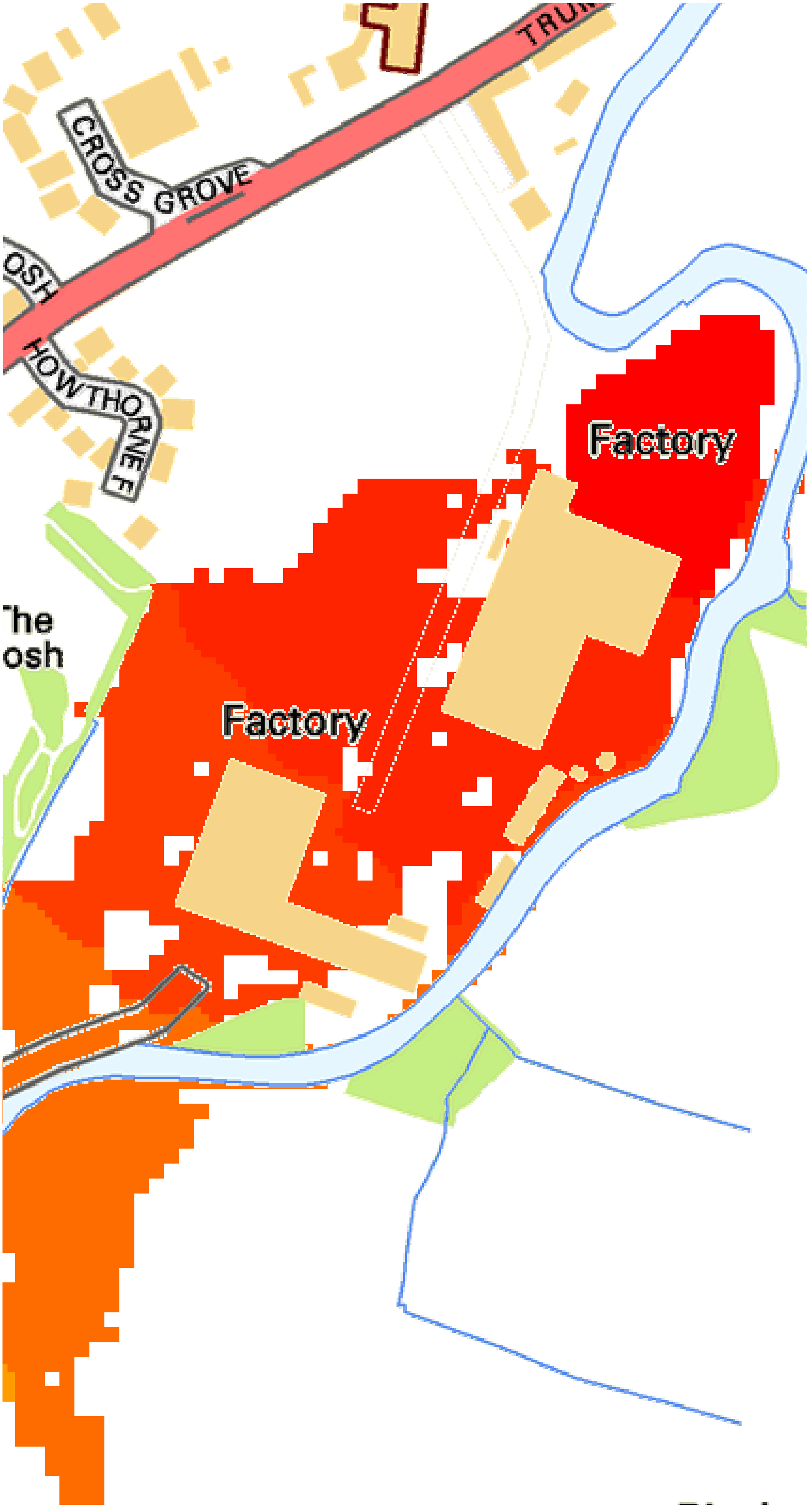
Flood Risk Modelling - Cleator Mill Site

Map Title

Maximum flow velocity for breach 1 (DTM 2013)

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	2.01
Drawing Scale at A3	1:1100



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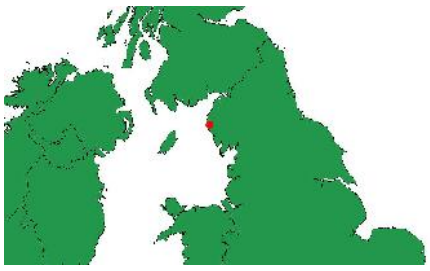

LEGEND

Water Level [mAOD]

- 50.340 - 51.758
- 51.758 - 53.175
- 53.175 - 54.593
- 54.593 - 56.010
- 56.010 - 57.428
- 57.428 - 58.845
- 58.845 - 60.263
- 60.263 - 61.681
- 61.681 - 63.098

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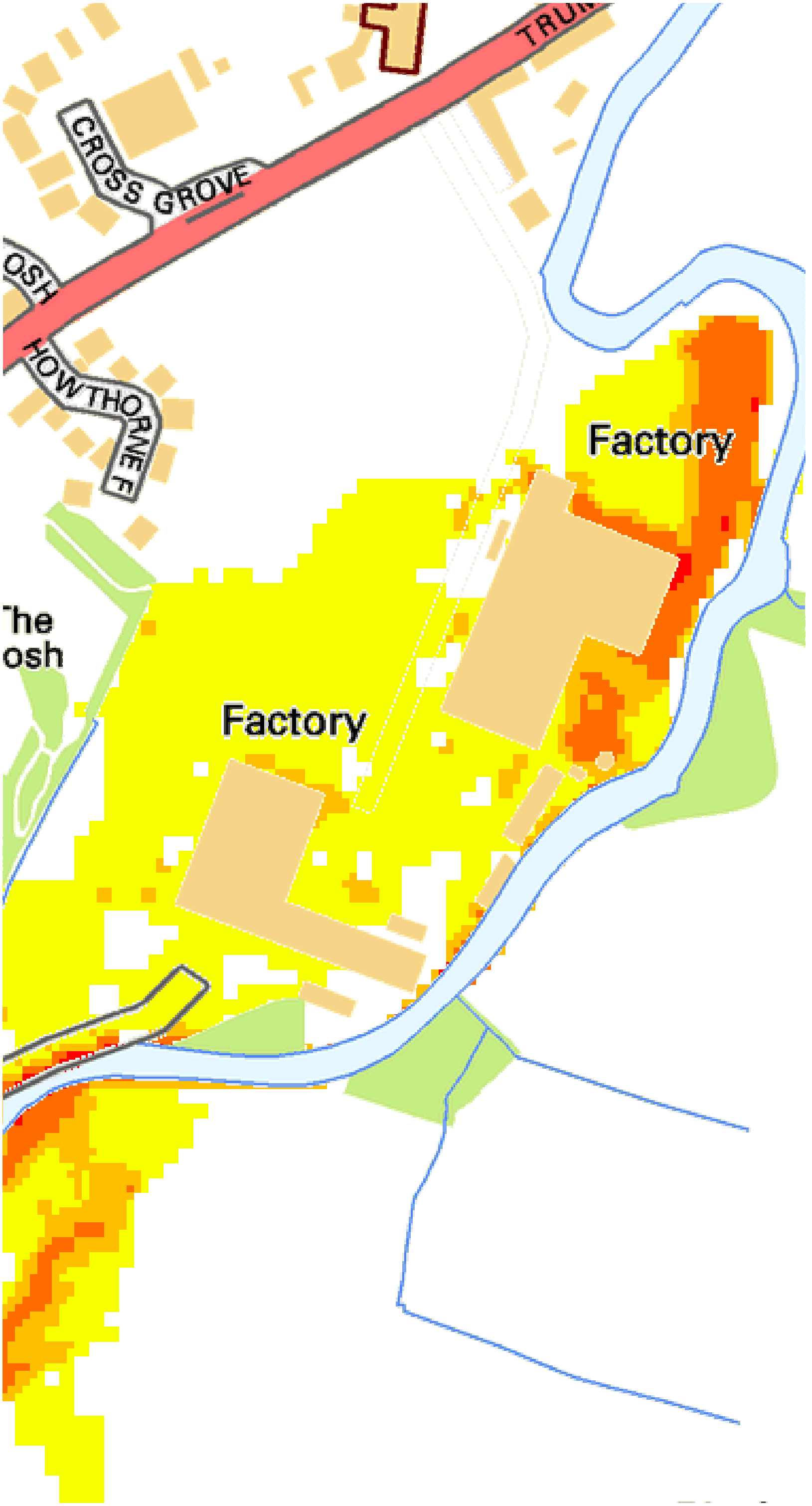
Map Title

Maximum water level for breach 1 (DTM 2013)

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	3.01
Drawing Scale at A3	1:1100



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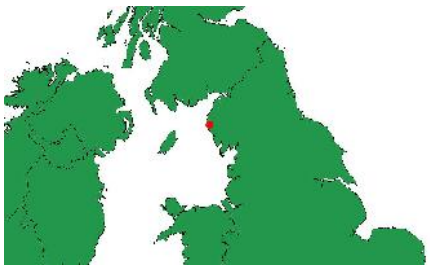

LEGEND

Flood Hazard Category

- Low
- Moderate
- Significant
- Extreme

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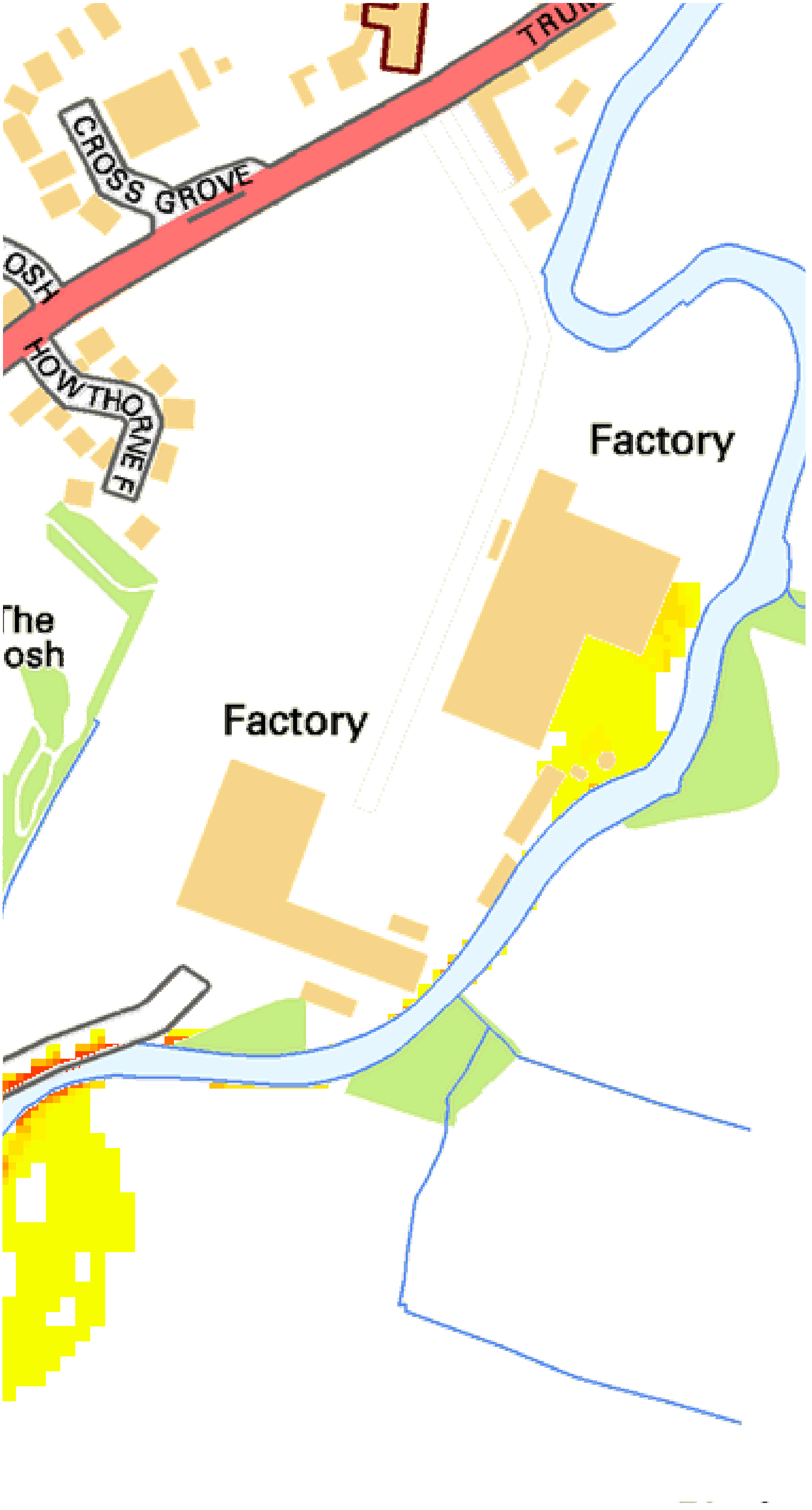
Project Title

