Resilience and Flood Risk

WWW.RABCONSULTANTS.CO.UK
enquiries@rabconsultants.co.uk

Lincoln Western Growth Corridor Technical Working Group Flood Risk Report – Update

10th September 2015
Final Version 2.0
RAB: 366

Lichfield Business Village, The Friary,
Lichfield, Staffordshire WS13 6QG
T. 01543 308 631

Unit 13, St Stephens Court, Willington,
Crook, County Durham DL15 0BF
T. 01388 748 366

Kingsbrook House, 7 Kingsway,
Bedford, Bedfordshire MK42 9BA
T. 01234 363 582

Revision history

Version	Date	Amendments	Issued to
Draft 1.0	31.07.15	Draft	Toby Forbes-Turner
Draft 2.0	04.08.15	Draft	WGC-TWG
Final 1.0	14.08.15	First issue	Toby Forbes-Turner
Final 2.0	10.09.15	**Section 1.1** – amended map **Section 5.1.1** – revised wording **Section 3.0** – areas obtained from shape files	Toby Forbes-Turner

Quality control

Action	Signature	Date
Prepared	G.M. Wilson	10.09.15
Checked	R.A. Burton	10.09.15
Approved	R.A. Burton	10.09.15

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RAB Lichfield Office

Lichfield Business Village
The Friary
Lichfield
Staffordshire WS13 6QG

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Executive Summary

The four partner authorities of the Central Lincolnshire Joint Planning Committee have identified the need for sustainable growth in Central Lincolnshire with a significant proportion within the Lincoln area. An assessment of flood risk and risk management options is needed to understand the contribution that the Sustainable Urban Extension site referred to as the Western Growth Corridor (WGC) could bring. A report was published in May 2013 (Appendix A) by the WGC Technical Working Group to provide supporting evidence to Central Lincolnshire Joint Planning Unit to assist with determining, in principle, the safe sustainable quantum of development. Since then, financial viability constraints have been revealed that change assumptions made within the original report, which has prompted this update work.

Ground raising above the expected flood level is required to mitigate the risk to residential and other more vulnerable development. This work has shown, in principle, the extent of land raising that can be achieved without significantly impacting on third parties, when considering breaches in either the Fossdyke or Witham during a 1% annual probability flood taking account of climate change. This result relies on mitigating the off-site impacts by improving the flood defences on the Coulson Road Main Drain and maintaining an open flow route at the east boundary of the WGC site.

By applying mitigation as detailed in this report, then the Technical Working Group consider that:

- *A significant ground raising extent (and hence 'more vulnerable' development extent) of approximately 104ha is feasible at the WGC, if mitigation is provided by increasing the Main Drain south bank height and keeping an open flow route at the east side.*

When considering the feasible extent of development platform, there still remains a significant amount of additional assessment work needed to determine the impact to / from the Upper Witham Internal Drainage Board systems and surface water. Additional mitigation works needed (beyond those detailed here), such as attenuation storage ponds, has the potential to interfere with water levels in the local drainage systems and may not provide the required storage capacity in the event of a main river breach, when the full complexity of the water system is considered. For these reasons the Technical Group recommend to the JPC that the determining authorities (Lincoln City Council and North Kesteven District Council) should require a developer to provide:

- *A Detailed Flood Risk Assessment and Water Level Management Plan to accompany any planning proposal at the Western Growth Corridor in line with the brief given in Section 5.1 of this report.*

As development is being proposed in an area outside of flood zone 1 (following the application of a Sequential Test) the Exception Test as prescribed by the National Planning Policy Framework will be applied. For the Exception Test to be passed, a site specific flood risk assessment must demonstrate that the development will be safe for its lifetime, without increasing flood risk elsewhere, will demonstrate that the development provides wider sustainability benefits to the community and, where possible, will reduce flood risk overall. To assist with this, a list of flood resilience measures has been provided in this report that a developer should address to increase resilience to the development and provide flood risk mitigation to the wider community. Consequently the Technical Group further recommend to the JPC that the determining authorities should require a developer to provide:

- *Additional physical works as part of any development at the Western Growth Corridor to provide greater flood resilience to the site and the wider area, in line with the brief given in Section 5.2 of this report.*

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1.0 Introduction

1.1 Background to the project

The four partner authorities of the Central Lincolnshire Joint Planning Committee (JPC) have identified the need for sustainable growth within Central Lincolnshire as a whole, a significant proportion of which, is planned within the Lincoln area. Practically, this will involve significant expansion of residential and commercial development while taking account of flood risk. The JPC have selected four potential Sustainable Urban Extension (SUE) areas for this purpose, one of which is the Western Growth Corridor (WGC).

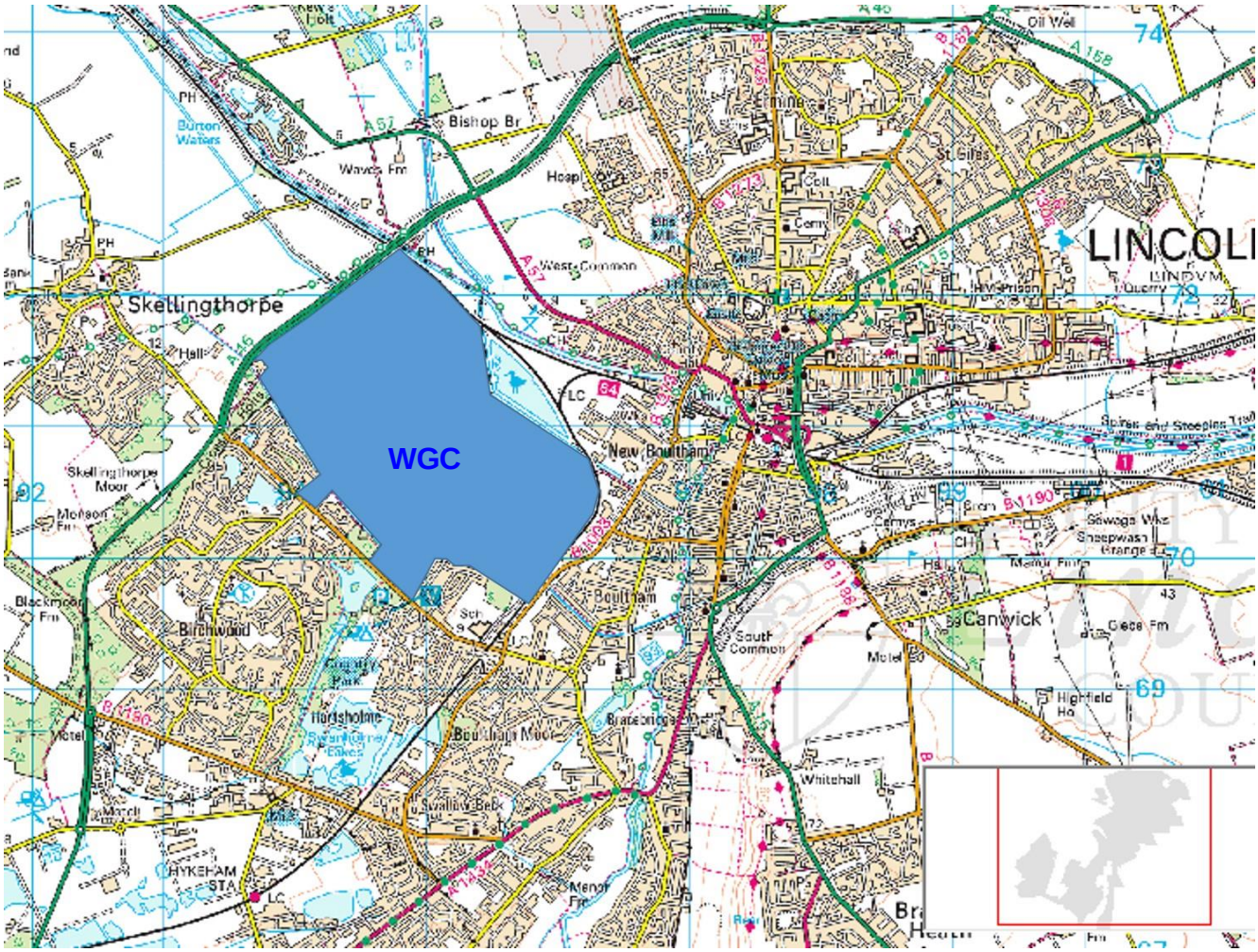


FIGURE 1 MAP OF LINCOLN SHOWING THE WGC

The Central Lincolnshire Joint Planning Unit (JPU) has undertaken a sequential test as prescribed by the National Planning Policy Framework to ensure that flood risk is correctly accounted for when assessing the options and deciding how best to allocate growth across the wider Lincoln area.

