# FLOOD RISK AND DRAINAGE ASSESSMENT

## Cleator Mill,
## Proposed Residential Development,
## Flood Risk Assessment.

| | |
|---|---|
| Reference | RO/FRA/RES/19002.1 |
| Date | November 2020 |
| Version | 1 |

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**Confidentiality Statement**

**Document History**

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# APPENDICES

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## CONFIDENTIALITY STATEMENT

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

Gleeson Regeneration Ltd
Rural Enterprise Centre
Redhills
Penrith
Cumbria
CA11 0DT

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 | 04.11.2020 |
| | | |
| | | |

# 1.0 EXECUTIVE SUMMARY

This assessment has looked at the implications of the proposed Residential developments 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 undertaken a comparison between the existing flood defences and modelled flood levels, the site is protected to a minimum of the 1:1000-year 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.

A proposed minimum FFL of 61.658m AOD has been recommended based upon the 1:100 plus climate change year return period plus 600mm freeboard.

Careful grading of the land and establishing the FFL will ensure that the surface water runoff passes through the site without risk of damage to property.

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 Gleeson Regeneration client to prepare a Flood Risk Assessment to support a planning application for a proposed residential development at Cleator in Cumbria.

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.

Envireau Water have been utilised to undertake Breach Analysis of the existing flood defences located on the North and Eastern boundaries. The proposed development site has previously been granted outline planning permission for residential use, with RWO Associates Flood Risk assessment reference RO/FRA/RES/13000.3 utilised as part of the previous planning application.

The site is currently Greenfield in nature and client wishes to create residential 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.

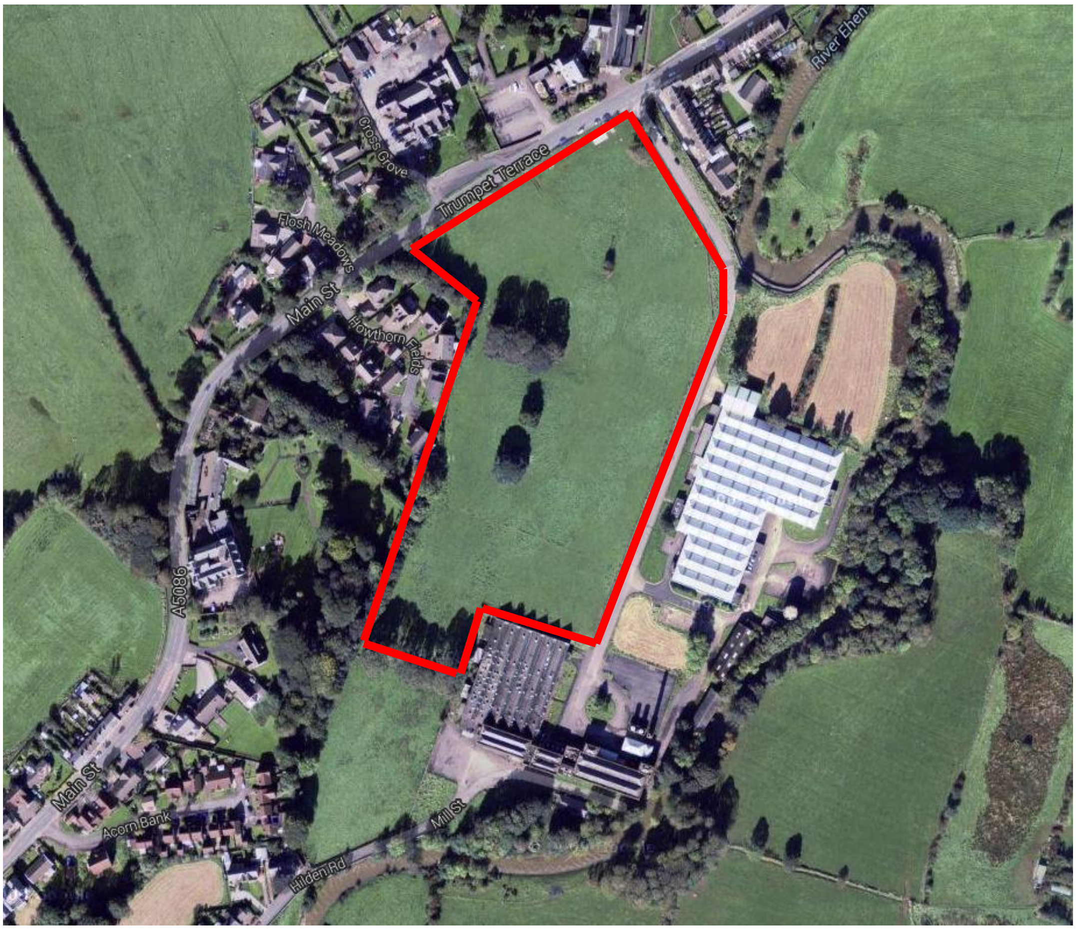



**Figure 1 – Site Location (Red line indicates approxiamte extents)**

The River Ehen forms the eastern and southern boundary, with residential dwellings located to the west and north. To the immediate south of the proposed development site is the former Kangol hat factory, with the building varying in age between the early 19th Century and the 1960's. The original building was a linen mill in the 19th Century. The eastern portion of the site has a derelict factory located on it, currently owned by Gates. The A5086 is on the north-western boundary of the proposed development site.

## 4.0 PROPOSED DEVELOPMENT

It is proposed to consider the site for residential development, with circa 115 dwellings to be constructed. 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 identified as E8) with the full map included in Appendix B.

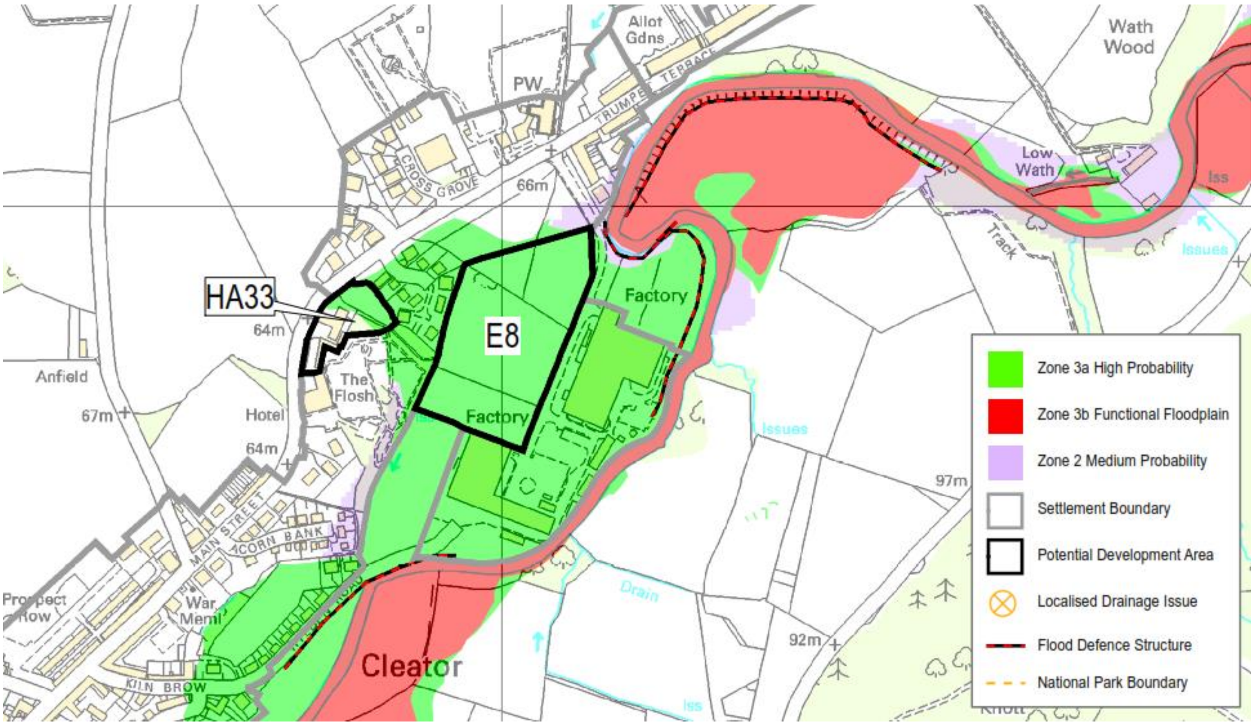


**Figure 2 – Copeland SFRA Extract**

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%), it will therefore be subject to the sequential and exception test in accordance with NPPF Technical Guidance.

A 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. Modelled flood levels have been reviewed based upon the Environment Agency hydraulic modelling with further breach analysis undertaken by Envireau Water on behalf of the developer. The Environment Agency modelled flood levels are included below in table 1.

| Cross Section reference | 10 Year | 25 Year | 50 Year | 75 Year | 100 Year | 100+CC Year | 200 Year | 1000 Year |
|---|---|---|---|---|---|---|---|---|
| 1896 | 63.74 | 63.852 | 63.898 | 63.941 | 63.972 | 64.029 | 64.7 | 64.939 |
| 1726 | 62.013 | 62.223 | 62.32 | 62.42 | 62.472 | 62.692 | 63.383 | 63.685 |
| 1806 | 63.052 | 63.284 | 63.418 | 63.553 | 63.621 | 63.823 | 63.779 | 64.135 |
| 1606 | 60.846 | 61.066 | 61.219 | 61.368 | 61.442 | 61.658 | 61.61 | 62.193 |
| 1502 | 60.275 | 60.504 | 60.626 | 60.744 | 60.808 | 61.001 | 60.953 | 61.398 |
| 1406 | 59.892 | 60.118 | 60.224 | 60.379 | 60.451 | 60.559 | 60.56 | 61.039 |
| 1299 | 59.379 | 59.549 | 59.64 | 59.733 | 59.775 | 59.912 | 60.56 | 61.039 |
| 1206 | 58.826 | 58.938 | 58.992 | 59.044 | 59.056 | 59.075 | 59.071 | 59.234 |

**Table 1 – Modelled Flood Levels (defended)**

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

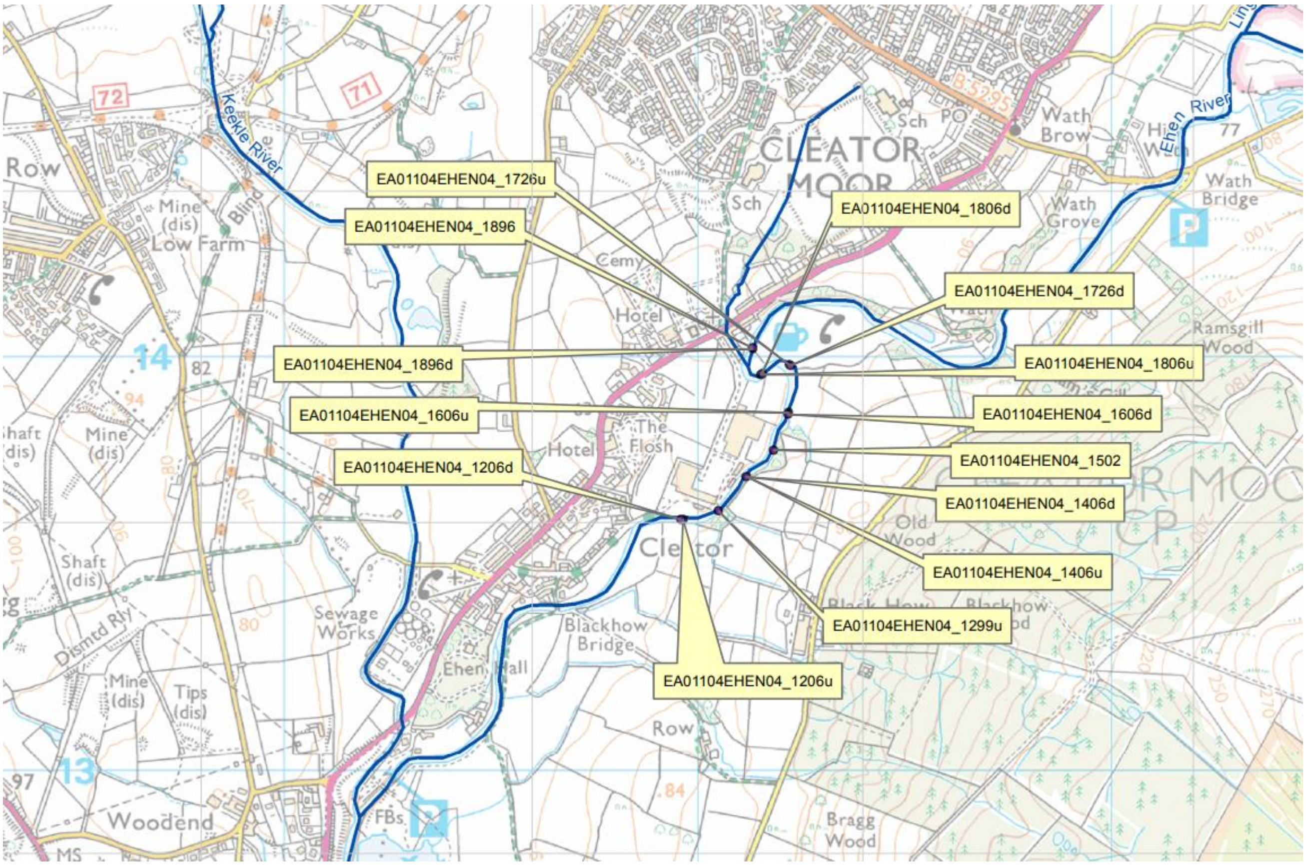



**Figure 3 – Modelled Node Locations**

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;

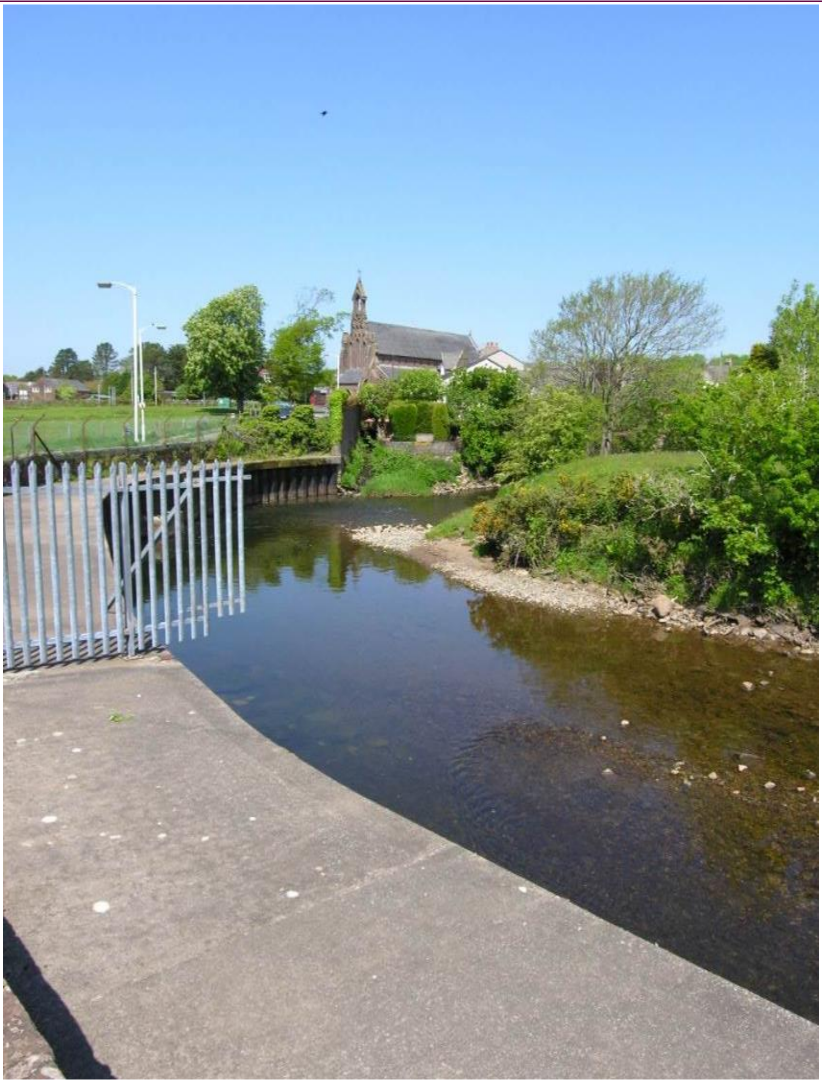


**Photo 1 – Hard flood defences between 1896 & 1726**

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-referenced against a topographical survey undertaken by Site; this is included in Appendix D; this includes sections showing the flood levels against the existing ground 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 from 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 it may have been possible for waters to back up the onsite drainage system causing localised flooding.

Having reviewed available data and previously prepared reports it is understood during the extensive flooding in Cumbria during 2008 & 2009 this site was not affected.

## Flood Defence Overtopping

There are flood defences affording the site protection from the risk of flooding, as identified in Appendix D. 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 riverbank do not appear to be adequately maintained to the required standard to ensure effective operation; the Environment Agency have graded these 4 'poor'. It is understood that further work has been undertaken on the flood defences, but this needs to be assessed as to suitability and graded accordingly. It is recommended that a full site walkover and grading of the defences be undertaken, subject to planning being granted.

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 and formally surveyed.

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

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 | 64.939 | 64.56 | n/a | 'very low hazard' |
| 1726 | 100 | 63.685 | 63.27 | n/a | 'very low hazard' |
| 1606 | 120 | 62.193 | 62.70 | n/a | 'very low hazard' |
| 1406 | 90 | 61.039 | 60.73 | n/a | 'very low hazard' |

**Table 2 – Risk of flood defence overtopping to people**

The findings in Table 2 from overtopping scenario shows that all cross sections have been classified as a 'very low hazard'.

As the site is protected to the 1:100 plus climate change year return period, this risk could be reduced by raising of ground levels within the residential. No flood storage compensation would be required given the ground level is significantly greater than the 1:100 year return period.

## Flood Defence Breaching

A detailed breach analysis has been prepared by Envireau Water based upon the requirements of the Environment Agency have been undertaken. 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 climate change as required under NPPF Technical Guidance. Figure 4 below shows the two breach locations which have been utilised and previously agreed with the Environment Agency.

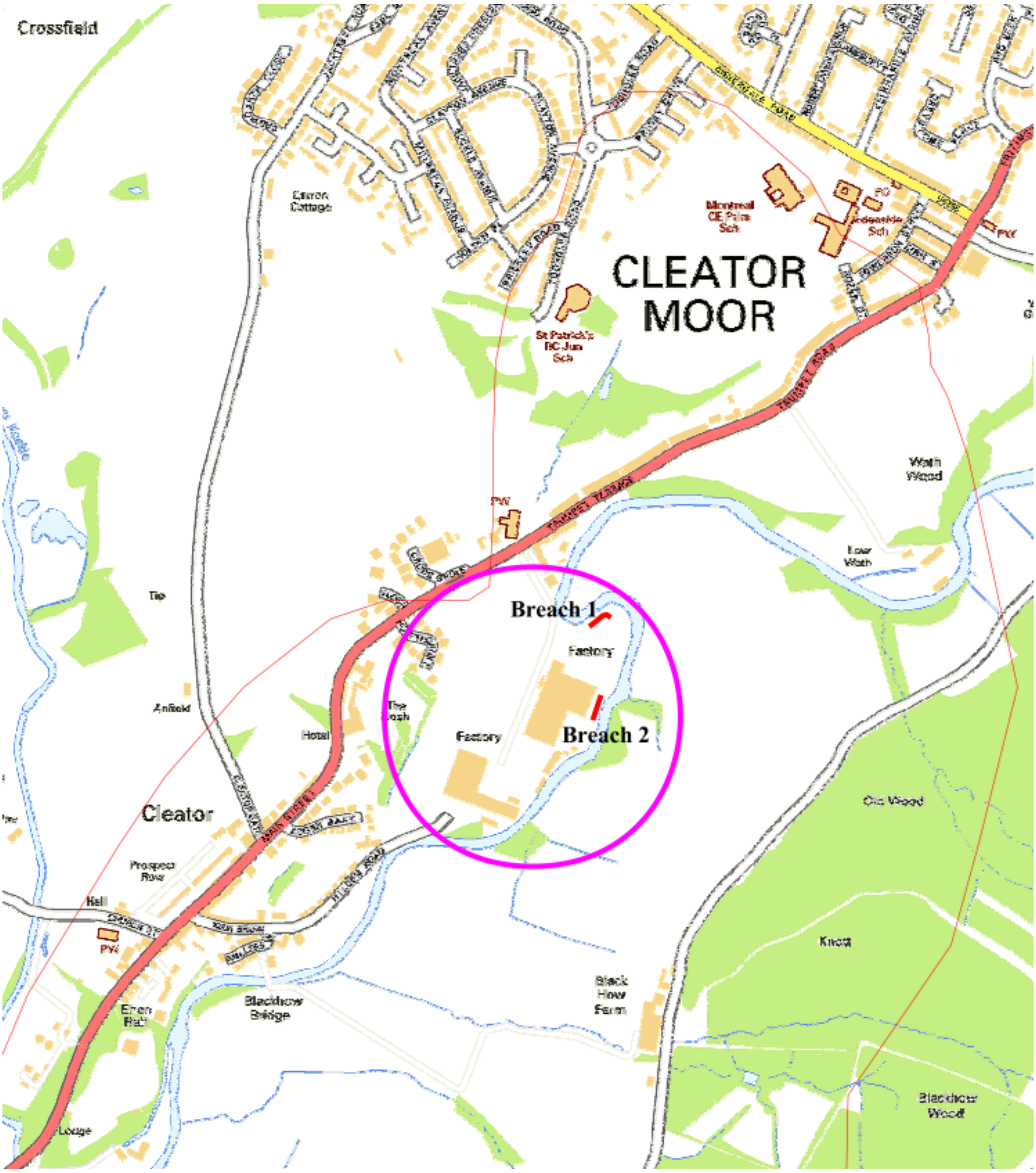


Figure 4 –Modelled Breach Locations

### 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 location of the breach event is indictated in Figure 4. 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 proposed residential development site.

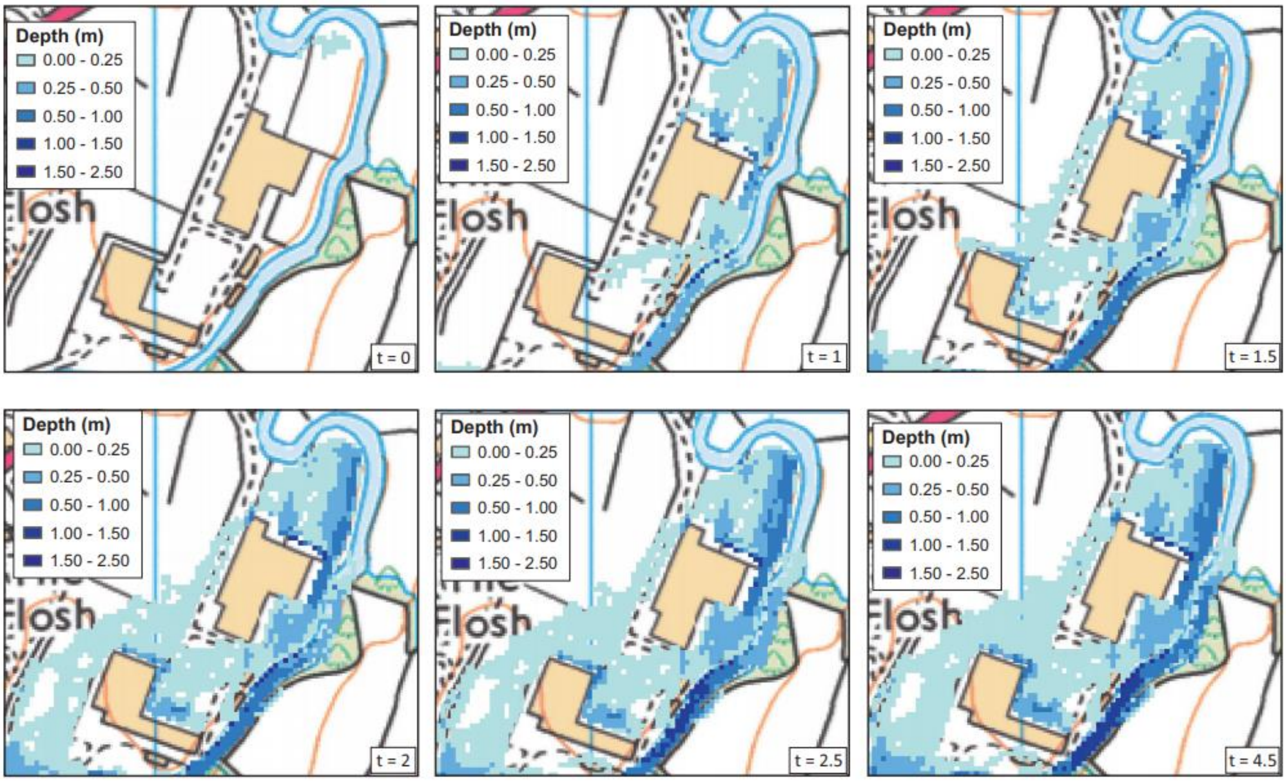



Figure 5 – Extract from Envireau Water of Breach 1

### 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 lcoation of the breach event is indictated in Figure 4. 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.

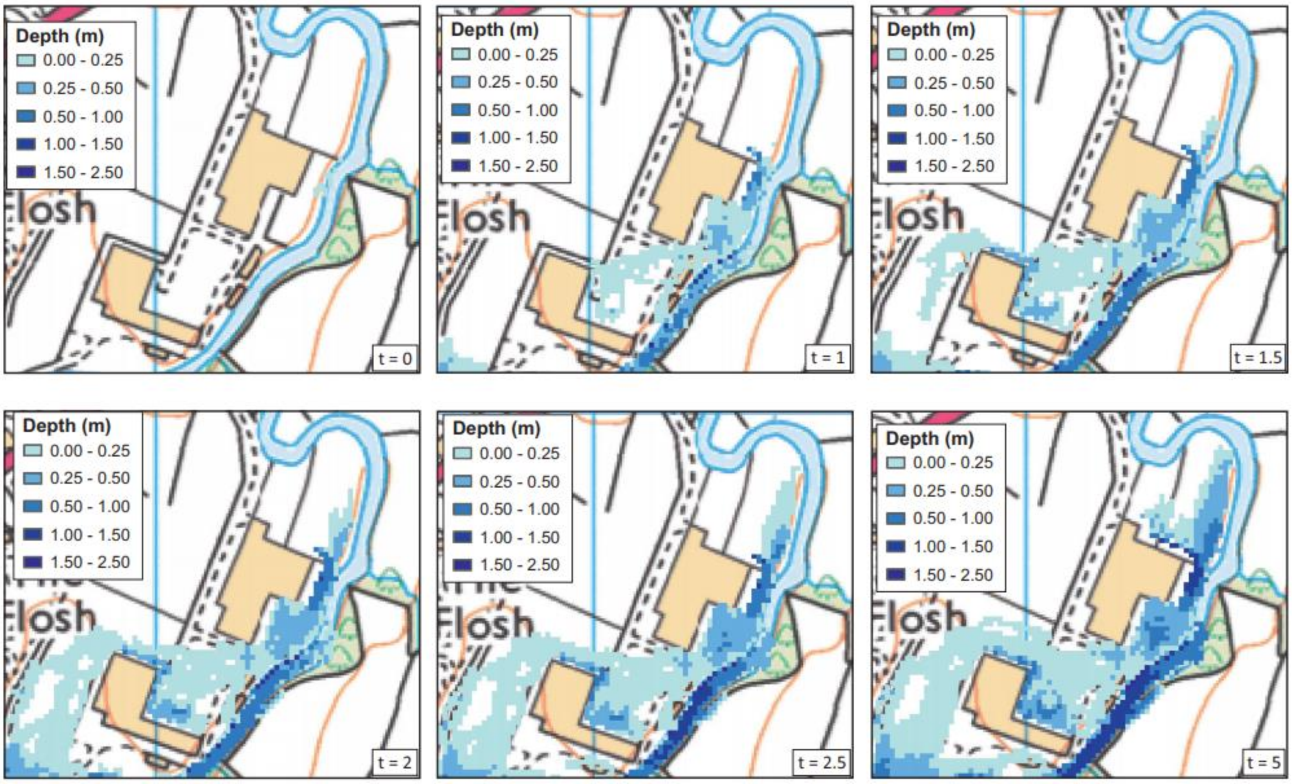



**Figure 6 – Extract from Envireau Water of Breach 2**

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

## Surface Water Flooding

The surface water flood map available on the Environment Agency website (see Figure 7) indicated that part of the site is at risk of flooding due to surface water. The commercial developments are at highest risk with the residential areas being at a medium risk. The surface water runoff is from the direction of the unnamed watercourse located on the northern side of Main Street which ultimately discharges to the River Ehen. It is understood that this is the predicted surface water flood route in the event of a blockage at the culvert under Main Street. Following various discussions was no known incidents of this occurring.

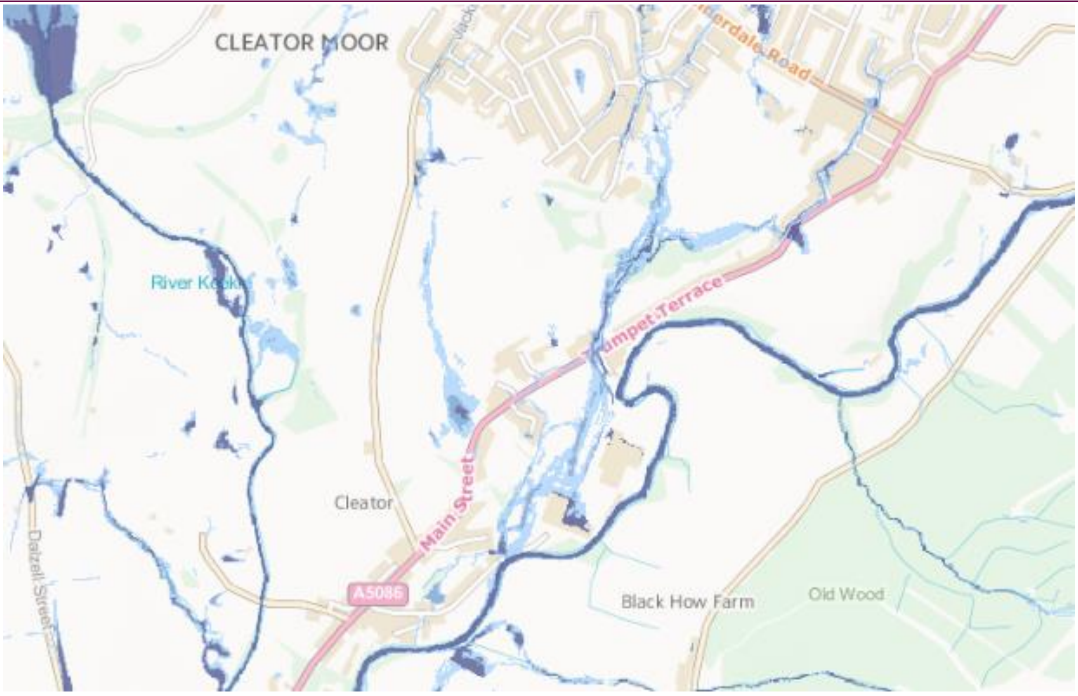



Figure 7 – Environment Agency Surface Water Flood Map

Flood risk from surface water can be mitigated by creating a flow route along the access road and through the multifunctional open space. Careful grading of the land and establishing the FFL will ensure that the flood water passes through the site without risk of damage to property.

Based upon the Environment Agency surface water flood map surface water runoff enters the River Ehen to the South West of the development site. Ground levels should be maintained to ensure this flood route can be utilised in the event of a surface water flooding incident.

## 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.

The most appropriate deemed model node point is 1606 which has a 1:100 plus climate change year return period flood level of 61.658m AOD. Applying a 600mm freeboard to this modelled flood level gives a proposed minimum FFL of 62.258m AOD.

This proposed FFL has been checked against the and in the event of a breach occurring in the northern flood defence, the proposed residential dwellings would remain protected from flooding.

## 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 always be achievable. In the event of a breach occurring in the northern flood defences, the extents of flooding do not impact upon the proposed access.

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 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 G.

## 9.0 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. It has been reported that the water quality within the River Ehen has been found to be Quality A in the past.

There is also a small issue located in the western boundary, which discharges into the River Ehen. A further small watercourse is shown flowing south west before sinking or being culverted approximately 75m from the northern end of the site.

The critical issue relating to the surface water run-off from 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 has been deemed as unacceptable, based upon this it is proposed to utilise infiltration to dispose of surface water as stated in section 8.0 of this report.

# 10.0 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.

Based upon the soil infiltration test results the use of soakaways to accommodate the surface water runoff is deemed as viable. It is recommended that further water monitoring be undertaken to ascertain the water level across the proposed development.

# 11.0 CONCLUSIONS

This assessment has looked at the implications of the proposed Residential developments 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 undertaken a comparison between the existing flood defences and modelled flood levels, the site is protected to a minimum of the 1:1000-year 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.

A proposed minimum FFL of 61.658m AOD has been recommended based upon the 1:100 plus climate change year return period plus 600mm freeboard.

Careful grading of the land and establishing the FFL will ensure that the surface water runoff passes through the site without risk of damage to property.

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.