Flood Risk Modelling - Cleator Mill Site

Map Title

Hazard categories for breach 1
(DTM 2013)

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	4.01
Drawing Scale at A3	1:1100



KEY PLAN

LEGEND

Depth [m]

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
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- 1.0 - 2.0
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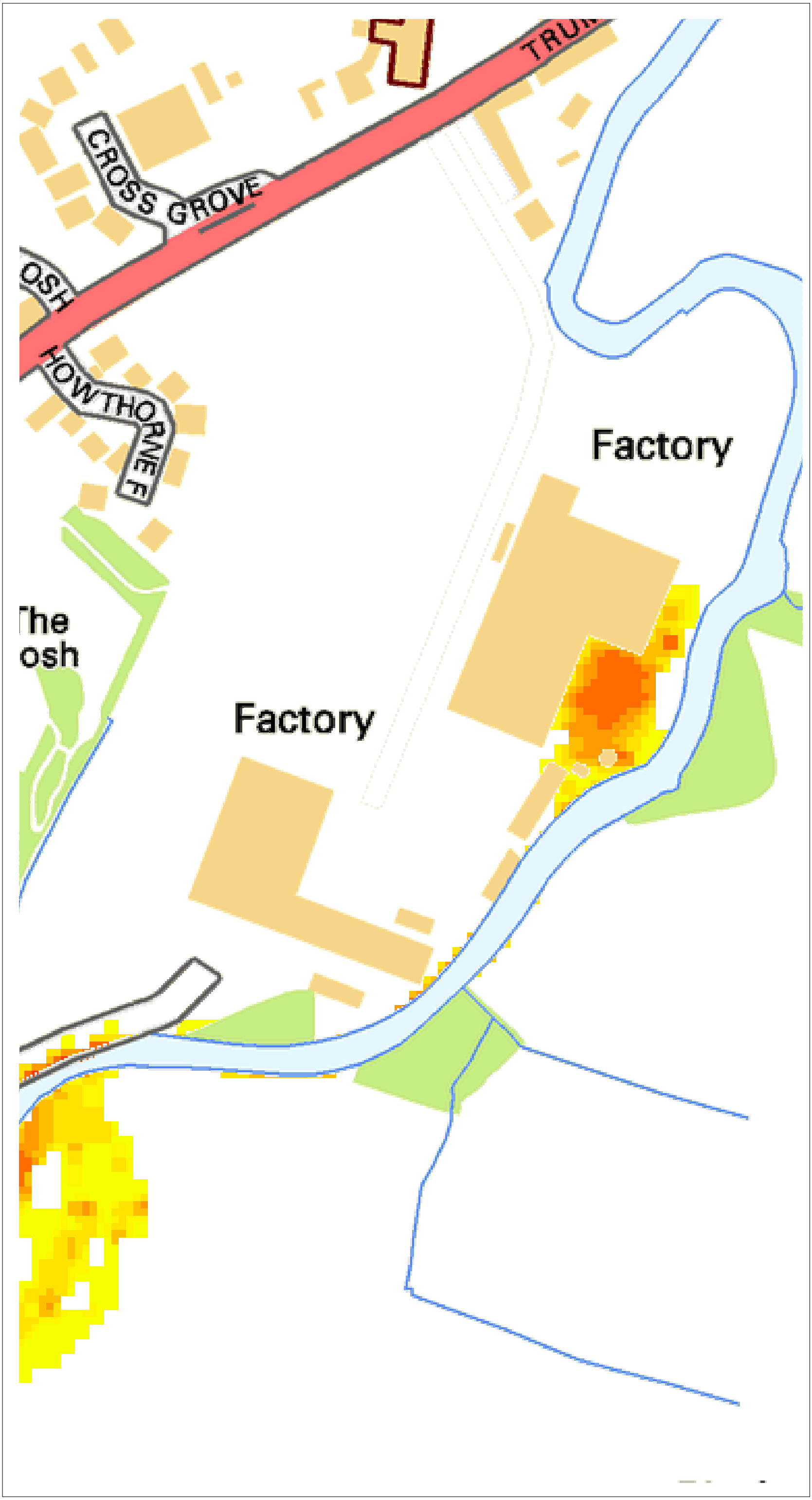
Project Title

Flood Risk Modelling - Cleator Mill Site

Map Title

Maximum flood depth for breach 2 (DTM 2013)

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	1.03
Drawing Scale at A3	1:1100



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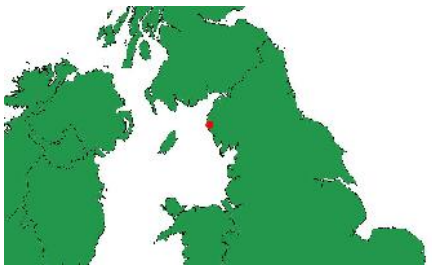

LEGEND

Velocity [m/s]

- 0.00 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

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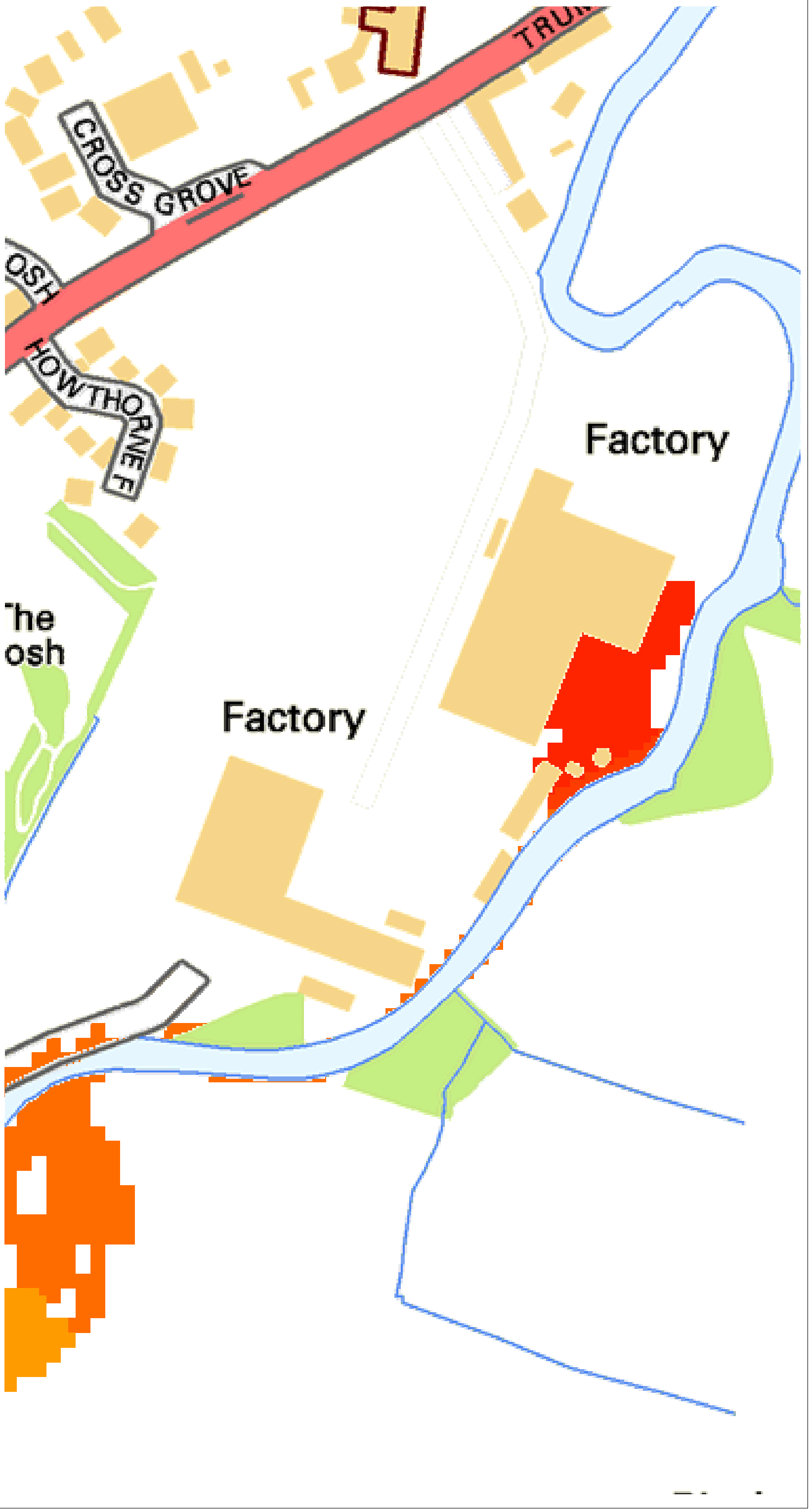
Maximum flow velocity for breach 2 (DTM 2013)

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	2.03
Drawing Scale at A3	1:1100



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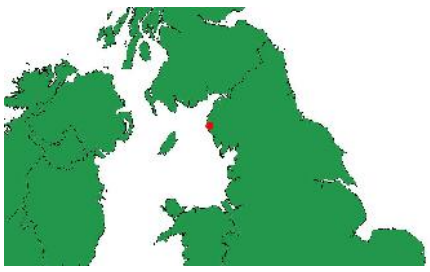

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Flood Risk Modelling - Cleator Mill Site

Map Title

Maximum water level for breach 2 (DTM 2013)