The WGC is almost entirely located within flood zone 3, however in order to meet the housing growth targets required in the emerging Central Lincolnshire Local Plan, due to limited sites being available especially within the Urban Area of Lincoln, some development is required in flood risk areas. As such, some of the housing requirements could be met by the WGC if the requirements of the

Exception Test are met, principally safety. Therefore there is a justification for running an exception test for the development of the WGC. Consequently, an assessment of flood risk and risk management options is needed to understand the contribution the site could bring as part of a strategic partnership approach to development whilst ensuring flood risk is reduced now and for the future.

It is clear that any significant development of the WGC would require extensive flood risk management measures to make development safe while not increasing flood risk at the site or elsewhere. Taylor-Wimpey previously considered this challenge for an extensive development proposal by quantifying flood risk and proposing risk mitigation measures within the WGC site to achieve a minimal overall impact on flood risk.

The Taylor-Wimpey work prompted a discussion paper between the strategic flood risk and planning partners to consider the wider impact of the WGC development and the need to find integrated solutions and mutual benefits (LWGC Discussion Paper Version 5.0 TCR 18_04_12).

This led to the establishment of a Lincoln Western Growth Corridor Technical Working Group (WGC-TWG) whose membership consists of representatives from the Environment Agency, Upper Witham Internal Drainage Board, Lincolnshire County Council as Lead Local Flood Authority and the Local Planning Authority, with project aim:

- To provide evidence – to support the LDF.
- To set principles – to govern any potential development on the site.
- To achieve consensus – on the issues facing the area and appropriate future.

and group objectives:

- Provide evidence and technical advice to the Steering Group.
- Propose a range of FRM approaches.
- Propose a representative range of development options and extents for testing.
- Facilitate information sharing and resources between stakeholders for assessing FRM options and testing the optimum deliverable approach to safe and sustainable development.

1.2 Initial work and the need for an update

The Technical Working Group met at regular intervals during 2012 and 2013 to advance the aims and objectives. The group published a report in May 2013 summarising the work done and advising, in principle, on: the extent of safe sustainable development; the flood risk mitigation measures needed to support the quantum of development and setting a brief of detailed assessment work that would be required to support a planning application.

A brief summary of the May 2013 report is given below. The full report is included in Appendix A.

- A review was made of the complex hydrology around Lincoln that may interact with the WGC site. All potential sources of flooding were considered.

- It was agreed that the only realistic way to manage flood risk at the site is by ground raising, with all 'more vulnerable' development to be built above a design flood level. Significant ground raising at the WGC however has the potential to increase flood levels elsewhere.
- The extensive flooding arising from a defence breach on either the Witham or Fossdyke was identified as the primary flood mechanism to be used as a design standard for initial 'in principle' testing.
- It was agreed that, for the purposes of 'in-principle' testing, safe and sustainable development is defined as a ground raising extent that produces no increase of flood hazard class[1] for any existing residents.
- A test regime was established utilising the Environment Agency's Upper Witham (InfoWorks) river model, with two flood defence breach locations: one on the River Witham (referred to as breach location L13) and one on the Fossdyke Navigation (referred to as breach location (L41).[2]
- Six WGC platform extents were tested, coded A to F, progressively extending away from the lowest risk south boundary of the site, adjacent to Boultham Catchwater (A being the smallest extent and F the largest).
- The shape of the six platform extents observed 3 constraints: (a) a road connection onto the platform with the A46 at the north-west corner (b) a road connection onto the platform with the B1003 at the east side, utilising land between Chieftain Way and Crusader Road (c) a corridor to the south with no land raising to allow flood water from Hartsholme Lake to pass north into the floodplain, in the unlikely event of a dam failure[3].
- The results showed that as long as an eastern flow route is kept open (as existing), such that the flows arising from a Witham breach are allowed to spread out onto the northern part of the WGC then the ground raising extent has no significant effect on offsite flood hazard during a Witham breach. Flood hazard may increase but not enough to increase hazard class.
- The ground raising extent does have a significant and detrimental effect on offsite flood hazard during a Fossdyke breach, with increased extent producing increased negative impact.

[1] Flood hazard is a combination of water depth and water velocity, which reflects the fact that shallow, slow moving water is less dangerous than deep, fast flowing water. Refer to page 4 of the main report (included in Appendix A) for a more detailed definition.
[2] Refer to Section 2.3 of the main report (included in Appendix A) for further details.
[3] The width of the flow corridor was judged without supporting modelling work. It was assumed that a width greater than the length of the dam along Skellingthorpe Road would be sufficient. The Hartsholme Lake reservoir inspecting engineer agreed that, in his opinion, the flow route would be more than sufficient (refer to Appendix C of the main report).

- The maximum ground raising extent that has no significant effect elsewhere during a Fossdyke breach is estimated to be approximately A to B, but not as far as extent C.
- By lowering an area of existing higher ground (the former tip) to provide mitigation, then extent D is achievable, but not as far as extent E.

The conclusions from the May 2013 report provided a basis on which to take forward the principle of partial development of the WGC. This included assessing viability against factors other than flood risk. Two facts have emerged since publication of the original report. Firstly, development of the WGC in line with the findings of the report would not be financially viable to a developer unless development extent E could be achieved. Secondly, the cost of lowering the existing tip is prohibitively expensive, and therefore this method does not offer a viable way of releasing higher development extents.

This has prompted the Technical Working Group to revisit the project, to investigate viable alternative mitigation measures that would unlock safe development to extent E. This report details the update work.

2.0 Stage 1 – Screening alternative mitigation options

The Technical Working Group met to discuss the update work and to propose potential alternative mitigation options to take forward for initial screening tests. Five mitigation options were identified:

Mitigation option 1 – optimise the eastern flow route and extent

The May 2013 work just showed the importance of allowing flows arising from a breach on the Witham to enter the WGC. Here, maximising the eastern development extent was investigated in more detail, using 3 extents (3 tests). In discussion with WSP Consultants, it was concluded that a small amount of tip lowering (to match adjacent ground) is financially viable, therefore this was included in the maximum east extent test.

Mitigation option 2 – upgrade to hard flood defences

Flood defences along both the Witham and Fossdyke consist of earth banks, which are referred to a 'soft defences'. In the event of defence breach failure, soft defences are expected to fail more extensively compared with flood walls, which are referred to as 'hard defences'. This is expected given the lower erosion resistance of soft defences. This difference in performance is captured by standards used by the Environment Agency when modelling breach failure. Soft defences are normally modelled with a 50m wide breach, while hard defences a 20m wide breach. The flood risk mitigation option of upgrading flood defences along the Witham and Fossdyke to hard defences was therefore tested by changing to a 20m breach width (compared with the 50m breach width used in the work of May 2013).

Mitigation option 3 – increase defence height on the Coulson Road Main Drain

The May 2013 work showed that in the event of a breach on the Fossdyke, with a high development extent, additional flooding (compared with the baseline) tended to occur at one location south of the Main Drain at Coulson Road. The effect of raising the embankments along this stretch of the Main Drain was tested (nominally raised by 1m on both sides).