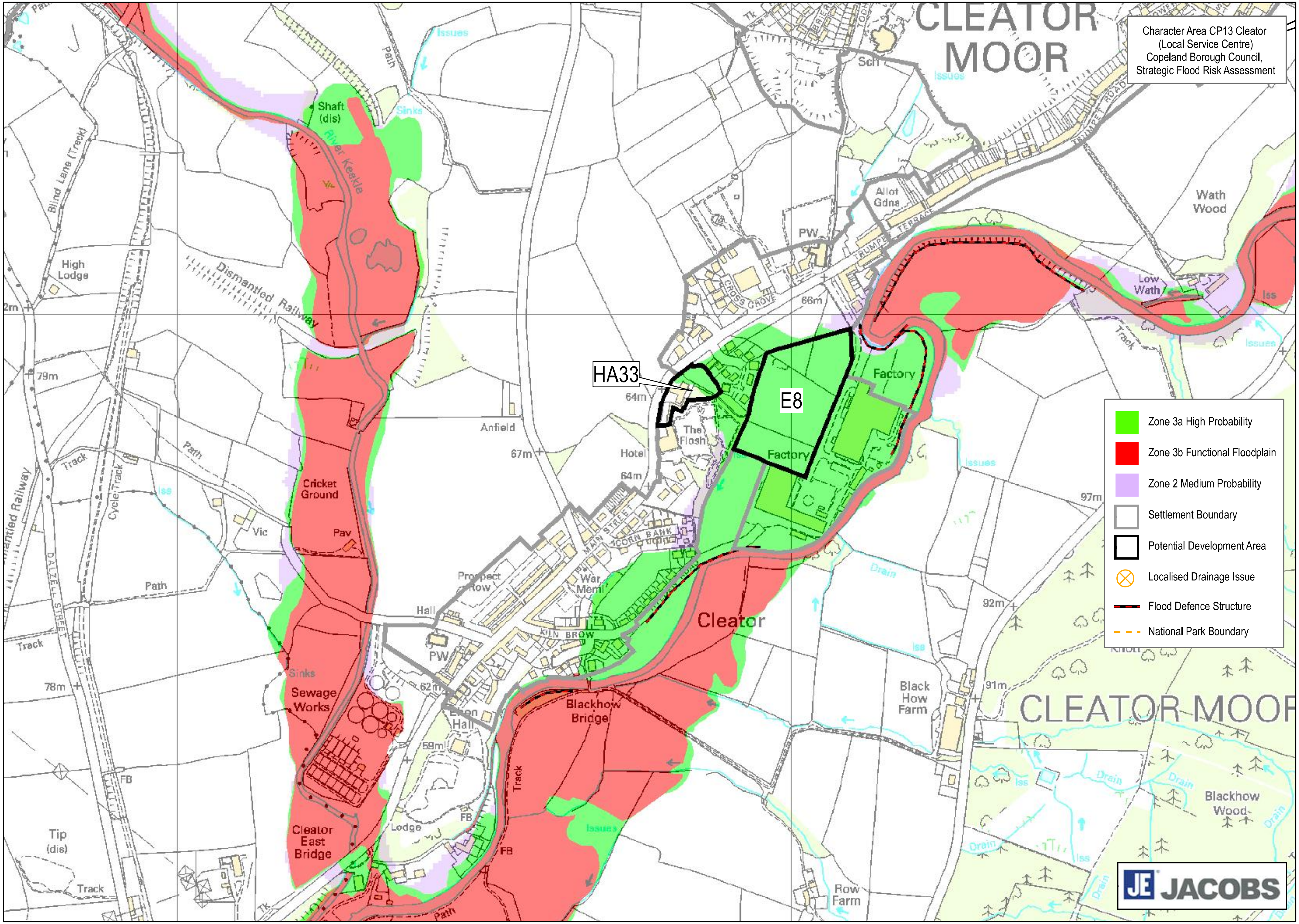
Any potential impact of the development can be adequately addressed by good drainage design.

**Ross Oakley**
For and behalf of RWO Associates Limited
November 2020

# Appendix A Site Location Plan


| Location Map | |
|---|---|
| **Site** | Cleator Mill - Residential |
| **Client** | Gleeson Regeneration |
| **Job Number** | 19002 |
| **Scale** | NTS |

# Appendix B Flood Map


Character Area CP13 Cleator
(Local Service Centre)
Copeland Borough Council,
Strategic Flood Risk Assessment
Zone 3a High Probability
Zone 3b Functional Floodplain
Zone 2 Medium Probability
Settlement Boundary
Potential Development Area
Localised Drainage Issue
Flood Defence Structure
National Park Boundary
E8
HA33
CLEATOR MOOR
Cleator
JACOBS

# Appendix C Proposed Site Layout

# Proposed Residential Development @ Cleator Mills. Cleator.

Knapton & Knapton Ltd

**MJGleeson**
the urban regeneration specialist


## Notes.

- Existing tree retained.
- Red line submission boundary.
- Existing tree removed.
- Indicative planting.
- Grass to front garden.
- Paving slab access to level threshold for principle entrance. Gradient not to exceed 1:12 for maximum 5m length.
- Private drives first 1.5m to be tarmac. Single drives 2.6m wide plus min 0.6m wide path. Min 3.2m overall.
- 1.8m high screen wall, to detail
- 1.8m high screen fence, to detail
- 600mm high plot division fence, to detail.
- House type code reference and plot number.
- Parking bays.
- Bin collection area for private drives only.
- Soakaway 2m square with 2m standoff.

## Rural elevation style.

Forterra Abbey Red multi facing brick.
Forterra Ashwell Yellow multi feature brick.
With flat grey roof tile.

# Schedule.

| TYPE | OCCUPANCY | ARRANGEMENT | No | GROSS INTERNAL FLOOR AREA (GIA) SQFT | GROSS INTERNAL FLOOR AREA (GIA) SQM | GIA TOTALS PER TYPE SQFT | GIA TOTALS PER TYPE SQM | Mix % | Mix% | Brief Mix |
|---|---|---|---|---|---|---|---|---|---|---|
| 201 | 2B | semi/town | 8 | 651 | 60.48 | 5,208 | 483.82 | 7% | | |
| 211 | 2B | semi/town | 6 | 651 | 60.48 | 3,906 | 362.87 | 5% | 12% | 10% |
| 301 | 3B | semi/town | 10 | 759 | 70.51 | 7,590 | 705.11 | 9% | | |
| 303 | 3B | semi/town | 10 | 772 | 71.72 | 7,720 | 717.19 | 9% | | |
| 311 | 3B | semi/town | 12 | 759 | 70.51 | 9,108 | 846.13 | 10% | 28% | 30% |
| 304 | 3B | detached | 7 | 772 | 71.72 | 5,404 | 502.03 | 6% | | |
| 337 | 3B | detached | 10 | 864 | 80.27 | 8,640 | 802.66 | 9% | | |
| 315 | 3B | detached | 10 | 816 | 75.81 | 8,160 | 758.06 | 9% | | |
| 314c | 3B | detached | 7 | 811 | 75.34 | 5,677 | 527.39 | 6% | 30% | 30% |
| 435 | 4B | detached | 13 | 1221 | 113.43 | 15,873 | 1474.60 | 11% | | |
| 403 | 4B | detached | 10 | 1048 | 97.36 | 10,480 | 973.59 | 9% | | |
| 436 | 4B | detached | 12 | 1167 | 108.41 | 14,004 | 1300.97 | 10% | 30% | 30% |
| | | | 115 | | | 101,770 | 9454.43 | 100% | 100% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| Gross Site Area | 10.29 | acres | Red Line Boundary | 4,598.60 | sqm |
| POS Area | 1.19 | acres | | | |
| Tree Belt | 0.00 | | | | |
| Nett Site Area | 9.10 | acres | Nett Site Area | 4,066.79 | sqm |
| Density | 11,183.52 | sqft/acre | | | |
| Density | 1,038.95 | sqm/acre | | | |

## Scale:

0m 10 20 30 40 50
Scale of meters

Designers of the Built Environment

Scale • 1:500 @ A1
Date • 21/10/20
Drg No • PL-01

Client • Gleeson Homes Ltd.
Site • Cleator Mills
Plan • Planning Layout 1:500.

Knapton & Knapton Ltd

# Appendix D Topographical Survey and Site Sections


| Date | Revisions | Drawn | Rev. |
| --- | --- | --- | --- |

Dwg Status: PRELIMINARY

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Client: GLEESON HOMES

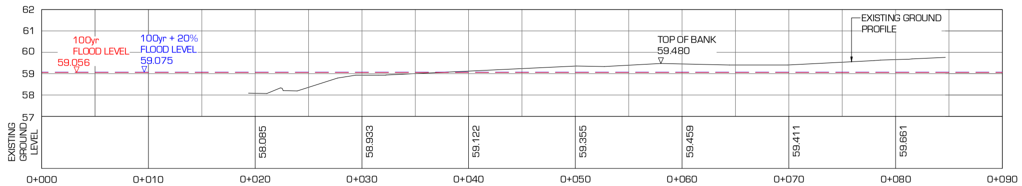
Project: CLEATOR MILL
CUMBRIA

Title: PLAN ON NODE SECTION LOCATIONS

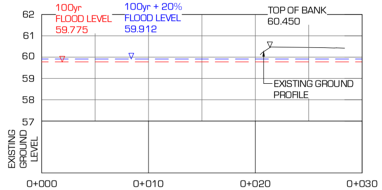
| Scale | Drawn | Checked | Date |
| --- | --- | --- | --- |
| 1:1000 | NN | RWO | 05.11.20 |

| Job No. | Drawing No. | Revision |
| --- | --- | --- |
| 19002 | 950 | - |

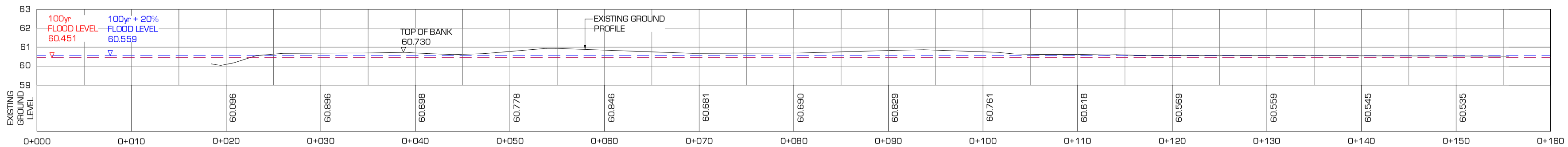
A1 - Do Not Scale.




1206 NODE PROFILE




1299 NODE PROFILE

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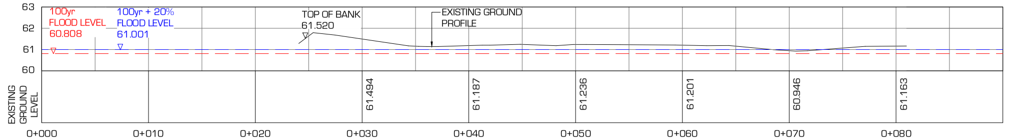


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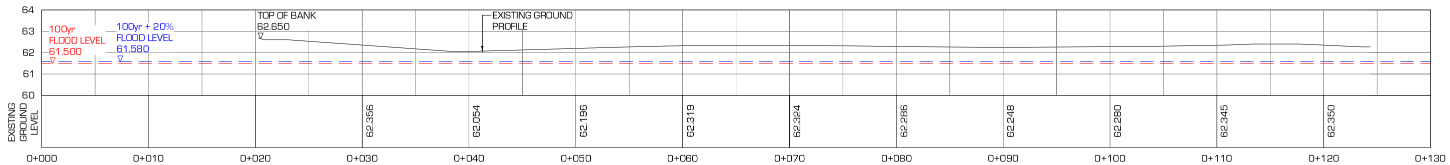


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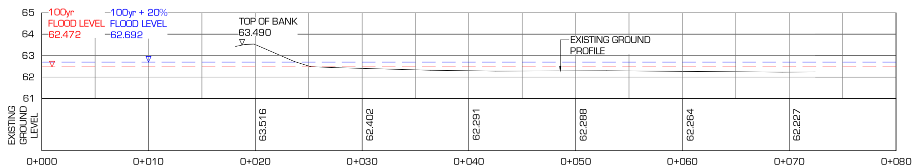


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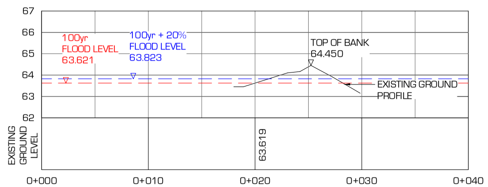


1806 NODE PROFILE

A1 - Do Not Scale.

| Date | Revisions | Drawn | Rev. |
|---|---|---|---|

Dwg Status: PRELIMINARY

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Project: CLEATOR MILL
CUMBRIA

Title: SECTIONS THROUGH NODES

| Scale | Drawn | Checked | Date |
|---|---|---|---|
| 250H 500V | NN | RWO | 05.11.20 |

| Job No. | Drawing No. | Revision |
|---|---|---|
| 19002 | 951 | - |

# 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

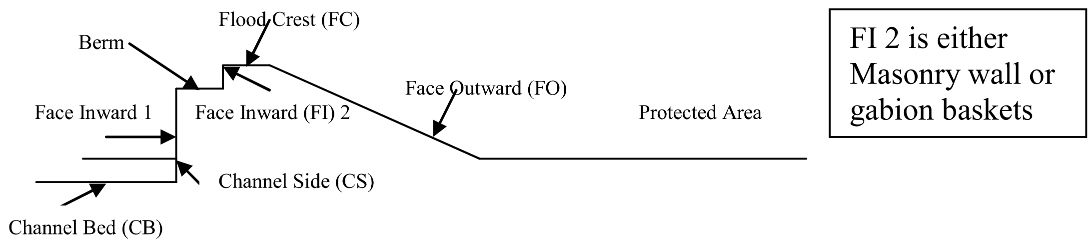
invasive, dense vegetation. The EA maps show this as no longer a formal embankment.

- 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:

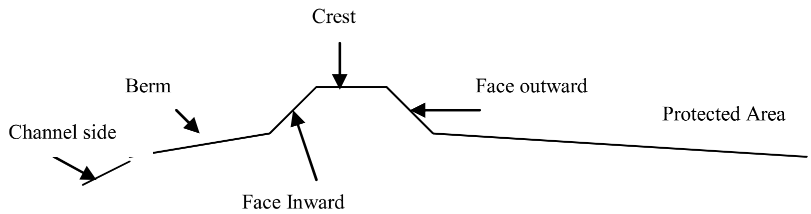
| | |
|---|---|
| 1 to 6 (upstream) | Fair to Good |
| 7 | Stonework seriously depleted |
| 8-12 | Fair to Good |
| 13 | Stonework seriously depleted |
| 14-20 | fair to Good |
| 21-25 | Majority of stonework stolen |
| 26 | Fair to Good |

### 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.

**John B. Chatterton**
**J Chatterton Associates (john@jchattertonassociates.co.uk)**
**Birmingham**
**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 Envireau Water Breach Analysis

# UPDATED FLOOD RISK MODELLING REPORT

## CLEATOR MILLS

For

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Ref: P19-310 Cleator Mills Breach Assessment \ RPT Cleator Model.docx
March 2020

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| Revision | Details | Completed by | Date | Checked by | Date |
|---|---|---|---|---|---|
| REV01 | Final | RH | 27/02/2020 | LC | 02/03/2020 |
| REV02 | | | | | |
| REV03 | | | | | |
| REV04 | | | | | |

# UPDATED FLOOD RISK MODELLING REPORT

## CLEATOR MILLS

## 1 INTRODUCTION

### 1.1 Background

Envireau Water has been commissioned to provide an updated flood defence breach analysis at Cleator Mills, Cleator, Cumbria, CA23 3DU. This work follows on from a previous flood defence breach analysis undertaken by Mott MacDonald based on the Environment Agency hydraulic model produced in 2010. The previous modelling report is provided in Appendix A.

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

### 1.2 Location and Setting

Cleator Mills (the "Site") is located to the south-east of Cleator Moor Village (Figure 1). The Site is centred on National Grid Reference NY 02067 13818. The River Ehen located adjacent to the north and eastern boundaries of the Site. The Site is split into three areas, the existing Kangol factory, a disused Kangol factory and a car park area. The flood defences are located between the river and Site.

### 1.3 Scope of Breach Analysis

The scope of the flood defence breach analysis is summarised below:

- Build a 2D model of the Site to replace the previous model developed by Mott MacDonald in 2013 which is not available.
- Obtain and apply new topographic survey information provided by RWO Associates (Appendix B) and LiDAR 1m Digital Terrain Model (DTM) from the Environment Agency dated 2013 (Ref. 1).
- Develop breach hydrographs using the updated 2016 Environment Agency hydraulic model for the River Ehen. The model was built and run using linked Flood modeller TUFLOW simulations.
- Prediction of flood extent, depth, velocities and hazard ratings for the 1 in 100 year plus climate change flood defence breach at two locations.

# 2 BREACH ANALYSIS

## 2.1 Breach Scenarios

Two breach scenarios are analysed in the updated assessment. The locations for the flood defence breaches were agreed with the Environment Agency in March 2010 and remain unchanged. Details of the two scenarios are provided in Table 1 below and shown on Figure 2.

**Table 1 Breach Location and Details**

| Breach Scenario | Location | Defence Type | Breach Width (m) | Point X | Point Y | Elevation (mAOD)` | Bank |
|---|---|---|---|---|---|---|---|
| Breach 1 | North of Site | Combination of gabion lined baskets and earth embankment | 40 | 302196 | 513947 | 64.52 | Right Bank |
| Breach 2 | East of Site | Earth Embankment | 40 | 302202 | 513840 | 62.49 | Right Bank |

The following criteria was agreed with the Environment Agency for the previous assessment and maintained for this update:

- One design event to be assessed – 1 in 100 year plus climate change.
- As both breach locations are on a fluvial river, the following breach width and time apply:
  - Combination of hard defence and earth bank: 40m width, 36 hours to closure.
  - Earth banks: 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 method used to assess the flood defence breach has been maintained from the previous assessment to ensure consistency between the two results. The method applied is summarised below.

- Review the updated Environment Agency hydraulic model which covers the entire River Ehen, including the two breach locations.
- Spill units representing the breach locations within the Environment Agency model were identified. Where necessary an interpolated channel cross section was added 40m downstream of the breach to ensure a breach width of 40m was achieved. Spill units that represent the breaches floodplains within the Environment Agency model are represented by 1D reservoir units with water exchanged between the river and floodplain via spill units.
- Where an interpolation was required a spill unit to connect it to the 1D reservoir unit was added to ensure all flood water from the main channel was captured.

- The breach was assumed to develop within a single one second timestep in the model run across the full 40m width. This represents a worst case scenario for the breach assessment.
- The breach was assumed to occur through the full embankment height to the surrounding ground level. This was represented within the Environment Agency model by lowering the elevation of the right bank spill at the breach location from the embankment level to the level of the surrounding floodplain.
- The level of the surrounding flood plain was obtained from the topographical survey provided by RWO Associates and 2013 Environment Agency LiDAR data. Table 2 identifies the embankment and floodplain elevation used within the model for each Breach. The floodplain elevations are above those used in the previous model due to the updated topographical survey and Environment Agency LiDAR data differing from that used in the previous model.

**Table 2 Flood Defence and Floodplain Elevations**

| Breach Number | Flood Defence Elevation (mAOD) | Floodplain Elevation (mAOD) |
|---|---|---|
| Breach 1 | 64.52 | 62.6 |
| Breach 2 | 62.49 | 61.5 |

- The hydrographs for the spill units representing the breach locations were used as an input to a 2D model of the Site to establish the flood depth, extent, velocity and hazard rating from each breach event.

# 3 2D HYDRODYNAMIC MODELLING

## 3.1 Approach

The 2D modelling approach is outlined below for assessing the two flood defence breaches for the 1 in 100 year plus climate change event:

1. Construct a 2D hydraulic model incorporating topographic data provided by RWO Associates and Environment Agency 1m LiDAR data dated 2013;
2. Insert the breach hydrographs for each scenario extracted from the updated Environment Agency River Ehen model;
3. Predict flood extents at the site for the specified return period of 1 in 100 year plus climate change;
4. Produce flood extent, depth, velocity and hazard maps.

The model was built and run within Flood Modeller v4.6.

## 3.2 Model Build

The model extent has been iteratively adjusted to cover a sufficient length of the River Ehen and the maximum flood plain extent which is flooded during the breach assessments. The same model extent was used for both breach scenario.

### 3.2.1 Digital Terrain Model

The DTM for the Site was produced using 1m resolution LiDAR dated 2013. To make sure flood water from the breach was no underestimated the DTM was edited to raise the channel elevation to the bank elevation. This ensured the watercourse channel was not available for storage or conveyance of the 'breached flows'. This is in accordance with the breach occurring at the same time as bank full conditions with the River Ehen.

Details of the grid used within the model is summarised in Table 3, each cell within the grid is assigned a z value, which is the elevation in mAOD. The previous assessment used a grid size of 7m, for this assessment a grid size of 5m was determined to provide sufficient detail for flood mapping, whilst not creating onerous model run times.

**Table 3 2D Model Grid Details**

| Grid Information | |
|---|---|
| Grid Size (spacing) | 5 m |
| Origin | 301,135N 512,883E (British National Grid) |
| Orientation | 0 degrees |
| Width of grid (in the east direction) | 1260 m |
| Height of grid (in the north direction | 1051 m |

### 3.2.2 Boundary Conditions

The inflow (upstream) boundary is a flow-time boundary assigned to the breach location via a polyline shapefile. The breach hydrograph extracted from the updated Environment Agency model was assigned to the polyline to simulate the flood defence breach. The breach hydrographs are shown in Figure 3.

The peak flow for Breach 2 is greater than the peak flow for Breach 1. We have assumed this is different from the previous model due to the inclusion of flow re-entering the River Ehen from the floodplain between Breach 1 and Breach 2 in the updated Environment Agency model. However, we would naturally expect to see a higher flow at Breach 2 than at Breach 1.

### 3.2.3 Manning's n

A roughness grid was applied to the 2D grid based on land classification. The roughness values (Table 4) allows the model to calculate the resistance provided by the land to the flood water.

**Table 4 Manning's n Values for Land Use Classification.**

| Land Classification | Manning's n (Roughness) |
|---|---|
| Water | 0.035 |
| Grassed floodplain | 0.055 |
| Buildings | 0.300 |
| Woodland | 0.120 |
| Roads and railways | 0.020 |

### 3.3 Flood Hazard Classification

The hazard rating has been defined using the method outlined in Defra's Flood Risks to People report (FD2321/TRA) (Ref 2). The hazard rating is calculated from depth, velocity and debris factor at each time step in the model. The equations governing this calculation are provided below:

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

Where, HR = (flood) hazard rating;
D = depth of flooding (m);
V = velocity of floodwaters (m/s); and
DF = debris factor

The debris factor varies with depth and velocity for each land use classification as shown in Table 5. The debris factor used within the flood mapping is Urban as the Site is occupied as a factory and used for car parking with no extensive woodland coverage.

**Table 5 Debris Factor for Land Use and Flood Depths (Table 4.1, FD2321/TRA)**

| Depths | Debris Factor | | |
|---|---|---|---|
| | Pasture/Arable | Woodland | Urban |
| 0 to 0.25 m | 0 | 0 | 0 |
| 0.25 to 0.75 m | 0 | 0.5 | 1 |
| d>0.75m and/or v>2 | 0.5 | 1 | 1 |

Hazard rating (HR) has been classified into four categories as defined within FD2321/TRA, the catergorise are listed in Table 6.

**Table 6 Hazard to People as a Function of Depth and Velocity (Table 4.2, FD2321/TRA)**

| Hazard Rating | Degree of Flood Hazard | Description |
|---|---|---|
| <0.75 | Low | Caution<br>*"Flood zone with shallow flowing water or deep standing water"* |
| 0.75 – 1.25 | Moderate | Dangerous for some (e.g. children)<br>*"Danger: Flood zone with deep or fast flowing water"* |
| 1.25 – 2.0 | Significant | Dangerous for most people<br>*"Danger: flood zone with deep fast flowing water"* |
| > 2.5 | Extreme | Dangerous to all<br>*"Extreme danger: flood zone with deep fast flowing water"* |

# 4 RESULTS

## 4.1 Breach 1

During a 1 in 100 year plus climate change event flood defence breach at location 1 flood water flows onto the floodplain progressing south flooding the existing factory. Water then flows each side of the existing factory flooding the car park area and the disused factory downstream. Flood water re-enters the River Ehen near the existing factory site. Figure 4 shows the progression of the flood wave across the Site from the initial time at which the flood breaches fail (t = 0 hour) to the maximum flood extent (t = 4.5 hour).

Flood depths in the vicinity of the existing factory building are significant reaching up to 1.46m near the existing factory building. In the wider area surrounding the existing factory and land around the disused factory water depths reach up to 0.6m. Water depths in the car parking area reach 0.45m. The remainder of the floodplain flood depth typically reaching 0.26m.

The velocity reaches a maximum of 3.2m$^3$/s at the Site. The highest velocities are located close to the breach location and along the eastern edge of the Site adjacent to the River Ehen.

The hazard rating for the Site is typically Low (<0.75), however the hazard increased in areas with deeper flooding or higher velocities. These areas are located adjacent to the eastern edge of the existing factory and along the banks of the River Ehen. The hazard level of these areas are moderate to significant indicating that it would be dangerous to people during a flood defence breach.

Compared to the previous assessment the maximum flood depth has increased from 0.9m to 1.46m in the vicinity of the existing factory, this in turn has increased the hazard rating in these areas of the Site. However the maximum flood extent at the Site remains the same. The velocities experienced on site are slightly increased from those predicted in the previous breach due to the higher peak in the breach hydrograph.

## 4.2 Breach 2

During a 1 in 100 year plus climate change event flood defence breach at location 2, flood water flow onto the floodplain encountering the existing factory where is it deflected south through the car park towards the disused factory. As the breach progresses water flows towards the disused factory with some water re-entering the River Ehen downstream of the breach location. Water builds around the existing factory and begins to flow north adjacent to the River Ehen, while water flows around the disused building to the west before flowing south and back into the River Ehen south of the Site. Figure 5 shows the progression of the flood wave across the Site from the initial time at which the flood defence fails (t = 0 hour) to the maximum flood extent (t = 5 hour).

Flood depths in the vicinity of the existing factory are significant reaching up to 1.21m in depth along the eastern wall of the factory. Flood depths at the car park reach 0.55m. Flood depths at the disused factory reach 0.64m with the remainder of the floodplain typically reaching 0.27m.

The velocity reaches a maximum of 3.2m/s at the Site, high velocities are experienced on the eastern edge of the existing factory and to the south of the disused factory.

The hazard rating for the Site during Breach 2 is typically Low (<0.75), however like Breach 1 there are areas of higher hazards associated with deeper flooding or higher velocities. These areas are located adjacent to the eastern edge of the existing factory and along the bank of the River Ehen. The hazard level of these areas are moderate to significant indicating that it would be dangerous to people during a flood defence breach.

In comparison to the previous assessment the maximum flood extent has increased due to the updated Environment Agency hydraulic model incorporating flow back into the River Ehen from the floodplain upstream. This has resulted in a higher peak in Breach 2's hydrograph compared to Breach 1's.

The flood depth has also increased under Breach 2 scenario from 0.5m to 1.21m in the vicinity of the existing factory. This has increased velocities and hazard ratings at the site as a result of the increased volume and peak in the flood defence breach hydrograph. Therefore, although the hazard rating for the Site is typically Low, the area small areas with a hazard rating rising to moderate or significant..

## 5 FLOOD MAPPING

Flood maps have been produced from the outputs of the 2D model. The maps show the maximum depth, velocity, water level and hazard rating for each Breach individually. Flood maps figures for Breach 1 (Figure 6a – 6d) are provided in Appendix C and flood maps figures for Breach 2 (Figure 7a – 7d) are provided in Appendix D. Table 7 summarise the flood maps.

**Table 7 Summary of Flood Maps**

| Figure Number | Parameter Shown | Breach Location | Return Perion |
|---|---|---|---|
| 6a | Depth | Breach 1 | 100 year + Climate Change |
| 6b | Velocity | Breach 1 | 100 year + Climate Change |
| 6c | Water Level | Breach 1 | 100 year + Climate Change |
| 6d | Hazard Rating | Breach 1 | 100 year + Climate Change |
| 7a | Depth | Breach 2 | 100 year + Climate Change |
| 7b | Velocity | Breach 2 | 100 year + Climate Change |
| 7c | Water Level | Breach 2 | 100 year + Climate Change |
| 7d | Hazard Rating | Breach 2 | 100 year + Climate Change |

## 6 ASSUMPTIONS AND LIMITATIONS

The following assumptions were made within the model:

- The River Ehen is at bank-full levels downstream of the breach.
- Flood defence and embankment levels within the updated Environment Agency model are correctly representing the modelled area.
- The updated Environment Agency model accounts for surface runoff within the modelled area.
- The Site is an urban environment with no extensive woodland or pastureland.

The following limitations apply to the hydraulic model:

- LiDAR data has a verified vertical accuracy of +/- 15cm.
- Models are not calibrated or verified for flood extent due to breaches due to the lack of observed historic data.
- The updated Environment Agency model was only run to peak producing results for 25 hours. To run the dam breaches for 36hours to closure, the rising limb has been used as a proxy for the falling limb.

# 7 CONCLUSIONS

An updated flood defence breach analysis has been undertaken for two breach locations adjacent to Cleator Mills. The breach assessment methodology has been maintained from previous assessment to ensure consistency between assessments. The breach hydrographs have been updated applying the updated Environment Agency 2016 River Ehen hydraulic model results.

A new 2D hydraulic model was constructed using a grid assigned levels from a DTM and flow-time boundary conditions representing the inflow from the flood defence breach. The 2D model grid covered an area representing the potential for flooding from the breach with a grid size of 5m.

A flood defence breach at location 1 would result in extensive flooding of the Site. The main areas affected are the existing factory and car park area and the disused factory downstream of the Site. The hazard rating for the majority of the Site was Low, however there were areas that had a Moderate to Significant hazard rating where the flood depth was greater. In these areas the breach poses a significant risk to people.

A flood defence breach at location 2 would result in less extensive flooding with flood water covering the eastern edge of the existing factory, car parking area and disused factory area. Similar to Breach, 1 the hazard rating for the majority of the Site was Low, with areas experiencing greater flood depths having a Moderate to Significant hazard rating. These areas pose a significant risk to people during a flood defence breach at location 2.

The extent of flooding experienced in Breach 1 remains similar to that experienced in the previous assessment however the flood extent in Breach 2 is increased from that identified in the previous assessment. The flood depths for both assessments are increased by 0.56m and 0.71m for Breach 1 and Breach 2 respectively. The increased depths on Site have resulted in an increase in hazard ratings in these areas, however the majority of the Site remains within the Low hazard category.

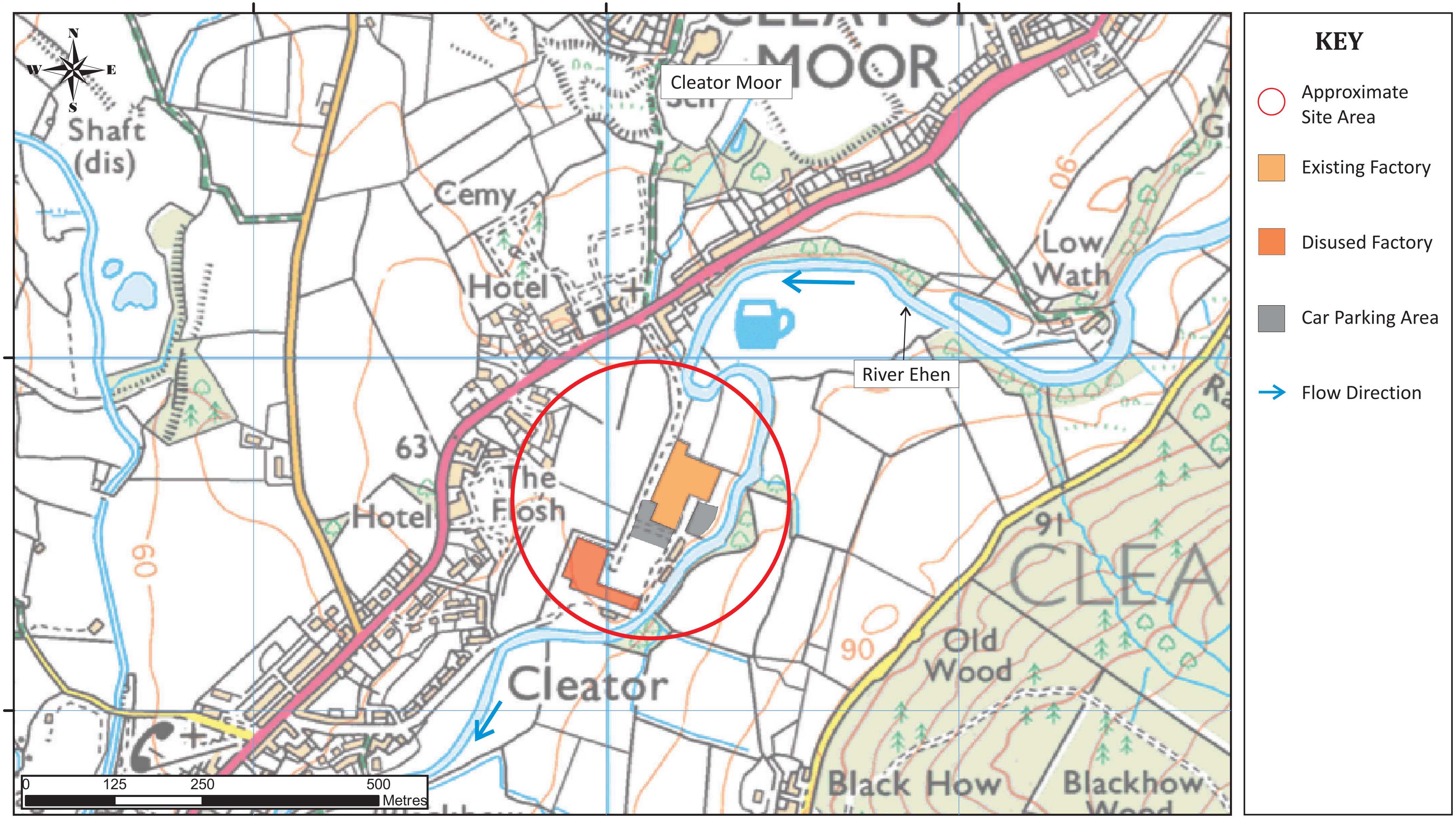
**Envireau Water**
**02/03/2020**

## REFERENCES

Ref.1 Environment Agency (2013). LIDAR Tiles DTM: 2013 DTM 1M. https://environment.data.gov.uk/DefraDataDownload/?Mode=survey

Ref.2 DEFRA (2006). Flood Risks to People – Phaser 2, FD2321/TR2 Guidance Document.