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	3.03
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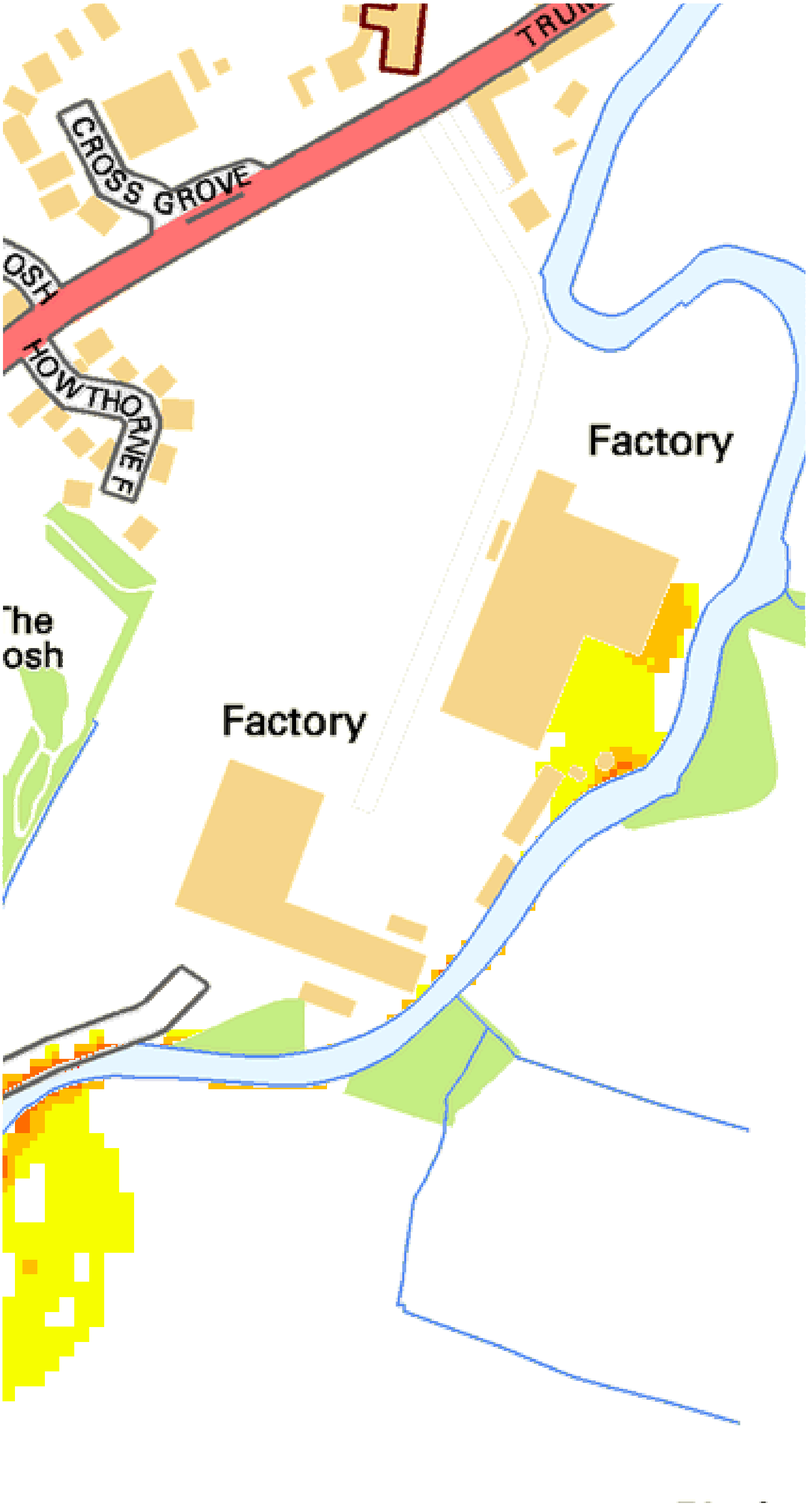

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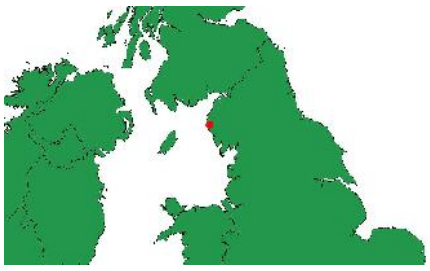

LEGEND

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- Significant
- Extreme

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Flood Risk Modelling - Cleator Mill Site

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Hazard categories for breach 2 (DTM 2013)

Date / Revision	14/10/2013
Modelled	IG
Checked	RJG
Approved	RJG
Drawing No.	4.03
Drawing Scale at A3	1:1100

Appendix G RWO Associates Drainage Statement

DRAINAGE STATEMENT

Cleator Mill,
New Commercial Centre

Reference	RO/Commercial/13000.1
Date	January 2014
Version	1

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CONTENTS

APPENDICES

CONFIDENTIALITY STATEMENT

This report is addressed to and may be relied upon by the following:

North Associates Ltd,
The Slack,
Wigton
Cumbria,
CA7 0LX

This report has been prepared for the sole use and reliance of the above named parties. This report shall not be relied upon or transferred to any other parties without the express written authorisation of RWO Associates Limited. No responsibility will be accepted where this report is used, either in its entirety or in part, by any other party.

DOCUMENT HISTORY

VERSION	PURPOSE/DESCRIPTION	DATE
1	Draft Issue – for client comment	21.01.2014

1.0 EXECUTIVE SUMMARY

This assessment has looked at the implications of the proposed Residential developments in relation to proposed drainage of the site.

A Surface Water Management Plan (SWMP) has been identified including the levels of treatment requirement to ensure the River Ehen water quality remains protected.

As the proposed surface water drainage system is a Sustainable Drainage System (SuDS) the rate of runoff from the proposed development site will not increase and as such the loading on the watercourse will not be impacted upon.

A foul discharge rate has been agreed with United Utilities, with a connection available from December 2014.

Any potential impact of the development can be adequately addressed by good drainage design.

2.0 INTRODUCTION

RWO Associates Ltd (RWO) has been instructed by North Associates on behalf of their client to prepare a Drainage Statement to establish best practice drainage principles relating to the proposed development site. This report has been prepared to support the planning application.

The sites are all currently Greenfield and client wishes to create residential developments; location plans are included in Appendix A.

3.0 THE SITE

The proposed development site is located to the east of Cleator, about 300m to the south of Cleator Moor and immediately to the west of the Lake Distract National Park, Figure 1 below shows the site location.

Figure 1 – Site Location

The River Ehen forms the eastern and southern boundary, with residential dwellings located to the west and north. To the immediate north of the proposed development site is a Greenfield area, which is being considered for use as residential by the land owner. The north eastern portion of the site has a derelict factory located on it currently owned by Gates.

It is proposed to construct new the Mills. The existing Mill is all one building but has had two infill buildings constructed in the 1960's, the 1960's buildings will be demolished as part of the

proposed scheme. One of the buildings will be replaced with a glass atrium style link and the other will have a glass bridge constructed at first floor level to create a link.

4.0 GROUND CONDITIONS

Elliot Environmental have undertaken the Site Investigation associated with the site with Geo Environmental Engineering undertaking further soil infiltration tests in accordance with BRE365. Elliot Environmental reported ground conditions to have Sand and Gravels, which prompted the further investigation works undertaken by Geo Environment Engineering.

Geo Environmental Engineering received instruction to undertake six soil infiltration tests across the site in accordance with BRE365. Figure 2 below shows the locations of the soil infiltration test results.

Figure 2 – Soil Infiltration Test Locations

SA01 recorded Topsoil from 0.00 – 0.40m with Sand & Gravel recorded from 0.40 – 2.00m, soil infiltration test results for this location have been calculated as 6.04665^{-5} m/s.

SA02 recorded Topsoil from 0.00 – 0.30m, Sand from 0.30 – 0.70m and 0.70 – 2.00m Sand & Gravel, soil infiltration test results for this location have been calculated as 4.97347^{-5} m/s.

SA03 recorded Topsoil from 0.00 – 0.20m with Sand recorded from 0.20 – 0.80m and Sand & Gravel from 0.80 – 2.00m, soil infiltration test results for this location have been calculated as 2.39464^{-5} m/s.

SA04 recorded Topsoil from 0.00 – 0.30m with Sand & Gravel recorded from 0.30 – 1.50m, soil infiltration test results for this location have been calculated as 2.27591^{-5} m/s.

SA05 recorded Topsoil from 0.00 – 0.35m with Sand recorded from 0.35 – 0.60m and Sand & Gravel from 0.60 – 2.00m, soil infiltration test results for this location have been calculated as 2.24551^{-5} m/s.

SA06 recorded Topsoil from 0.00 – 0.50m with Sand & Gravel recorded from 0.50 – 0.90m and Sand & Gravel from 0.90 – 1.50m, soil infiltration test results for this location have been calculated as 4.22297^{-5} m/s.

All of the recorded soil infiltration rates are well within the acceptable rates and as such the site will be suitable to utilise infiltration. Based upon this in accordance with Building Regulations and the CIRIA SuDS train, surface water should discharge into suitable designed soil infiltration drainage systems.

Geo Environmental Engineering report is included in Appendix B.

5.0 RECEIVING WATERS

The nearest watercourse is the River Ehen, which generally flows in a south westerly direction. The Ehen is located on the immediate eastern and southern boundaries of the proposed development site. Elliot Environmental have reported that the water quality within the River Ehen has been found to be Quality A in the past.

The critical issue relating to the surface water run-off form the proposed development site relates to the River Ehen which is classified as a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC). It is understood that a direct discharge to the River Ehen was been deemed as unacceptable, based upon this it is proposed to utilise infiltration to dispose of surface water as stated in section 4.0 of this report.

It is worth noting that the chemical status of the surface water in the area is not assessed by the Environment Agency and it is understood that there are no plans to do so by 2015.

6.0 SURFACE WATER MANAGEMENT PLAN

The surface water management plan associated with this development site has been considered utilising the following documentation;

- Building Regulations Part H,
- Sewers for Adoption,
- CIRIA C697

Soil Infiltration

Section 4.0 Ground Conditions, includes a summary of the soil infiltration test results which have been undertaken by Geo Environmental Engineering in accordance with BRE 365. A total of six tests have been undertaken, a summary of the results is below in table 1.

Soil Infiltration Test	Results
SA01	6.04665^{-5} m/s
SA02	4.97347^{-5} m/s
SA03	2.39464^{-5} m/s
SA04	2.27591^{-5} m/s
SA05	2.24551^{-5} m/s
SA06	4.22297^{-5} m/s

Table 1 – Soil Infiltration Test Results

The above summary of soil infiltration test results demonstrate that soil infiltration can be utilised across the proposed development site.

Watercourse Protection

Given the classification of the River Ehen there is a requirement to ensure that the watercourse is protected during construction. There are known outfall points to the River Ehen and these will need to be blocked off prior to any works commencing on site. This will ensure that the risk of any contaminants getting washed into the watercourse is limited. All water during the construction phase should be disposed of to the public sewerage system ensuring treatment prior to discharge. This will require the contractor to agree a temporary discharge point with United Utilities.