Mitigation option 4 – utilising flood storage in the Fossdyke Navigation

It is expected that the timing of flood peaks for the River Till and Fossdyke Navigation will not coincide. Assuming that the Fossdyke flow rises and falls before the Till, then it may be possible to reduce downstream flood risk (at both WGC and Lincoln), by applying a timed flow control system on the Fossdyke just downstream of the Till-Fossdyke junction.

The idea is to have a structure in fully open position initially to allow the Fossdyke peak flow to pass unrestricted, then reducing the flow ahead of the Till peak arriving at the Till-Fossdyke junction. In this way the peak Till flow can partially backflow west into the Fossdyke, occupying any available storage. The structure would then fully open again once the risk of flooding has passed.

The results from the existing May 2013 modelling work were reviewed to understand whether hydrological conditions were likely to support this approach.

Mitigation option 5 – utilise compartmentalisation

A single breach test on the Fossdyke (at L41) was run to test the option of a flood management compartment being created at Pyewipe junction, by raising the north bank of the Main Drain to match the lowest level of the surrounding railway and road embankments.

2.1 Results - Mitigation Option 1 – optimise the eastern flow route and extent

2.1.1 Option 1.1 - Low eastern extent (just exceeds extent C from May 2013)

- Eastern flow route fully open.
- 50m breach on the Witham.
- No lowering of the tip.

FIGURE 2 DEFINITION OF OPTION 1.1. RED LINES SHOW THE AREA OF GROUND RAISING SUPERIMPOSED ONTO A SCREENSHOT FROM GOOGLE MAPS TAKEN ON 08/05/2013.

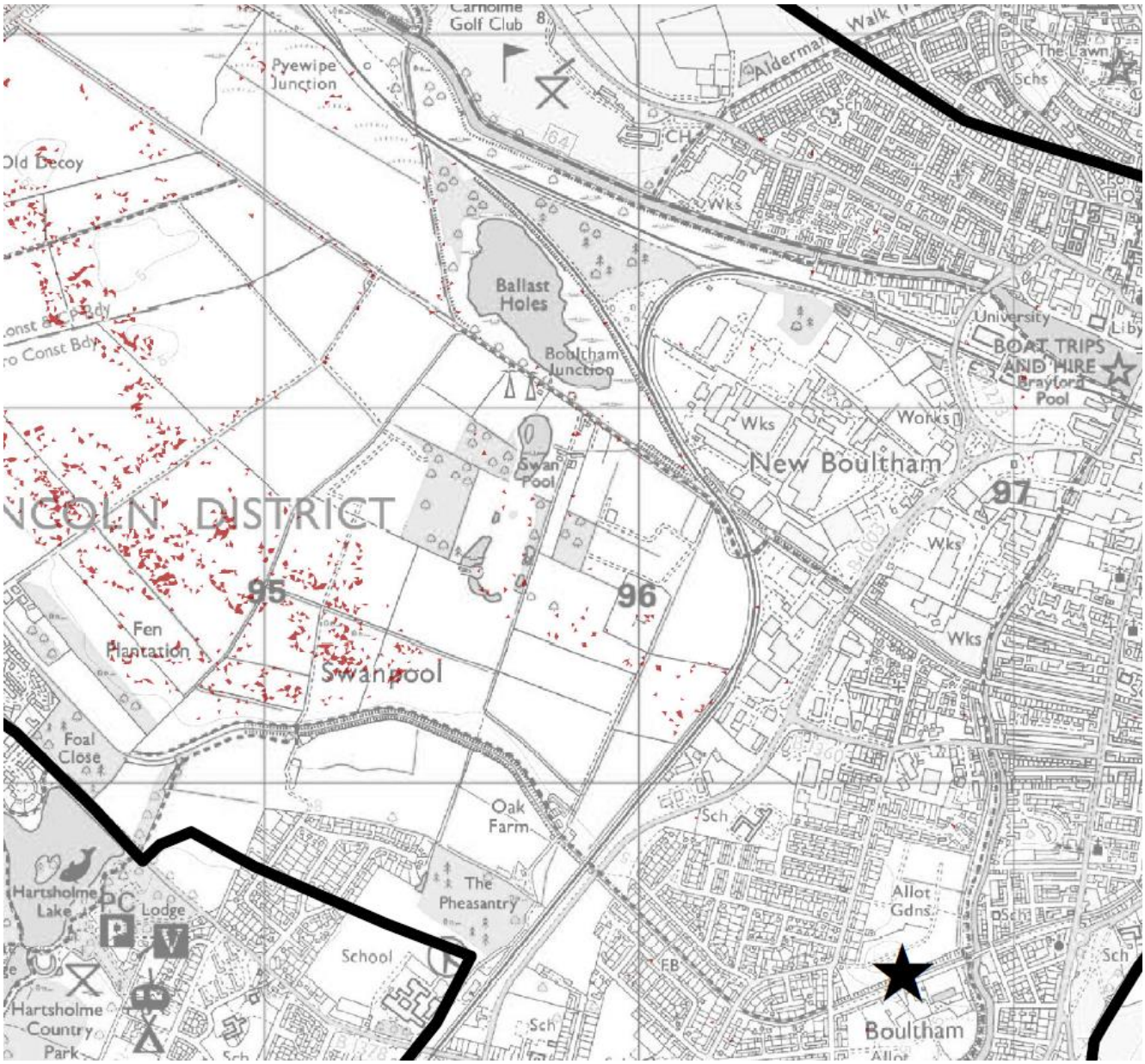


FIGURE 3 RESULTS FROM OPTION 1.1. RED COLOURATION SHOWS WHERE FLOOD HAZARD CATEGORY HAS INCREASED.

Summary of results for Option 1.1:

- No increase of flood hazard rating.

2.1.2 Option 1.2 - Medium eastern extent

- Eastern flow route open, but with the south of the 2 east flows closed*.
- 50m breach on the Witham.
- No lowering of the tip.

FIGURE 4 DEFINITION OF OPTION 1.2. RED LINES SHOW THE AREA OF GROUND RAISING SUPERIMPOSED ONTO A SCREENSHOT FROM GOOGLE MAPS TAKEN ON 08/05/2013.