# FIGURES






envireau WATER

Ref: P19-310 Cleator Mills Breach Assessment\FIG 1
Site Setting
Date: 27/02/2020

**RWO Associates -Cleator Mills**

Figure 1

Site Setting

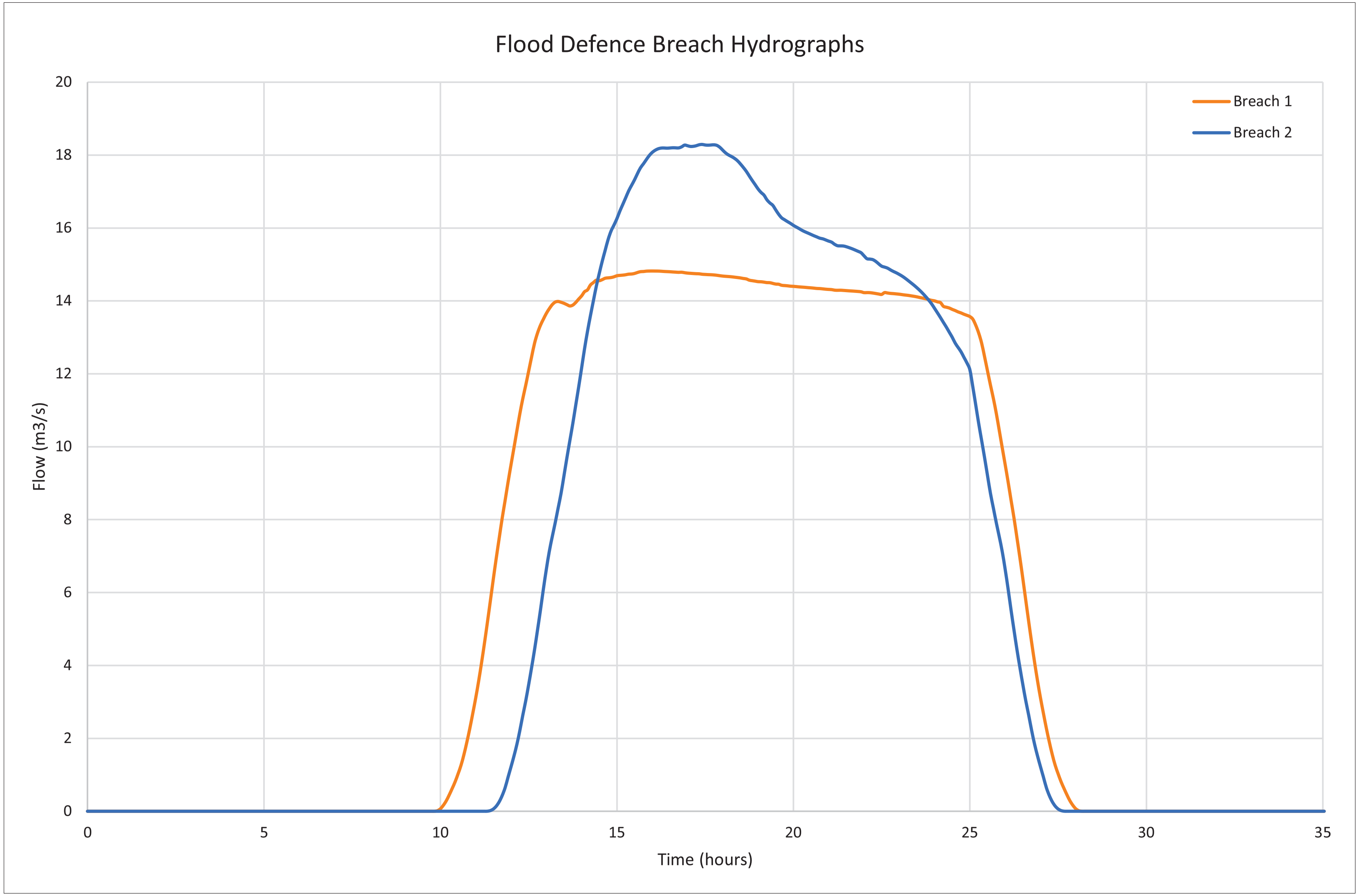



**KEY**

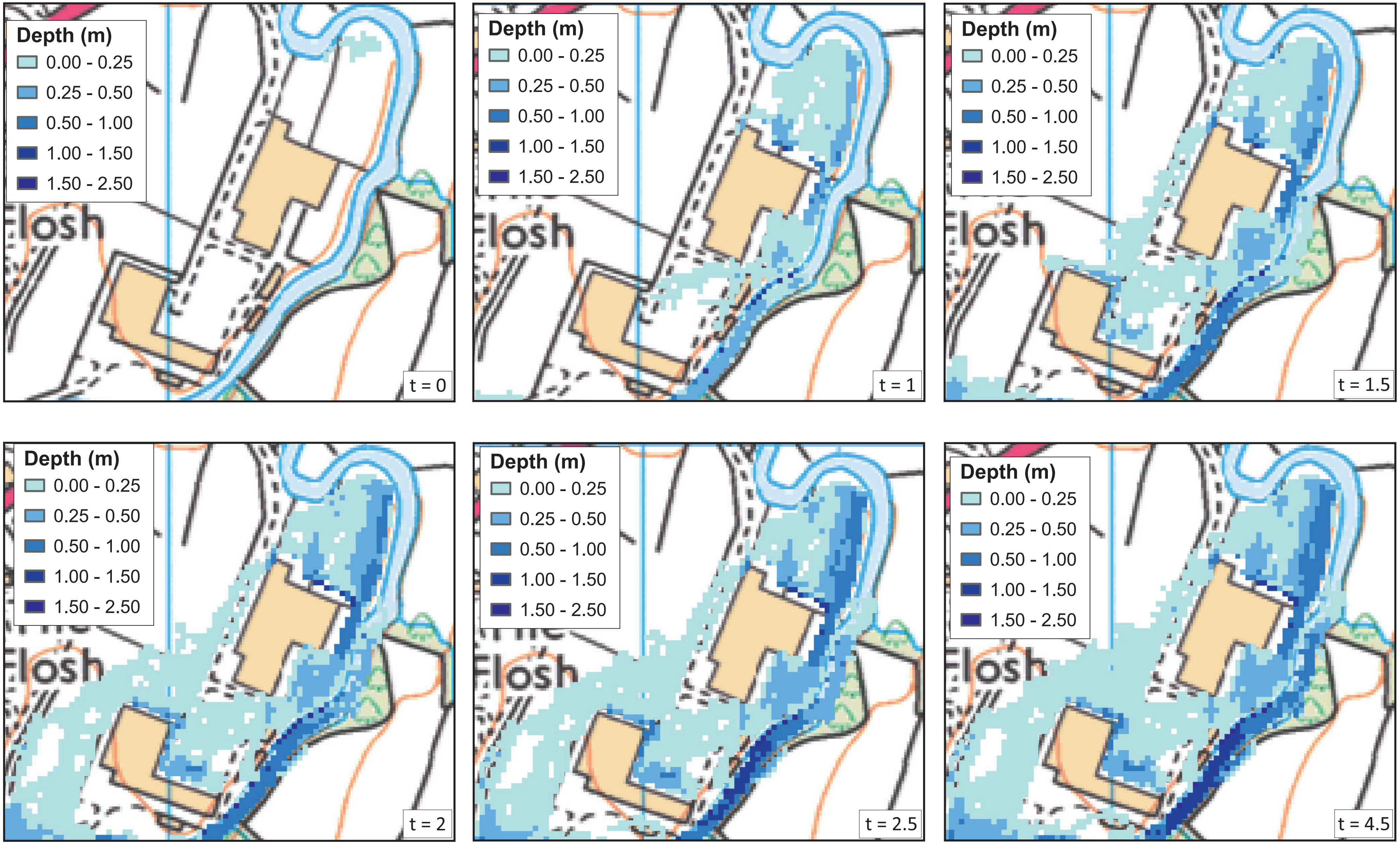
- Breach 1 Location (orange line)
- Breach 2 Location (blue line)

envireau WATER

| | |
|---|---|
| Ref: P19-310 Cleator Mills Breach Assessment\FIG 2 Breach Locations<br>Date: 02/03/2020 | **RWO Associates - Cleator Mills** |
| Figure 2 | Flood Defence Breach Locations |




| | |
|---|---|
| Ref: P19-310 Cleator Mills Breach Assessment\Flood Defence Breach Hydrographs<br>Date: 02/03/2020 | **RWO Associates -Cleator Mills** |
| Figure 3 | Flood Defence Breach Hydrographs |



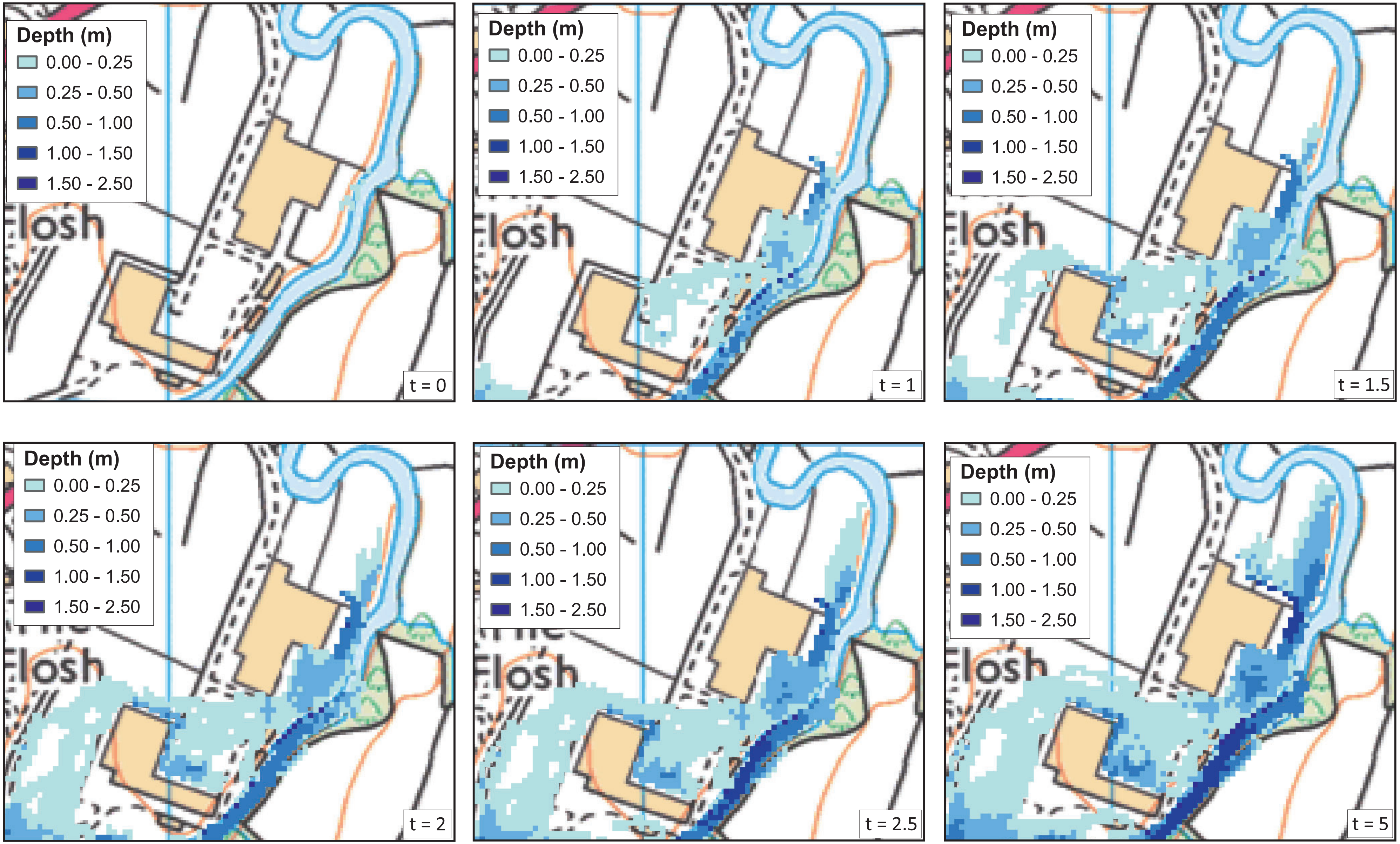

Ref: 19-310 Cleator Mills Breach Assessment\FIG 4
B1 Flood Wave
Date: 28/02/2020

envireau WATER

**RWO Associates - Cleator Mills**

Figure 4

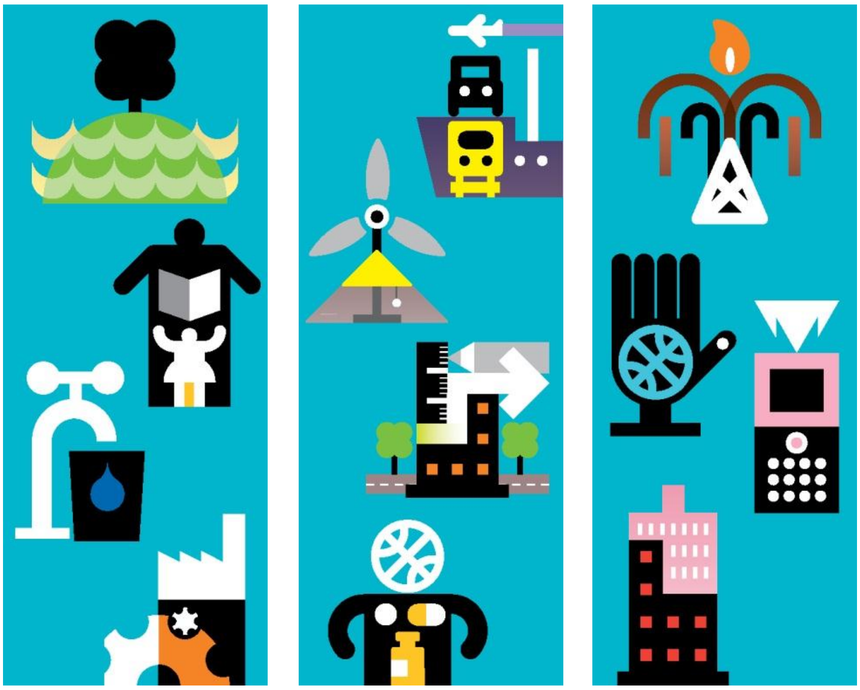
Breach 1 Flood Wave Progression




envireau WATER

| | |
|---|---|
| Ref: 19-310 Cleator Mills Breach Assessment\FIG 5<br>B2 Flood Wave<br>Date: 28/02/2020 | **RWO Associates - Cleator Mills** |
| Figure 5 | Breach 2 Flood Wave Progression |

# APPENDIX A
# PREVIOUS MODEL REPORT



# Updated Flood Risk Modelling - Cleator Mills Site

Modelling Report

October 2013

RWO Associates

RWO ASSOCIATES

Mott MacDonald

# Updated Flood Risk Modelling - Cleator Mills Site

Modelling Report

October 2013

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# Issue and revision record

| Revision | Date | Originator | Checker | Approver | Description | Standard |
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# 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

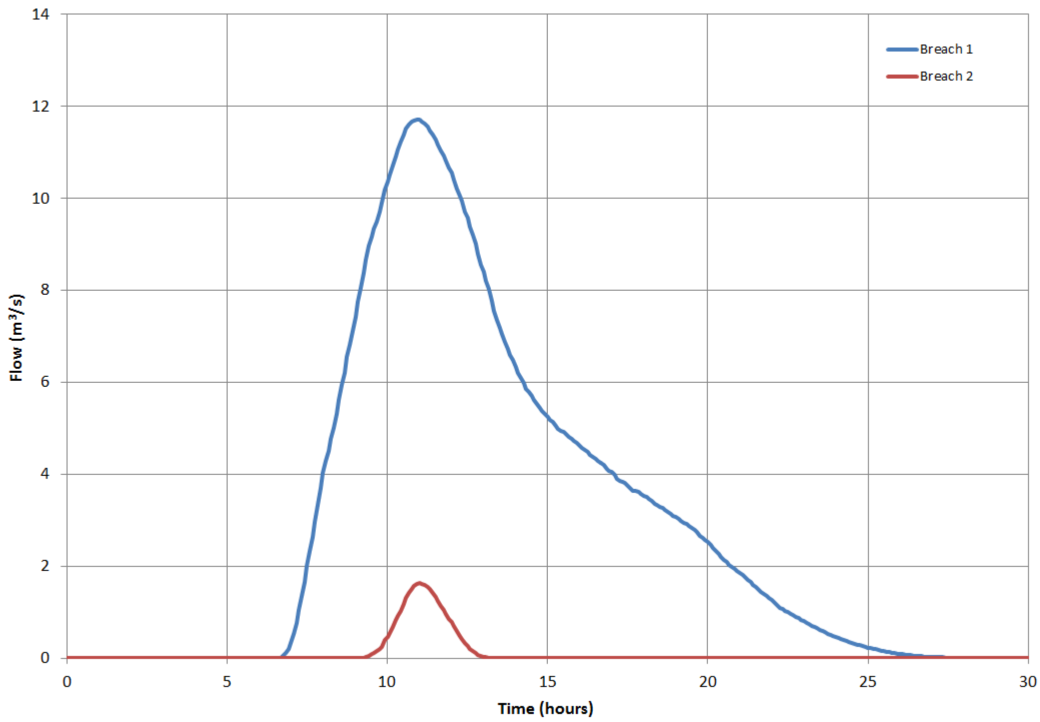



Figure 3.1 – Breach hydrographs

### 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.

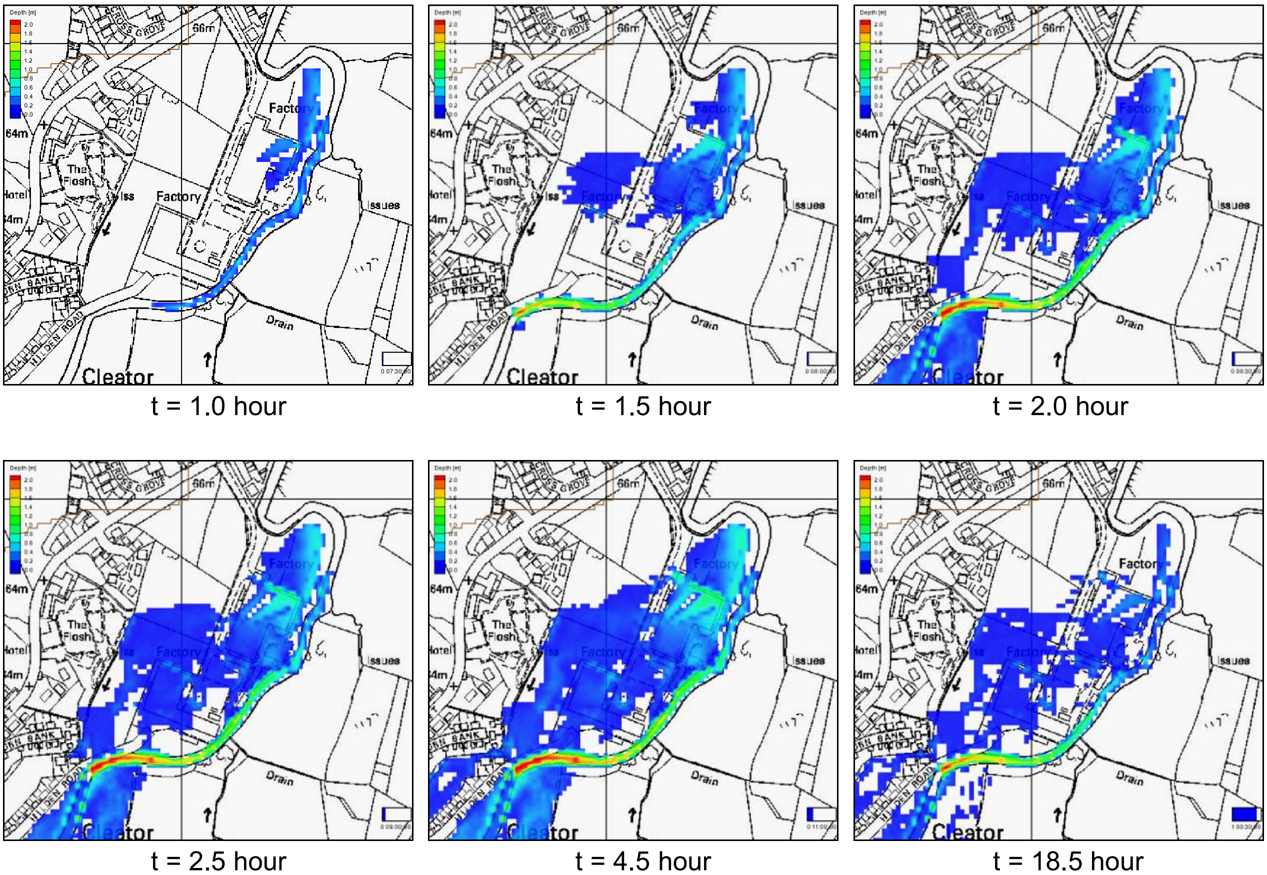



Figure 4.1 – Progress of flood wave from Breach 1

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).

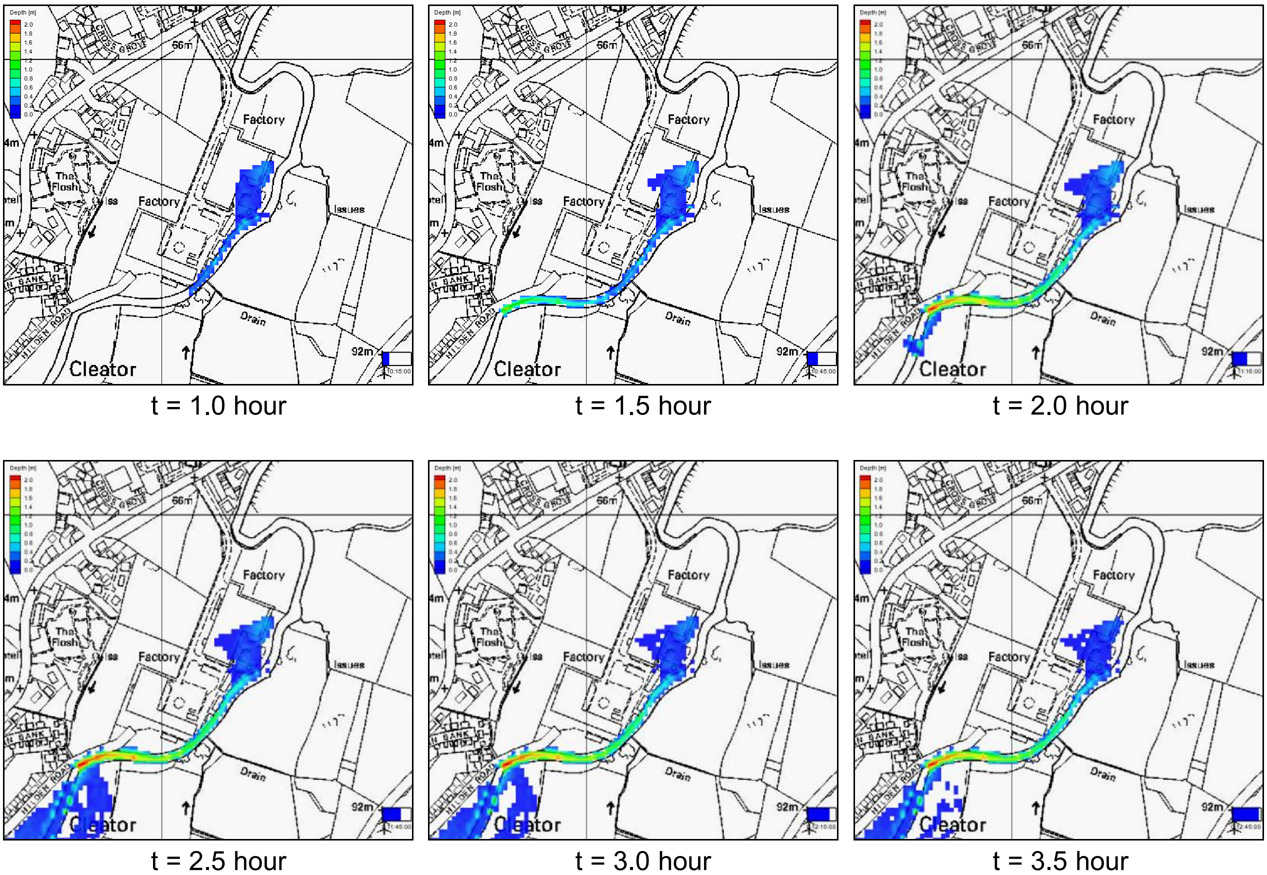



Figure 4.2 – Progress of flood wave from Breach 2

# 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.

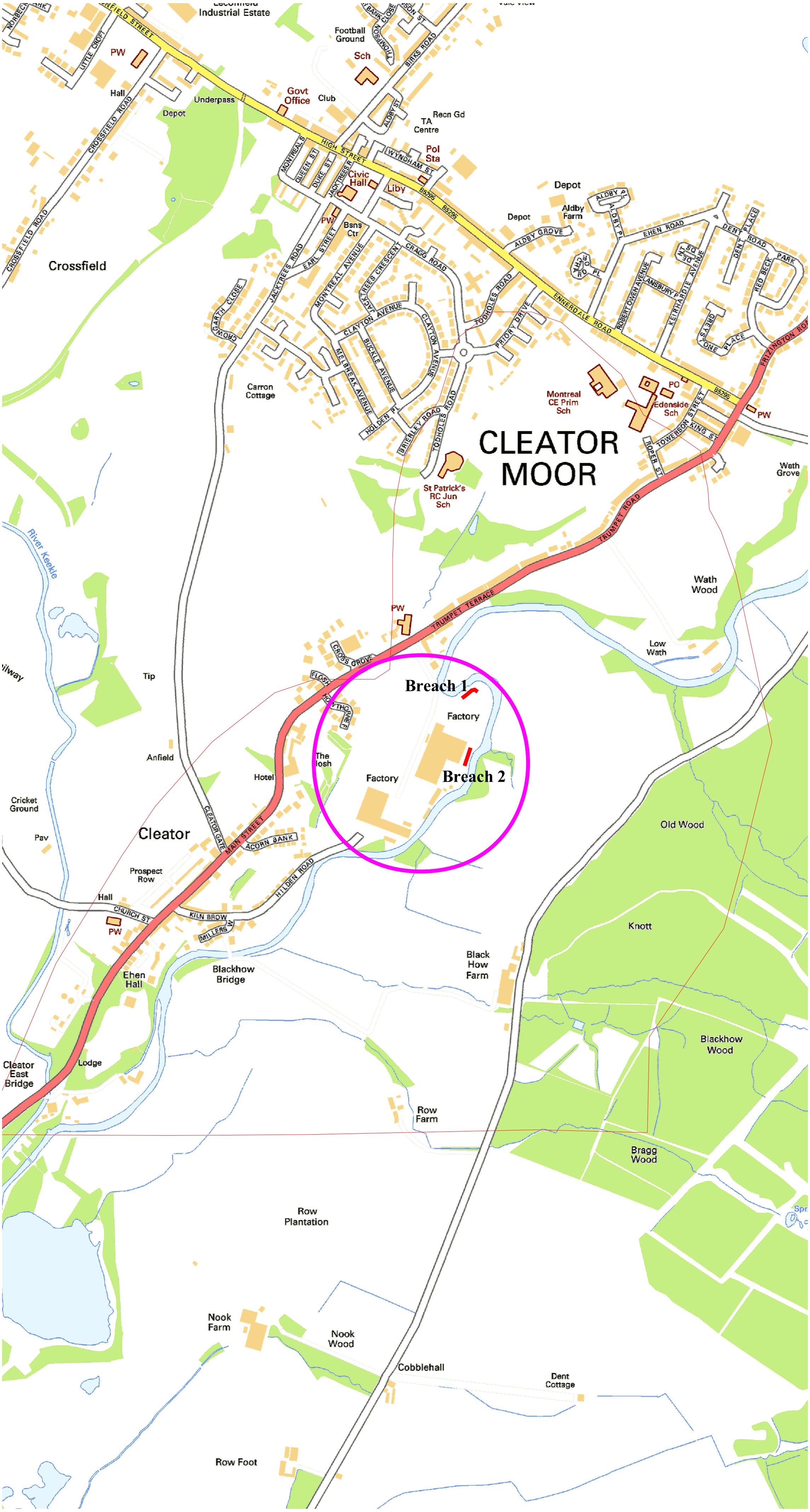
During a breach in the earth embankment east of the site (Breach 2), floodwaters covered the existing building and parts of the car park area. Flood depths generally remained low (0 to 0.25m) through the site, although there were small areas in the vicinity of the factory building where there was deeper 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 ____ 15
Appendix B. Flood Maps ____ 16

# Appendix A. Study Area




## KEY PLAN

## LEGEND

Extent of 2D Domain

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Project Title

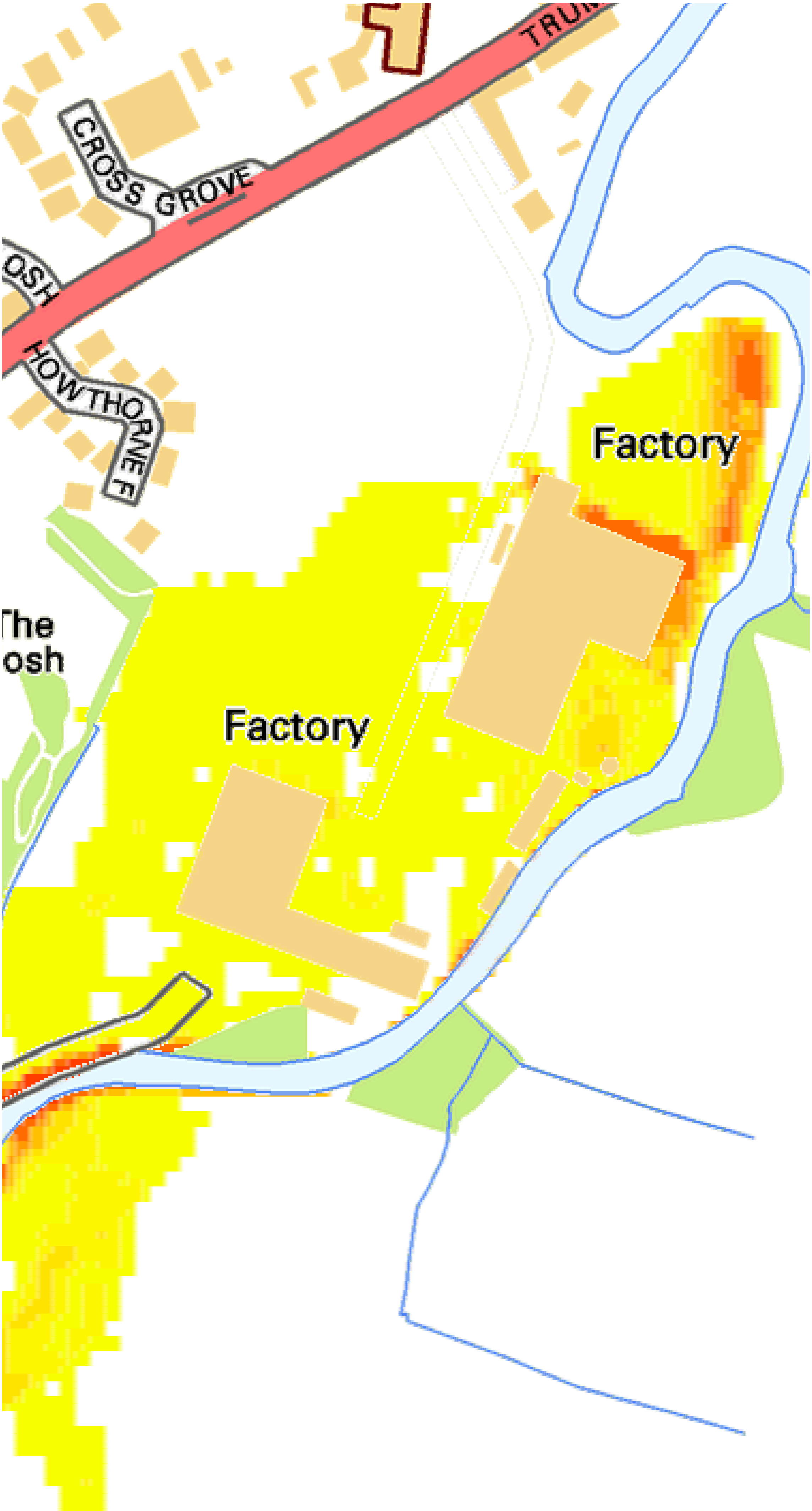
Flood Risk Modelling - Cleator Mill Site

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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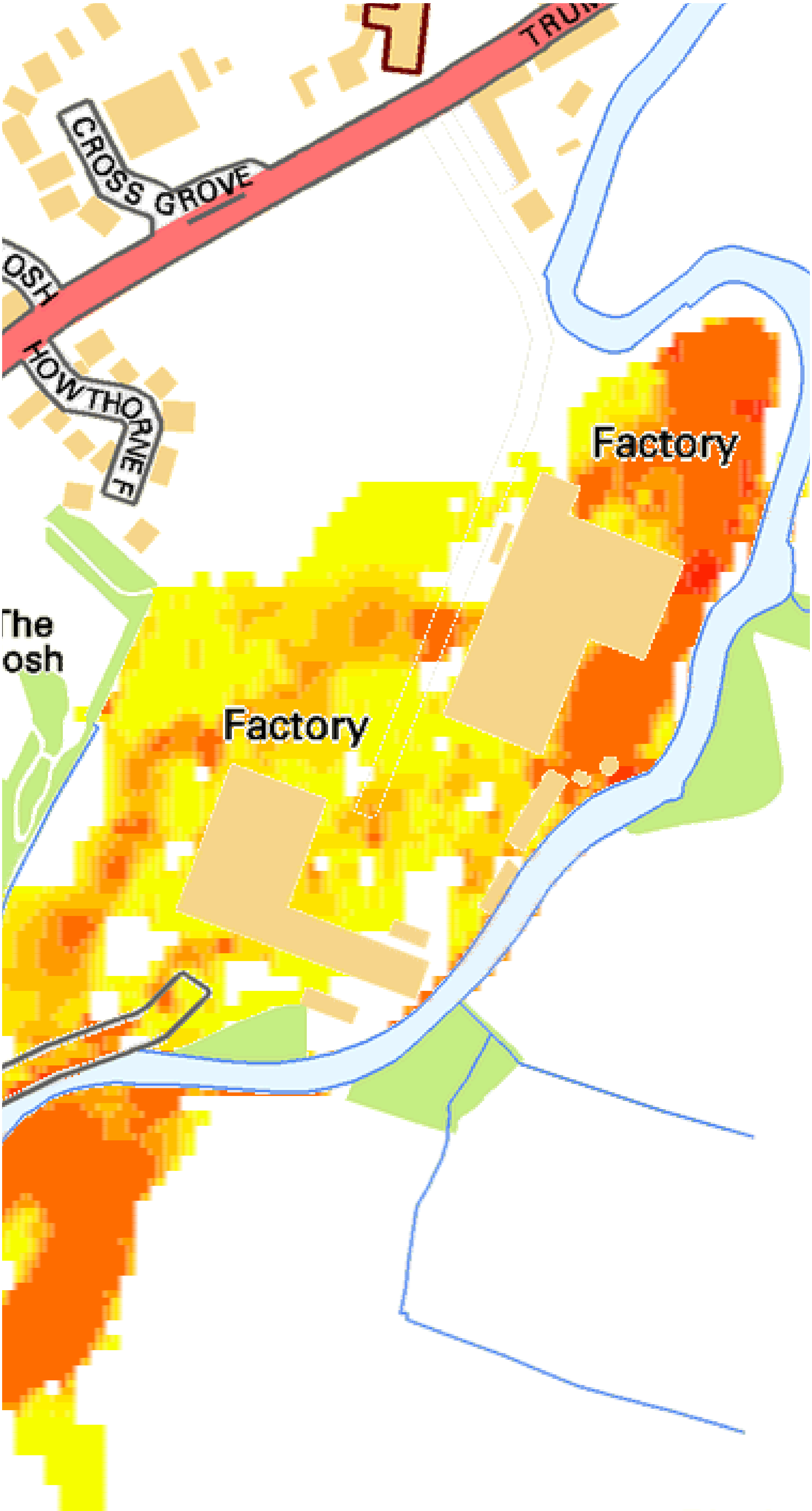
Project Title