Further consideration will need to be given during the construction phase to the risk of fuel stores which should be fully bunded ensuring any leakage is contained. In addition the use of vehicles near to the watercourse should be considered and it is recommended a temporary bund be established along the line of the River Ehen and monitored with any spillage's being cleaned.

The contractor undertaking the proposed works will need to ensure they are fully compliant with PPG6 (Working at construction and demolition sites) Pollution and Prevention Guidelines, which is the Environment Agencies issued guidance.

PPG6 guidance can be located;

http://www.environment-agency.gov.uk/static/documents/Business/EA-PPG6_-_03_2012_Final.pdf

PPG6 covers the guidance relating to pollution prevention and management which the contractor will need to ensure they adhere to during the full program of works.

The existing drainage has been surveyed and is included in Appendix C.

Surface Water Proposal

The surface water strategy has been designed taking into consideration the SUDS Train. The level of treatment requirement has been reviewed based upon Table 3.3 of CIRIA C697 show below.

Table 3.3 *Number of treatment train components (assuming effective pre-treatment is in place)*

Receiving water sensitivity → / Runoff catchment characteristic ↓	Low	Medium	High
Roofs only	1	1	1
Residential roads, parking areas, commercial zones	2	2	2
Refuse collection/ industrial areas/ loading bays/lorry parks/highways	3	3	3

Based upon Table 3.3 of CIRIA C697 a maximum of two levels of treatment are required given the receiving watercourse's (River Ehen) catergorisation of SAC and SSSI and proposed development of residential dwellings.

Table 5.10 of CIRIA C697 (included below) shows the treatment options for achieving the required levels of treatsment.

Table 5.10 *Examples of SUDS treatment trains*

	Example	Infiltration	Permeable pavement	Vegetative filtering and detention	Granular filtering and detention	Retention (permanent pond)	Wetland/sand filter	Proprietary oil/silt/debris traps
Number of components:1								
Component sequence	A	1	1	1	1	1	1	
Number of components:2								
Component sequence	A	2	1	1	1			1
	B		1	2		2		2
	C			1	1	2		
Number of components:3								
Component sequence	A		1	3	1	2		
	B		1	1	1	2 + 3		
	C			1	2	3	3	
Number of components:4								
Component sequence	A			1	2	3	4	
	B			4	1	2 + 3		

A number (1) indicates that the system could feature as the first component in the management train for that particular example. If several components are labelled with a (1), this implies that any one of them would be suitable for this position.

As stated in table 3.3 two levels of treatment are required for parking areas and commercial zones, parking areas etc and one level of treatment for Roofs only. Utilising table 5.10 above the roof water will be able to discharge to Infiltration which it is recommended be dealt with via a central infiltration system, such as a cellular soak away. Car parks and roads will need to discharge via two levels of treatment as such it is recommended that either permeable paving be utilised or granular filtering with a discharge to soak away.

As the roof water will discharge via infiltration this ensures one level of treatment as required under CIRIA C697 guidance. The driveways will discharge via permeable paving providing the first level of treatment and then onto an infiltration system, ensuring the required second level of treatment is provided.

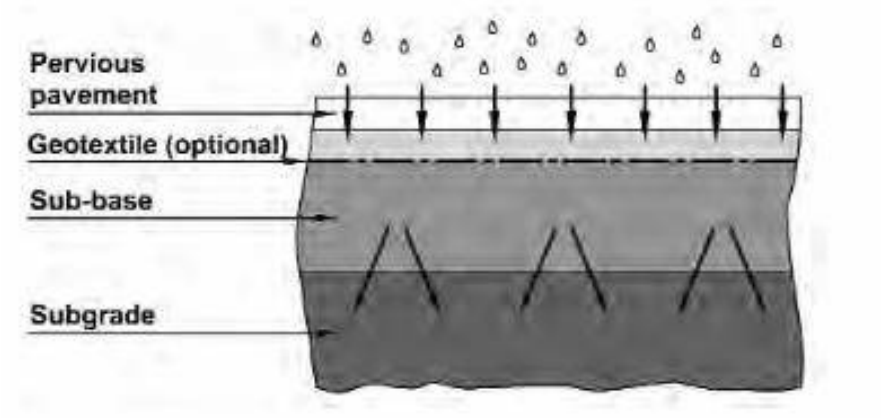


Figure 12.1(a) *Pervious pavement system types: Type A – Total Infiltration*

Figure 3 – Typical detail for Permeable Paving (extract from CIRIA C697)

Typical sections through modular box systems for both infiltration and storage/attenuation application modes are presented in Figures 13.1 and 13.2.

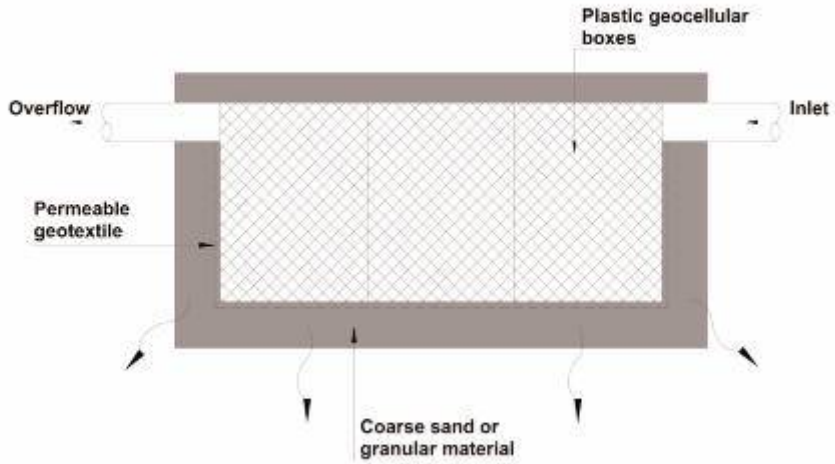


Figure 13.1 *Schematic of modular box system in soakaway mode*

Figure 4 – Typical Soakaway (extract from CIRIA C697)

The roads and car parks will need to utilise two levels of treatment in accordance with Table 3.3 of CIRIA C697 including a pre-treatment to ensure the proposed Sustainable Urban Drainage System (SuDS) performs as designed. For the purposes of ensuring an easy maintained road drainage system it is recommended that the road drainage discharge via granular drains or permeable surfacing and onto a central soakaway unit. As defined in Table 5.10 of CIRIA C697 the filter drain will provide the first level of treatment with the infiltration basin providing the second level of treatment.

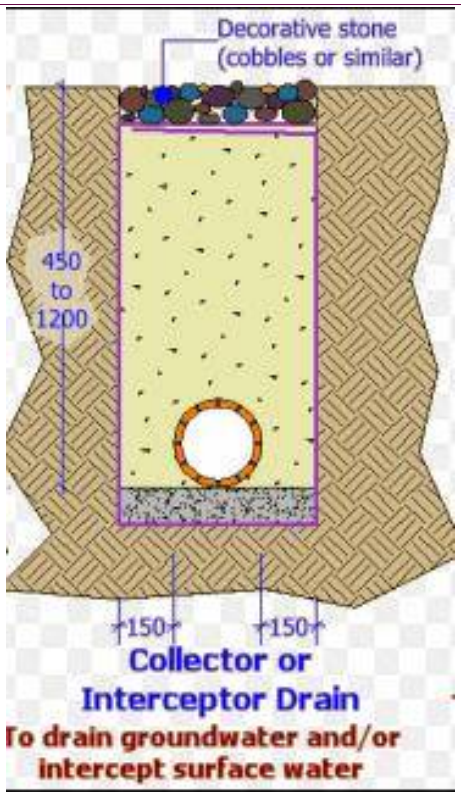


Figure 5 – Typical detail for a Granular Drain

As required under Building Regulations/Sewers for Adoption the surface water drainage system will need to be designed to;

- No surcharge for the 1 in 2 year event
- No flooding for the 1 in 30 year event
- No building flooding for the 1 in 100 year event with a 30% allowance for climate

Any flooding for the 100 year event with climate change will need to be stored on site to protect third party land from potential overland flows.

The Surface Water Management Plan (SWMP) as set out above will ensure the River Ehen receives no direct surface water flows and that the water quality will not be impacted upon by the proposed residetial development.

Including in Appendix D are the fact sheets regarding each proposed element of the SuDS surface water drainage system.

7.0 FOUL WATER

Foul water will discharge to the public sewerage system as agreed with United Utilities. A free discharge for foul flows has been agreed on the basis that a connection is not made before December 2014.

A copy of the correspondence is included in Appendix E.

8.0 CONCLUSIONS

This assessment has looked at the implications of the proposed Residential developments in relation to proposed drainage of the site.

A Surface Water Management Plan (SWMP) has been identified including the levels of treatment requirement to ensure the River Ehen water quality remains protected.

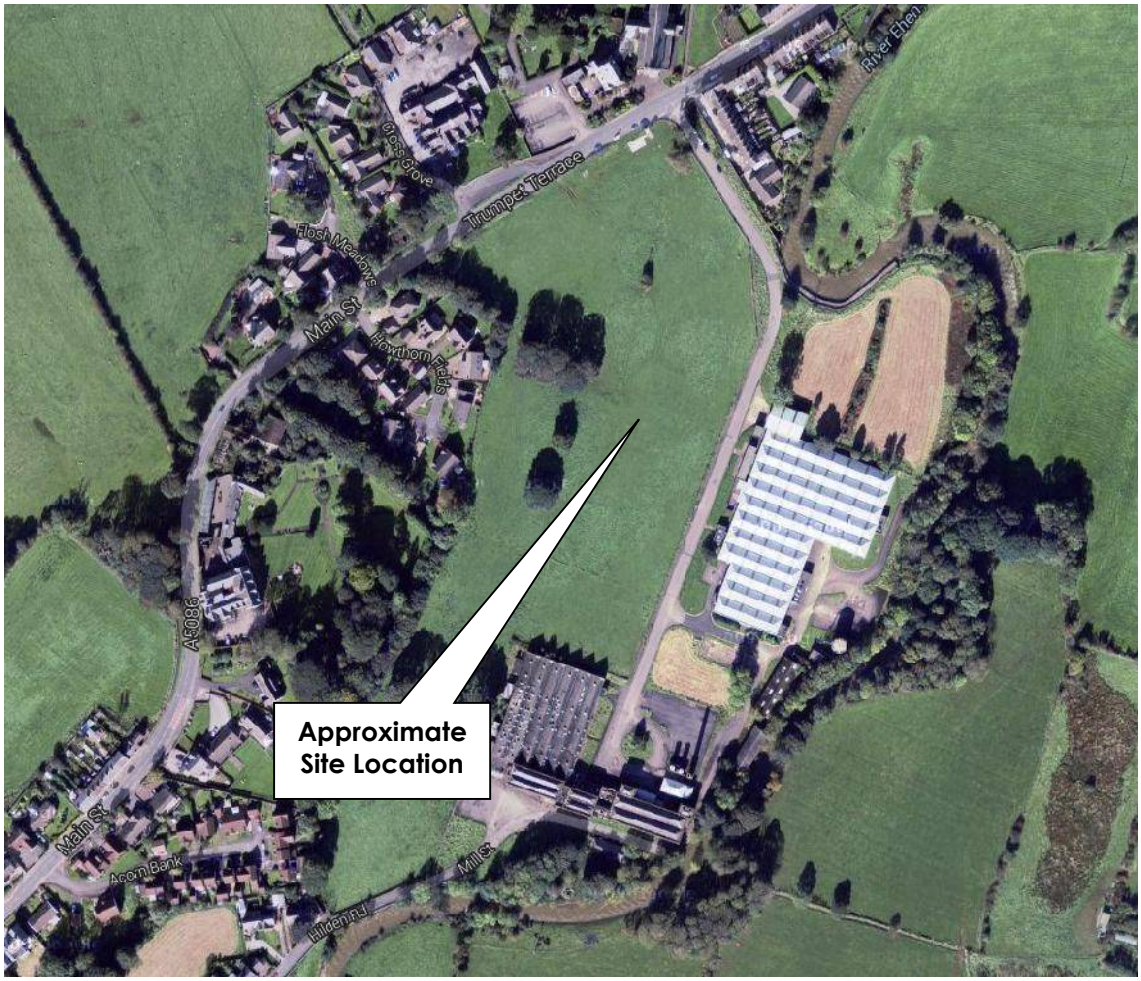
As the proposed surface water drainage system is a Sustainable Drainage System (SuDS) the rate of runoff from the proposed development site will not increase and as such the loading on the watercourse will not be impacted upon.