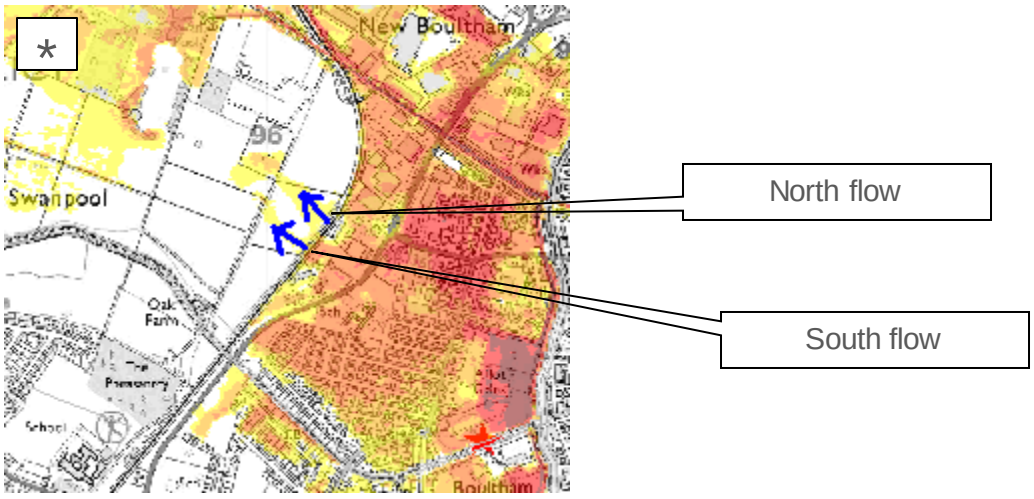


FIGURE 5 SCREENSHOT FROM THE BASELINE WITHAM BREACH MODELLING SHOWING THE 2 STRANDS OF EAST FLOW

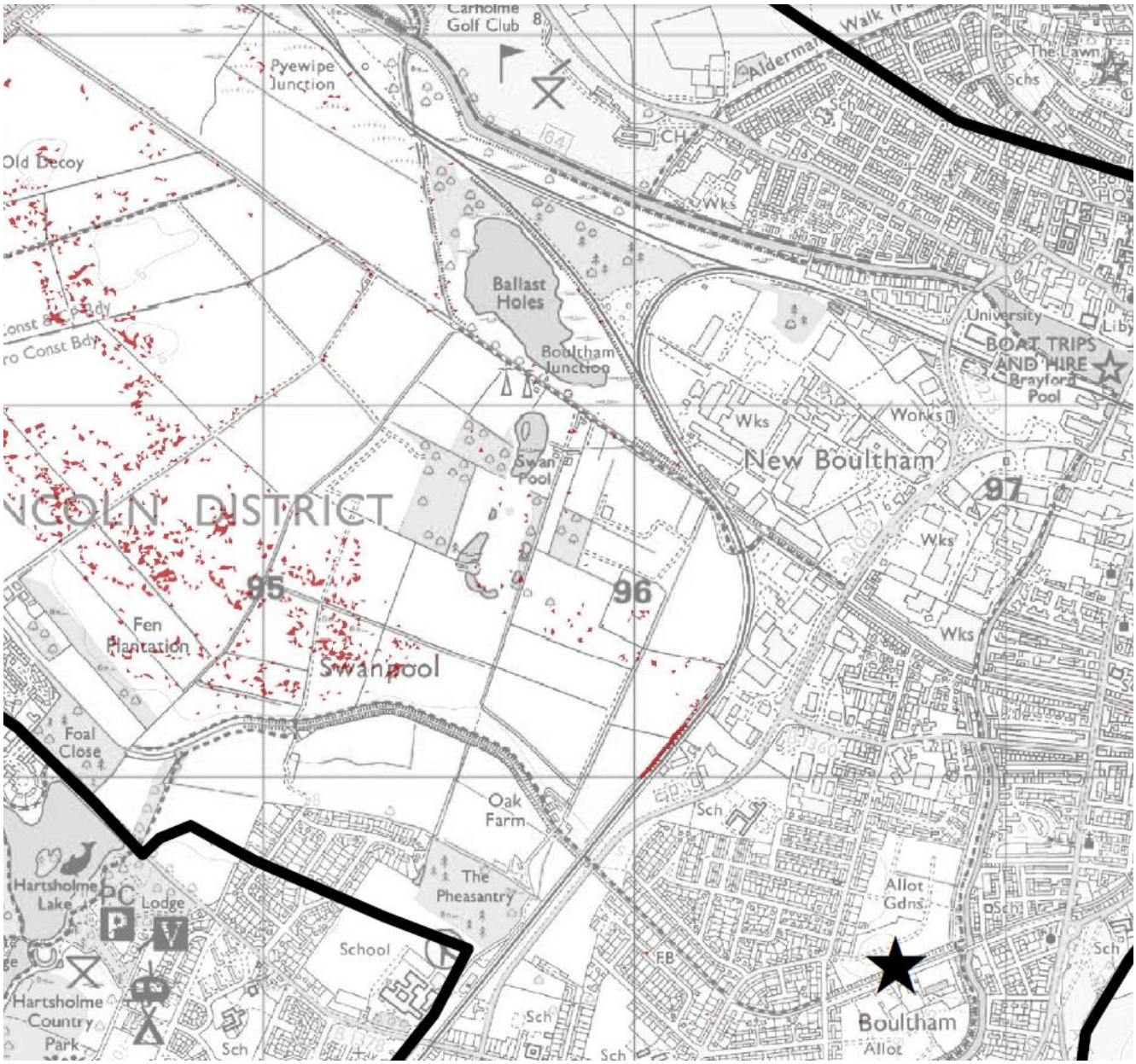


FIGURE 6 RESULTS FROM OPTION 1.2. RED COLOURATION SHOWS WHERE FLOOD HAZARD CATEGORY HAS INCREASED.

Summary of results for Option 1.2:

- No increase of flood hazard rating.

2.1.3 Option 1.3 - High eastern extent

- Eastern flow route open, but with the south of the 2 east flows closed (see 2.1.2).
- 50m breach on the Witham.
- Partial tip lowering to adjacent ground level[4].

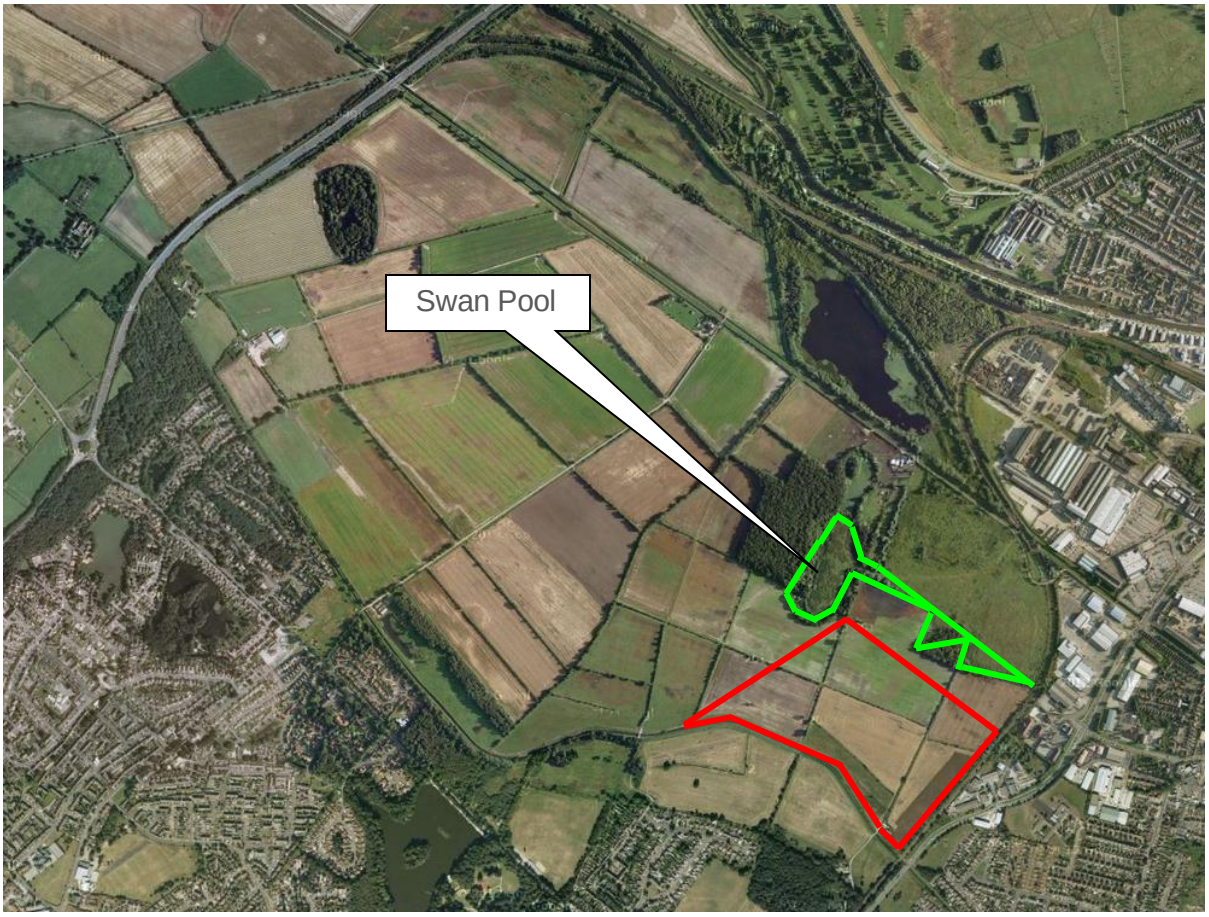


FIGURE 7 DEFINITION OF OPTION 1.3. RED LINES SHOW THE AREA OF GROUND RAISING AND GROUND LOWERING IN GREEN SUPERIMPOSED ONTO A SCREENSHOT FROM GOOGLE MAPS TAKEN ON 08/05/2013.