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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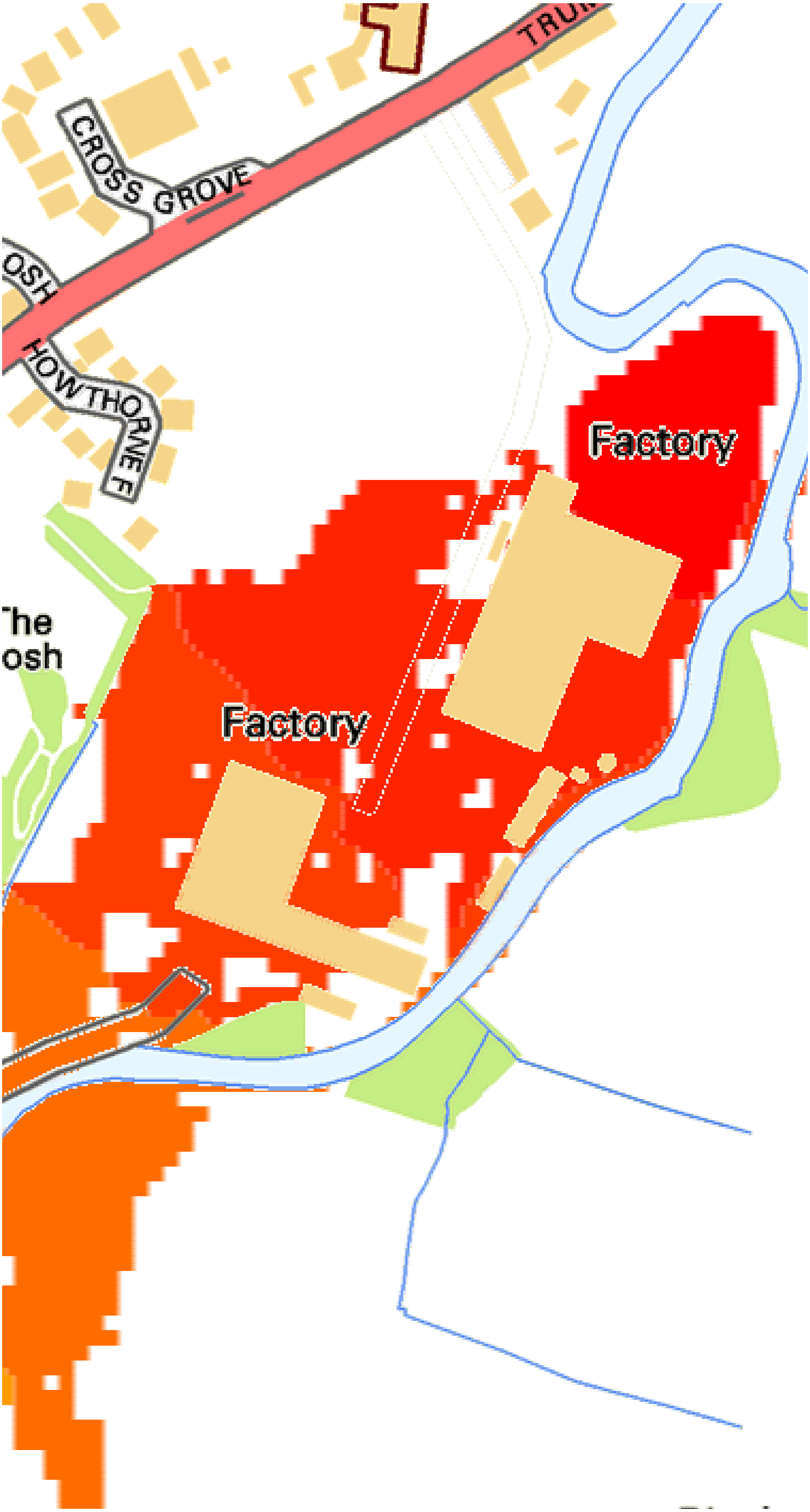
Project Title

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 |




KEY PLAN

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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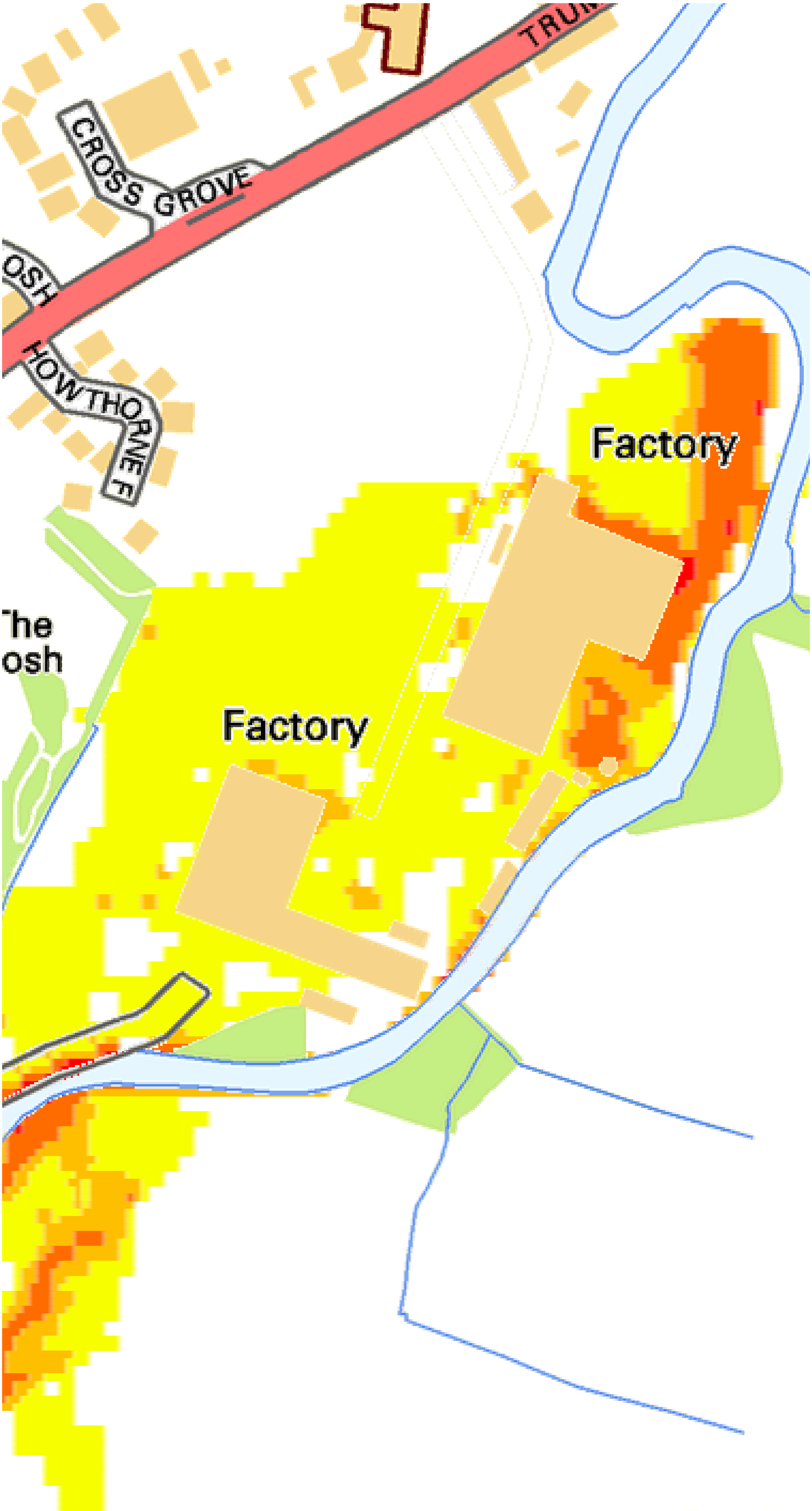
Project Title

Flood Risk Modelling - Cleator Mill Site

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 |




KEY PLAN

LEGEND

**Flood Hazard Category**

- Low
- Moderate
- Significant
- Extreme

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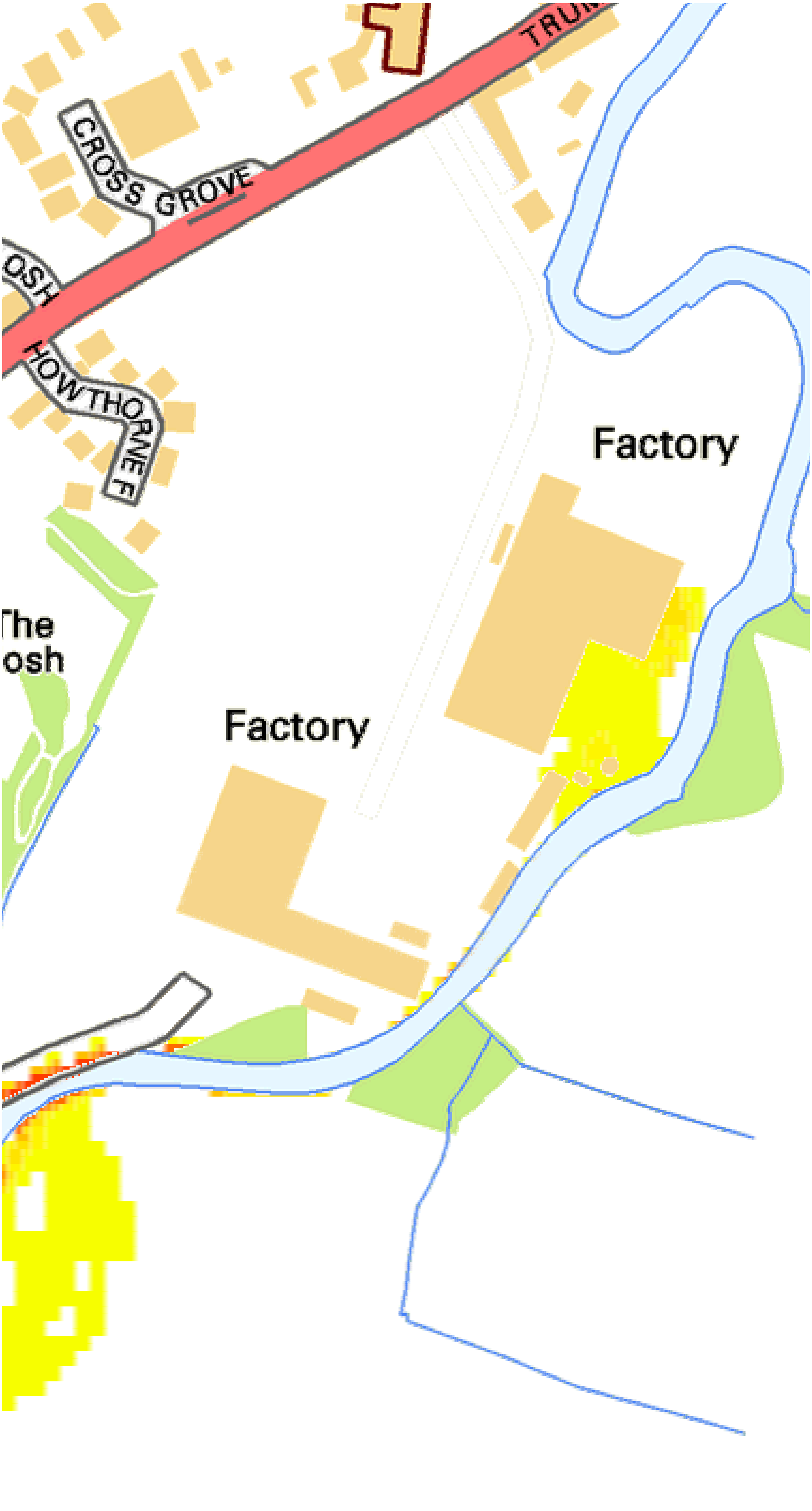
Project Title

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
- 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 2 (DTM 2013)

| | |
|---|---|
| Date / Revision | 14/10/2013 |
| Modelled | IG |
| Checked | RJG |
| Approved | RJG |
| Drawing No. | 1.03 |
| 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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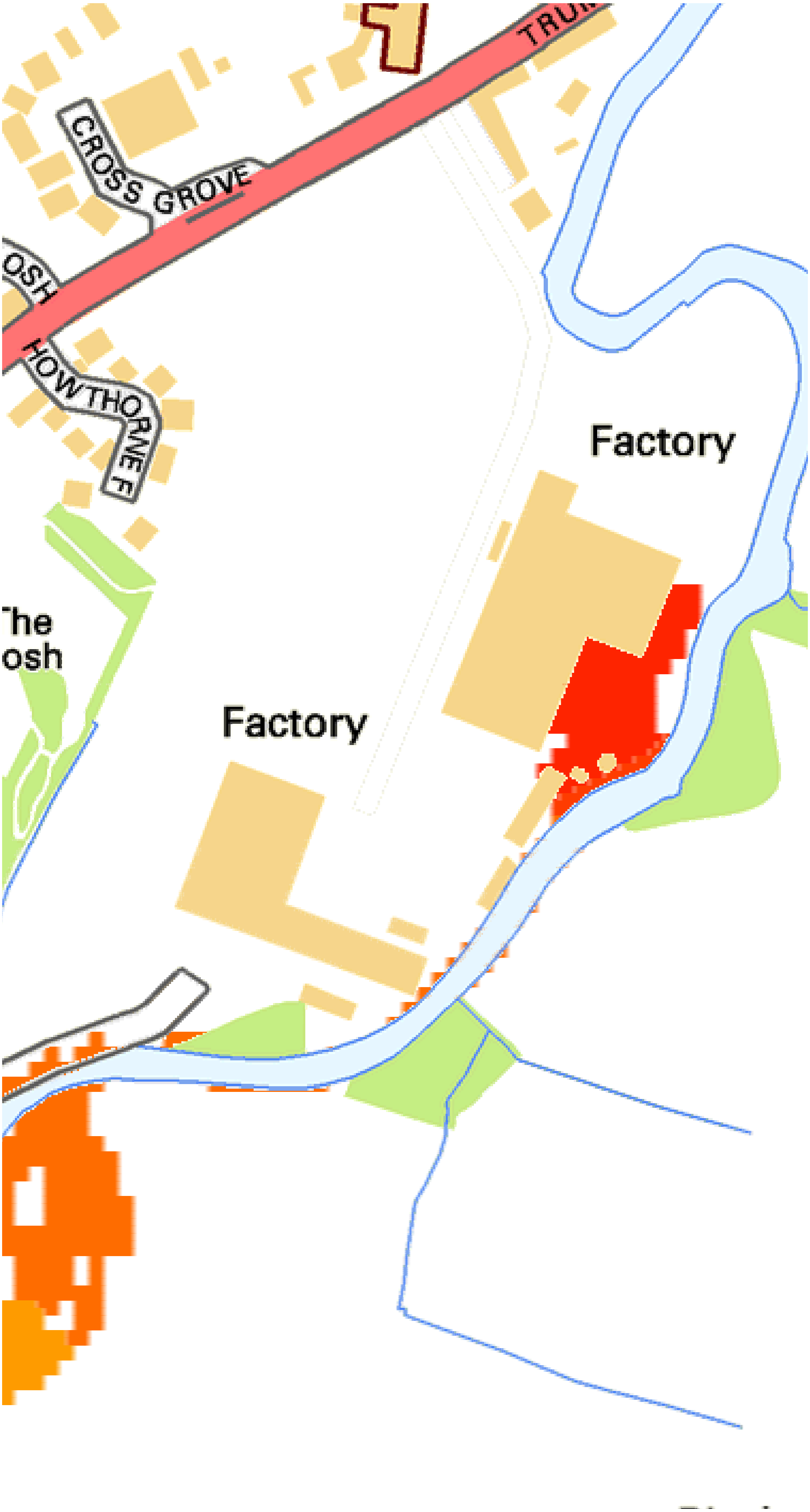
Project Title

Flood Risk Modelling - Cleator Mill Site

Map Title

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 |




KEY PLAN

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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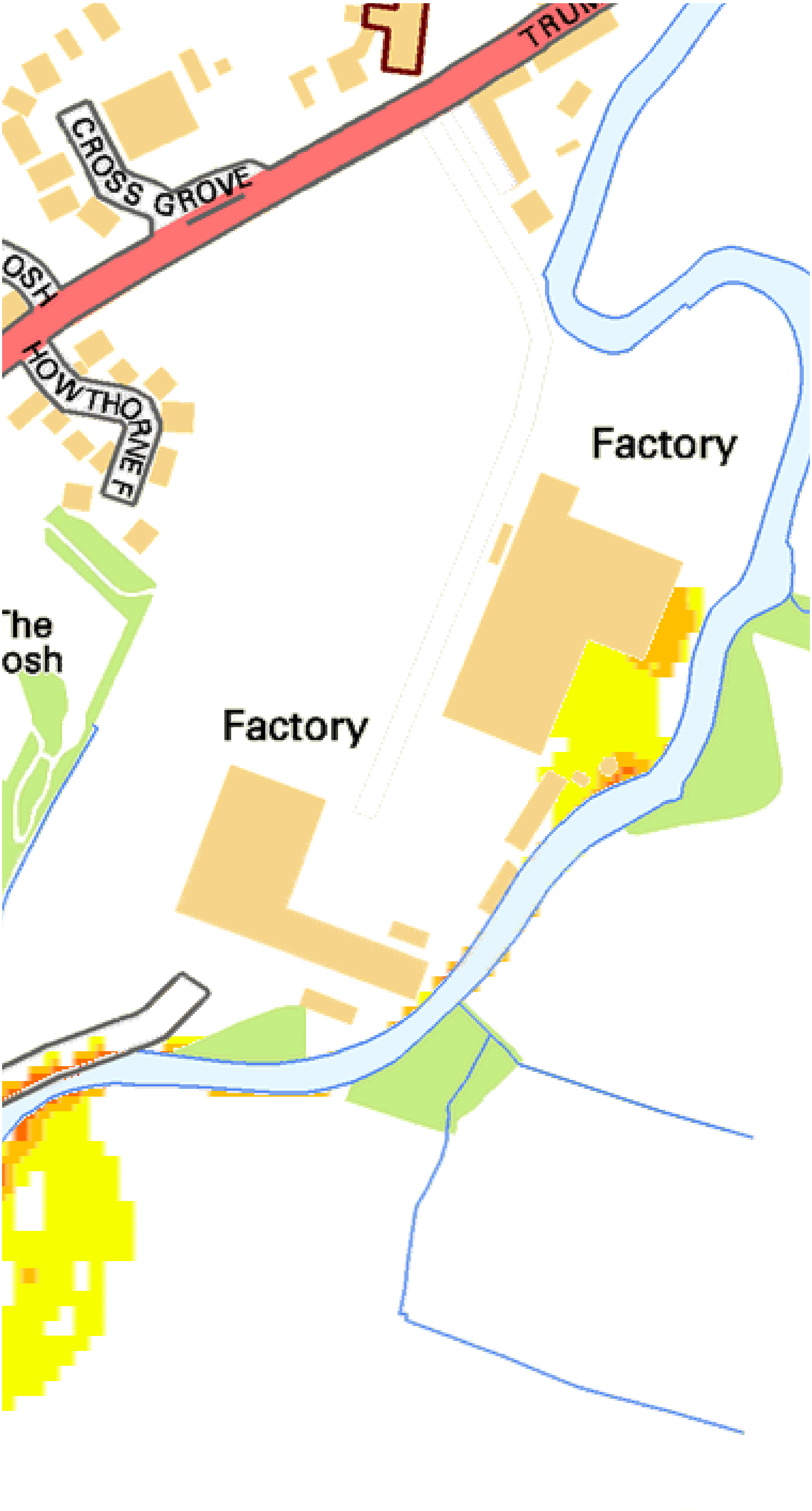
Project Title

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 |
| Drawing Scale at A3 | 1:1100 |




KEY PLAN

LEGEND

**Flood Hazard Category**

- Low
- Moderate
- Significant
- Extreme

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Project Title

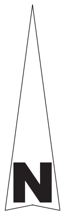
Flood Risk Modelling - Cleator Mill Site

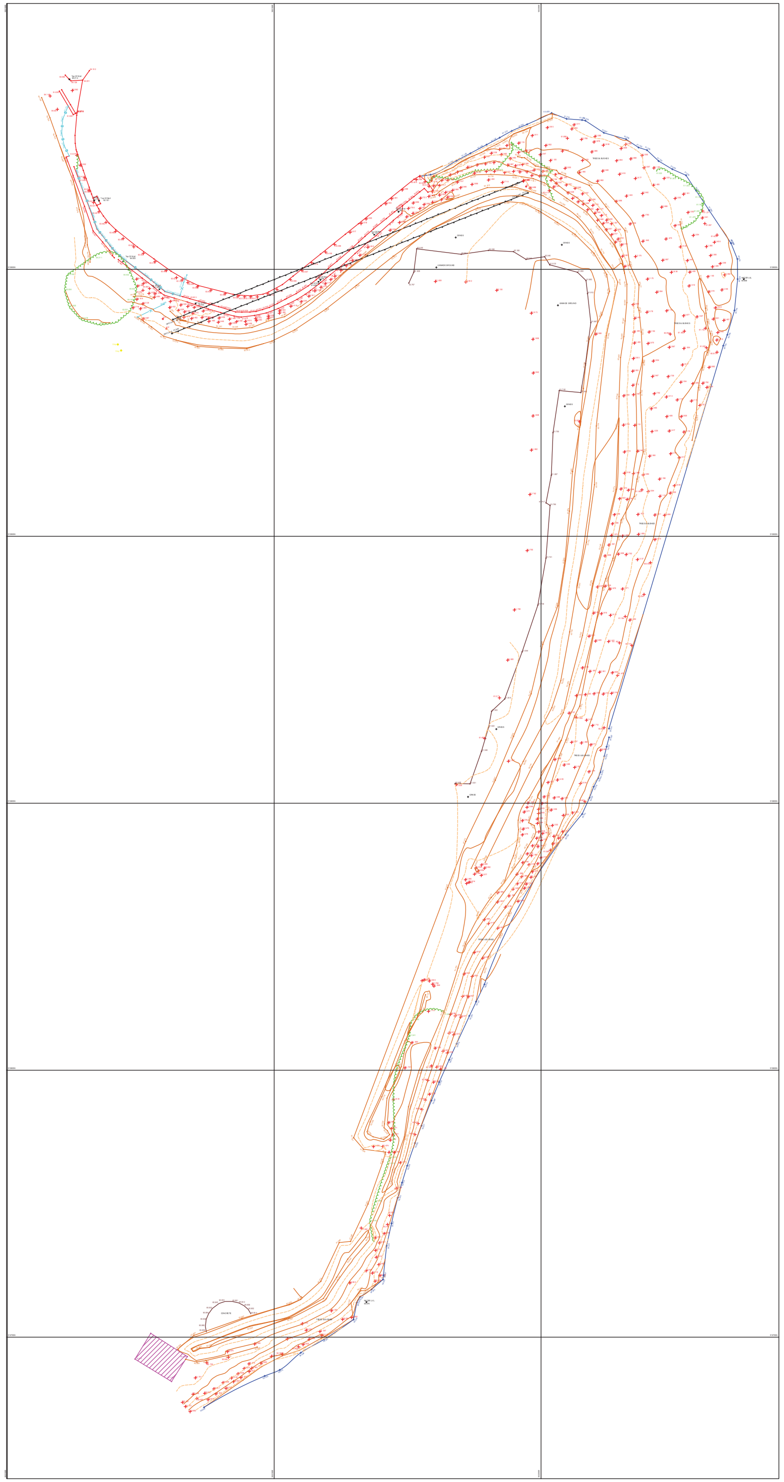
Map Title

Hazard categories for breach 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 B
# RWO ASSOCIATES TOPOGRAPHICAL SURVEY



## KEY

LINETYPES

- VERGE
- FENCE - CHAIN LINK
- FENCE - METAL
- FENCE - WOODEN
- FENCE - POST & RAIL
- HEDGE
- WALL
- BARRIER
- CHANNEL LINE
- CONCRETE EDGE
- FOOTPATH
- TRACK
- BUILDING
- TREE
- GATE
- SURVEY STATION
- EAVES

## UTILITY KEY

LINETYPES

- BT BELOW GROUND
- BT ABOVE GROUND
- BT ASSUMED ROUTE
- CATV BELOW GROUND
- CATV ABOVE GROUND
- CATV ASSUMED ROUTE
- COMMS BELOW GROUND
- COMMS ABOVE GROUND
- COMMS ASSUMED ROUTE
- GAS BELOW GROUND
- GAS ABOVE GROUND
- GAS ASSUMED ROUTE
- ELECTRIC BELOW GROUND
- ELECTRIC ABOVE GROUND
- ELECTRIC ASSUMED ROUTE
- WATER BELOW GROUND
- WATER ABOVE GROUND
- WATER ASSUMED ROUTE
- UNKNOWN BELOW GROUND
- UNKNOWN ABOVE GROUND
- GPR BELOW GROUND
- COMBINED WATER SEWER
- ASSUMED COMBINED WATER SEWER ROUTE
- FOUL WATER SEWER
- ASSUMED FOUL WATER SEWER ROUTE
- STORM WATER SEWER
- ASSUMED STORM WATER SEWER ROUTE
- REINSTATEMENT SCAR
- SURVEY BOUNDARY

ABBREVIATIONS

| | | | |
|---|---|---|---|
| (AC) | ASSUMED CONNECTION | INT | INTERCEPTOR |
| A/G | ABOVE GROUND | KV | KILO VOLT |
| (AR) | ASSUMED ROUTE | LD | LOOP DETECTOR |
| ASB | ASBESTOS CEMENT | LH | LAMP HOLE |
| AV | AIR VALVE | LP | LAMP POST |
| BB | BELISHA BEACON | LV | LOW VOLTAGE |
| BD | BACK DROP | MK | MARKER |
| BL | BASE LEVEL | MH | MANHOLE |
| BO | BOLLARD | MT | METER |
| BOL | BOLLARD LIGHT | M/WELL | MONITORING WELL |
| BT | BRITISH TELECOM | O/H | OVERHEAD |
| CATV | CABLE TELEVISION | PE | POLYETHYLENE |
| CB | CONTROL BOX | PTG | PIPE TO GROUND |
| CI | CAST IRON | PVC | POLYVINYL CHLORIDE |
| CL | COVER LEVEL | TFR | TAKEN FROM RECORDS |
| CR | CABLE RISER | RE | RODDING EYE |
| CWS | COMBINED WATER SEWER | RED | REDUNDANT SERVICE |
| d | DEPTH OF SERVICE | RWP | RAIN WATER PIPE |
| DCH | DRAINAGE CHANNEL | SC | STOP COCK |
| DI | DUCTILE IRON | SI | SPUN IRON |
| DIS | DISUSED | SOF | SOFFIT |
| EOT | END OF TRACE | SP | SOIL PIPE |
| EP | ELECTRIC POLE | SWS | SURFACE WATER SEWER |
| ER | EARTH ROD | SV | STOP VALVE |
| FFP | FUEL TANK FILL POINT | TL | TRAFFIC LIGHT |
| FH | FIRE HYDRANT | TLC | TRAFFIC LIGHT COVER |
| FWS | FOUL WATER SEWER | TP | TELECOM POLE |
| GPR | GROUND PENETRATING RADAR | UTL | UNABLE TO LIFT |
| GR | GAS RISER | UTS | UNABLE TO SURVEY |
| GV | GAS VALVE | UTT | UNABLE TO TRACE |
| GY | GULLY | VC | VITRIFIED CLAY |
| HV | HIGH VOLTAGE | VP | VENT PIPE |
| IC | INSPECTION COVER | WL | WATER LEVEL |
| Id | INVERT DEPTH | WO | WASH OUT |
| IL | INVERT LEVEL | WR | WATER RISER |

DISCLAIMER

Unless otherwise stated, all services shown on this plan have been surveyed using approved detectors and the connections between manholes, if not traced, are assumed to be direct.

No guarantee can be given that all services have been shown.
In ideal conditions the depth accuracies for the underground utilities located is +/- 10% of depth.

Utilities traced using GPR techniques show depths approximately from ground level to the top of the utility. Utilities traced using Electromagnetic techniques provide an estimated depth which is measured from ground level to the centre of the utility. Drainage and pipes traced using Sonde Electromagnetic techniques show depths at approximately the Invert Level.

Where services are shown as 'Taken From Records' on the drawing we are not liable for any loss that may arise due to a lack of accuracy in that guided information.

Due to BT's policy we are not permitted to lift their inspection chamber covers.

Reference should be made to the methodology used on site as detailed within the latest version of SiteScan Procedures for Utility Location Surveys.

SiteScan recommend that all excavations are to be carried out in accordance with HSG 47 (Avoiding Danger from Underground Services).

Plan accuracies of the order of + or - 150mm may be achieved but this figure will depend on the depth of the service below ground level. Where similar services run in close proximity, separation may be impossible. Successful tracing of non-metallic pipes may be limited.

Existing record information showing underground services is often incomplete and of doubtful accuracy. It should be regarded only as an indication and cannot be guaranteed.