A foul discharge rate has been agreed with United Utilities, with a connection available from December 2014.

Any potential impact of the development can be adequately addressed by good drainage design.

Ross Oakley
For and behalf of RWO Associates Limited
January 2013

Appendix A Site Location Plan



Location Map	
Site	Cleator Mill - Residential
Client	North Associates
Job Number	13000
Scale	NTS

Appendix B Geo Environmental Engineering Soil Infiltration Tests

Appendix C Existing Drainage Survey

Appendix D CIRIA C697 Fact Sheets

Soakaways 6.5

Description

Soakaways are square or circular excavations, either filled with rubble or lined with brickwork, pre-cast concrete or polyethylene rings/perforated storage structures surrounded by granular backfill. They can be grouped and linked together to drain large areas including highways. The supporting structure and backfill can be substituted by modular, geocellular units (see Chapter 13). Soakaways provide stormwater attenuation, stormwater treatment and groundwater recharge.

KEY DESIGN CRITERIA

- design to meet site drainage standards – generally 1 in 10 or 1 in 30 year design event
- site infiltration rate assumed for design should be based on appropriate site investigations and should include an appropriate factor of safety
- appropriate pre-treatment is required
- if used, fill material should provide >30 per cent void space
- minimum distance of 1 m from the base to the seasonally high groundwater table
- minimum distance of 5 m from foundations.

ADVANTAGES

- minimal net land take
- provides groundwater recharge
- good volume reduction and peak flow attenuation
- good community acceptability
- easy to construct and operate
- can be retrofitted.

DISADVANTAGES

- not suitable for poor draining soils
- field investigations required to confirm infiltration rates
- not suitable for locations where infiltrating water may put structural foundations at risk, or where infiltrating water may adversely affect existing drainage patterns
- not appropriate for draining polluted runoff
- increased risk of groundwater pollution
- some uncertainty over long-term performance
- possible reduced performance during long wet periods
- where property owner responsible for operation and maintenance, performance difficult to guarantee.

PERFORMANCE

Peak flow reduction:	Good
Volume reduction:	Good
Water quality treatment:	Good
Amenity potential:	Poor
Ecology potential:	Poor

TREATMENT TRAIN SUITABILITY

Source control:	Yes
Conveyance:	No
Site system:	Yes
Regional system:	No

SITE SUITABILITY

Residential:	Yes
Commercial/industrial:	Yes
High density:	Yes
Retrofit:	Yes
Contaminated sites/sites above vulnerable groundwater	No

COST IMPLICATIONS

Land-take:	Low
Capital cost:	Low
Maintenance burden:	Low

POLLUTANT REMOVAL

Total suspended solids:	Medium
Nutrients:	Low
Heavy metals:	Medium

KEY MAINTENANCE REQUIREMENTS:

- removal of sediments/debris from pre-treatment device
- monitoring performance (using observation well).

Trenches

9

Description

Trenches are shallow excavations filled with rubble or stone that create temporary subsurface storage for either infiltration or filtration of stormwater runoff. Ideally they should receive lateral inflow from an adjacent impermeable surface, but point source inflows may be acceptable. Infiltration trenches allow water to exfiltrate into the surrounding soils from the bottom and sides of the trench. Filtration or filter trenches can be used to filter and convey stormwater to downstream SUDS components.

KEY DESIGN CRITERIA

- excavated trench 1–2 m depth filled with stone aggregate
- effective upstream pre-treatment to remove sediment and fine silts
- Infiltration should not be used where groundwater is vulnerable or to drain pollution hotspots
- observation wells and/or access points for maintenance of perforated pipe components.

ADVANTAGES

- infiltration can significantly reduce both runoff rates and volumes. It has been shown that important hydraulic benefits are also achieved with filter trenches
- infiltration provides a significant reduction in the pollutant load discharged to receiving body
- trenches can be incorporated easily into site landscaping and fit well beside roads.

DISADVANTAGES

- high clogging potential without effective pre-treatment – not for sites with fine particled soils (clays/silts) in upstream catchment
- build-up of pollution/blockages difficult to see
- high historic failure rate due to poor maintenance, wrong siting or high debris input
- limited to relatively small catchments
- high cost of replacing filter material should blockage occur.

PERFORMANCE:

Infiltration Trench (IT); Filter Trench (FT)	
Peak flow reduction:	Medium
Volume reduction:	Low (FT) High (IT)
Water quality treatment:	High
Amenity potential:	Low
Ecology potential:	Low

TREATMENT TRAIN SUITABILITY:

Source control:	Yes (IT)
Conveyance:	Yes
Site system:	No
Regional system:	No

SITE SUITABILITY:

Residential:	Yes
Commercial/Industrial:	Yes
High density:	Yes
Retrofit:	Yes
Contaminated sites/sites above vulnerable groundwater	No (IT) Yes (FT)

COST IMPLICATIONS:

Land-take:	Low
Capital cost:	Low (IT) Medium (if liner required)
Maintenance burden:	Medium

POLLUTANT REMOVAL

Total suspended solids:	High
Nutrients:	Low/Medium
Heavy metals:	High

KEY MAINTENANCE REQUIREMENTS

- Regular inspection for signs of clogging
- Removal of sediment from pre-treatment system
- Removal and cleaning or replacement of stone.

Pervious pavements 12

Description

Pervious pavements provide a pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into the underlying layers. The water is temporarily stored before infiltration to the ground, reuse, or discharge to a watercourse or other drainage system. Pavements with aggregate sub-bases can provide good water quality treatment.

KEY DESIGN CRITERIA

- pervious surface and sub-base to be structurally designed for site purpose and design vehicular loading
- surface infiltration rate should normally be an order of magnitude greater than the design rainfall intensity
- temporary subsurface storage volume to meet requirements for infiltration and/or controlled discharge
- geotextile may be specified as a filtration treatment component near the top of the structure
- soil and other material must be prevented from contaminating the pavement surface and sub-structure.

ADVANTAGES

- effective in removing urban runoff pollutants
- lined systems can be used where infiltration is not desirable, or where soil integrity would be compromised
- significant reduction in volume and rate of surface runoff
- suitable for installation in high density development
- good retrofit capability
- no additional land take, allows dual use of space
- low maintenance
- removes need for gully pots and manholes
- eliminates surface ponding and surface ice.
- good community acceptability.

DISADVANTAGES

- cannot be used where large sediment loads may be washed/carried onto the surface
- in the UK, current practice is to use on highways with low traffic volumes, low axle loads and speeds of less than 30 mph
- risk of long-term clogging and weed growth if poorly maintained.

PERFORMANCE:

Peak flow reduction:	Good
Volume reduction:	Good
Water quality treatment:	Good
Amenity potential:	Poor
Ecology potential:	Poor

TREATMENT TRAIN SUITABILITY:

Source control:	Yes
Conveyance:	No
Site system:	Yes
Regional system:	No

SITE SUITABILITY:

Residential:	Yes
Commercial/industrial:	Yes
High density:	Yes
Retrofit:	Yes
Contaminated sites/sites above vulnerable groundwater (with liner)	Yes

COST IMPLICATIONS:

Net Land-take:	Low
Capital cost:	Medium
(Net capital cost:	Low)
Maintenance cost:	Low

POLLUTANT REMOVAL:

Total suspended solids:	High
Nutrients:	High
Heavy metals:	High

KEY MAINTENANCE REQUIREMENTS

- sweeping
- regular brushing and vacuuming.

Geocellular/modular systems 13

Description

Modular plastic geocellular systems with a high void ratio that can be used to create a below ground infiltration (soakaway) or storage structure.

KEY DESIGN CRITERIA

- standard storage design using limiting discharges to determine storage volumes
- structural design to relevant standards for appropriate surface loadings
- appropriate geotextile/geomembrane for wrapping.

ADVANTAGES

- modular and flexible
- dual usage ie infiltration and/or storage
- high void ratios (up to 96%) providing high storage volume capacity
- lightweight, easy to install and robust
- capable of managing high flow events
- can be installed beneath trafficked or non-trafficked areas (providing structural performance is proven to be sufficient)
- long-term physical and chemical stability
- can be installed beneath public open spaces, eg play areas.

DISADVANTAGES

- no water quality treatment.

PERFORMANCE:

Peak flow reduction:	Good
Volume reduction (storage only)	Poor
Volume reduction (with infiltration)	Good
Water quality treatment:	Poor
Amenity potential	Poor
Ecology potential:	Poor

TREATMENT TRAIN SUITABILITY:

Source control:	Yes
Conveyance:	Possible
Site system:	Yes
Regional system:	Yes

SITE SUITABILITY:

Residential:	Yes
Commercial/Industrial:	Yes
High density:	Yes
Retrofit:	Yes
Contaminated sites/sites above vulnerable groundwater (with liner)	Yes

COST IMPLICATIONS:

Land-take:	Low
Capital cost:	Low
Maintenance burden:	Low

POLLUTANT REMOVAL:

Total suspended solids:	Low
Nutrients:	None
Heavy metals:	Low

KEY MAINTENANCE REQUIREMENTS

- regular inspection of silt traps, manholes, pipework and pre-treatment devices, with removal of sediment and debris as required.