[4] It should be noted that following this work, WSP Consultants advised that while a small area of ground lowering of the tip is viable, as shown, the location should not include Swan Pool.

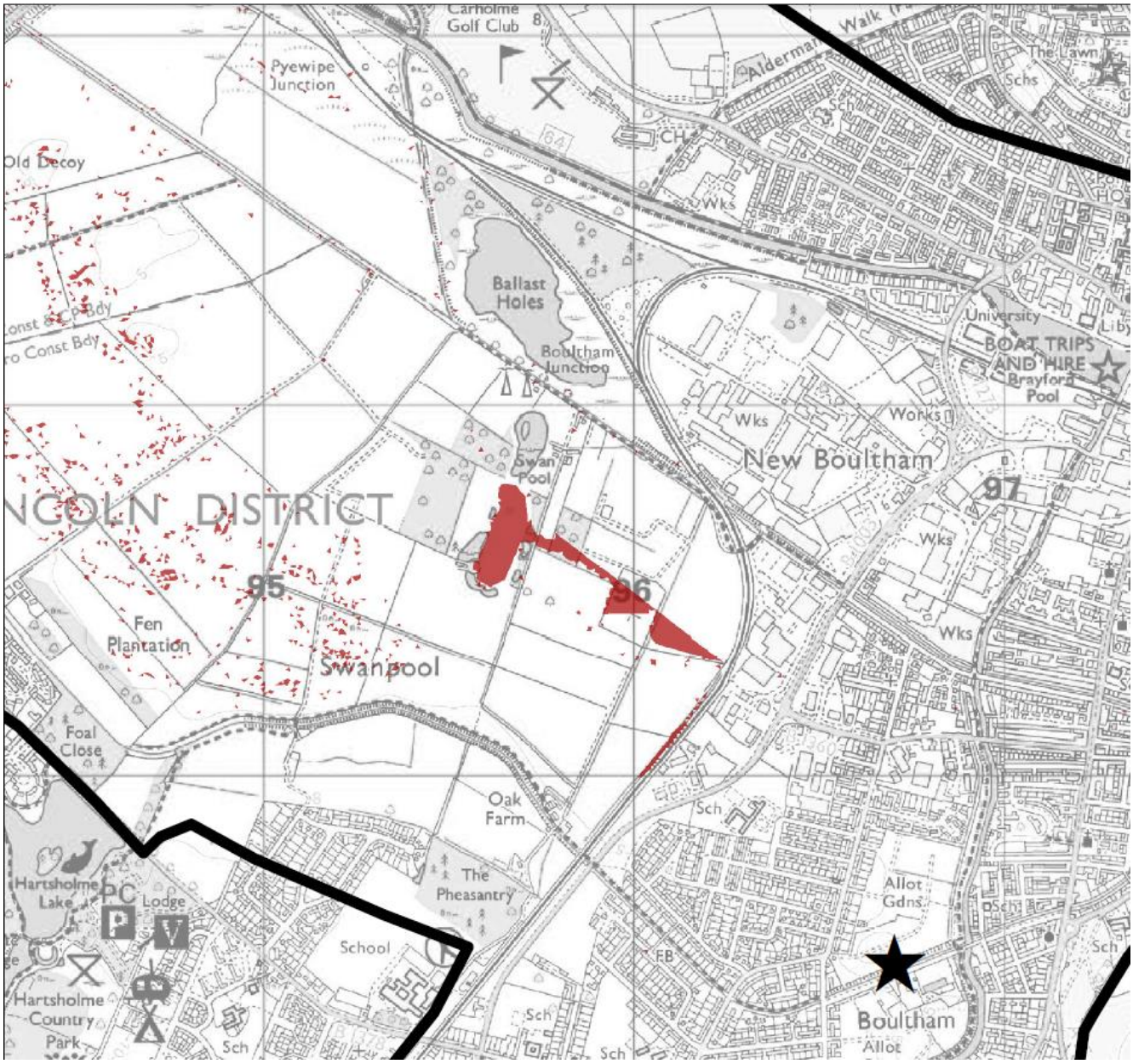


FIGURE 8 RESULTS FROM OPTION 1.3. RED COLOURATION SHOWS WHERE FLOOD HAZARD CATEGORY HAS INCREASED.

Summary of results for Option 1.3:

- No increase of flood hazard rating.

2.2 Results - Mitigation Option 2 – upgrade to hard flood defences

2.2.1 Option 2.1 – Hard defences along the Witham

- Ground raising extent to the west is the same as extent C from May 2013.
- Maximum eastern extent, with east flow fully closed.
- 20m breach on the Witham.
- No lowering of the tip.

FIGURE 9 DEFINITION OF OPTION 2.1. RED LINES SHOW THE AREA OF GROUND RAISING SUPERIMPOSED ONTO A SCREENSHOT FROM GOOGLE MAPS TAKEN ON 08/05/2013.

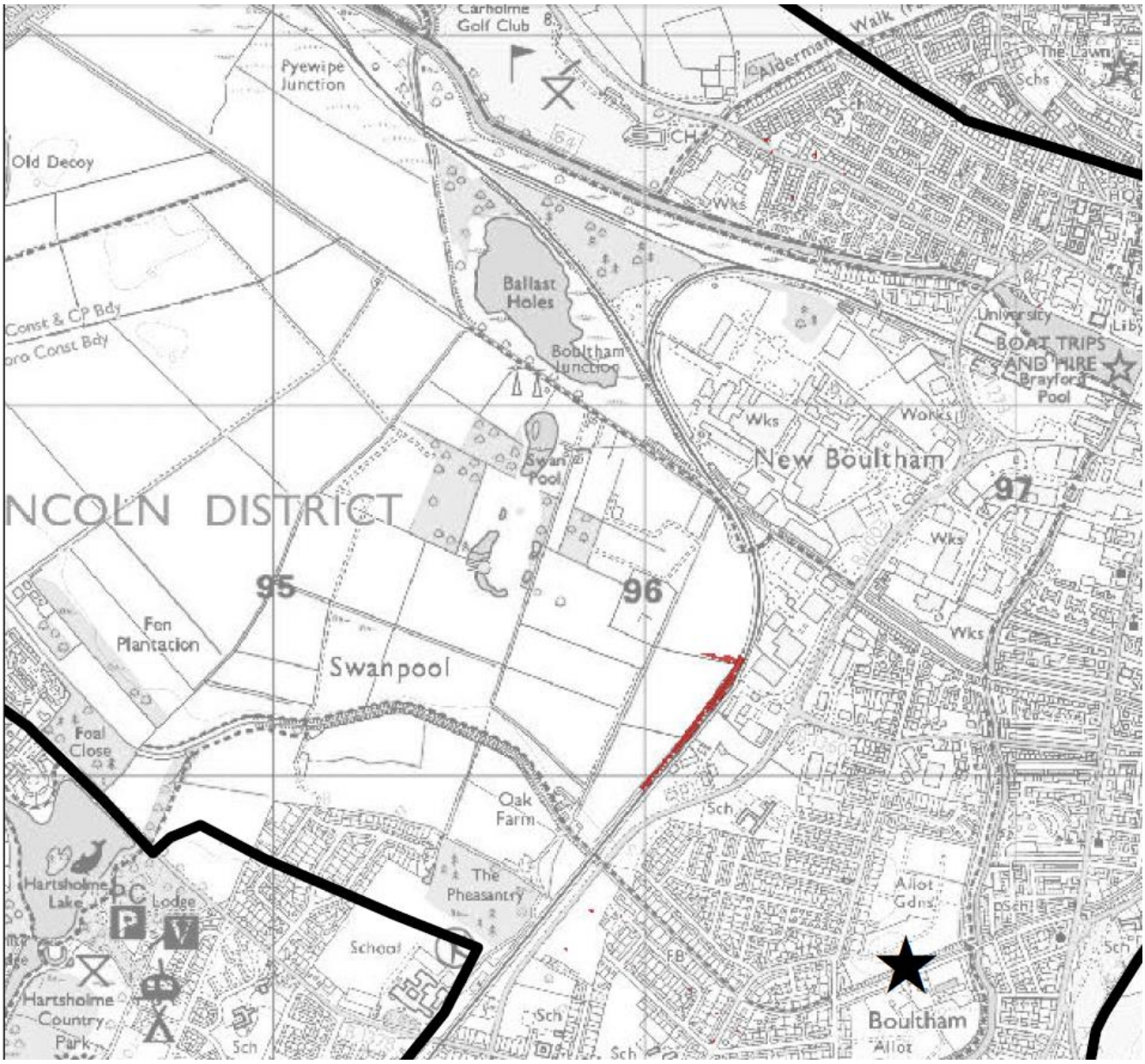


FIGURE 10 RESULTS FROM OPTION 2.1. RED COLOURATION SHOWS WHERE FLOOD HAZARD CATEGORY HAS INCREASED.