## NOTES

| REV | AMENDMENT | DRAWN | CHECKED |
|---|---|---|---|
| A | INITIAL RELEASE | NP | NG |

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T: 0191 257 2911
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SiteScan
Information to build on

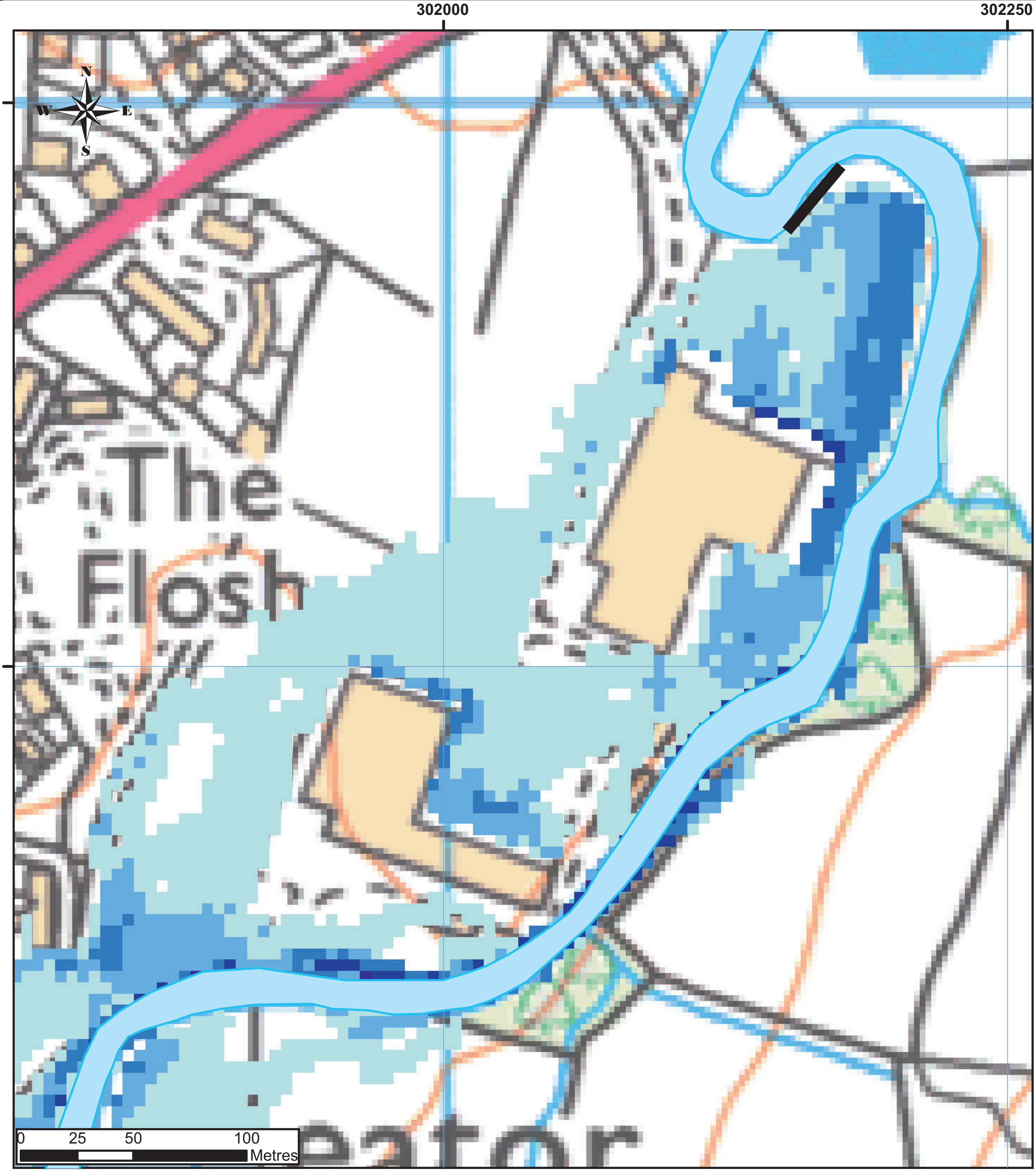
CLIENT: RWO ASSOCIATES

PROJECT TITLE: KANGOL FACTORY, CLEATOR

DRAWING TITLE: TOPOGRAPHICAL SURVEY

| | | |
|---|---|---|
| SCALE AT A1: 1:500 @ A1 | DATE: 24.03.15 | GRID/DATUM: OS |
| SURVEYED BY: NP/NSC | DRAWN BY: NSC | APPROVED: NG |
| PROJECT No.: P20004 | SHEET No.: 1/1 | REV: A |

# APPENDIX C
# BREACH 1 FLOOD MAPS – FIGURES 6A, 6B, 6C AND 6D






**Flood Depth (m)**

**KEY**

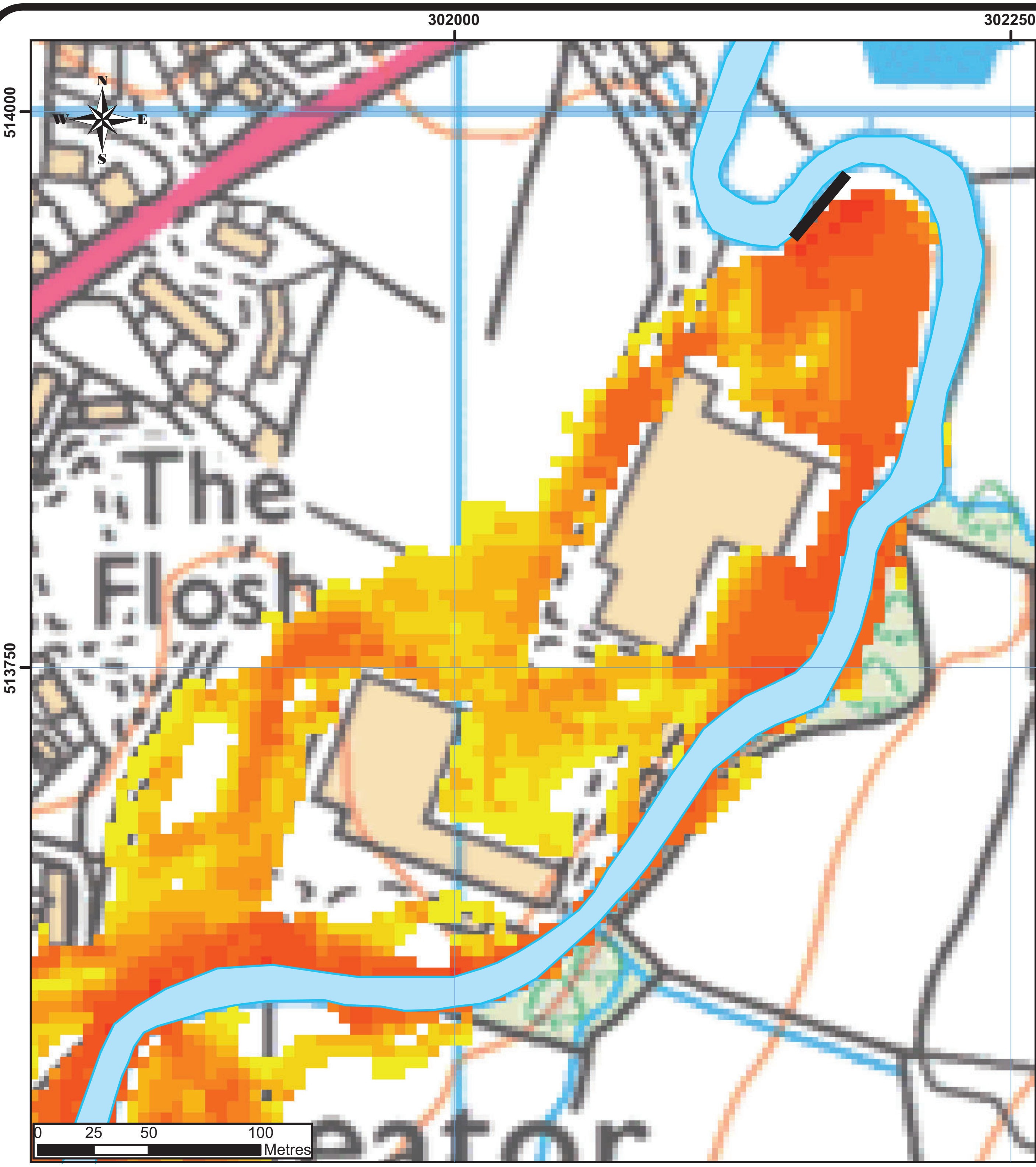
| Flood Depth (m) |
|---|
| 0.01 - 0.25 |
| 0.25 - 0.50 |
| 0.50 - 1.00 |
| 1.00 - 1.50 |
| 1.50 - 2.50 |

Breach 1 Location

River Ehen

envireau WATER

| Ref: P19-310 Cleator Mills Breach Assessment\FIG 6a B1 Max Depth Date: 02/03/2020 | RWO Associates - Cleator Mills |
|---|---|
| Figure 6a | Breach 1 Maximum Flood Depth |






**KEY**

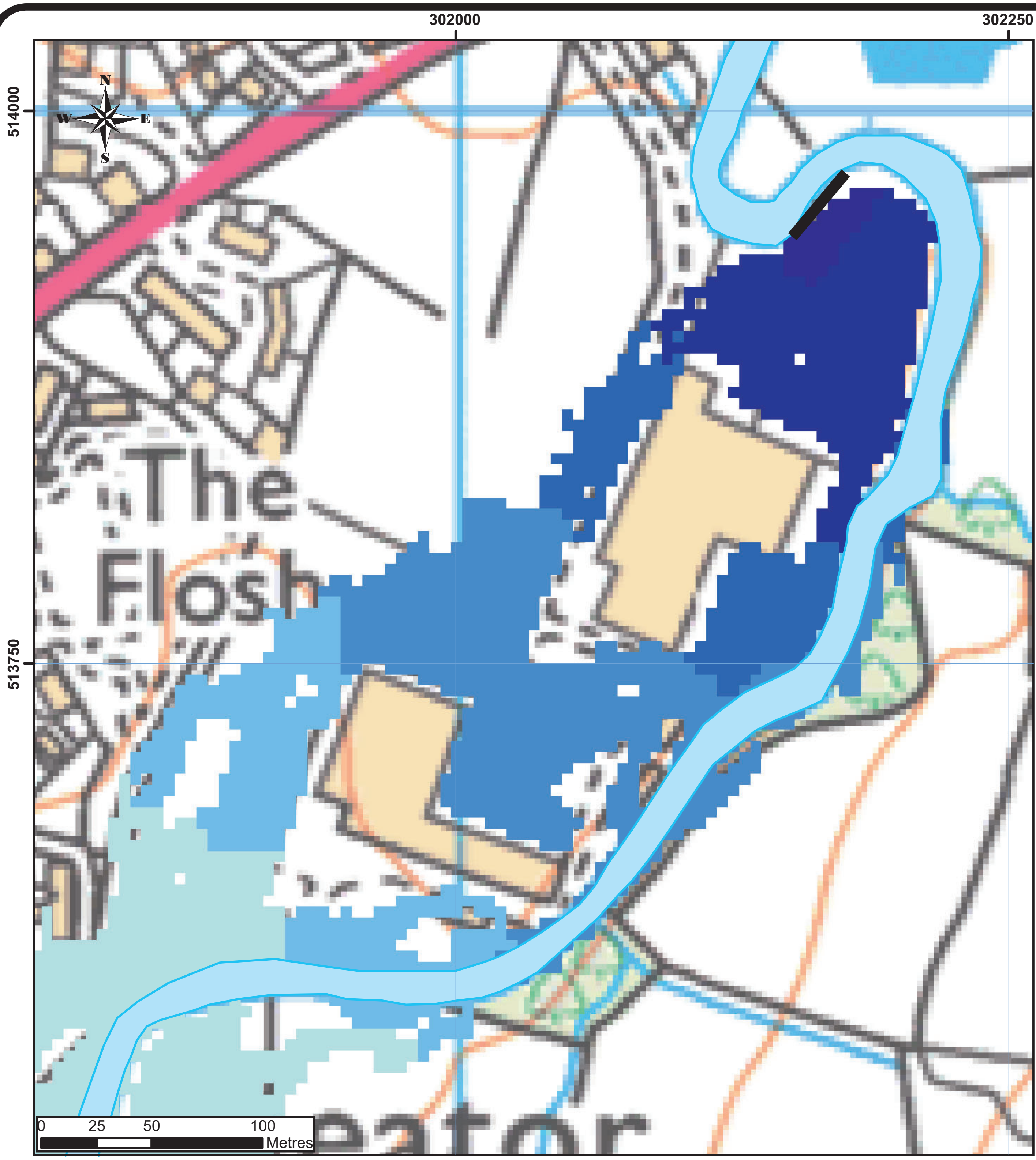
**Velocity (m/s)**

- < 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

- Breach 1 Location
- River Ehen

envireau WATER

| | |
|---|---|
| Ref: P19-310 Cleator Mills Breach Assessment\FIG 6b B1 Max Velocity<br>Date: 02/03/2020 | **RWO Associates - Cleator Mills** |
| Figure 6b | Breach 1 Maximum Velocity |






**WaterLevel (mAOD)**

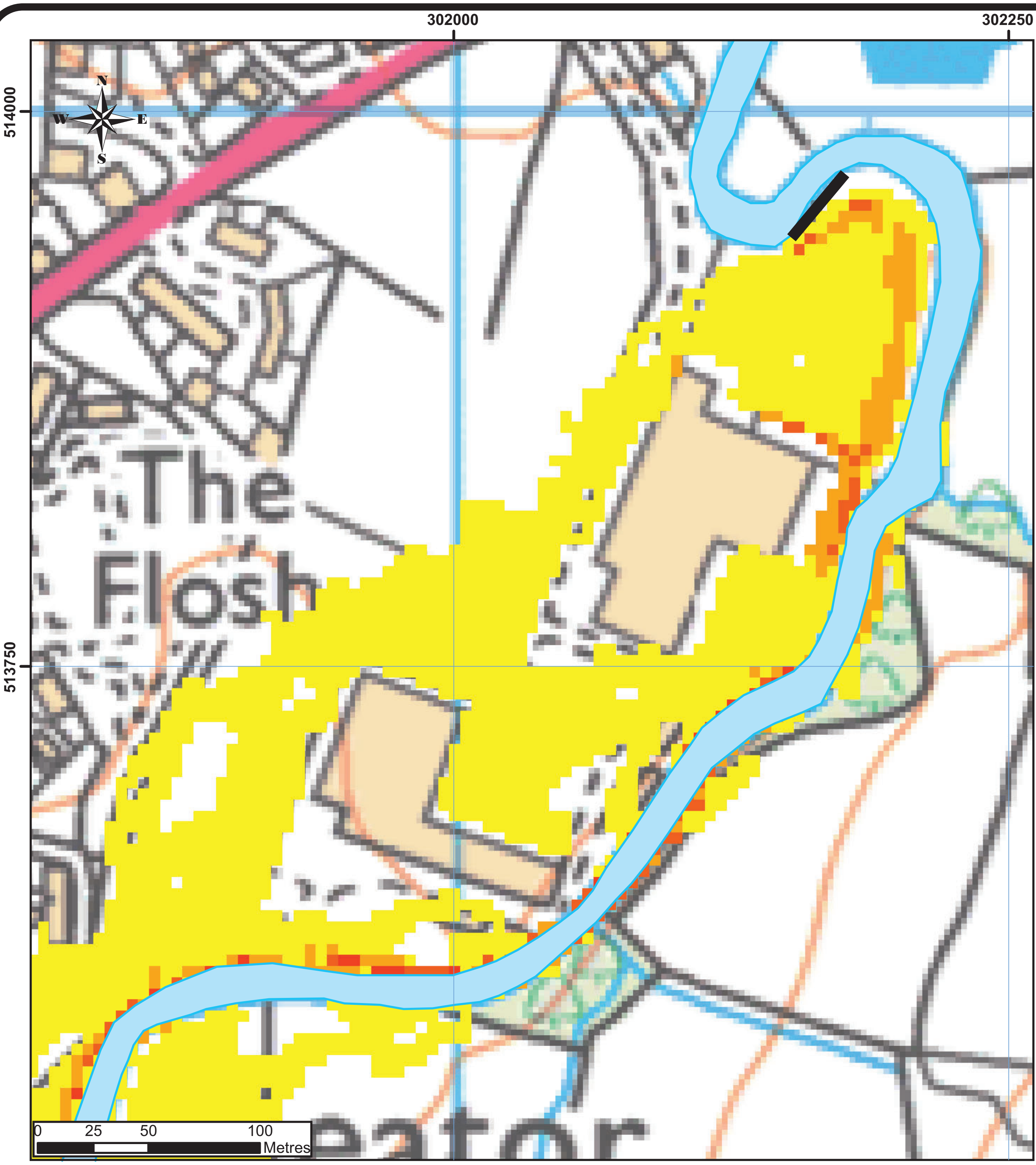
- < 59
- 59 - 60
- 60 - 61
- 61 - 62
- 62 - 63
- > 63

**KEY**

- Breach 1 Location
- River Ehen

envireau WATER

| Ref: P19-310 Cleator Mills Breach Assessment\FIG 6c B1 Max Water Level<br>Date: 02/03/2020 | **RWO Associates - Cleator Mills** |
|---|---|
| Figure 6c | Breach 1 Maximum Water Level |






**KEY**

**Flood Hazard Catergory**

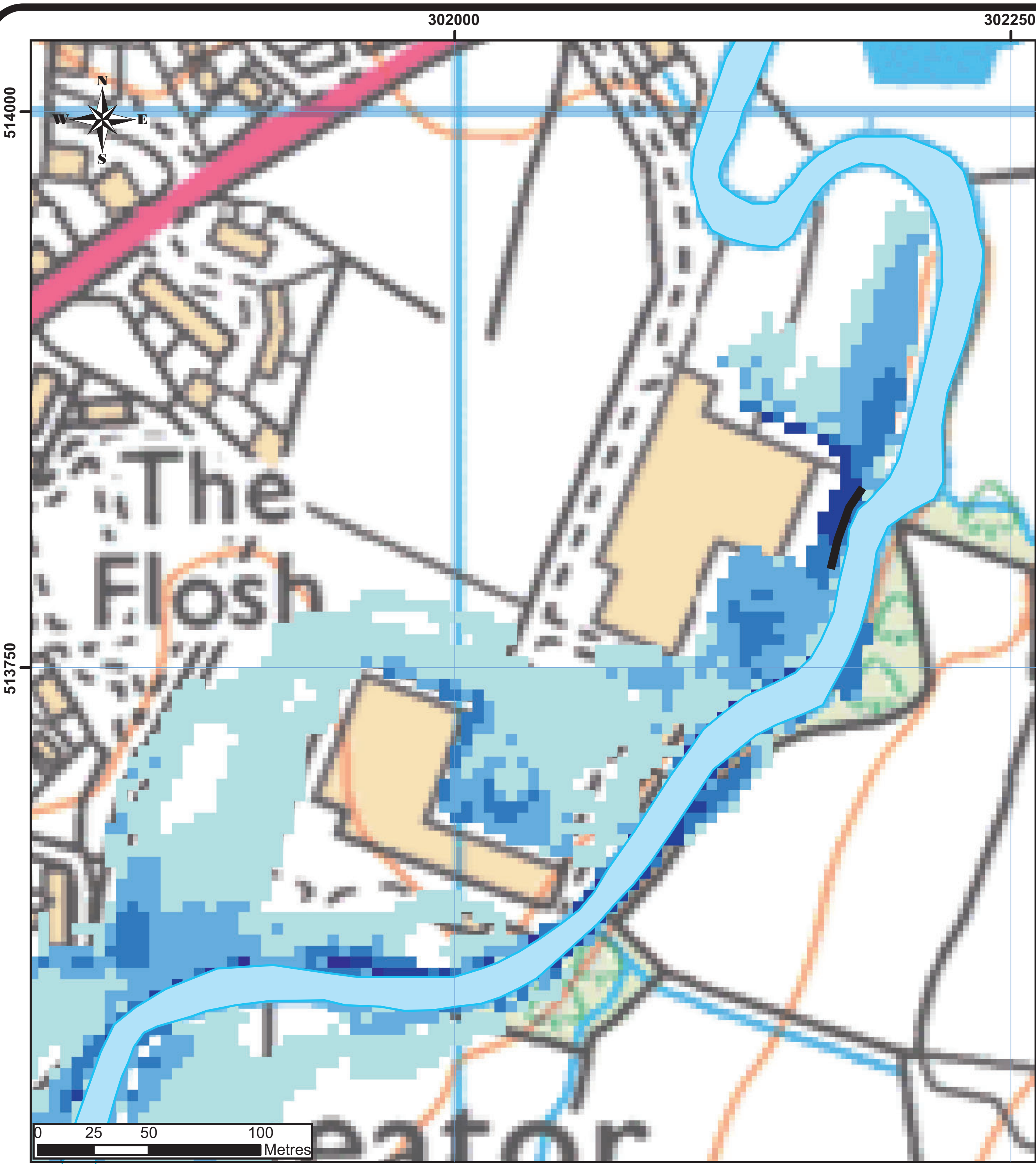
- Low
- Moderate
- Significant
- Extreme

- Breach 1 Location
- River Ehen

envireau WATER

| | |
|---|---|
| Ref: P19-310 Cleator Mills Breach Assessment\FIG 6d B1 Hazard Rating<br>Date: 02/03/2020 | **RWO Associates - Cleator Mills** |
| Figure 6d | Breach 1 Hazard Rating |

# APPENDIX C
# BREACH 2 FLOOD MAPS – FIGURES 7A, 7B, 7C AND 7D






**Flood Depth (m)**

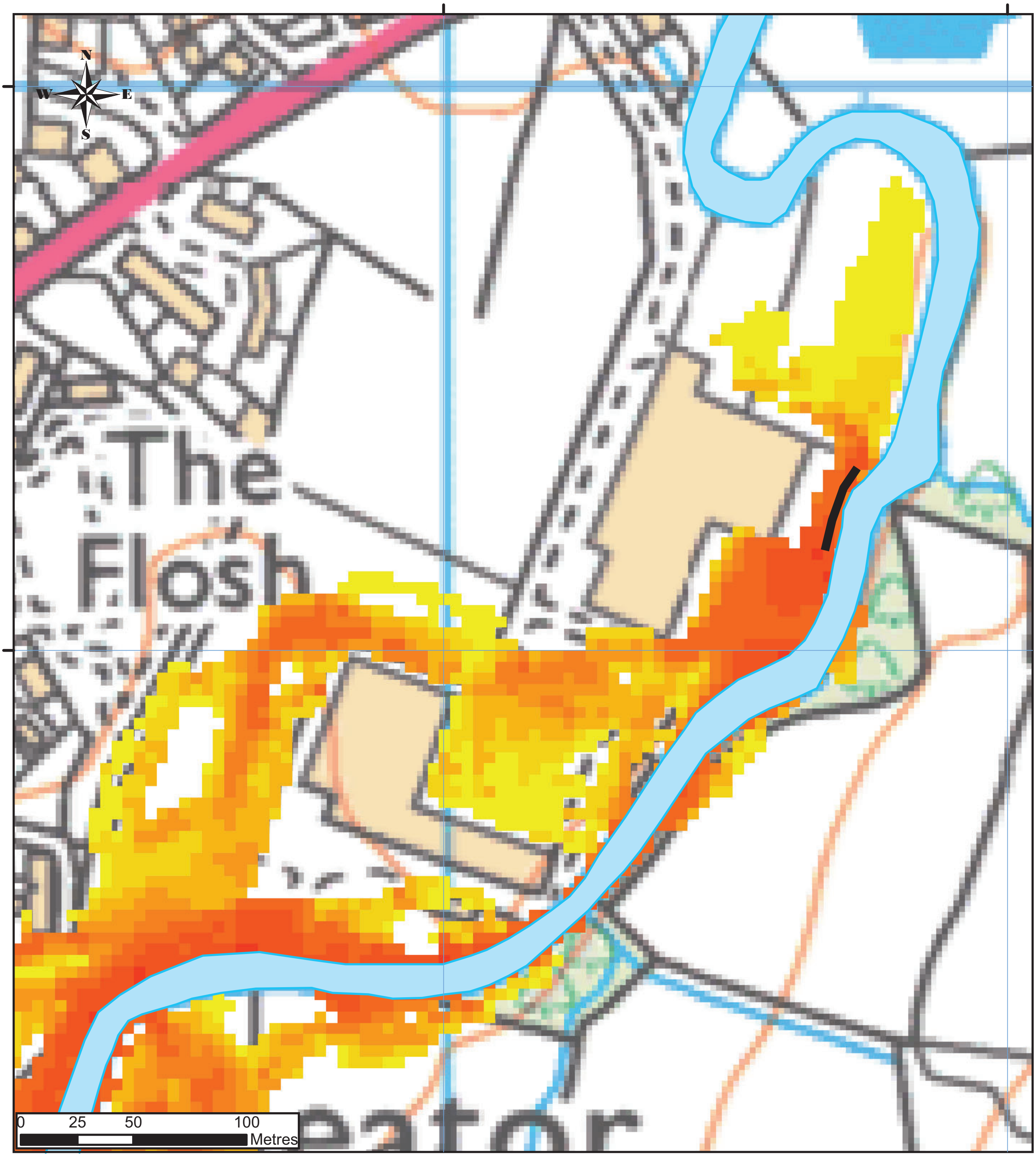
- 0.01 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.50

**KEY**

- Breach 2 Location
- River Ehen

envireau WATER

| Ref: P19-310 Cleator Mills Breach Assessment\FIG 7a B2 Max Depth<br>Date: 02/03/2020 | **RWO Associates - Cleator Mills** |
|---|---|
| Figure 7a | Breach 2 Maximum Flood Depth |






## KEY

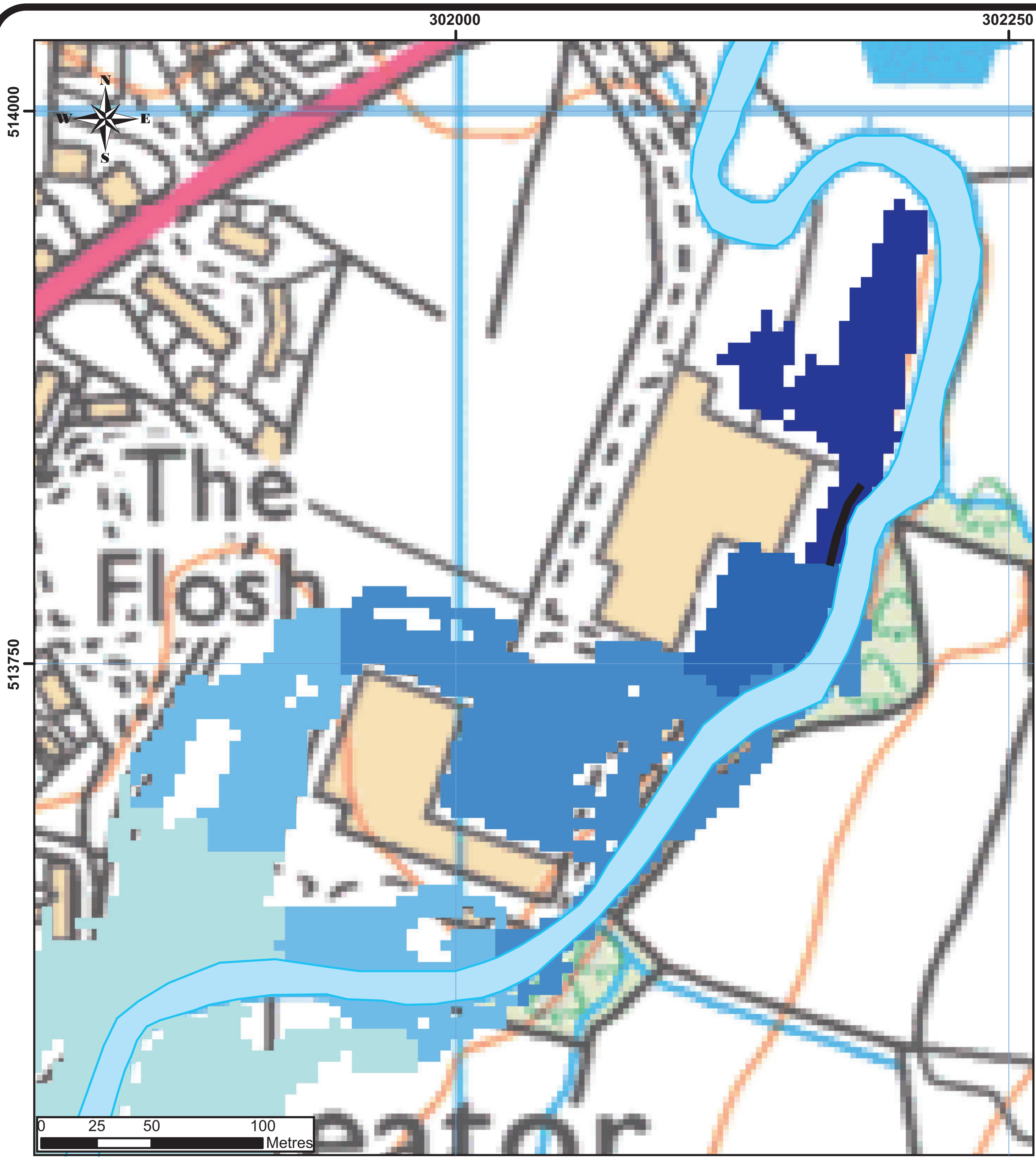
**Velocity (m/s)**

- < 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

- Breach 2 Location
- River Ehen

envireau WATER

| | |
|---|---|
| Ref: P19-310 Cleator Mills Breach Assessment\FIG 7b B2 Max Velocity<br>Date: 02/03/2020 | **RWO Associates - Cleator Mills** |
| Figure 7b | Breach 2 Maximum Velocity |






**KEY**

WaterLevel (mAOD)

- < 59
- 59 - 60
- 60 - 61
- 61 - 62
- 62 - 63
- > 63

- Breach 2 Location
- River Ehen

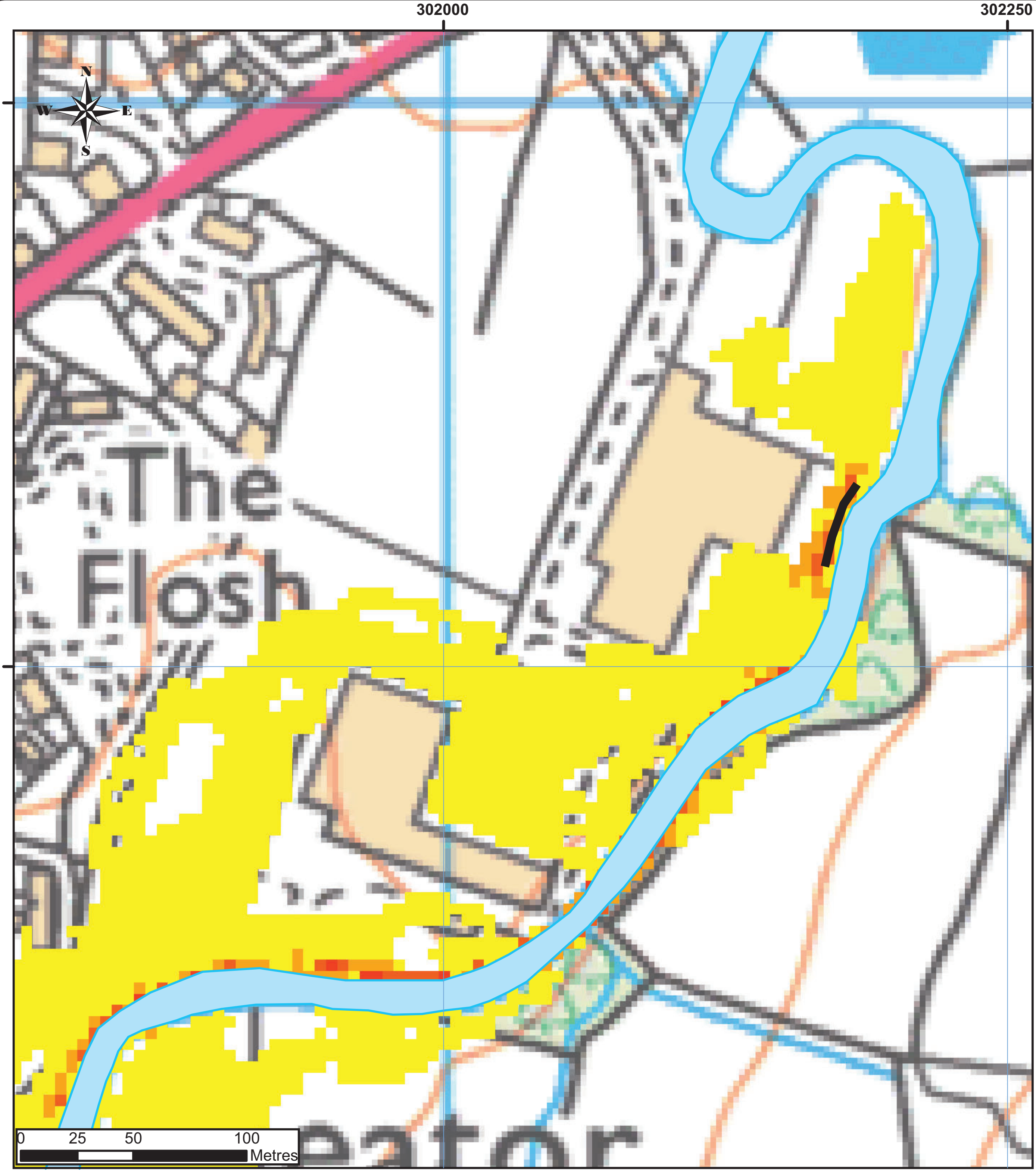
envireau WATER

Ref: P19-310 Cleator Mills Breach Assessment\FIG 7c B2 Max Water Level
Date: 02/03/2020

**RWO Associates - Cleator Mills**

Figure 7c

Breach 2 Maximum Water Level






**KEY**

**Flood Hazard Catergory**

- Low
- Moderate
- Significant
- Extreme

- Breach 2 Location
- River Ehen

envireau WATER

| | |
|---|---|
| Ref: P19-310 Cleator Mills Breach Assessment\FIG 7d B2 Hazard Rating<br>Date: 02/03/2020 | **RWO Associates - Cleator Mills** |
| Figure 7d | Breach 2 Hazard Rating |

# Appendix G Soil Infiltration Test Results

FAO Ross Oakley
RWO Associates Ltd
6A
Union Quay
North Shields
NE30 1HJ

**Sent by Email**

21st October 2013

Dear Ross,

**Re: Land at Cleator Mills – Soakaway Test Letter Report**

Please find attached to this letter the following information:

- Exploratory Hole Location Plan (TP01 to TP06)
- Trial Pit Logs
- Soakaway Test Workbook Extracts (SA01 to SA06 inclusive)

From the trial pit logs it can be seen that the ground conditions typically comprised grass and topsoil over sand and gravel with many cobbles and boulders to the terminal depths of the trial pits between c.1.50m and c.2.00m below current ground levels. No water ingress was noted within the trial pits, although the sand and gravel materials were generally unstable with the materials posing a risk of sidewall collapse.

As requested in-situ soakaway tests were undertaken at the six trial pit locations at depths varying between c.0.50m and c.2.00m below ground levels. All the trial pits successfully drained completely within 2 hours of commencing the tests.

I trust the above and attached is to your satisfaction and if you have any questions or then please call or email.

Yours Faithfully

.........................................................