Appendix E United Utilities Correspondence

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Appendix H Environmental Agency Flood Data

Table D1(1): POST NOVEMBER 2009 PEAK FLOWS & WATER LEVELS (RIVER EHEN & TRIBUTARIES)

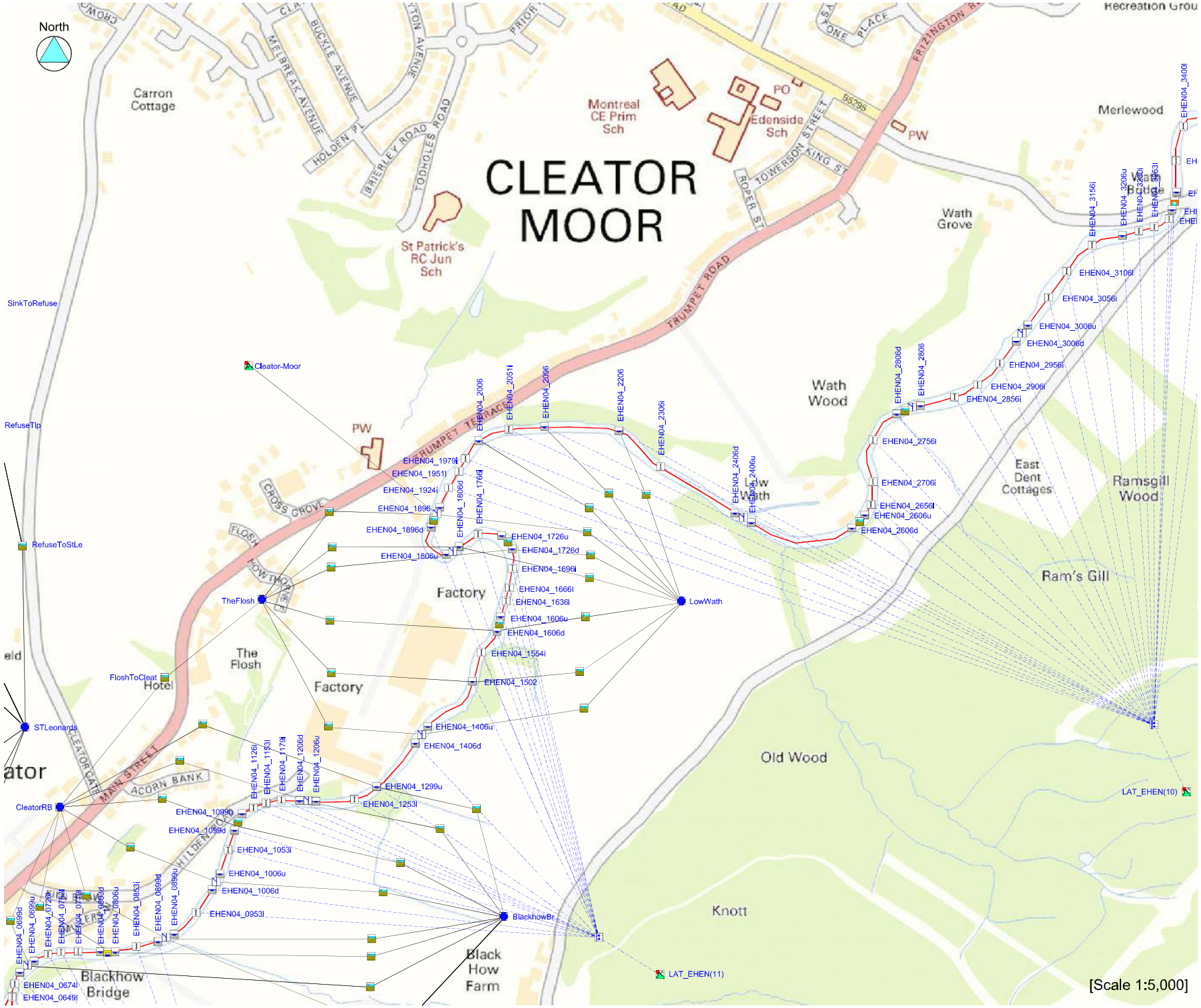
JBA Consulting
South Barn
Broughton Hall
Skipton BD23 3AE

						2-year		5-year		10-year		25-year		50-year		75-year	
Model Node	OS NGR	Location Description	LB Level	Right Bank Location Description	RB Level	Flow	Water Level	Flow	Water Level	Flow	Water Level	Flow	Water Level	Flow	Water Level	Flow	Water Level
Label Ref.		(Major Features)	(mAOD)	(Major Features)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)
EHEN04_4100u	NY 0364 1485	Open Fields	78.37	Open Fields	77.14	40.92	76.34	54.32	76.64	62.67	76.78	75.81	76.97	86.77	77.11	93.99	77.20
EHEN04_3900u	NY 0349 1473	Hazelholme Farm	77.25	Open Fields	75.85	40.95	75.68	54.36	75.95	62.73	76.11	75.91	76.36	86.89	76.50	94.09	76.58
EHEN04_3700u	NY 0330 1477	Immediately D/S of Hole Beck	74.98	Immediately D/S of Hole Beck	74.88	43.36	74.54	57.52	74.86	65.61	75.01	80.86	75.24	92.77	75.39	100.47	75.48
EHEN04_3500u	NY 0326 1458	Immediately D/S of Mere Beck	72.43	Immediately D/S of Mere Beck	72.60	43.37	72.66	57.53	72.94	65.61	73.08	80.89	73.38	92.81	73.65	100.52	73.85
EHEN04_3300u	NY 0317 1445	Wath Bridge	73.47	Wath Bridge	72.40	45.32	72.36	60.02	72.64	67.72	72.79	84.88	73.15	97.55	73.47	105.80	73.70
EHEN04_3206u	NY 0310 1440	Open Fields	73.03	Merlewood Residential Area (Cleator)	71.41	45.33	71.70	60.05	71.88	67.75	71.97	84.93	72.13	97.62	72.25	105.88	72.32
EHEN04_3006u	NY 0296 1427	Ramsgill Wood	77.21	Wath Wood	70.34	45.37	70.08	60.10	70.29	67.81	70.39	85.05	70.58	97.77	70.70	106.04	70.77
EHEN04_2806	NY 0280 1416	Ramsgill Wood	69.22	Wath Wood	69.69	45.41	69.00	60.16	69.23	67.88	69.33	85.17	69.53	97.91	69.64	106.20	69.71
EHEN04_2606u	NY 0273 1400	Ramsgill Wood	69.11	Low Wath	66.93	45.45	67.13	60.21	67.38	67.94	67.50	85.29	67.73	98.06	67.88	106.36	67.97
EHEN04_2406u	NY 0255 1402	Ramsgill Wood	69.39	Low Wath	65.33	45.49	65.53	60.26	65.79	68.00	65.92	85.40	66.17	98.20	66.31	106.52	66.41
EHEN04_2206	NY 0239 1413	Open Fields	65.35	Woods	68.97	45.52	64.63	60.31	64.94	68.05	65.09	85.52	65.37	98.35	65.48	106.68	65.55
EHEN04_2096	NY 0228 1413	Open Fields	64.89	Woods	68.53	45.54	64.25	60.34	64.58	68.09	64.74	85.38	65.03	95.71	65.14	102.16	65.19
EHEN04_2006	NY 0219 1411	Open Fields	65.04	Trumpet Terrace (Cleator)	72.75	45.56	63.67	60.37	63.96	68.12	64.09	85.41	64.28	95.27	64.38	101.20	64.43
EHEN04_1896	NY 0213 1402	Open Fields	63.84	Brookside (Cleator)	65.09	45.58	63.28	60.40	63.63	68.06	63.78	84.23	63.98	93.04	64.07	98.19	64.12
EHEN04_1806u	NY 0215 1396	Open Fields	63.72	Cleator Mills	63.52	46.23	62.45	61.24	62.67	68.54	62.77	81.34	62.94	87.51	63.01	90.97	63.06
EHEN04_1726u	NY 0222 1398	Open Fields	63.57	Cleator Mills	63.40	46.24	62.12	61.25	62.34	68.55	62.44	81.35	62.60	87.54	62.67	91.00	62.71
EHEN04_1606u	NY 0222 1387	Open Fields	62.64	Cleator Mills	62.49	46.25	60.73	61.26	61.01	68.57	61.14	81.38	61.34	87.58	61.43	91.04	61.47
EHEN04_1502	NY 0218 1377	Open Fields	63.70	Cleator Mills	61.48	46.26	59.62	61.27	59.90	68.58	60.02	81.41	60.26	87.61	60.40	91.07	60.49
EHEN04_1406u	NY 0212 1371	Open Fields	62.11	Cleator Mills	60.44	46.26	59.21	61.28	59.51	68.59	59.63	81.49	59.91	88.12	60.08	92.08	60.19
EHEN04_1299u	NY 0205 1363	Open Fields	61.92	Cleator Mills	60.02	46.27	58.76	61.29	59.04	68.80	59.14	87.08	59.33	100.24	59.45	108.71	59.51
EHEN04_1206u	NY 0196 1361	Open Fields	58.63	Cleator Mills	59.19	46.28	58.29	61.29	58.53	68.74	58.62	86.65	58.78	99.36	58.87	107.45	58.93
EHEN04_1099u	NY 0186 1359	Open Fields	58.21	Hilden Road	58.47	46.22	57.81	59.03	58.05	64.62	58.14	77.07	58.30	85.41	58.39	90.65	58.44
EHEN04_1006u	NY 0183 1350	Open Fields	57.71	Hilden Road	57.45	46.23	56.99	59.02	57.19	64.52	57.25	76.61	57.35	84.18	57.41	88.63	57.45
EHEN04_0899u	NY 0176 1342	Blackhow Bridge Tributary	56.79	Kiln Brow Residential Area	56.90	45.71	56.57	54.89	56.80	58.47	56.88	65.80	57.03	69.80	57.11	72.01	57.15
EHEN04_0806u	NY 0167 1340	Blackhow Bridge	57.73	Blackhow Bridge	56.95	46.05	56.07	55.31	56.29	58.78	56.37	65.92	56.56	69.26	56.67	70.83	56.73
EHEN04_0699u	NY 0157 1339	Open Fields	55.95	Ehen Bank	56.21	46.08	55.02	56.67	55.26	60.97	55.35	70.55	55.57	76.07	55.69	79.14	55.76
EHEN04_0599u	NY 0153 1330	Open Fields	55.37	Ehen Hall	56.40	46.27	54.71	59.87	54.94	66.05	55.03	81.00	55.23	91.29	55.35	97.64	55.42
EHEN04_0498	NY 0152 1320	Open Fields	54.30	Forge mill Channel	54.19	46.28	54.04	59.48	54.30	65.22	54.39	77.98	54.55	86.08	54.64	91.24	54.70
EHEN04_0432u	NY 0152 1313	Open Fields	54.19	Forge Mill	53.95	46.29	53.50	58.97	53.74	63.44	53.81	72.53	53.96	77.87	54.08	81.15	54.14
EHEN04_0323u	NY 0144 1305	Open Fields	54.08	Forge Mill	54.22	46.30	52.92	58.99	53.17	63.46	53.26	72.56	53.42	77.92	53.52	81.20	53.59
EHEN04_0169u	NY 130 1302	Open Fields	53.58	Forge Mill	53.97	46.32	52.50	59.02	52.77	63.49	52.87	72.64	53.04	78.36	53.15	82.07	53.22
EHEN04_0092u	NY 0124 1295	Ehen/Keekle Confluence Footbridge	53.82	Ehen/Keekle Confluence Footbridge	53.42	46.34	52.19	59.06	52.45	63.50	52.56	72.68	52.72	78.77	52.81	82.92	52.87