Summary of results for Option 2.1:

- No increase of flood hazard rating.

2.2.2 Option 2.2 – Hard defences along the Fossdyke

- Ground raising extent is entirely the same as extent C from May 2013.
- East flow fully open.
- 20m breach on the Fossdyke.
- No lowering of the tip.

FIGURE 11 DEFINITION OF OPTION 2.2. RED LINES SHOW THE AREA OF GROUND RAISING SUPERIMPOSED ONTO A SCREENSHOT FROM GOOGLE MAPS TAKEN ON 08/05/2013.

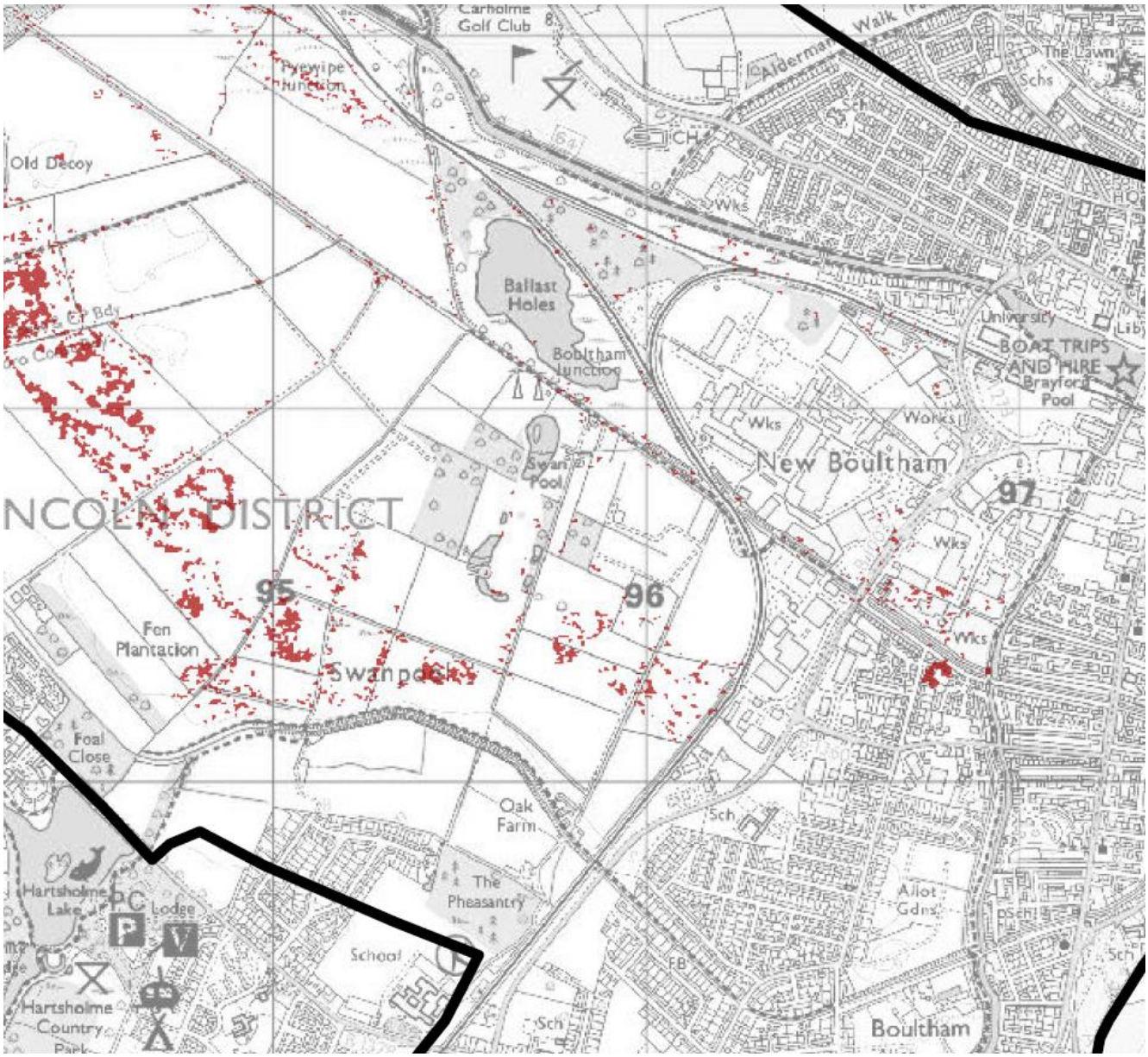


FIGURE 12 RESULTS FROM OPTION 2.2. RED COLOURATION SHOWS WHERE FLOOD HAZARD CATEGORY HAS INCREASED.

Summary of results for Option 2.2:

- No improvement compared to extent C results from May 2013.

2.3 Results - Mitigation Option 3 – increase defence height on Coulson Road Main Drain

- Ground raising extent is entirely the same as extent C from May 2013.
- East flow fully open.
- 50m breach on the Fossdyke.
- No lowering of the tip.
- Main Drain north and south bank heights raised by 1m adjacent to Coulson Road.

FIGURE 13 DEFINITION OF OPTION 3. RED LINES SHOW THE AREA OF GROUND RAISING SUPERIMPOSED ONTO A SCREENSHOT FROM GOOGLE MAPS TAKEN ON 08/05/2013.