Curtis R. Evans *B.Sc (Hons) FGS*
Director
For and On Behalf Of Geo Environmental Engineering Ltd

Visit our *NEW* Website: www.geoenvironmentalengineering.com Email: info@geoenvironmentalengineering.com

Tel: 08456 768 895, Mob: 07883 440 186

GEO Environmental Engineering

## GEO2013-776: Exploratory Hole Location Plan (Approximate Locations – Not to Scale)


**Website:** www.geoenvironmentalengineering.com
**Email:** info@geoenvironmentalengineering.com
**Telephone:** 08456 768 895

GEO Environmental Engineering

## GEO2013-776: TP01

| Depth From (m) | Depth To (m) | Strata Description | Legend | Testing / Samples |
|---|---|---|---|---|
| 0.00 | 0.40 | TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets. | | |
| 0.40 | 2.00 | Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout. | | 0.50m Soakaway Test (results on SA01) |
| | | End of trial pit<br>Trial pit remained dry on completion<br>Trial pit noted as unstable below c.1.50m<br>Soakaway test completed from c.0.50m to c.1.50m | | |

**Site:** Land at Cleator Mills
**Client Reference:** N/A
**Engineer:** CE
**Plant:** JCB3CX

**Log Notes:**
Spt = Standard Penetration test (blows per 300mm n300)
HSV = Hand Shear Vane (result in $kN/m^2$)
CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage)
LP = Limited Penetration (HSV/CBR)
NP = No penetration (HSV/CBR)
B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub

## GEO2013-776: TP02

| Depth From (m) | Depth To (m) | Strata Description | Legend | Testing / Samples |
|---|---|---|---|---|
| 0.00 | 0.30 | TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets. | | |
| 0.30 | 0.70 | Red brown slightly gravelly SAND. | | |
| 0.70 | 2.00 | Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout. | | 1.00m Soakaway Test (results on SA02) |
| | | End of trial pit<br>Trial pit remained dry on completion<br>Trial pit noted as unstable below c.1.50m<br>Soakaway test completed from c.1.00m to c.2.00m | | |

| | |
|---|---|
| **Site:** Land at Cleator Mills<br>**Client Reference:** N/A<br>**Engineer:** CE<br>**Plant:** JCB3CX | **Log Notes:**<br>Spt = Standard Penetration test (blows per 300mm n300)<br>HSV = Hand Shear Vane (result in kN/m$^2$)<br>CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage)<br>LP = Limited Penetration (HSV/CBR)<br>NP = No penetration (HSV/CBR)<br>B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub |

## GEO2013-776: TP03

| Depth From (m) | Depth To (m) | Strata Description | Legend | Testing / Samples |
|---|---|---|---|---|
| 0.00 | 0.20 | TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets. | | |
| 0.20 | 0.80 | Red brown slightly gravelly SAND. | | |
| 0.80 | 2.00 | Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout. | | 1.00m Soakaway Test (results on SA03) |
| | | End of trial pit<br>Trial pit remained dry on completion<br>Trial pit noted as unstable below c.0.80m<br>Soakaway test completed from c.1.00m to c.2.00m | | |

| | |
|---|---|
| **Site:** Land at Cleator Mills<br>**Client Reference:** N/A<br>**Engineer:** CE<br>**Plant:** JCB3CX | **Log Notes:**<br>Spt = Standard Penetration test (blows per 300mm n300)<br>HSV = Hand Shear Vane (result in kN/$m^2$)<br>CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage)<br>LP = Limited Penetration (HSV/CBR)<br>NP = No penetration (HSV/CBR)<br>B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub |

## GEO2013-776: TP04

| Depth From (m) | Depth To (m) | Strata Description | Legend | Testing / Samples |
|---|---|---|---|---|
| 0.00 | 0.30 | TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets. | | |
| 0.30 | 1.50 | Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout. | | 0.50m Soakaway Test (results on SA04) |
| | | End of trial pit<br>Trial pit remained dry on completion<br>Trial pit noted as unstable below c.1.00m<br>Soakaway test completed from c.0.50m to c.1.50m | | |

| | |
|---|---|
| **Site:** Land at Cleator Mills<br>**Client Reference:** N/A<br>**Engineer:** CE<br>**Plant:** JCB3CX | **Log Notes:**<br>Spt = Standard Penetration test (blows per 300mm n300)<br>HSV = Hand Shear Vane (result in kN/$m^2$)<br>CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage)<br>LP = Limited Penetration (HSV/CBR)<br>NP = No penetration (HSV/CBR)<br>B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub |

## GEO2013-776: TP05

| Depth From (m) | Depth To (m) | Strata Description | Legend | Testing / Samples |
|---|---|---|---|---|
| 0.00 | 0.35 | TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets. | | |
| 0.35 | 0.60 | Red brown slightly gravelly SAND. | | |
| 0.60 | 2.00 | Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout. | | 1.00m Soakaway Test (results on SA05) |
| | | End of trial pit<br>Trial pit remained dry on completion<br>Trial pit noted as unstable below c.1.50m<br>Soakaway test completed from c.1.00m to c.2.00m | | |

| | |
|---|---|
| **Site:** Land at Cleator Mills<br>**Client Reference:** N/A<br>**Engineer:** CE<br>**Plant:** JCB3CX | **Log Notes:**<br>Spt = Standard Penetration test (blows per 300mm n300)<br>HSV = Hand Shear Vane (result in $kN/m^2$)<br>CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage)<br>LP = Limited Penetration (HSV/CBR)<br>NP = No penetration (HSV/CBR)<br>B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub |

## GEO2013-776: TP06

| Depth From (m) | Depth To (m) | Strata Description | Legend | Testing / Samples |
|---|---|---|---|---|
| 0.00 | 0.50 | MADE GROUND: TURF over TOPSOIL: Grass over dark brown sandy gravelly clayey topsoil with some rootlets and rare brick pieces. | | |
| 0.50 | 0.90 | Red brown slightly gravelly SAND. | | 0.50m Soakaway Test (results on SA06) |
| 0.90 | 1.50 | Medium dense appearing reddish brown SAND and GRAVEL. Many cobbles and boulders noted throughout. | | |
| | | End of trial pit<br>Trial pit remained dry on completion<br>Trial pit noted as unstable below c.1.00m<br>Soakaway test completed from c.0.50m to c.1.50m | | |

| | |
|---|---|
| **Site:** Land at Cleator Mills<br>**Client Reference:** N/A<br>**Engineer:** CE<br>**Plant:** JCB3CX | **Log Notes:**<br>Spt = Standard Penetration test (blows per 300mm n300)<br>HSV = Hand Shear Vane (result in kN/$m^2$)<br>CBR = California Bearing Ratio by Mexe Cone Penetrometer (result as percentage)<br>LP = Limited Penetration (HSV/CBR)<br>NP = No penetration (HSV/CBR)<br>B = Bulk Bag, J = Amber Glass Jar, T = Plastic Tub |

**CALCULATIONS/SKETCHES**

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | GEO2013-776 Land at Cleator Mills | | | | |
| JOB No | 2013-776 | PREPARED BY | CRE | SHEET No | SA 01 |
| DATE | 21-Oct-13 | CHECKED BY | CRE/GE | REV | P1 |

REF | OUTPUT

**Calculation of soil infiltration rate in accordance with BRE Digest 365**

Length of trial pit = $L_{TP}$ = 3.000 *m*
Width of trial pit = $W_{TP}$ = 0.450 *m*
Effective Depth = $D_{TP}$ = 1.500 *m* *(measured below incoming invert)*

75% Effective Depth of trial pit = $D_{75}$ = ( $D_{TP}$ x 0.75 ) = 1.125 *m*
50% Effective Depth of trial pit = $D_{50}$ = ( $D_{TP}$ x 0.50 ) = 0.750 *m*
25% Effective Depth of trial pit = $D_{25}$ = ( $D_{TP}$ x 0.25 ) = 0.375 *m*

Pit Voids = PV = 100 % *(For open pits, PV = 100%. For stone filled pits, PV = 30%)*

Carry out 3 tests, each measuring the time taken for water levels
to fall from 75% effective depth to 25% effective depth

Test No 1 time to fall from 75% to 25% eff depth = $T_1$ = 40.0 *mins*
Test No 2 time to fall from 75% to 25% eff depth = $T_2$ = *mins*
Test No 3 time to fall from 75% to 25% eff depth = $T_3$ = *mins*

TAKE THE LONGEST OF THE 3 TESTS ABOVE = $T_L$ = 40.0 *mins*

Volume of water escaping during this test between $D_{75}$ and $D_{25}$
= $V_{TP75\_25}$ = ( $L_{TP}$ x $W_{TP}$ x ($D_{75}$ - $D_{25}$) x PV) = 1.013 *cu m.*

The mean surface area through which the above volume escapes, is the *wetted area.*
Only 50% of the effective depth is allowed in the calculation.

*ie* $A_{P50}$ = (Wet Base Area + 50% of Wet Sides Area)
$A_{P50}$ = ($L_{TP}$ x $W_{TP}$) + ($2L_{TP}+2W_{TP}$) x $D_{50}$
$A_{P50}$ = 1.350 + 5.175
$A_{P50}$ = 6.525 *sq m*

Soil Infiltration Rate = f = $\frac{V_{TP75\_25}}{A_{P50} \times 60 \times T_L}$ *m/s*

**Soil Infiltration Rate = f = 6.46552E-05 *m/s***

Notes: Pit drained completely within 40 minutes.

**CALCULATIONS/SKETCHES**

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | GEO2013-776 Land at Cleator Mills | | | | |
| JOB No | 2013-776 | PREPARED BY | CRE | SHEET No | SA 02 |
| DATE | 21-Oct-13 | CHECKED BY | CRE/GE | REV | P1 |

REF | OUTPUT

**Calculation of soil infiltration rate in accordance with BRE Digest 365**

Length of trial pit = $L_{TP}$ = 2.000 *m*

Width of trial pit = $W_{TP}$ = 0.450 *m*

Effective Depth = $D_{TP}$ = 2.000 *m* *(measured below incoming invert)*

75% Effective Depth of trial pit = $D_{75}$ = ( $D_{TP}$ x 0.75 ) = 1.500 *m*

50% Effective Depth of trial pit = $D_{50}$ = ( $D_{TP}$ x 0.50 ) = 1.000 *m*

25% Effective Depth of trial pit = $D_{25}$ = ( $D_{TP}$ x 0.25 ) = 0.500 *m*

Pit Voids = PV = 100 % *(For open pits, PV = 100%. For stone filled pits, PV = 30%)*

Carry out 3 tests, each measuring the time taken for water levels
to fall from 75% effective depth to 25% effective depth

| | | | | | |
|---|---|---|---|---|---|
| Test No 1 | time to fall from 75% to 25% eff depth | = | $T_1$ | = | 52.0 *mins* |
| Test No 2 | time to fall from 75% to 25% eff depth | = | $T_2$ | = | *mins* |
| Test No 3 | time to fall from 75% to 25% eff depth | = | $T_3$ | = | *mins* |

TAKE THE LONGEST OF THE 3 TESTS ABOVE = $T_L$ = 52.0 *mins*

Volume of water escaping during this test between $D_{75}$ and $D_{25}$

= $V_{TP75\_25}$ = ( $L_{TP}$ x $W_{TP}$ x ($D_{75}$ - $D_{25}$) x PV) = 0.900 *cu m.*

The mean surface area through which the above volume escapes, is the *wetted area.*
Only 50% of the effective depth is allowed in the calculation.

*ie* $A_{P50}$ = (Wet Base Area + 50% of Wet Sides Area)

$A_{P50}$ = ($L_{TP}$ x $W_{TP}$) + ($2L_{TP}+2W_{TP}$) x $D_{50}$

$A_{P50}$ = 0.900 + 4.900

$A_{P50}$ = 5.800 *sq m*

Soil Infiltration Rate = f = $\frac{V_{TP75\_25}}{A_{P50} \times 60 \times T_L}$ *m/s*

**Soil Infiltration Rate = f = 4.97347E-05** ***m/s***

Notes: Pit drained completely within 52 minutes.

**CALCULATIONS/SKETCHES**

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | GEO2013-776 Land at Cleator Mills | | | | |
| JOB No | 2013-776 | PREPARED BY | CRE | SHEET No | SA 03 |
| DATE | 21-Oct-13 | CHECKED BY | CRE/GE | REV | P1 |

REF | OUTPUT

**Calculation of soil infiltration rate in accordance with BRE Digest 365**

Length of trial pit = $L_{TP}$ = 2.500 *m*

Width of trial pit = $W_{TP}$ = 0.500 *m*

Effective Depth = $D_{TP}$ = 2.000 *m* *(measured below incoming invert)*

75% Effective Depth of trial pit = $D_{75}$ = ( $D_{TP}$ x 0.75 ) = 1.500 *m*

50% Effective Depth of trial pit = $D_{50}$ = ( $D_{TP}$ x 0.50 ) = 1.000 *m*

25% Effective Depth of trial pit = $D_{25}$ = ( $D_{TP}$ x 0.25 ) = 0.500 *m*

Pit Voids = PV = 100 % *(For open pits, PV = 100%. For stone filled pits, PV = 30%)*

Carry out 3 tests, each measuring the time taken for water levels
to fall from 75% effective depth to 25% effective depth

Test No 1 time to fall from 75% to 25% eff depth = $T_1$ = 120.0 *mins*

Test No 2 time to fall from 75% to 25% eff depth = $T_2$ = *mins*

Test No 3 time to fall from 75% to 25% eff depth = $T_3$ = *mins*

TAKE THE LONGEST OF THE 3 TESTS ABOVE = $T_L$ = 120.0 *mins*

Volume of water escaping during this test between $D_{75}$ and $D_{25}$

= $V_{TP75\_25}$ = ( $L_{TP}$ x $W_{TP}$ x ($D_{75}$ - $D_{25}$) x PV) = 1.250 *cu m.*

The mean surface area through which the above volume escapes, is the *wetted area.*
Only 50% of the effective depth is allowed in the calculation.

*ie* $A_{P50}$ = (Wet Base Area + 50% of Wet Sides Area)

$A_{P50}$ = ($L_{TP}$ x $W_{TP}$) + ($2L_{TP}+2W_{TP}$) x $D_{50}$

$A_{P50}$ = 1.250 + 6.000

$A_{P50}$ = 7.250 *sq m*

Soil Infiltration Rate = f = $\frac{V_{TP75\_25}}{A_{P50} \times 60 \times T_L}$ *m/s*

**Soil Infiltration Rate = f = 2.39464E-05 *m/s***

Notes: Pit drained completely within 120 minutes.

SA03.xls

**CALCULATIONS/SKETCHES**

| PROJECT | GEO2013-776 Land at Cleator Mills | | | | |
|---|---|---|---|---|---|
| JOB No | 2013-776 | PREPARED BY | CRE | SHEET No | SA 04 |
| DATE | 21-Oct-13 | CHECKED BY | CRE/GE | REV | P1 |

REF | OUTPUT

**Calculation of soil infiltration rate in accordance with BRE Digest 365**

Length of trial pit = $L_{TP}$ = 2.600 *m*
Width of trial pit = $W_{TP}$ = 0.500 *m*
Effective Depth = $D_{TP}$ = 1.500 *m* *(measured below incoming invert)*

75% Effective Depth of trial pit = $D_{75}$ = ( $D_{TP}$ x 0.75 ) = 1.125 *m*
50% Effective Depth of trial pit = $D_{50}$ = ( $D_{TP}$ x 0.50 ) = 0.750 *m*
25% Effective Depth of trial pit = $D_{25}$ = ( $D_{TP}$ x 0.25 ) = 0.375 *m*

Pit Voids = PV = 100 % *(For open pits, PV = 100%. For stone filled pits, PV = 30%)*

Carry out 3 tests, each measuring the time taken for water levels
to fall from 75% effective depth to 25% effective depth

Test No 1 time to fall from 75% to 25% eff depth = $T_1$ = 120.0 *mins*
Test No 2 time to fall from 75% to 25% eff depth = $T_2$ = *mins*
Test No 3 time to fall from 75% to 25% eff depth = $T_3$ = *mins*

TAKE THE LONGEST OF THE 3 TESTS ABOVE = $T_L$ = 120.0 *mins*

Volume of water escaping during this test between $D_{75}$ and $D_{25}$
= $V_{TP75\_25}$ = ( $L_{TP}$ x $W_{TP}$ x ($D_{75}$ - $D_{25}$) x PV) = 0.975 *cu m.*

The mean surface area through which the above volume escapes, is the *wetted area.*
Only 50% of the effective depth is allowed in the calculation.

*ie* $A_{P50}$ = (Wet Base Area + 50% of Wet Sides Area)
$A_{P50}$ = ($L_{TP}$ x $W_{TP}$) + ($2L_{TP}$+$2W_{TP}$) x $D_{50}$
$A_{P50}$ = 1.300 + 4.650
$A_{P50}$ = 5.950 *sq m*

Soil Infiltration Rate = f = $\frac{V_{TP75\_25}}{A_{P50} \times 60 \times T_L}$ *m/s*

**Soil Infiltration Rate = f = 2.27591E-05 *m/s***

Notes: Pit drained completely within 120 minutes.

**CALCULATIONS/SKETCHES**

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | GEO2013-776 Land at Cleator Mills | | | | |
| JOB No | 2013-776 | PREPARED BY | CRE | SHEET No | SA 05 |
| DATE | 21-Oct-13 | CHECKED BY | CRE/GE | REV | P1 |

REF | OUTPUT

**Calculation of soil infiltration rate in accordance with BRE Digest 365**

Length of trial pit = $L_{TP}$ = 2.700 *m*

Width of trial pit = $W_{TP}$ = 0.450 *m*

Effective Depth = $D_{TP}$ = 2.000 *m* *(measured below incoming invert)*

75% Effective Depth of trial pit = $D_{75}$ = ( $D_{TP}$ x 0.75 ) = 1.500 *m*

50% Effective Depth of trial pit = $D_{50}$ = ( $D_{TP}$ x 0.50 ) = 1.000 *m*

25% Effective Depth of trial pit = $D_{25}$ = ( $D_{TP}$ x 0.25 ) = 0.500 *m*

Pit Voids = PV = 100 % *(For open pits, PV = 100%. For stone filled pits, PV = 30%)*

Carry out 3 tests, each measuring the time taken for water levels to fall from 75% effective depth to 25% effective depth

Test No 1 time to fall from 75% to 25% eff depth = $T_1$ = 120.0 *mins*

Test No 2 time to fall from 75% to 25% eff depth = $T_2$ = *mins*

Test No 3 time to fall from 75% to 25% eff depth = $T_3$ = *mins*

TAKE THE LONGEST OF THE 3 TESTS ABOVE = $T_L$ = 120.0 *mins*

Volume of water escaping during this test between $D_{75}$ and $D_{25}$

= $V_{TP75\_25}$ = ( $L_{TP}$ x $W_{TP}$ x ($D_{75}$ - $D_{25}$) x PV) = 1.215 *cu m.*

The mean surface area through which the above volume escapes, is the *wetted area.*
Only 50% of the effective depth is allowed in the calculation.

*ie* $A_{P50}$ = (Wet Base Area + 50% of Wet Sides Area)

$A_{P50}$ = ($L_{TP}$ x $W_{TP}$) + ($2L_{TP}+2W_{TP}$) x $D_{50}$

$A_{P50}$ = 1.215 + 6.300

$A_{P50}$ = 7.515 *sq m*

Soil Infiltration Rate = f = $\dfrac{V_{TP75\_25}}{A_{P50} \times 60 \times T_L}$ *m/s*

**Soil Infiltration Rate = f = 2.24551E-05 *m/s***

Notes: Pit drained completely within 120 minutes.

SA05.xls

**CALCULATIONS/SKETCHES**

| PROJECT | GEO2013-776 Land at Cleator Mills | | | | |
|---|---|---|---|---|---|
| JOB No | 2013-776 | PREPARED BY | CRE | SHEET No | SA 06 |
| DATE | 21-Oct-13 | CHECKED BY | CRE/GE | REV | P1 |

REF | OUTPUT

**Calculation of soil infiltration rate in accordance with BRE Digest 365**

Length of trial pit = $L_{TP}$ = 2.500 *m*
Width of trial pit = $W_{TP}$ = 0.450 *m*
Effective Depth = $D_{TP}$ = 1.500 *m* *(measured below incoming invert)*

75% Effective Depth of trial pit = $D_{75}$ = ( $D_{TP}$ x 0.75 ) = 1.125 *m*
50% Effective Depth of trial pit = $D_{50}$ = ( $D_{TP}$ x 0.50 ) = 0.750 *m*
25% Effective Depth of trial pit = $D_{25}$ = ( $D_{TP}$ x 0.25 ) = 0.375 *m*

Pit Voids = PV = 100 % *(For open pits, PV = 100%. For stone filled pits, PV = 30%)*

Carry out 3 tests, each measuring the time taken for water levels
to fall from 75% effective depth to 25% effective depth

Test No 1 time to fall from 75% to 25% eff depth = $T_1$ = 60.0 *mins*
Test No 2 time to fall from 75% to 25% eff depth = $T_2$ = *mins*
Test No 3 time to fall from 75% to 25% eff depth = $T_3$ = *mins*

TAKE THE LONGEST OF THE 3 TESTS ABOVE = $T_L$ = 60.0 *mins*

Volume of water escaping during this test between $D_{75}$ and $D_{25}$
= $V_{TP75\_25}$ = ( $L_{TP}$ x $W_{TP}$ x ($D_{75}$ - $D_{25}$) x PV) = 0.844 *cu m.*

The mean surface area through which the above volume escapes, is the *wetted area.*
Only 50% of the effective depth is allowed in the calculation.

*ie* $A_{P50}$ = (Wet Base Area + 50% of Wet Sides Area)
$A_{P50}$ = ($L_{TP}$ x $W_{TP}$) + ($2L_{TP}+2W_{TP}$) x $D_{50}$
$A_{P50}$ = 1.125 + 4.425
$A_{P50}$ = 5.550 *sq m*

Soil Infiltration Rate = f = $\frac{V_{TP75\_25}}{A_{P50} \times 60 \times T_L}$ *m/s*

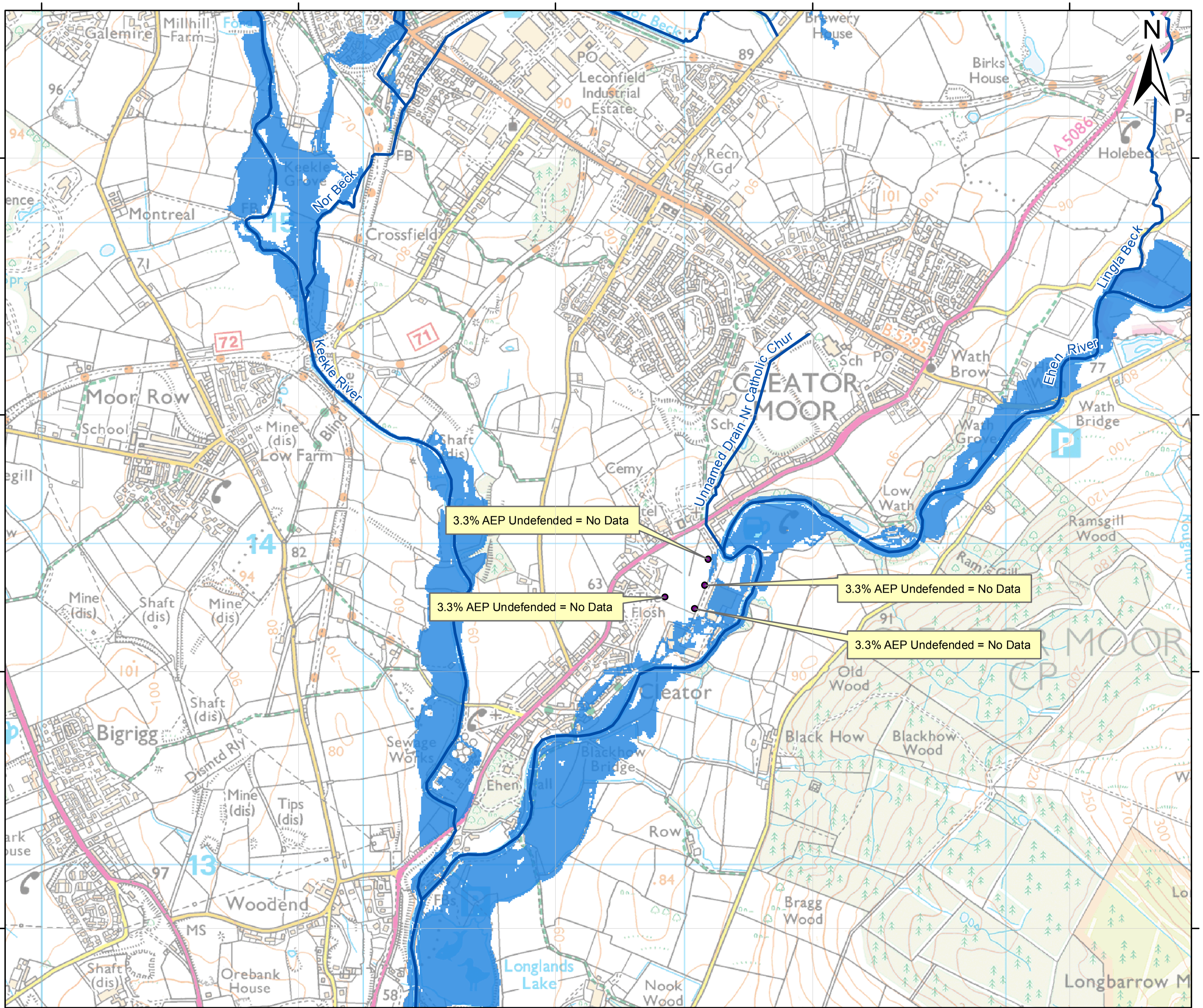
**Soil Infiltration Rate = f = 4.22297E-05 *m/s***

Notes: Pit drained completely within 60 minutes.

GEO Environmental Engineering

Geotechnical
&
Environmental
Drilling Experts
&
Consultants

# Appendix H Environment Agency Flood Data




# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 10 July 2019*
*Our Ref: CL132929*
*NGR: 301,733 514,107*

## Key

Main River

**1 in 30 Undefended Scenario**

**mAOD**

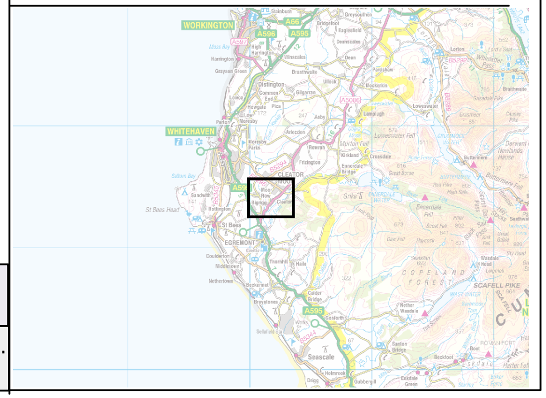
High : 113.229

Low: 0

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

**Flood Zone 2** shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

**ABDs** (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.



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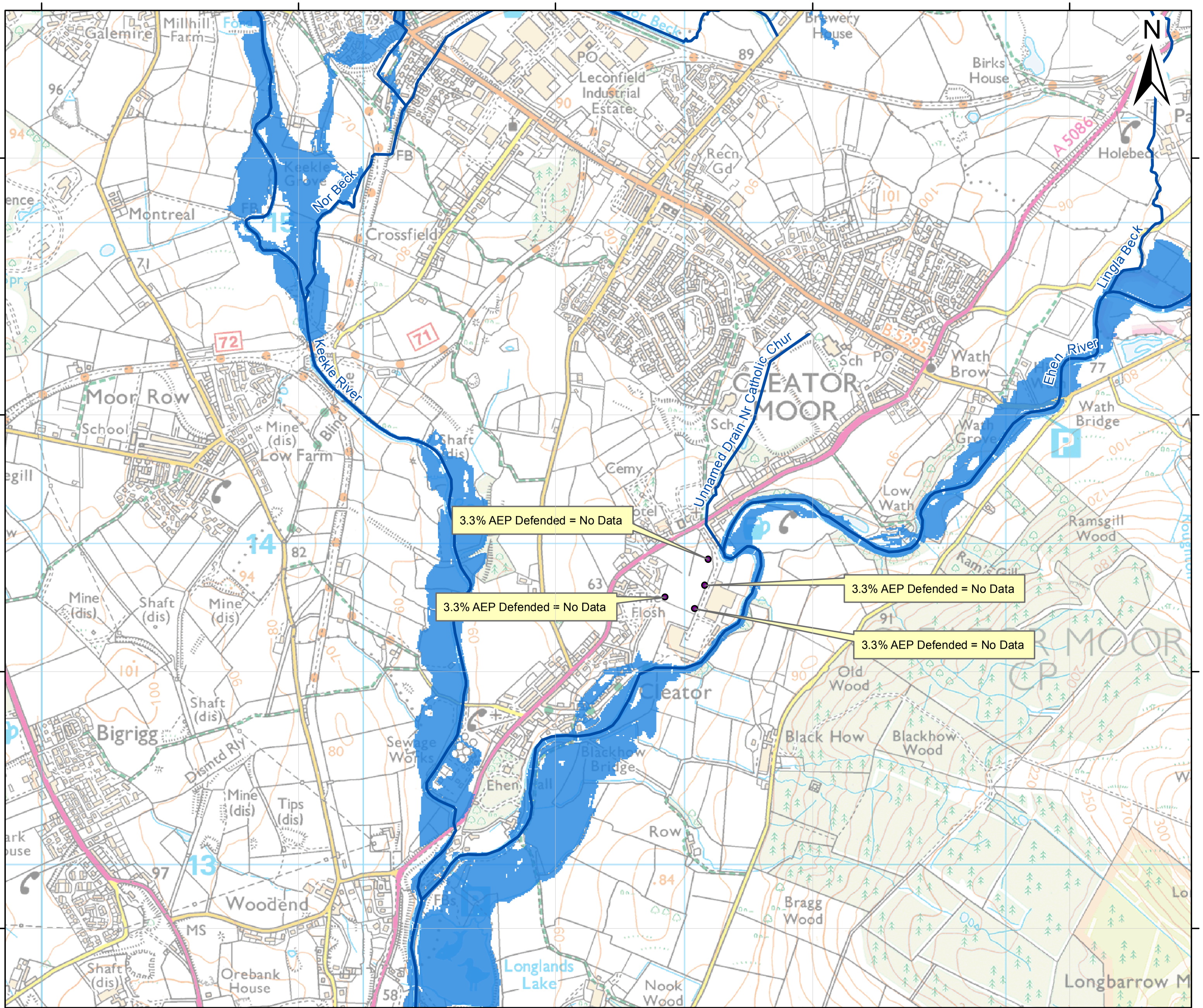


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*Produced: 10 July 2019*
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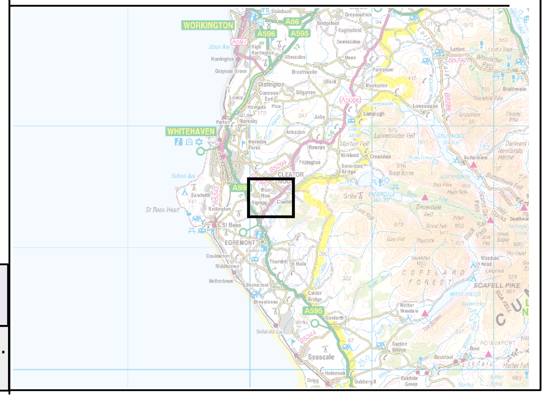

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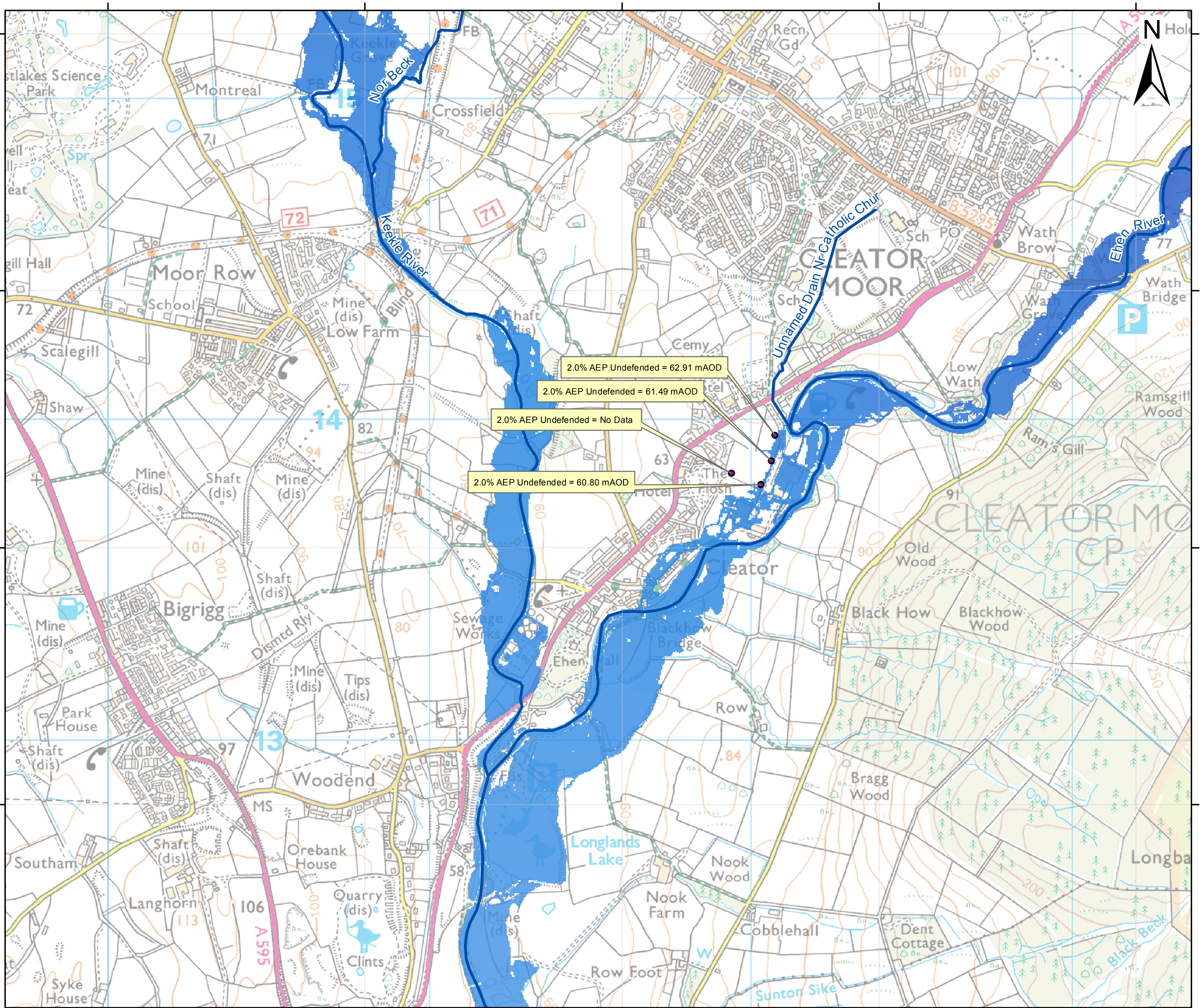


# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 09 July 2019*
*Our Ref: CL132929*
*NGR: 301,526 513,720*

## Key

Main River

**1 in 50 Undefended Scenario**

**mAOD**

High : 113.229

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

**Flood Zone 2** shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

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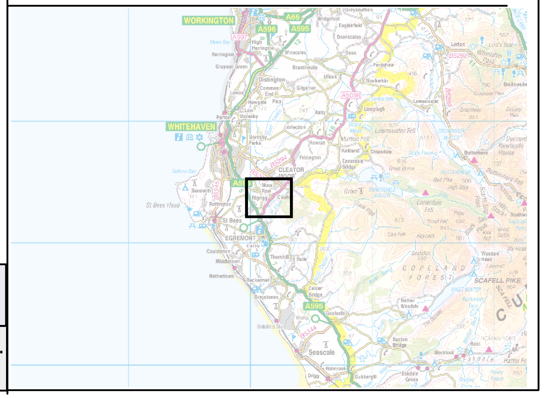