EHEN04_0008	NY 0119 1289	Cleator GS (former location of)	53.05	Cleator GS (former location of)	51.73	46.36	52.04	60.38	52.28	66.07	52.37	78.44	52.48	87.19	52.55	92.80	52.61
EHEN03_5958u	NY 0116 1281	Woodend Pond	52.00	Woodend	55.87	68.89	51.94	88.73	52.17	99.92	52.25	112.98	52.34	123.98	52.41	131.89	52.46
EHEN03_5758u	NY 0116 1262	Woodend pond	51.96	Woodend Mill	51.60	68.97	50.66	83.61	50.91	89.49	51.00	95.66	51.12	100.57	51.20	104.06	51.26
EHEN03_5631u	NY 0115 1249	Woodend Dismantled Railway Footbridge	53.02	Woodend Dismantled Railway Footbridge	53.02	69.02	50.25	83.68	50.40	89.59	50.47	95.79	50.55	100.74	50.61	104.24	50.65
EHEN03_5358	NY 0114 1223	Egremont Water Feature Weir No.1	49.73	Egremont Water Feature Weir No.1	51.75	65.96	49.77	77.65	49.92	81.99	50.01	86.07	50.13	89.19	50.21	91.35	50.26
EHEN03_5158	NY 0127 1209	Egremont Water Feature Weir No.2	49.22	Egremont Water Feature Weir No.2	49.28	61.96	49.02	75.65	49.18	83.91	49.27	95.33	49.38	104.17	49.45	109.94	49.50
EHEN03_4958u	NY 0140 1195	Open Fields	50.90	Open Fields	48.37	52.74	47.79	60.95	47.93	65.72	47.99	72.34	48.07	78.37	48.14	82.35	48.18
EHEN03_4758u	NY 0143 1176	Open Fields	47.74	Open Fields	47.67	52.59	46.96	59.30	47.11	62.67	47.17	66.92	47.25	70.46	47.31	72.61	47.35
EHEN03_4558u	NY 0152 1158	Briscoemill Bridge	48.28	Briscoemill Bridge	46.98	52.84	46.20	59.24	46.38	62.12	46.46	65.28	46.55	67.57	46.64	68.69	46.71
EHEN03_4413u	NY 0154 1144	Mill Lea	48.51	Briscoe Road Residential Area	46.05	52.82	45.80	58.31	46.02	60.23	46.15	61.66	46.32	62.91	46.46	64.64	46.54
EHEN03_4213u	NY 0141 1131	Mill Lea Weir	45.26	Mill Lea Weir	45.28	69.58	45.42	90.35	45.62	104.42	45.72	125.09	45.86	142.04	45.96	153.42	46.02
EHEN03_4132	NY 0133 1129	Playing Fields	45.08	Back Gardens of Briscoe Road Residential Area	45.19	69.31	45.06	86.38	45.25	97.85	45.33	114.72	45.42	128.81	45.48	138.26	45.52
EHEN03_4013	NY 0126 1121	Playing Fields	44.94	Esat Road Residential Area	48.58	69.32	44.54	83.44	44.74	91.32	44.84	102.38	44.97	112.18	45.05	118.69	45.10
EHEN03_3936	NY 0128 1114	Playing Fields	44.69	Wyndham Terrace	46.78	69.33	44.08	83.46	44.28	91.34	44.38	102.00	44.51	110.17	44.64	115.18	44.74
EHEN03_3813	NY 0136 1135	Open Fields	44.37	High Mill House	43.86	69.35	43.20	83.48	43.46	91.37	43.61	102.04	43.82	111.01	44.02	117.58	44.10
EHEN03_3609	NY 0141 1085	Egremont F/Bridge (D/S Face)	44.37	Egremont F/Bridge (D/S Face)	43.86	69.59	42.89	90.40	43.27	104.52	43.48	125.19	43.77	142.17	44.11	153.58	44.18
EHEN03_3587i	NY 0141 1082	Interpolated XS U/S Egremont GS	44.37	Interpolated XS U/S Egremont GS	43.86	69.60	42.47	90.42	42.75	104.54	42.88	125.21	43.38	142.12	43.92	153.56	43.97
EHEN03_3577i	NY 0141 1079	Egremont GS (Interpolated XS)	44.37	Egremont GS (Interpolated XS)	43.86	69.60	42.47	90.42	42.75	104.54	42.88	125.21	43.25	142.12	43.49	153.56	43.48
EHEN03_3567i	NY 0136 1135	Interpolated XS D/S Egremont GS	44.37	Interpolated XS D/S Egremont GS	43.86	69.60	42.34	90.42	42.62	104.54	42.76	125.22	43.15	142.12	43.40	153.57	43.39
EHEN03_3712u	NY 0139 1095	Open Channel	43.39	Wyndham Place	43.90	69.60	42.27	90.42	42.50	104.54	42.65	125.22	42.88	142.13	43.09	153.57	43.25
EHEN03_3613u	NY 0140 1085	Egremont Fields Footbridge	43.66	Egremont Fields Footbridge	43.45	69.60	42.27	90.42	42.54	104.55	42.71	125.23	42.97	142.13	43.12	153.58	43.20
EHEN03_3533u	NY 0140 1077	Open Fields	42.66	A595(T) New Egremont Bypass Road	43.01	69.61	42.10	90.43	42.36	104.55	42.54	125.24	42.75	142.12	42.90	153.59	42.99
EHEN03_3477u	NY 0138 1072	A595(T) New Bypass Bridge	47.33	A595(T) New Egremont Bypass Bridge	48.18	69.61	41.96	90.44	42.18	104.57	42.34	125.26	42.56	142.12	42.69	153.62	42.78
EHEN03_3396u	NY 0136 1065	A595(T) New Egremont Bypass Road	42.17	Beck Green (Egremont)	43.14	69.63	41.34	90.45	41.62	104.58	41.74	125.28	41.90	142.13	42.01	153.65	42.09
EHEN03_3301u	NY 0141 1057	A595(T) New Egremont Bypass Road	40.84	Beck Green (Egremont)	41.68	69.64	41.00	90.47	41.24	104.60	41.38	125.31	41.57	142.16	41.71	153.69	41.80
EHEN03_3220u	NY 0143 1049	A595(T) New Egremont Bypass Road	40.53	Egremont Nursery	40.48	69.65	40.49	90.48	40.70	104.63	40.82	125.36	41.00	142.29	41.13	153.83	41.21
EHEN03_3101u	NY 0139 1038	Black Beck Tributary	40.85	Cross Side (Egremont)	39.98	69.67	39.83	90.50	40.05	104.65	40.13	125.38	40.24	142.28	40.33	153.84	40.38
EHEN03_3005u	NY 0131 1034	Woodbank	40.80	Cross Side (Egremont)	39.47	70.34	39.27	91.27	39.44	105.68	39.64	126.82	39.78	143.97	39.92	155.71	40.00
EHEN03_2901	NY 0121 1037	Egremont Bridge End Concrete Weir	40.63	Egremont Bridge End Concrete Weir	39.25	70.36	38.96	91.27	39.06	105.69	39.13	126.81	39.32	143.96	39.50	155.72	39.62
EHEN03_2780u	NY 0101 1040	Egremont Bridge (A595 Old Road)	39.35	Egremont Bridge (A595 Old Road)	40.26	70.37	38.03	91.28	38.33	105.70	38.51	126.81	38.78	143.98	38.98	155.73	39.13
EHEN03_2726u	NY 0101 1038	Bridge End	38.18	Skirting Beck Tributary	37.77	70.37	37.55	91.28	37.78	105.71	37.91	126.82	38.10	143.99	38.21	155.74	38.27
EHEN03_2613u	NY 0095 1032	Egremont Rugby Football Ground	37.70	Allotment Gardens	37.27	70.79	37.09	91.74	37.27	106.32	37.45	127.70	37.68	144.40	37.82	154.91	37.89
EHEN03_2534u	NY 0093 1025	Egremont Rugby Football Ground Pavilion	37.84	Dale View Gardens (Egremont)	42.32	70.78	36.58	91.75	36.84	106.33	37.00	127.71	37.21	144.15	37.34	154.08	37.41