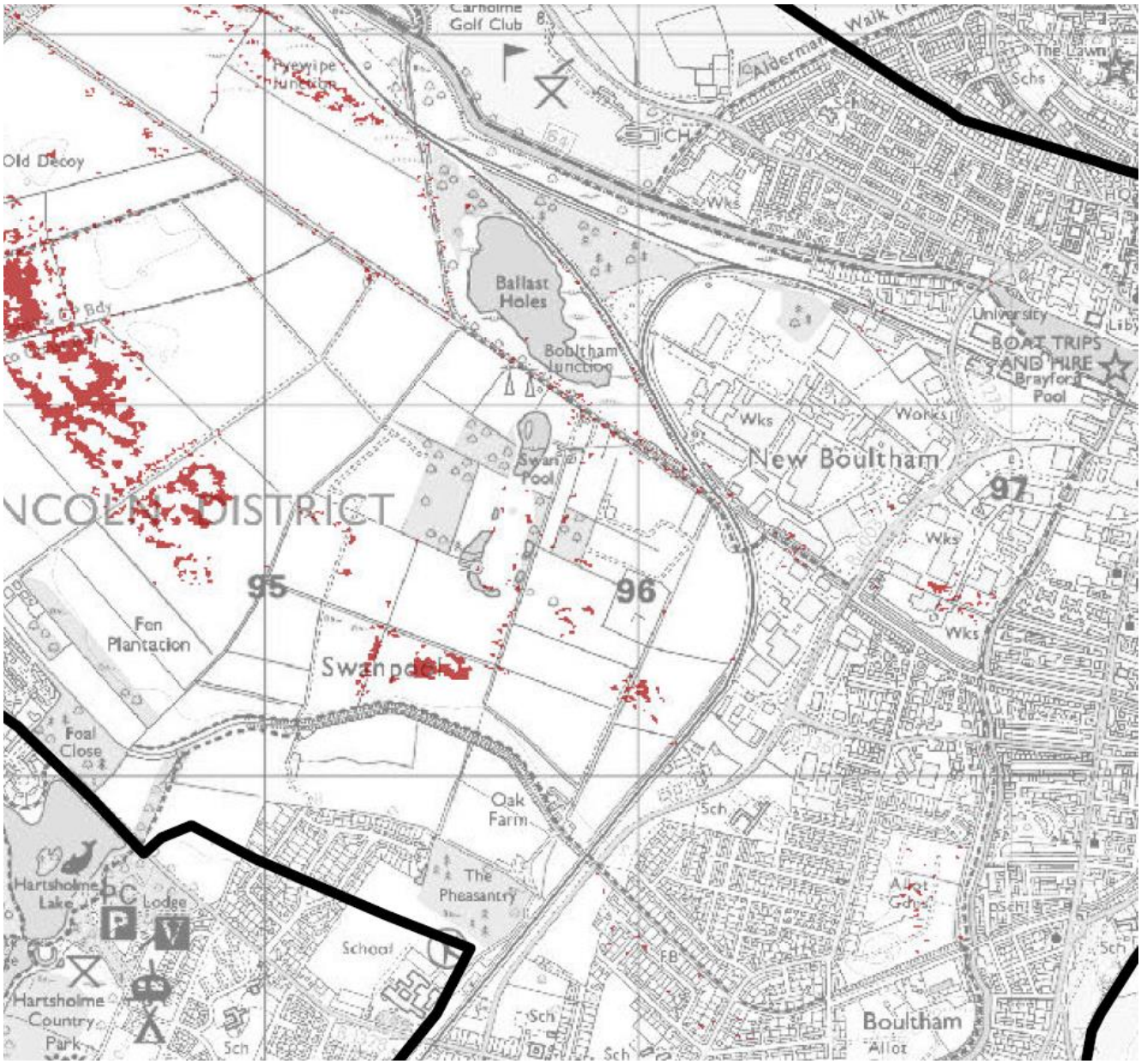


FIGURE 14 RESULTS FROM OPTION 3. RED COLOURATION SHOWS WHERE FLOOD HAZARD CATEGORY HAS INCREASED.

Summary of results for Option 3:

- No increase of flood hazard rating. An improvement compared to extent C from May 2013.

2.4 Results - Mitigation Option 4 – utilising flood storage in the Fossdyke Navigation

- Baseline hydrology results from May 2013 were reviewed.