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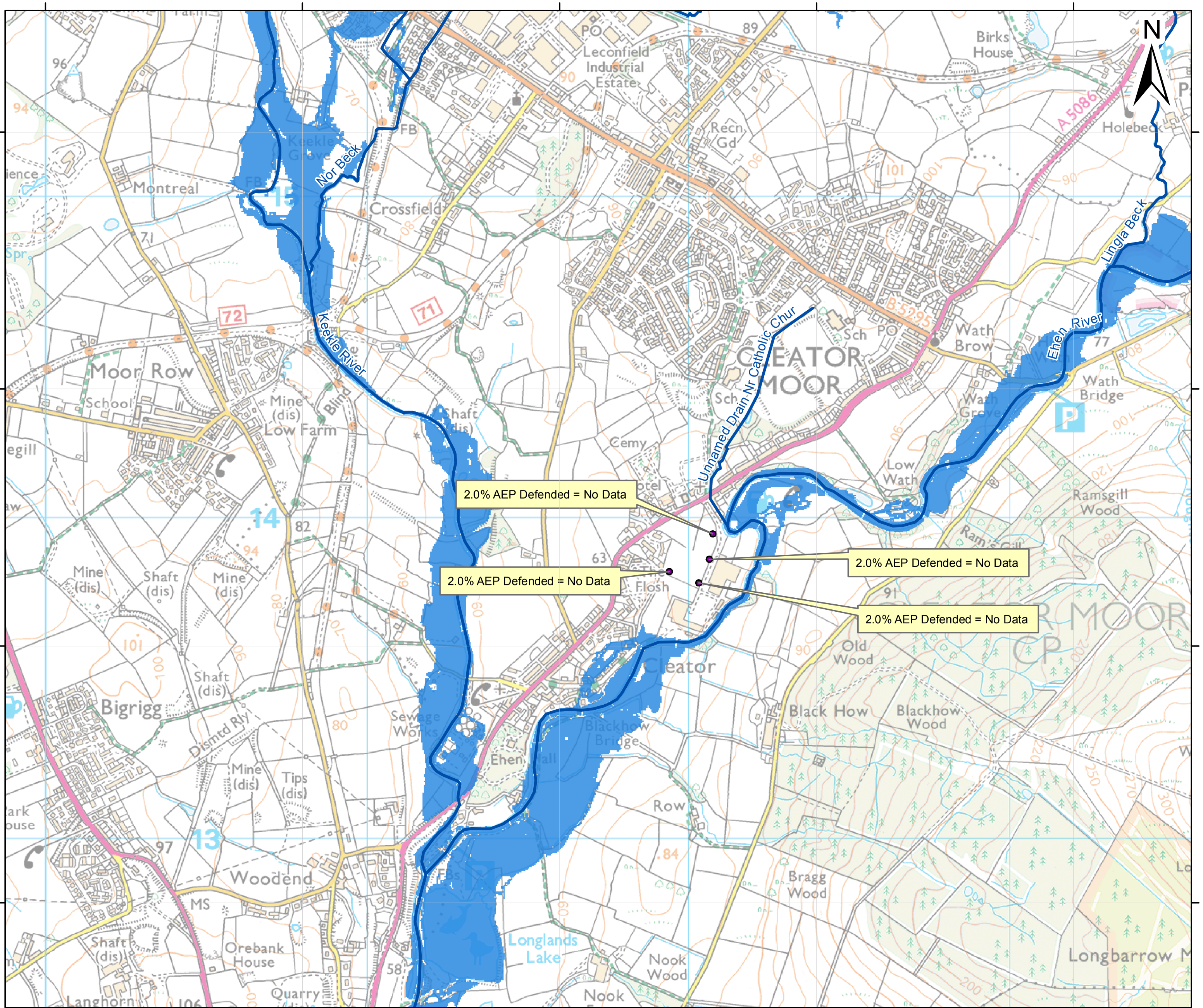


# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 10 July 2019*
*Our Ref: CL132929*
*NGR: 301,720 514,026*

## Key

Main River

**1 in 50 Defended Scenario**

**mAOD**

High : 113.329

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

**Flood Zone 2** shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

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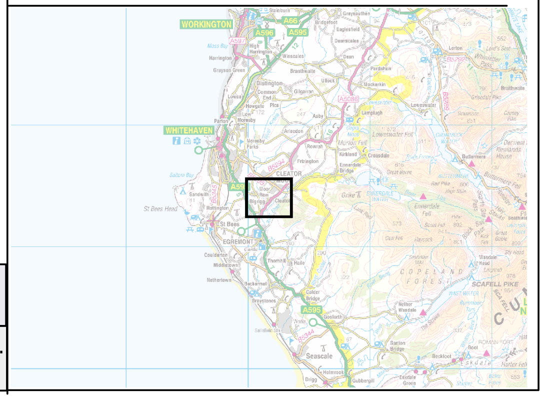

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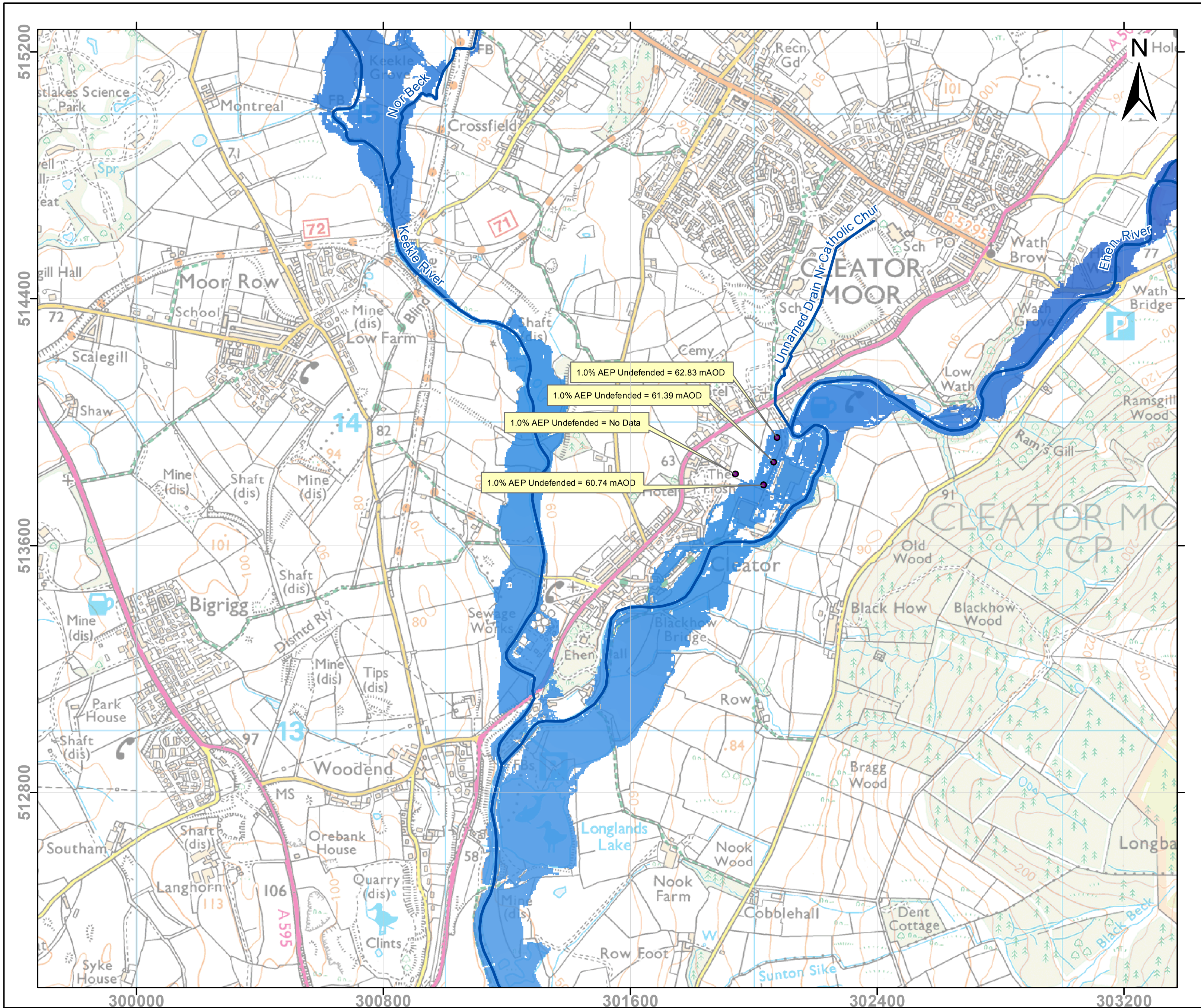


# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 09 July 2019*
*Our Ref: CL132929*
*NGR: 301,526 513,720*

## Key

Main River

**1 in 100 Undefended Scenario**

**mAOD**

High : 113.343

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

**Flood Zone 2** shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

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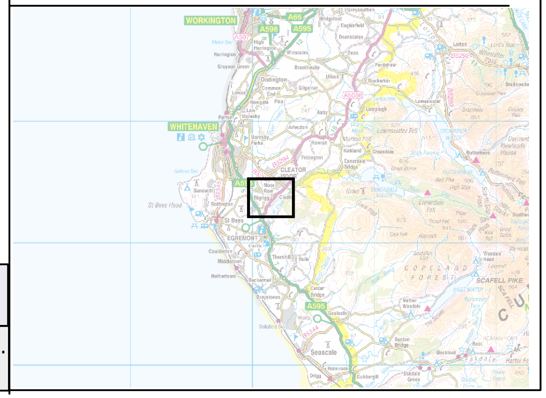


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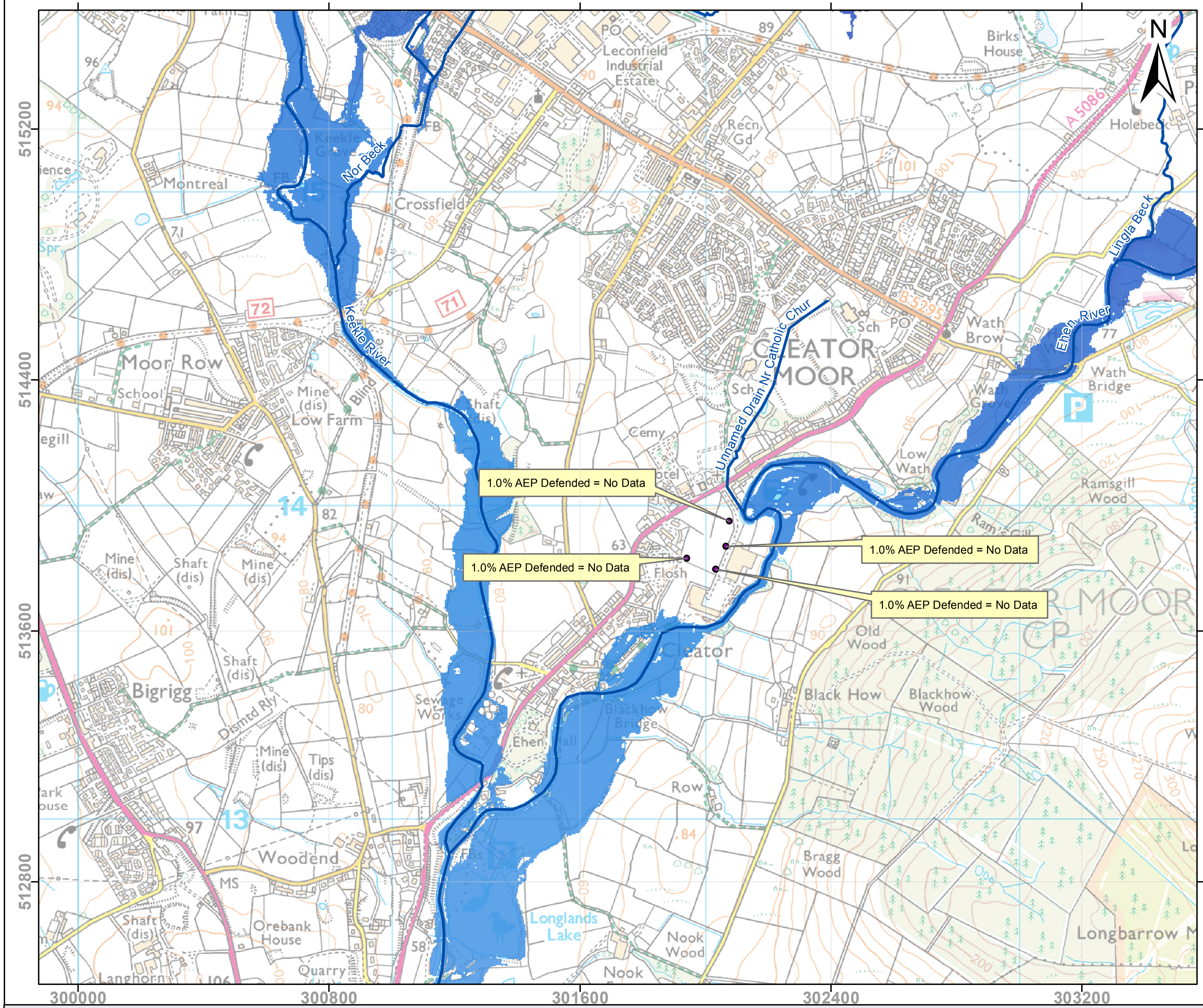
# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 10 July 2019*
*Our Ref: CL132929*
*NGR: 301,720 514,026*




## Key

Main River

**1 in 100 Defended Scenario**

**mAOD**

High : 113.325

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

**Flood Zone 2** shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

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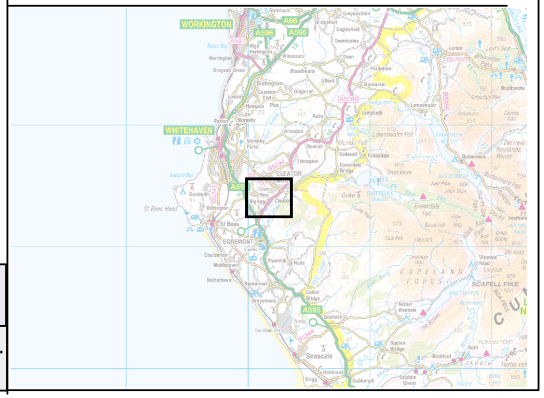

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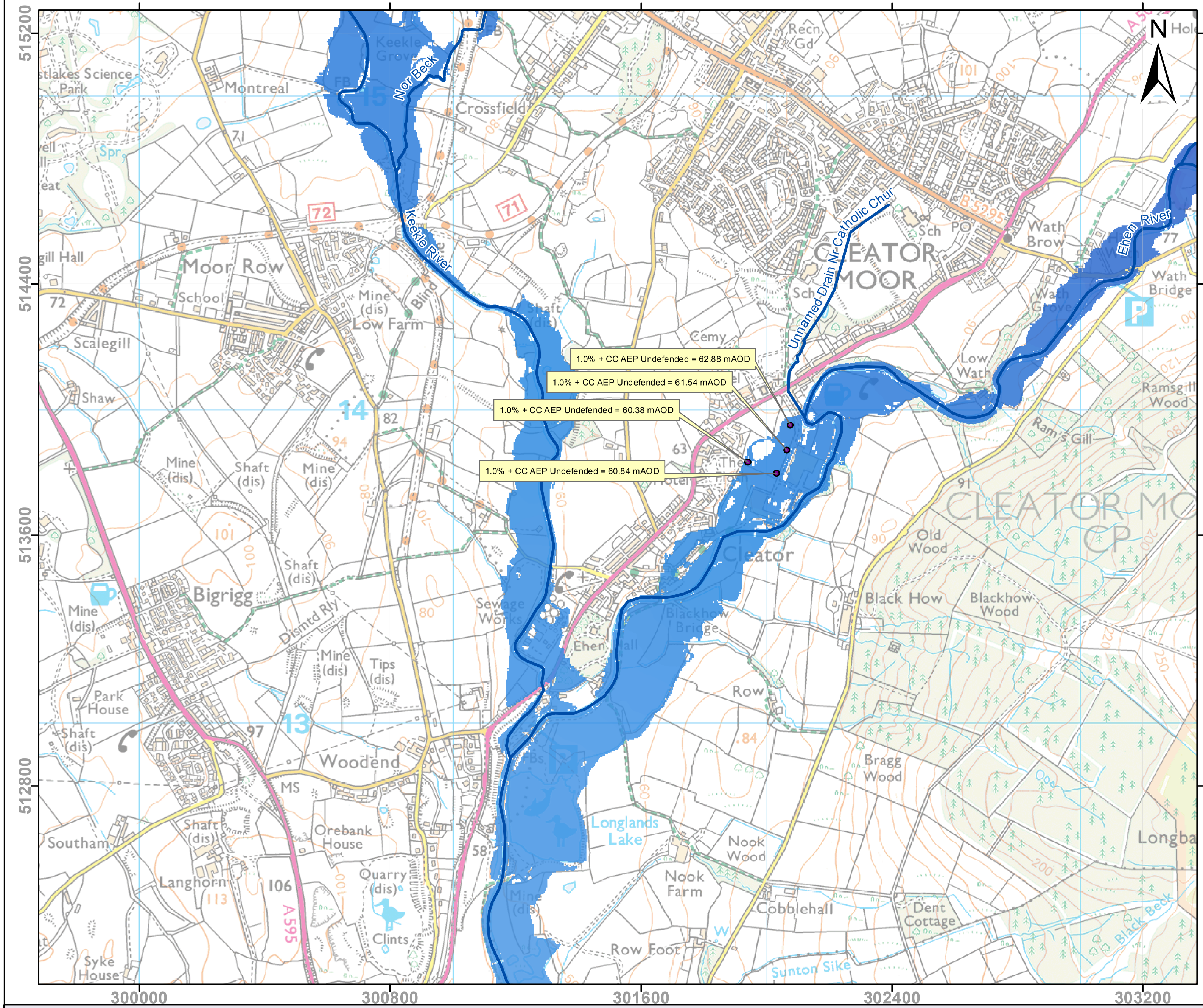


# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 09 July 2019*
*Our Ref: CL132929*
*NGR: 301,526 513,720*

**Key**

Main River

**1 in 100 + CC Undefended**

**mAOD**

High : 113.547

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

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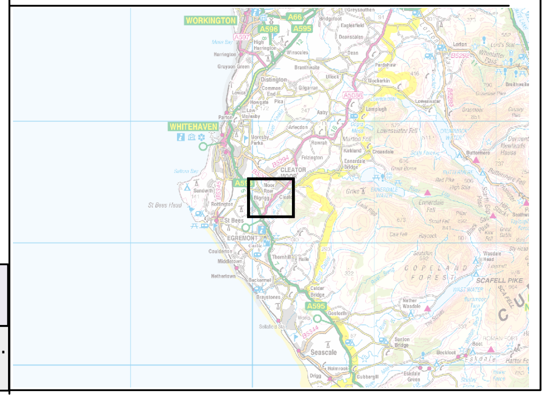


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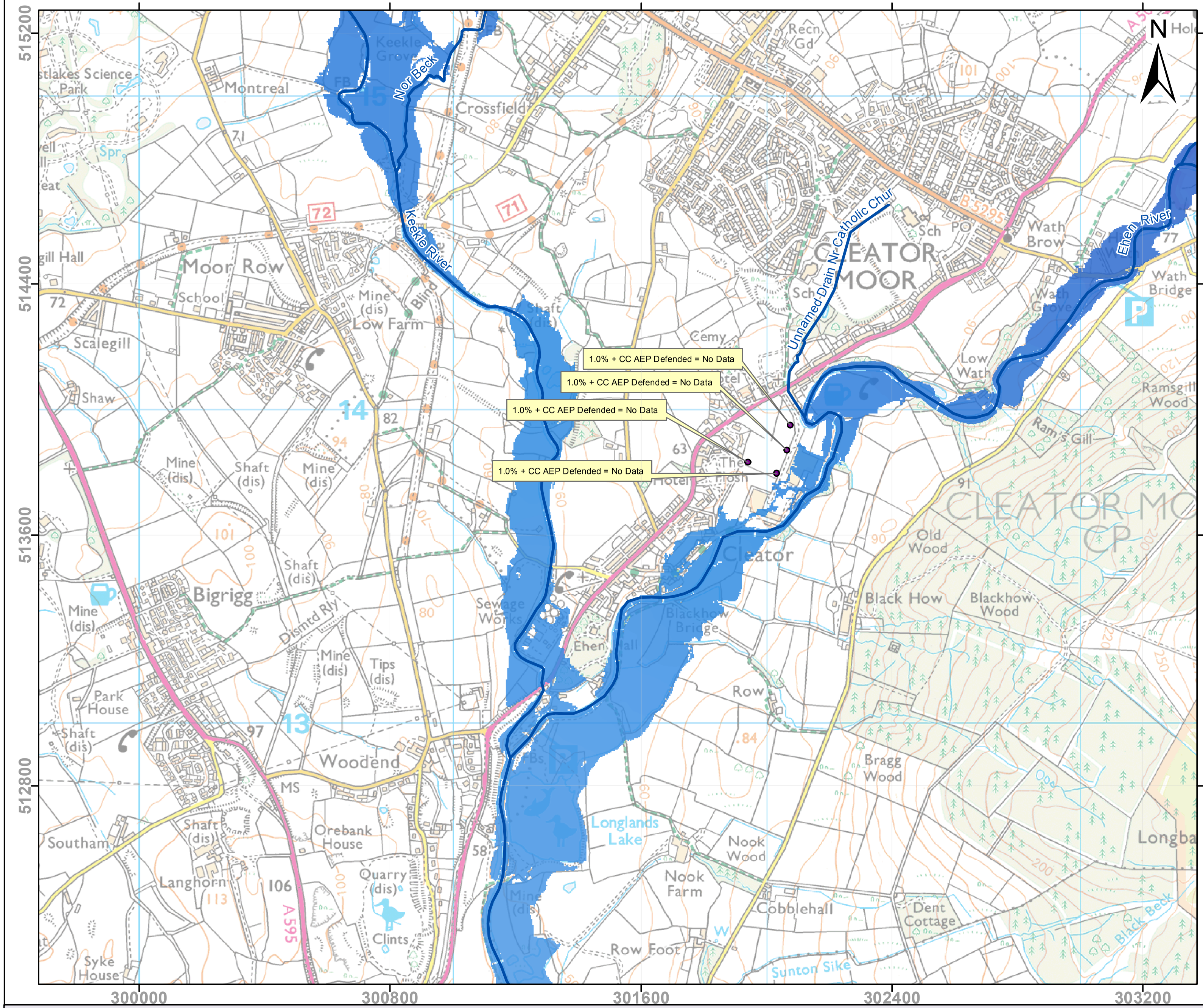


# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 09 July 2019*
*Our Ref: CL132929*
*NGR: 301,526 513,720*

**Key**

Main River

**1 in 100 + CC Defended Scenario**

**mAOD**

High : 113.542

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

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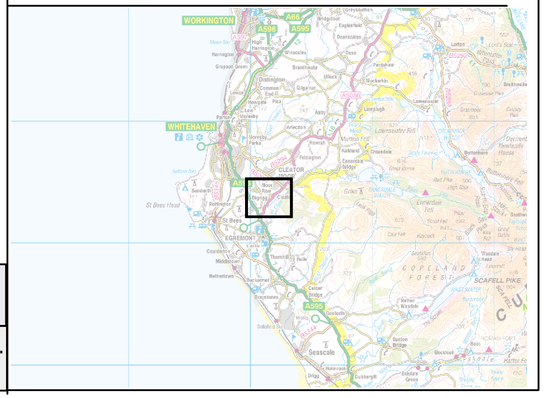

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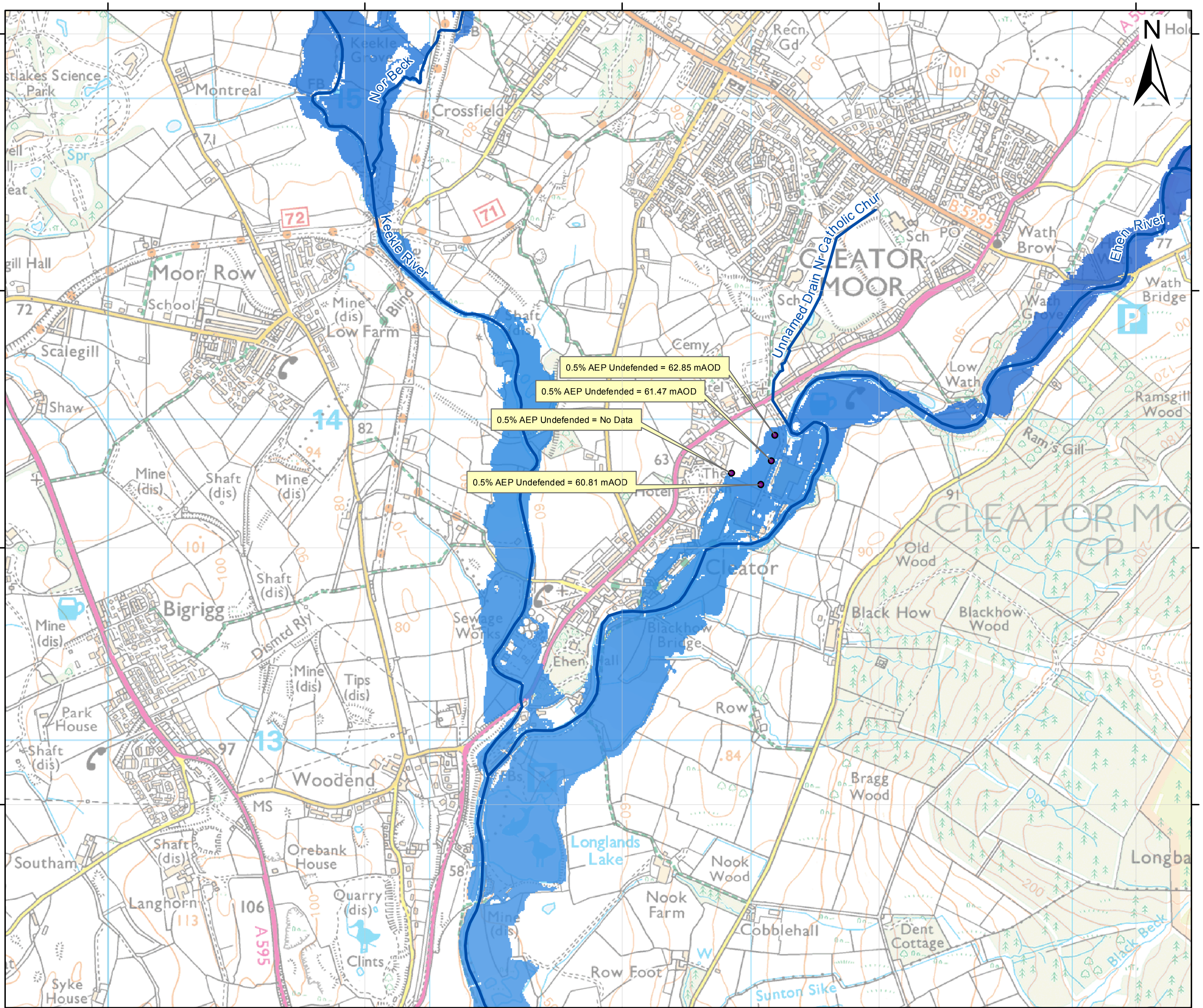


# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 09 July 2019*
*Our Ref: CL132929*
*NGR: 301,526 513,720*

## Key

Main River

**1 in 200 Undefended Scenario**

**mAOD**

High : 113.464

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
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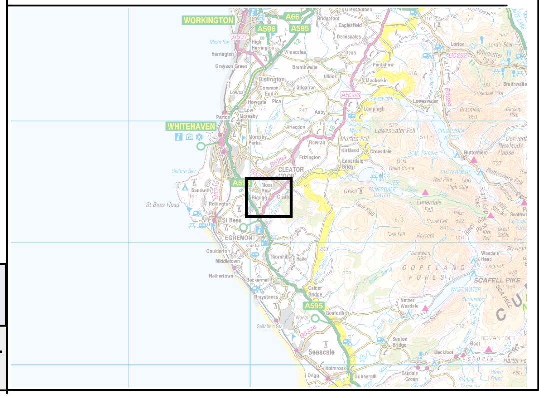

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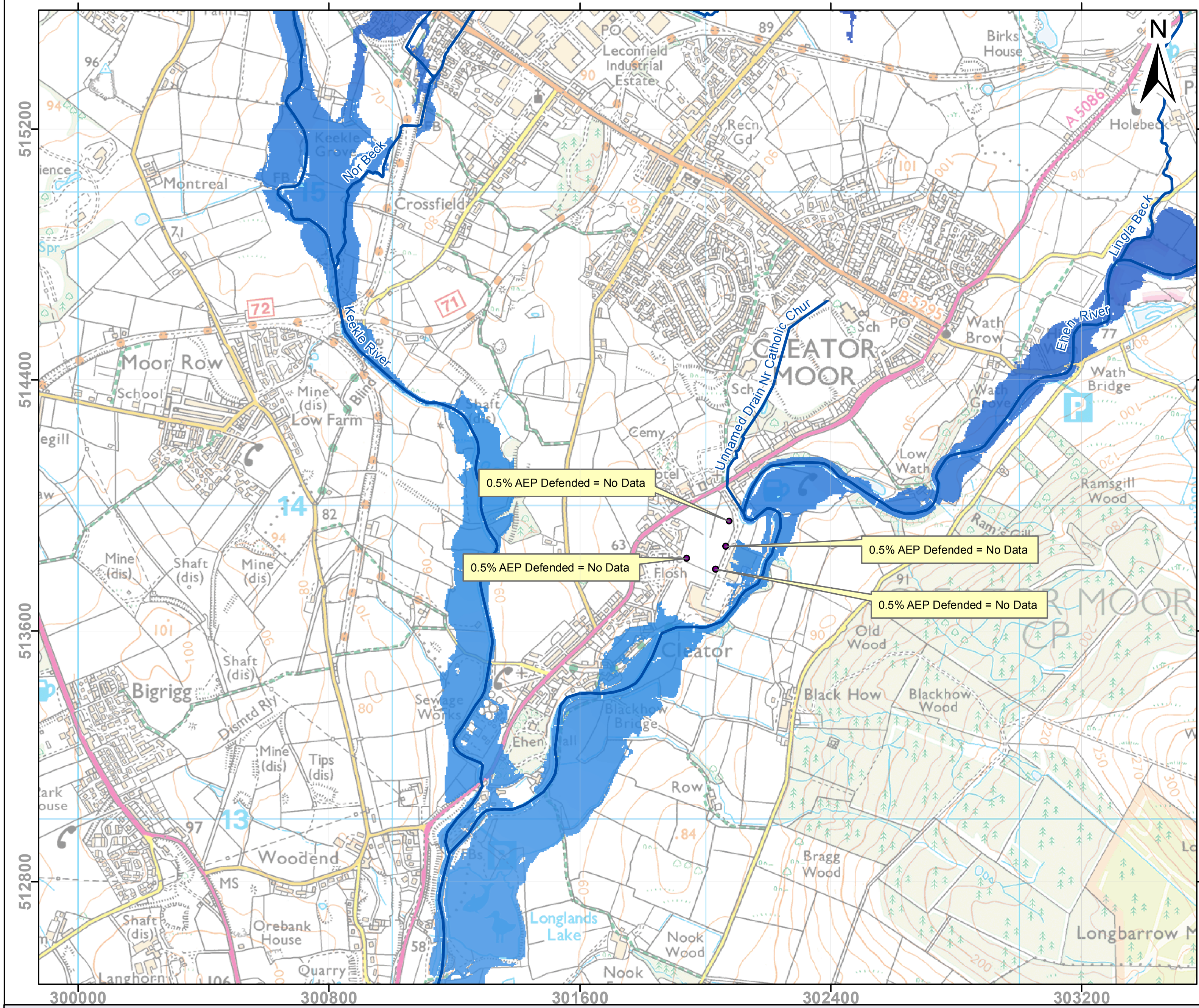


# Fluvial Model Level Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 10 July 2019*
*Our Ref: CL132929*
*NGR: 301,720 514,026*

## Key

Main River

**1 in 200 Defended Scenario**

**mAOD**

High : 113.456

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
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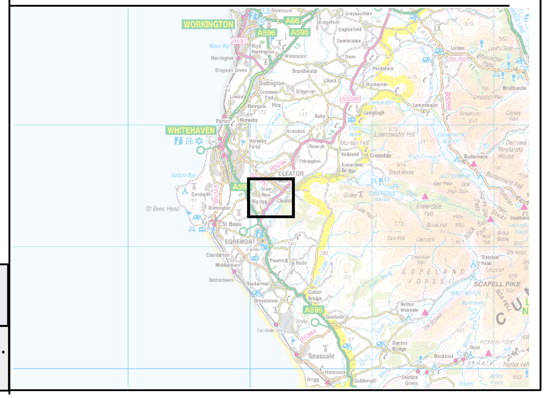

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*Produced: 10 July 2019*
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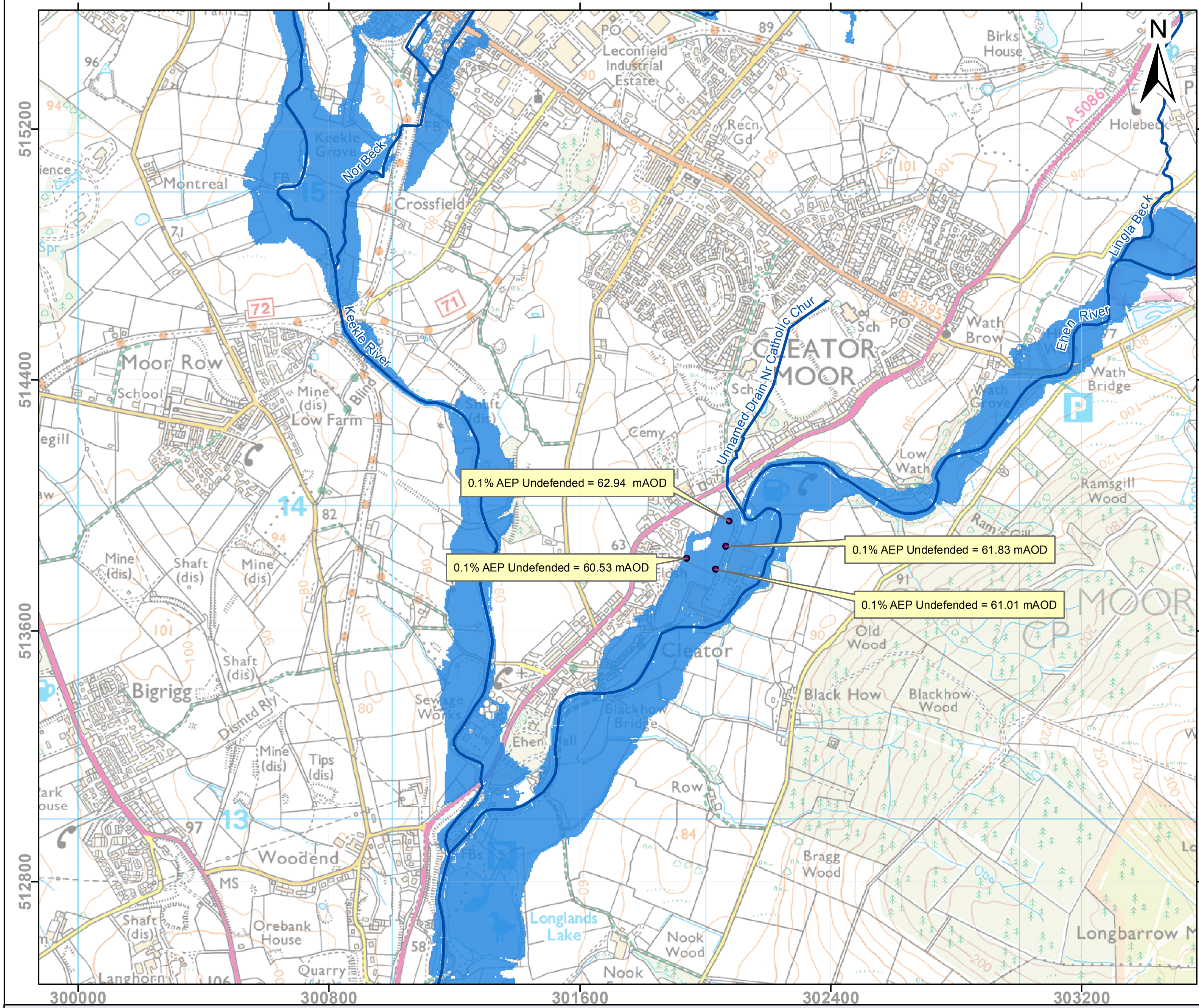
*NGR: 301,720 514,026*