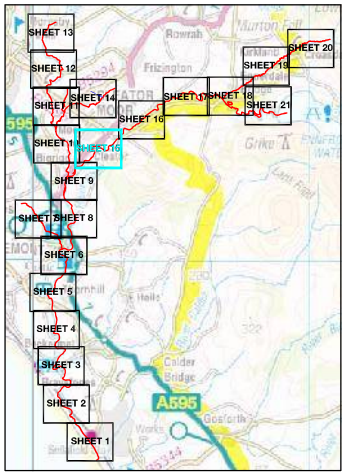
Table D1(2): POST NOVEMBER 2009 PEAK FLOWS & WATER LEVELS (RIVER EHEN & TRIBUTARIES)

JBA Consulting
South Barn
Broughton Hall
Skipton BD23 3AE

						100-year		100-year+20%		150-year		200-year		1000-year	
Model Node	OS NGR	Location Description	LB Level	Right Bank Location Description	RB Level	Flow	Water Level	Flow	Water Level	Flow	Water Level	Flow	Water Level	Flow	Water Level
Label Ref.		(Major Features)	(mAOD)	(Major Features)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)	(m3/s)	(mAOD)
EHEN04_4900u	NY 0421 1532	Open Fields	81.90	Open Fields	81.94	100.81	82.09	114.10	82.21	107.23	82.15	114.02	82.21	153.84	82.53
EHEN04_4700u	NY 0408 1518	Open Fields	82.49	Open Fields	80.68	100.90	80.61	114.18	80.74	107.31	80.67	114.10	80.74	153.94	81.06
EHEN04_4500u	NY 0395 1508	Open Fields	80.12	Open Fields	79.53	100.99	79.96	114.27	80.10	107.39	80.03	114.17	80.10	154.03	80.44
EHEN04_4300u	NY 0381 1495	Open Fields	78.53	Open Fields	80.47	101.08	78.41	114.35	78.51	107.47	78.46	114.25	78.51	154.13	78.73
EHEN04_4100u	NY 0364 1485	Open Fields	78.37	Open Fields	77.14	101.18	77.29	114.43	77.44	107.55	77.36	114.33	77.44	154.23	77.83
EHEN04_3900u	NY 0349 1473	Hazelholme Farm	77.25	Open Fields	75.85	101.27	76.66	114.51	76.79	107.63	76.72	114.41	76.79	154.33	77.12
EHEN04_3700u	NY 0330 1477	Immediately D/S of Hole Beck	74.98	Immediately D/S of Hole Beck	74.88	108.25	75.57	121.61	75.71	114.74	75.64	120.72	75.70	163.16	76.10
EHEN04_3500u	NY 0326 1458	Immediately D/S of Mere Beck	72.43	Immediately D/S of Mere Beck	72.60	108.30	73.99	121.66	74.28	114.80	74.14	120.76	74.25	163.20	74.80
EHEN04_3300u	NY 0317 1445	Wath Bridge	73.47	Wath Bridge	72.40	112.20	73.85	126.82	74.16	119.34	74.01	124.72	74.12	170.45	74.68
EHEN04_3206u	NY 0310 1440	Open Fields	73.03	Merlewood Residential Area (Cleator)	71.41	112.26	72.37	126.90	72.49	119.40	72.43	124.79	72.47	170.51	72.82
EHEN04_3006u	NY 0296 1427	Ramsgill Wood	77.21	Wath Wood	70.34	112.39	70.82	127.07	70.93	119.54	70.88	124.95	70.91	170.65	71.22
EHEN04_2806	NY 0280 1416	Ramsgill Wood	69.22	Wath Wood	69.69	112.51	69.77	127.24	69.88	119.67	69.82	125.12	69.86	170.78	70.18
EHEN04_2606u	NY 0273 1400	Ramsgill Wood	69.11	Low Wath	66.93	112.64	68.04	127.41	68.18	119.81	68.10	125.27	68.16	170.91	68.54
EHEN04_2406u	NY 0255 1402	Ramsgill Wood	69.39	Low Wath	65.33	112.76	66.47	127.58	66.62	119.95	66.55	125.43	66.60	171.04	67.02
EHEN04_2206	NY 0239 1413	Open Fields	65.35	Woods	68.97	112.89	65.59	127.75	65.67	120.08	65.63	125.59	65.66	171.17	65.89
EHEN04_2096	NY 0228 1413	Open Fields	64.89	Woods	68.53	106.92	65.23	118.28	65.30	112.43	65.26	116.63	65.29	150.74	65.50
EHEN04_2006	NY 0219 1411	Open Fields	65.04	Trumpet Terrace (Cleator)	72.75	105.49	64.47	115.63	64.55	110.43	64.51	114.17	64.54	142.51	64.70
EHEN04_1896	NY 0213 1402	Open Fields	63.84	Brookside (Cleator)	65.09	101.87	64.15	110.27	64.22	106.03	64.19	109.10	64.21	131.37	64.39
EHEN04_1806u	NY 0215 1396	Open Fields	63.72	Cleator Mills	63.52	93.14	63.08	98.80	63.15	95.89	63.12	97.97	63.14	111.20	63.28
EHEN04_1726u	NY 0222 1398	Open Fields	63.57	Cleator Mills	63.40	93.16	62.74	98.83	62.80	95.92	62.77	98.00	62.79	111.23	62.93
EHEN04_1606u	NY 0222 1387	Open Fields	62.64	Cleator Mills	62.49	93.20	61.50	98.88	61.58	95.96	61.54	98.05	61.57	111.28	61.73
EHEN04_1502	NY 0218 1377	Open Fields	63.70	Cleator Mills	61.48	93.22	60.54	98.91	60.70	95.99	60.62	98.08	60.68	111.33	60.97
EHEN04_1406u	NY 0212 1371	Open Fields	62.11	Cleator Mills	60.44	94.66	60.27	101.79	60.45	98.06	60.36	100.72	60.43	120.43	60.68
EHEN04_1299u	NY 0205 1363	Open Fields	61.92	Cleator Mills	60.02	114.36	59.54	129.08	59.63	121.56	59.59	126.95	59.62	168.56	59.87
EHEN04_1206u	NY 0196 1361	Open Fields	58.63	Cleator Mills	59.19	112.75	58.97	126.34	59.05	119.44	59.01	124.40	59.04	160.63	59.25
EHEN04_1099u	NY 0186 1359	Open Fields	58.21	Hilden Road	58.47	94.03	58.47	102.53	58.56	98.24	58.51	101.33	58.55	123.61	58.76
EHEN04_1006u	NY 0183 1350	Open Fields	57.71	Hilden Road	57.45	91.42	57.47	98.32	57.51	94.89	57.49	97.36	57.51	114.79	57.62
EHEN04_0899u	NY 0176 1342	Blackhow Bridge Tributary	56.79	Kiln Brow Residential Area	56.90	73.43	57.18	76.60	57.24	75.10	57.21	76.20	57.23	83.38	57.39
EHEN04_0806u	NY 0167 1340	Blackhow Bridge	57.73	Blackhow Bridge	56.95	71.62	56.76	73.44	56.87	72.66	56.81	73.23	56.86	75.53	57.12
EHEN04_0699u	NY 0157 1339	Open Fields	55.95	Ehen Bank	56.21	80.90	55.80	86.20	55.92	83.52	55.86	85.42	55.90	98.51	56.24
EHEN04_0599u	NY 0153 1330	Open Fields	55.37	Ehen Hall	56.40	101.59	55.46	113.22	55.57	107.23	55.51	111.46	55.55	143.12	55.82
EHEN04_0498	NY 0152 1320	Open Fields	54.30	Forge mill Channel	54.19	94.41	54.73	103.68	54.82	98.92	54.78	102.28	54.81	127.11	55.00
EHEN04_0432u	NY 0152 1313	Open Fields	54.19	Forge Mill	53.95	83.21	54.17	89.39	54.27	86.16	54.23	88.42	54.26	105.59	54.43
EHEN04_0323u	NY 0144 1305	Open Fields	54.08	Forge Mill	54.22	83.25	53.63	88.57	53.75	86.12	53.69	87.88	53.73	97.58	54.01
EHEN04_0169u	NY 130 1302	Open Fields	53.58	Forge Mill	53.97	84.45	53.27	91.09	53.41	87.87	53.34	90.16	53.39	103.14	53.72
EHEN04_0092u	NY 0124 1295	Ehen/Keekle Confluence Footbridge	53.82	Ehen/Keekle Confluence Footbridge	53.42	85.64	52.90	93.58	53.02	89.60	52.96	92.42	53.00	110.82	53.28
EHEN04_0008	NY 0119 1289	Cleator GS (former location of)	53.05	Cleator GS (former location of)	51.73	96.44	52.65	107.04	52.77	101.64	52.71	105.46	52.75	132.35	53.01
EHEN03_5958u	NY 0116 1281	Woodend Pond	52.00	Woodend	55.87	137.97	52.49	156.30	52.59	147.14	52.54	153.34	52.58	195.74	52.79
EHEN03_5758u	NY 0116 1262	Woodend pond	51.96	Woodend Mill	51.60	106.68	51.30	114.31	51.42	110.55	51.36	113.10	51.40	130.07	51.65
EHEN03_5631u	NY 0115 1249	Woodend Dismantled Railway Footbridge	53.02	Woodend Dismantled Railway Footbridge	53.02	106.85	50.67	114.53	50.76	110.74	50.72	113.30	50.74	130.32	50.92
EHEN03_5358	NY 0114 1223	Egremont Water Feature Weir No.1	49.73	Egremont Water Feature Weir No.1	51.75	92.91	50.30	97.34	50.40	95.20	50.35	96.64	50.39	105.48	50.61
EHEN03_5158	NY 0127 1209	Egremont Water Feature Weir No.2	49.22	Egremont Water Feature Weir No.2	49.28	113.98	49.53	126.00	49.65	119.90	49.60	124.06	49.63	151.65	49.86
EHEN03_4958u	NY 0140 1195	Open Fields	50.90	Open Fields	48.37	85.21	48.20	91.65	48.26	87.09	48.22	90.15	48.25	137.90	48.50
EHEN03_4758u	NY 0143 1176	Open Fields	47.74	Open Fields	47.67	74.06	47.37	77.19	47.44	74.96	47.40	76.46	47.43	90.98	47.61
EHEN03_4558u	NY 0152 1158	Briscoemill Bridge	48.28	Briscoemill Bridge	46.98	69.24	46.76	69.89	46.92	69.71	46.84	69.77	46.90	72.06	47.27
EHEN03_4413u	NY 0154 1144	Mill Lea	48.51	Briscoe Road Residential Area	46.05	66.32	46.60	74.68	46.77	70.31	46.68	73.31	46.74	89.15	47.12
EHEN03_4213u	NY 0141 1131	Mill Lea Weir	45.26	Mill Lea Weir	45.28	161.42	46.07	187.09	46.20	173.95	46.14	182.87	46.18	245.77	46.44
EHEN03_4132	NY 0133 1129	Playing Fields	45.08	Back Gardens of Briscoe Road Residential Area	45.19	144.93	45.54	166.47	45.60	155.40	45.57	162.87	45.59	216.91	45.78
EHEN03_4013	NY 0126 1121	Playing Fields	44.94	Esat Road Residential Area	48.58	123.34	45.13	138.37	45.21	130.63	45.17	135.88	45.20	170.27	45.54
EHEN03_3936	NY 0128 1114	Playing Fields	44.69	Wyndham Terrace	46.78	118.69	44.81	129.91	45.01	124.16	44.91	128.09	44.98	152.42	45.58
EHEN03_3813	NY 0136 1135	Open Fields	44.37	High Mill House	43.86	122.16	44.19	136.02	44.45	129.03	44.31	133.86	44.39	162.55	45.30
EHEN03_3609	NY 0141 1085	Egremont F/Bridge (D/S Face)	44.37	Egremont F/Bridge (D/S Face)	43.86	161.64	44.35	187.34	44.72	174.19	44.53	183.11	44.64	245.92	45.62
EHEN03_3587i	NY 0141 1082	Interpolated XS U/S Egremont GS	44.37	Interpolated XS U/S Egremont GS	43.86	161.66	44.19	187.37	44.62	174.25	44.41	183.14	44.53	245.96	45.56
EHEN03_3577i	NY 0141 1079	Egremont GS (Interpolated XS)	44.37	Egremont GS (Interpolated XS)	43.86	161.66	43.56	187.37	43.80	174.25	43.68	183.14	43.76	245.96	44.25
EHEN03_3567i	NY 0136 1135	Interpolated XS D/S Egremont GS	44.37	Interpolated XS D/S Egremont GS	43.86	161.66	43.43	187.38	43.65	174.26	43.54	183.15	43.61	245.98	44.11
EHEN03_3712u	NY 0139 1095	Open Channel	43.39	Wyndham Place	43.90	161.67	43.33	187.38	43.61	174.27	43.48	183.15	43.56	245.98	44.02
EHEN03_3613u	NY 0140 1085	Egremont Fields Footbridge	43.66	Egremont Fields Footbridge	43.45	161.67	43.28	187.39	43.56	174.27	43.44	183.16	43.51	245.99	44.03
EHEN03_3533u	NY 0140 1077	Open Fields	42.66	A595(T) New Egremont Bypass Road	43.01	161.68	43.09	187.40	43.31	174.28	43.19	183.17	43.27	246.01	43.80
EHEN03_3477u	NY 0138 1072	A595(T) New Bypass Bridge	47.33	A595(T) New Egremont Bypass Bridge	48.18	161.70	42.84	187.43	43.03	174.30	42.93	183.19	43.00	246.04	43.39
EHEN03_3396u	NY 0136 1065	A595(T) New Egremont Bypass Road	42.17	Beck Green (Egremont)	43.14	161.73	42.14	187.47	42.30	174.34	42.22	183.23	42.27	246.09	42.61
EHEN03_3301u	NY 0141 1057	A595(T) New Egremont Bypass Road	40.84	Beck Green (Egremont)	41.68	161.77	41.86	187.51	42.04	174.38	41.95	183.27	42.01	246.15	42.41



KEYPLAN



LEGEND

- Centreline
- Latertal Inflow Connections
- FEH Boundary
- Interpolate
- Lateral Inflow
- Reservoir
- NC Boundary
- Culvert Inlet
- Open Channel
- Culvert Outlet
- Spill
- Rectangular Conduit
- Rectangular Bridge
- Symmetrical Conduit
- Arch Bridge
- Sprung Arch Conduit
- Junction
- Circular Conduit

All Arch & Rectangular Bridges modelled as shown below

JBA consulting

Nov-2009 Cumbrian Floods

FIGURE C2

River Ehen Catchment
Schematic of River Ehen Model
(Sheet 15 of 21)

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