## Key

Main River

**1 in 1000 Undefended Scenario**

**mAOD**

High : 114.31

Low: 0

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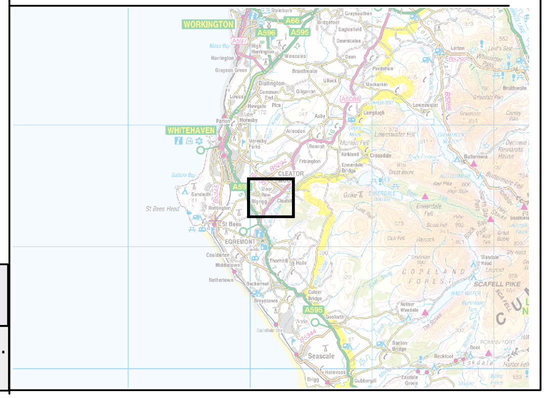

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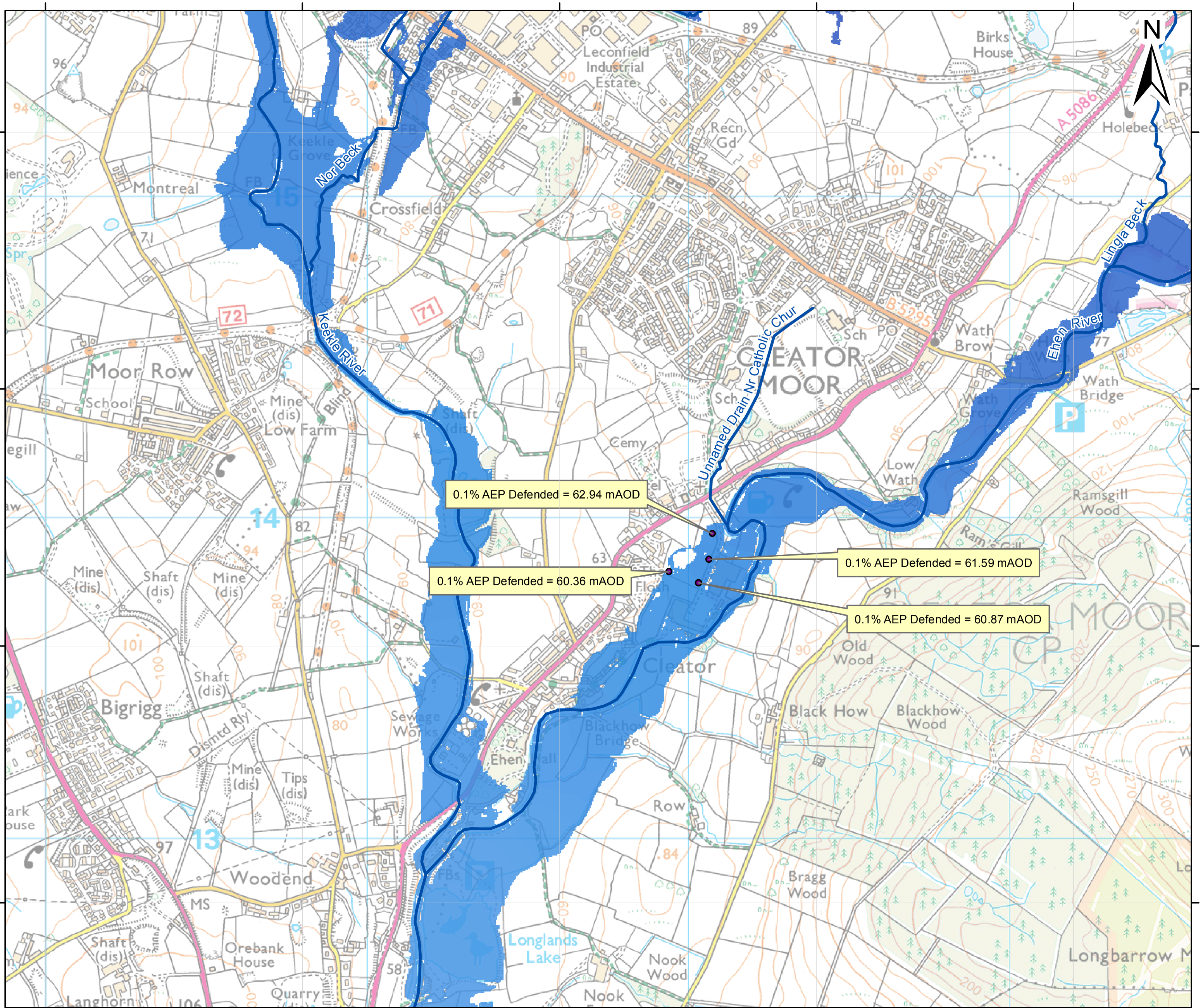


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*Produced: 10 July 2019*
*Our Ref: CL132929*
*NGR: 301,720 514,026*

## Key

Main River

**1 in 1000 Defended Scenario**

**mAOD**

High : 114.319

Low : 0

**Flood Zone 3** shows the area that could be affected by flooding:
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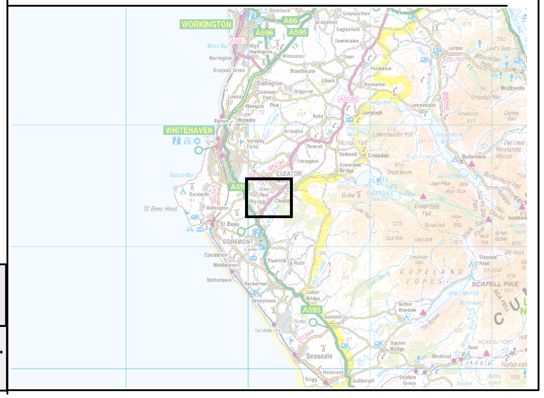

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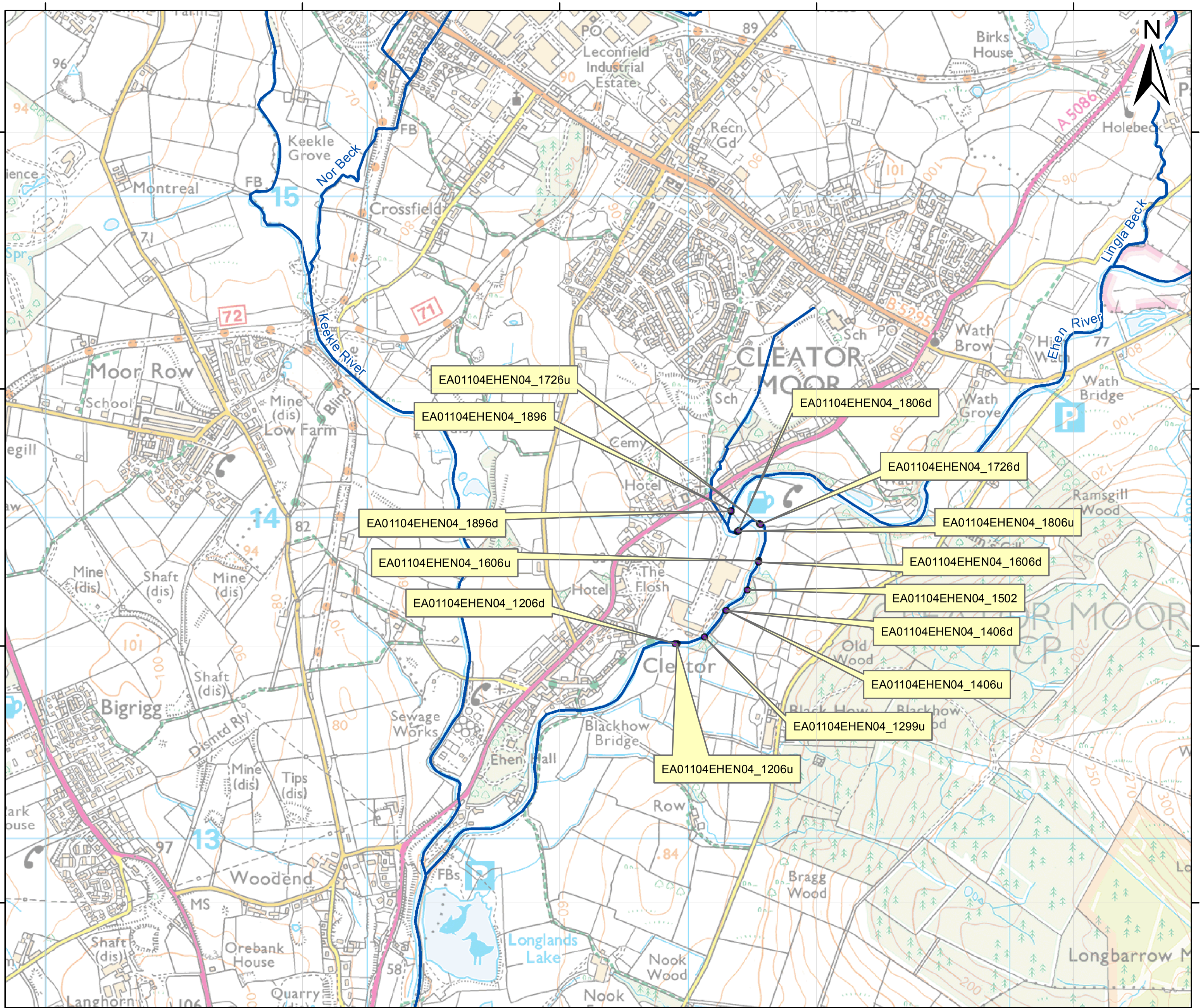


# Node Point Location Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 10 July 2019*
*Our Ref: CL132929*
*NGR: 301,720 514,026*

## Key

- Modelled Node Point
- Main River

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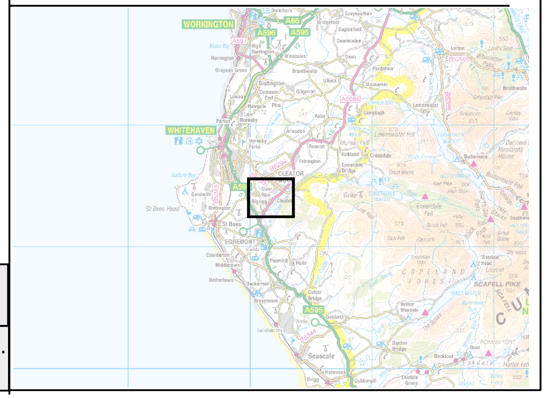

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| Node Point ID | Defended Model Flood group | Return Period(Yrs) | Water Level (maod | Flow (cumecs) |
|---|---|---|---|---|
| EA01104EHEN4_1726d | EA1104FRMEHEN2015_def | 10 | 62.013 | 85.003 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015_def | 25 | 62.223 | 101.675 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015_def | 50 | 62.32 | 111.803 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015_def | 75 | 62.42 | 122.091 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015_def | 100 | 62.472 | 127.207 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015_def | 100+CC | 62.692 | 143.88 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015_def | 200 | 63.383 | 140.216 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015_def | 1000 | 63.685 | 173.534 |
| | | | | |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015_def | 10 | 62.772 | 67.006 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015_def | 25 | 62.972 | 101.675 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015_def | 50 | 63.086 | 111.803 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015_def | 75 | 63.198 | 122.091 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015_def | 100 | 63.251 | 127.207 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015_def | 100+CC | 63.419 | 143.88 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015_def | 200 | 63.779 | 92.749 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015_def | 1000 | 64.135 | 100.247 |
| | | | | |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015_def | 10 | 63.052 | 77.551 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015_def | 25 | 63.284 | 86.275 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015_def | 50 | 63.418 | 89.701 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015_def | 75 | 63.553 | 91.197 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015_def | 100 | 63.621 | 91.358 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015_def | 100+CC | 63.823 | 93.242 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015_def | 200 | 63.779 | 92.749 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015_def | 1000 | 64.135 | 100.247 |
| | | | | |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015_def | 10 | 63.948 | 76.434 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015_def | 25 | 64.086 | 85.916 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015_def | 50 | 64.146 | 90.072 |

| | | | | |
|---|---|---|---|---|
| EA01104EHEN4_1896 | EA1104FRMEHEN2015_def | 75 | 64.194 | 92.974 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015_def | 100 | 64.223 | 94.056 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015_def | 100+CC | 64.291 | 98.815 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015_def | 200 | 64.015 | 100.488 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015_def | 1000 | 64.152 | 116.027 |
| | | | | |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015_def | 10 | 63.74 | 77.543 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015_def | 25 | 63.852 | 87.567 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015_def | 50 | 63.898 | 92.126 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015_def | 75 | 63.941 | 95.293 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015_def | 100 | 63.972 | 96.513 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015_def | 100+CC | 64.029 | 101.484 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015_def | 200 | 64.7 | 120.715 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015_def | 1000 | 64.939 | 147.259 |
| | | | | |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015_def | 10 | 63.052 | 77.551 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015_def | 25 | 63.284 | 86.275 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015_def | 50 | 63.418 | 89.701 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015_def | 75 | 63.553 | 91.197 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015_def | 100 | 63.621 | 91.358 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015_def | 100+CC | 63.823 | 93.242 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015_def | 200 | 64.276 | 97.704 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015_def | 1000 | 63.754 | 86.424 |
| | | | | |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015_def | 10 | 61.545 | 85.032 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015_def | 25 | 61.765 | 101.24 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015_def | 50 | 61.882 | 111.013 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015_def | 75 | 61.994 | 121.169 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015_def | 100 | 62.052 | 126.737 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015_def | 100+CC | 62.231 | 145.965 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015_def | 200 | 62.192 | 141.565 |

| | | | | |
|---|---|---|---|---|
| EA01104EHEN4_1606u | EA1104FRMEHEN2015_def | 1000 | 62.545 | 185.438 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015_def | 10 | 60.834 | 85.032 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015_def | 25 | 61.064 | 101.24 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015_def | 50 | 61.208 | 111.013 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015_def | 75 | 61.354 | 121.169 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015_def | 100 | 61.427 | 126.737 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015_def | 100+CC | 61.666 | 145.965 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015_def | 200 | 61.61 | 129.311 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015_def | 1000 | 62.193 | 165.107 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015_def | 10 | 60.275 | 85.057 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015_def | 25 | 60.504 | 101.728 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015_def | 50 | 60.626 | 111.889 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015_def | 75 | 60.744 | 122.965 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015_def | 100 | 60.808 | 129.137 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015_def | 100+CC | 61.001 | 151.25 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015_def | 200 | 60.953 | 146.021 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015_def | 1000 | 61.398 | 198.323 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015_def | 10 | 59.892 | 85.08 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015_def | 25 | 60.118 | 101.697 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015_def | 50 | 60.224 | 111.657 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015_def | 75 | 60.379 | 122.255 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015_def | 100 | 60.451 | 128.097 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015_def | 100+CC | 60.559 | 149.927 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015_def | 200 | 60.56 | 144.657 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015_def | 1000 | 61.039 | 202.596 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015_def | 10 | 59.892 | 85.08 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015_def | 25 | 60.118 | 101.697 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015_def | 50 | 60.244 | 111.657 |

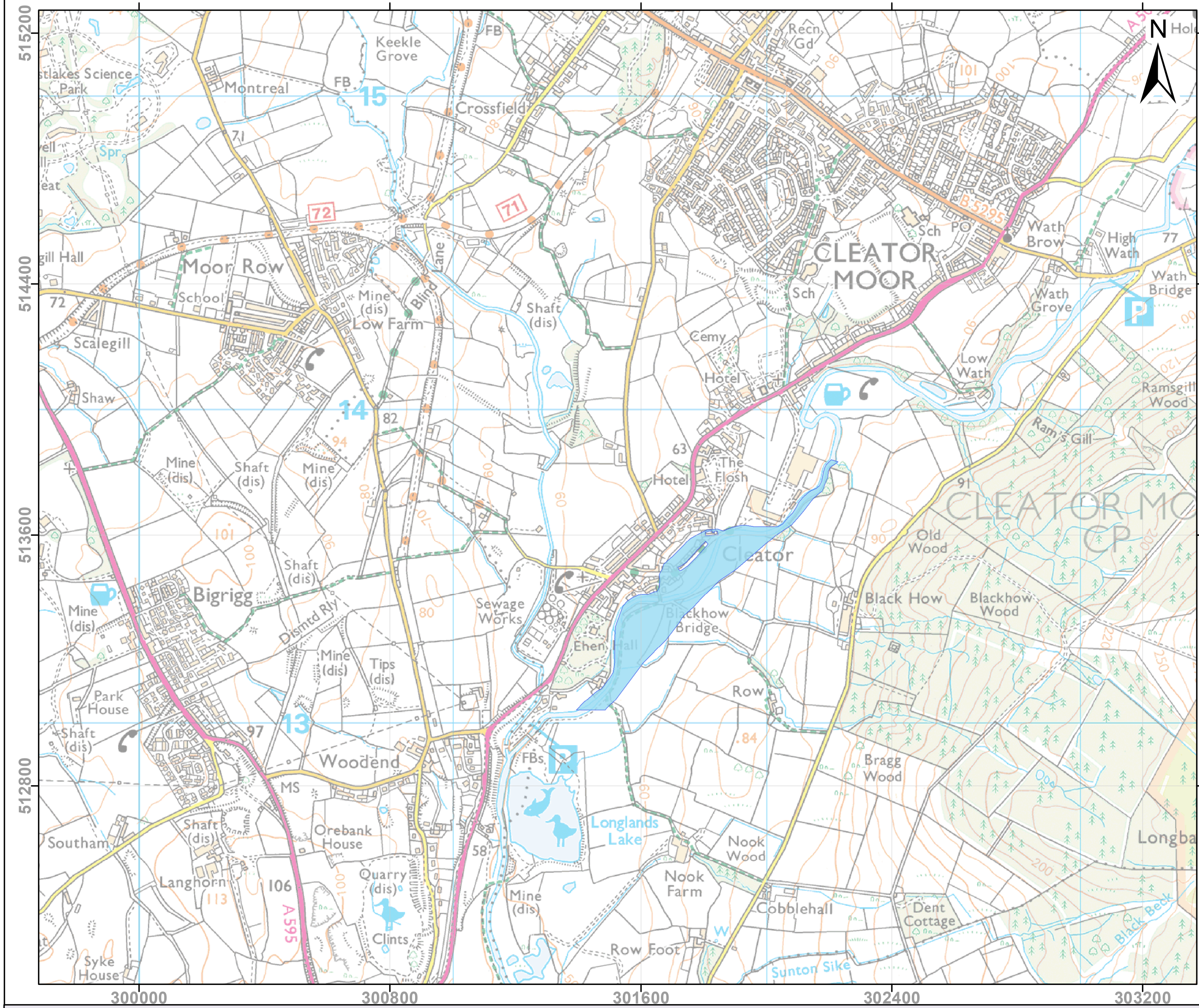
| | | | | |
|---|---|---|---|---|
| EA01104EHEN4_1406u | EA1104FRMEHEN2015_def | 75 | 60.379 | 122.255 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015_def | 100 | 60.451 | 128.097 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015_def | 100+CC | 60.599 | 149.927 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015_def | 200 | 60.953 | 146.021 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015_def | 1000 | 61.398 | 198.323 |
| | | | | |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015_def | 10 | 59.379 | 85.106 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015_def | 25 | 59.549 | 101.801 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015_def | 50 | 59.64 | 111.974 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015_def | 75 | 59.733 | 123.071 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015_def | 100 | 59.775 | 129.253 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015_def | 100+CC | 59.912 | 152.206 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015_def | 200 | 60.56 | 144.657 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015_def | 1000 | 61.039 | 202.596 |
| | | | | |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015_def | 10 | 58.826 | 85.128 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015_def | 25 | 58.938 | 101.546 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015_def | 50 | 58.992 | 111.299 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015_def | 75 | 59.044 | 121.701 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015_def | 100 | 59.056 | 127.645 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015_def | 100+CC | 59.075 | 150.014 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015_def | 200 | 59.88 | 146.482 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015_def | 1000 | 60.205 | 210.945 |
| | | | | |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015_def | 10 | 58.826 | 85.128 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015_def | 25 | 58.938 | 101.546 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015_def | 50 | 58.992 | 111.299 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015_def | 75 | 59.044 | 121.701 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015_def | 100 | 59.056 | 127.645 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015_def | 100+CC | 59.075 | 150.014 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015_def | 200 | 59.071 | 144.439 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015_def | 1000 | 59.234 | 203.897 |

| Node Point ID | Undefended Model Flood group | Return Period(Yrs) | Water Level (maod) | Flow (cumecs) |
|---|---|---|---|---|
| EA01104EHEN4_1726d | EA1104FRMEHEN2015 | 10 | 62.024 | 85.635 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015 | 25 | 62.203 | 98.295 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015 | 50 | 62.29 | 104.334 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015 | 75 | 62.392 | 109.629 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015 | 100 | 62.443 | 112.064 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015 | 100+CC | 62.208 | 119.508 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015 | 200 | 62.241 | 140.216 |
| EA01104EHEN4_1726d | EA1104FRMEHEN2015 | 1000 | 63.035 | 135.814 |
| | | | | |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015 | 10 | 62.78 | 85.635 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015 | 25 | 62.933 | 98.295 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015 | 50 | 63.003 | 104.334 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015 | 75 | 63.062 | 109.629 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015 | 100 | 63.089 | 112.064 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015 | 100+CC | 63.17 | 119.508 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015 | 200 | 63.383 | 118.004 |
| EA01104EHEN4_1726u | EA1104FRMEHEN2015 | 1000 | 63.339 | 135.814 |
| | | | | |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015 | 10 | 63.097 | 67.006 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015 | 25 | 63.284 | 69.381 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015 | 50 | 63.367 | 71.016 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015 | 75 | 63.438 | 72.753 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015 | 100 | 63.469 | 73.652 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015 | 100+CC | 63.563 | 76.122 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015 | 200 | 63.544 | 75.778 |
| EA01104EHEN4_1806d | EA1104FRMEHEN2015 | 1000 | 63.754 | 86.424 |
| | | | | |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015 | 10 | 63.778 | 64.737 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015 | 25 | 63.844 | 66.953 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015 | 50 | 63.887 | 68.838 |

| | | | | |
|---|---|---|---|---|
| EA01104EHEN4_1896 | EA1104FRMEHEN2015 | 75 | 63.929 | 71.243 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015 | 100 | 63.949 | 72.743 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015 | 100+CC | 64.016 | 78.371 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015 | 200 | 64.002 | 77.1 |
| EA01104EHEN4_1896 | EA1104FRMEHEN2015 | 1000 | 64.458 | 112.23 |
| | | | | |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015 | 10 | 63.601 | 65.878 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015 | 25 | 63.667 | 68.625 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015 | 50 | 63.707 | 70.898 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015 | 75 | 63.743 | 73.527 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015 | 100 | 63.758 | 75.168 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015 | 100+CC | 63.805 | 81.063 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015 | 200 | 63.794 | 79.925 |
| EA01104EHEN4_1896d | EA1104FRMEHEN2015 | 1000 | 63.925 | 97.461 |
| | | | | |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015 | 10 | 63.097 | 67.006 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015 | 25 | 63.284 | 69.381 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015 | 50 | 63.367 | 71.016 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015 | 75 | 63.438 | 72.753 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015 | 100 | 63.469 | 73.652 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015 | 100+CC | 63.563 | 76.122 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015 | 200 | 63.544 | 75.778 |
| EA01104EHEN4_1806u | EA1104FRMEHEN2015 | 1000 | 63.754 | 86.424 |
| | | | | |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015 | 10 | 61.556 | 85.791 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015 | 25 | 61.738 | 99.175 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015 | 50 | 61.834 | 106.938 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015 | 75 | 61.928 | 115.064 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015 | 100 | 61.974 | 119.209 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015 | 100+CC | 62.107 | 132.378 |
| EA01104EHEN4_1606u | EA1104FRMEHEN2015 | 200 | 62.077 | 129.311 |

| | | | | |
|---|---|---|---|---|
| EA01104EHEN4_1606u | EA1104FRMEHEN2015 | 1000 | 62.468 | 165.107 |
| | | | | |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015 | 10 | 60.846 | 85.791 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015 | 25 | 61.066 | 99.175 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015 | 50 | 61.219 | 106.938 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015 | 75 | 61.368 | 115.064 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015 | 100 | 61.442 | 119.209 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015 | 100+CC | 61.658 | 132.378 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015 | 200 | 61.61 | 141.565 |
| EA01104EHEN4_1606d | EA1104FRMEHEN2015 | 1000 | 62.193 | 165.107 |
| | | | | |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015 | 10 | 60.291 | 85.849 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015 | 25 | 60.51 | 100.509 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015 | 50 | 60.632 | 109.947 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015 | 75 | 60.75 | 120.011 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015 | 100 | 60.814 | 125.364 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015 | 100+CC | 60.984 | 143.259 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015 | 200 | 60.947 | 139.137 |
| EA01104EHEN4_1502 | EA1104FRMEHEN2015 | 1000 | 61.321 | 193.319 |
| | | | | |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015 | 10 | 59.906 | 86.039 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015 | 25 | 60.115 | 101.387 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015 | 50 | 60.238 | 110.983 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015 | 75 | 60.397 | 121.057 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015 | 100 | 60.435 | 126.415 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015 | 100+CC | 60.562 | 144.742 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015 | 200 | 60.549 | 140.363 |
| EA01104EHEN4_1406d | EA1104FRMEHEN2015 | 1000 | 61.039 | 194.063 |
| | | | | |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015 | 10 | 59.09 | 86.039 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015 | 25 | 60.115 | 101.387 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015 | 50 | 60.238 | 110.983 |

| | | | | |
|---|---|---|---|---|
| EA01104EHEN4_1406u | EA1104FRMEHEN2015 | 75 | 60.367 | 121.057 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015 | 100 | 60.435 | 126.415 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015 | 100+CC | 60.562 | 144.742 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015 | 200 | 60.549 | 140.363 |
| EA01104EHEN4_1406u | EA1104FRMEHEN2015 | 1000 | 60.998 | 194.063 |
| | | | | |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015 | 10 | 59.39 | 86.067 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015 | 25 | 59.547 | 101.558 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015 | 50 | 59.634 | 111.404 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015 | 75 | 59.725 | 121.991 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015 | 100 | 59.767 | 127.705 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015 | 100+CC | 59.881 | 1146.854 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015 | 200 | 59.854 | 142.423 |
| EA01104EHEN4_1299u | EA1104FRMEHEN2015 | 1000 | 60.162 | 201.548 |
| | | | | |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015 | 10 | 58.833 | 86.088 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015 | 25 | 58.937 | 101.308 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015 | 50 | 58.989 | 110.761 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015 | 75 | 59.039 | 120.695 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015 | 100 | 59.059 | 126.069 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015 | 100+CC | 59.088 | 144.551 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015 | 200 | 59.08 | 140.338 |
| EA01104EHEN4_1206u | EA1104FRMEHEN2015 | 1000 | 59.218 | 195.285 |
| | | | | |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015 | 10 | 58.833 | 86.088 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015 | 25 | 58.937 | 101.308 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015 | 50 | 58.989 | 110.761 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015 | 75 | 59.039 | 120.695 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015 | 100 | 59.059 | 126.069 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015 | 100+CC | 59.088 | 144.551 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015 | 200 | 59.08 | 140.338 |
| EA01104EHEN4_1206d | EA1104FRMEHEN2015 | 1000 | 59.218 | 195.285 |




# Historic Flood Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 09 July 2019*
*Our Ref: CL132929*
*NGR: 301,526 513,720*

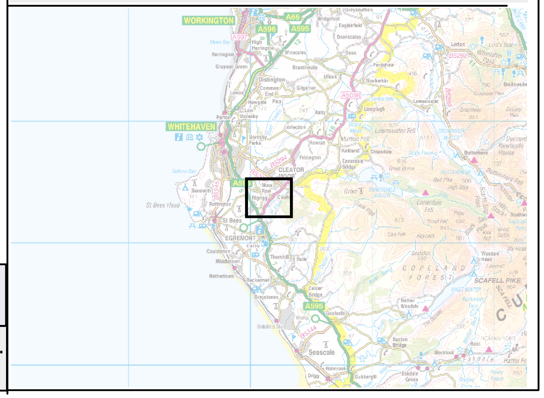
**Key**

November 2009 Recorded Flood Outline

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

**Flood Zone 2** shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

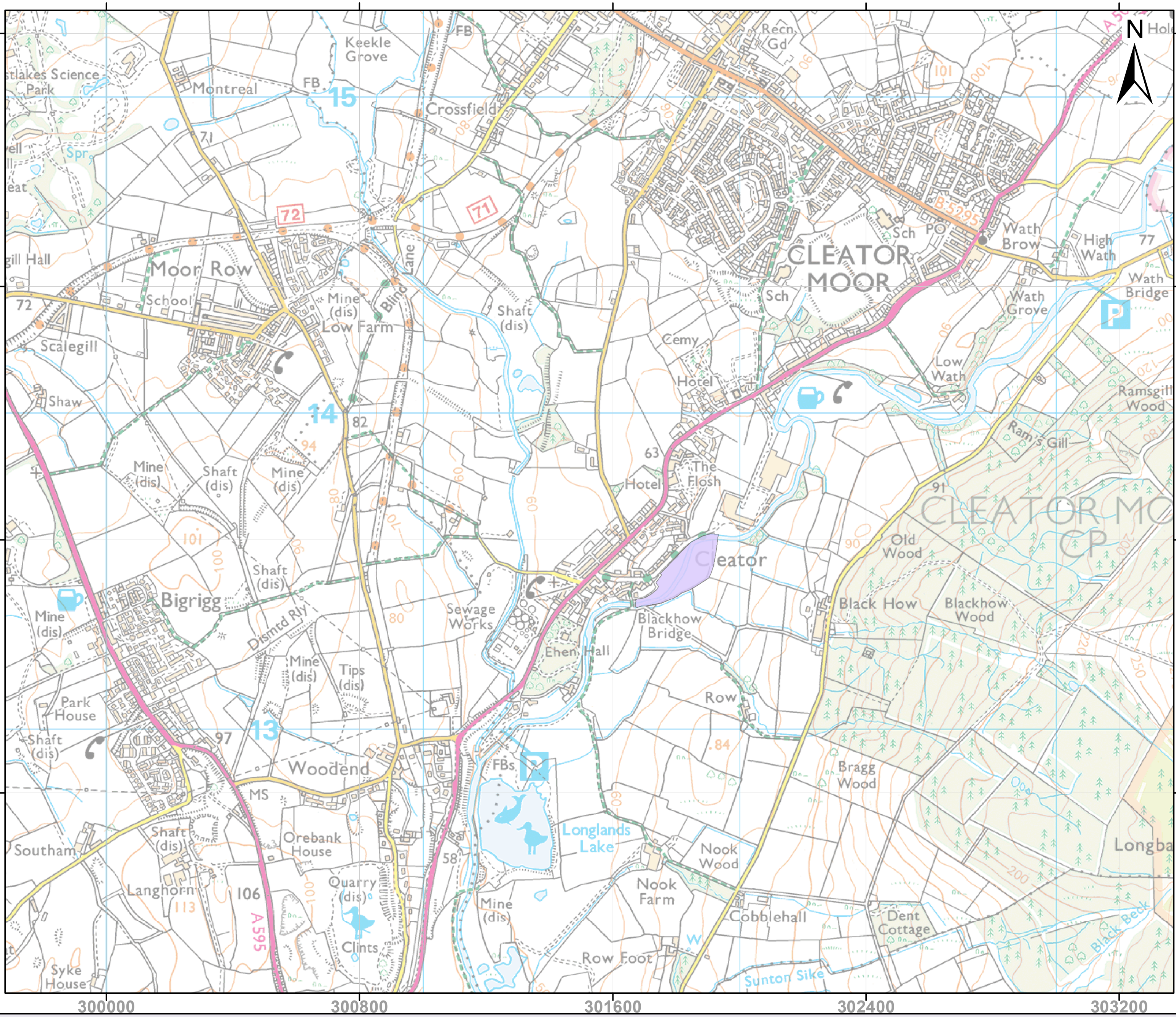
**ABDs** (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.

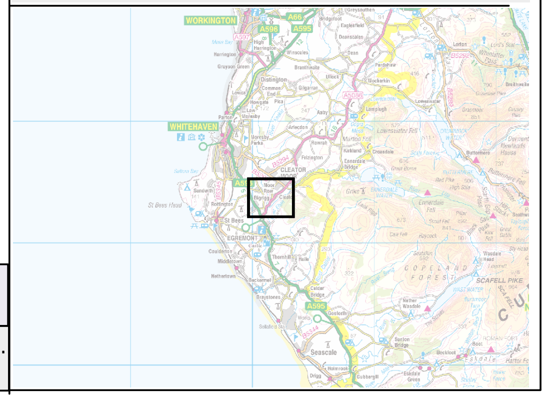



Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.



**Contact Us:** National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk




**Environment Agency**

# Historic Flood Map: Cleator Mills, Cleator, CA23 3DU

*Produced: 09 July 2019*
*Our Ref: CL132929*
*NGR: 301,526 513,720*

## *Key*

October 2017 Recorded Flood Outline

**Flood Zone 3** shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of happening each year
- or from a river with a 1.0% or greater chance of happening each year.

**Flood Zone 2** shows the extent of an extreme flood from rivers or the sea with up to 0.1% chance of occurring each year.

**ABDs** (Areas Benefiting from Defences) show the area benefiting from defences during a 0.5% tidal, or 1.0% fluvial flood event.

Modelled water levels with climate change using +20% flow allowances are not suitable for the majority of planning purposes. New climate change allowances can be checked on the following website; www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.



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