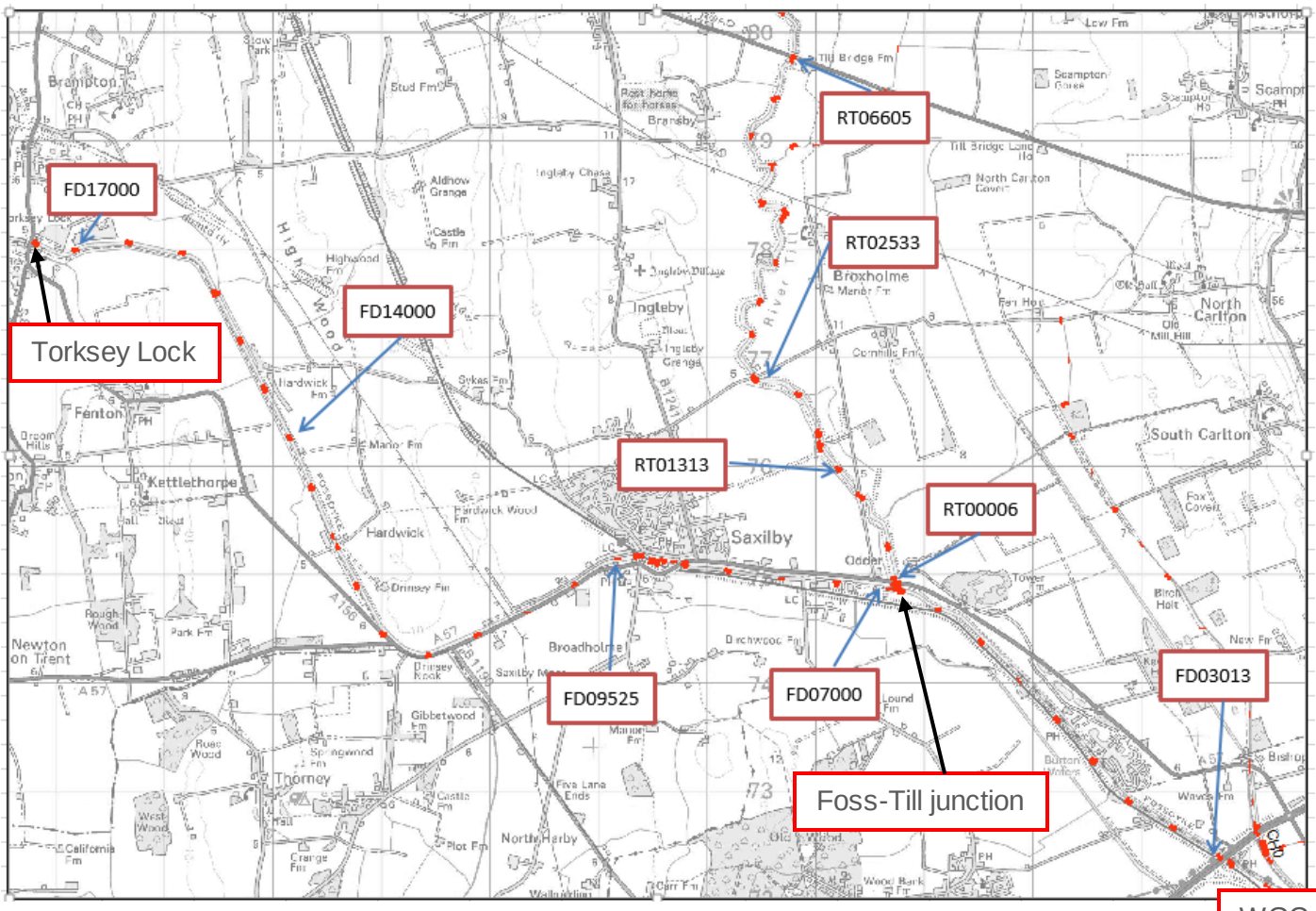


FIGURE 15 MAP SHOWING KEY LOCATIONS AND IDENTIFICATION CODING FOR RESULTS REFERRED TO BELOW

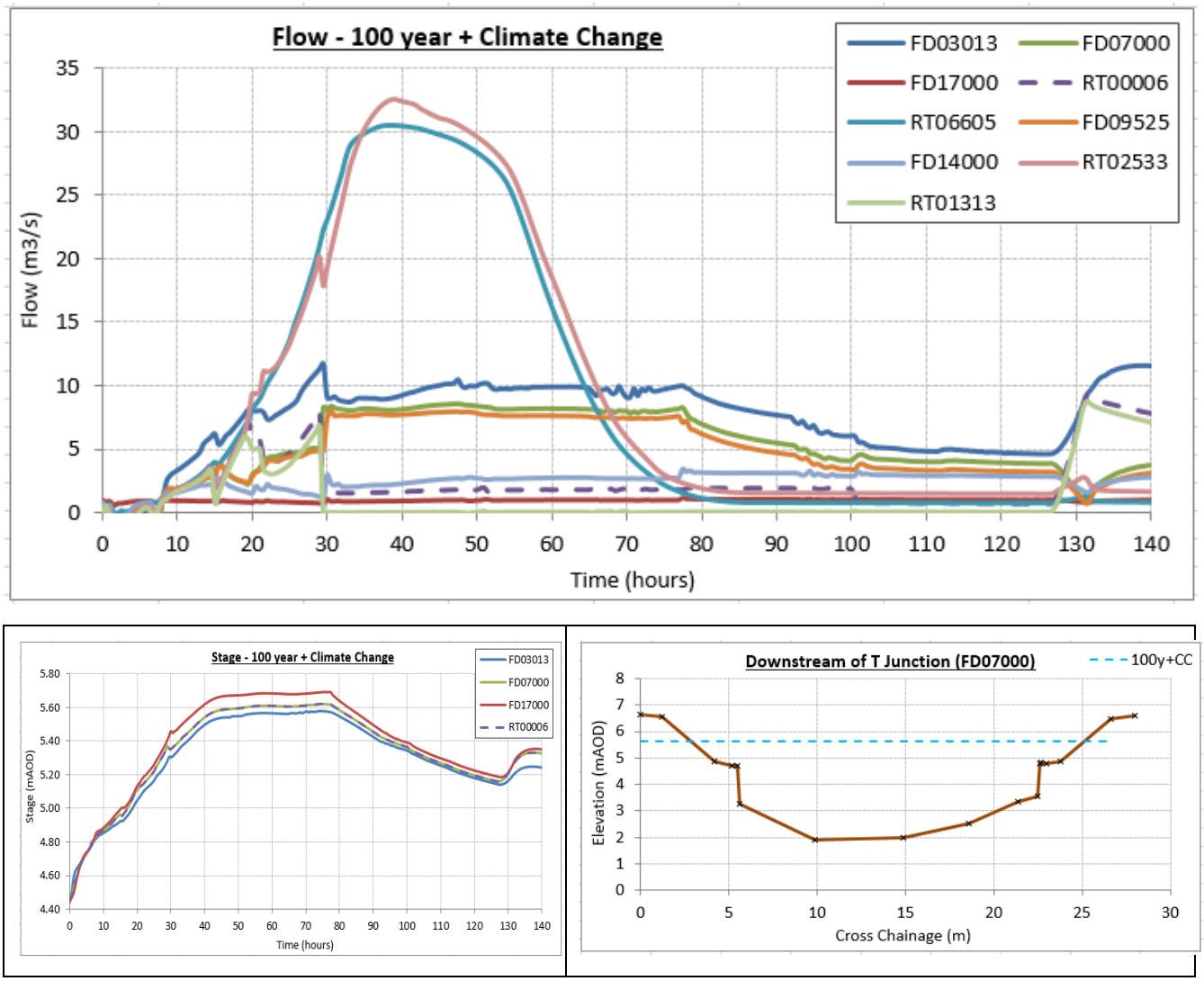


FIGURE 16 RESULTS FOR OPTION 4.

Key findings relevant to Option 4:

- The River Till contribution to flows in the Fossdyke is very low due to the effect of upstream attenuation storage.
- The River Witham flows west along the Fossdyke during a flood, so the Fossdyke is filling rather than draining.
- The River Witham is the main driver of flood levels in the Fossdyke during a flood.
- There is low available storage volume in the Fossdyke.
- There is low likelihood of this Option providing much benefit.

2.5 Results - Mitigation Option 5 – utilise compartmentalisation

- Ground raising extent is entirely the same as extent C from May 2013.
- East flow fully open.
- 50m breach on the Fossdyke.
- No lowering of the tip.
- The defence height along the north bank of the Main Drain was raised to 6mAOD, from a typical level of 5.0 – 5.5mAOD, to hold a greater volume of water prior to overtopping onto land to the south.

FIGURE 17 DEFINITION OF OPTION 5. RED LINES SHOW THE AREA OF GROUND RAISING, WHILE BLUE LINES SHOW THE FLOOD STORAGE COMPARTMENT SUPERIMPOSED ONTO A SCREENSHOT FROM GOOGLE MAPS TAKEN ON 08/05/2013.

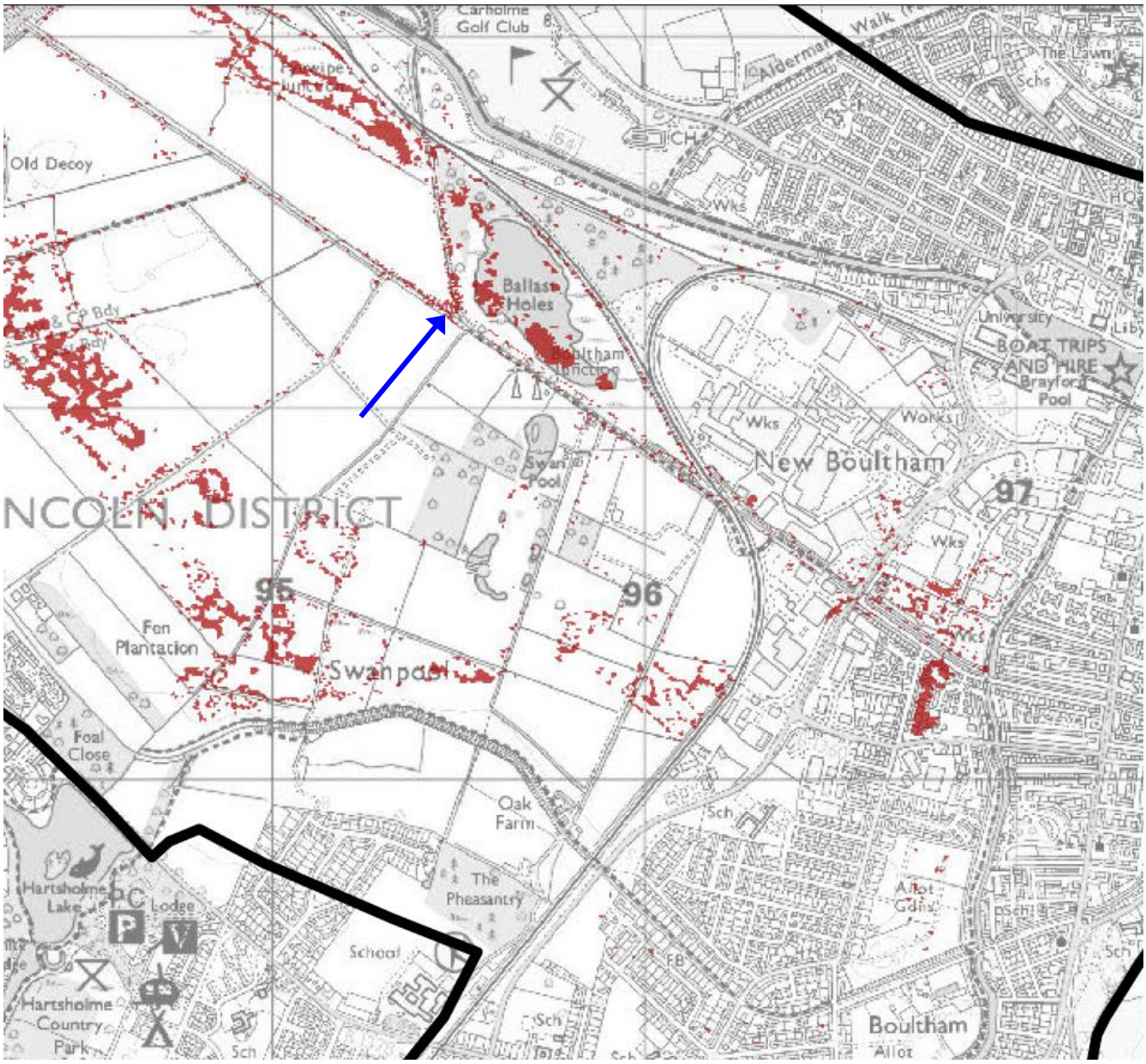


FIGURE 18 RESULTS FROM OPTION 5. RED COLOURATION SHOWS WHERE FLOOD HAZARD CATEGORY HAS INCREASED.

Summary of results for Option 5:

- A more extensive area of flood hazard increase was produced compared with the result for extent C from May 2013.
- There is a connection between the Main Drain and land to the north that defeats the compartmentalisation concept. This funnels breach flood water into the Main Drain more effectively, and hence causes more flooding south of Coulson Road.
- More work is needed to pursue this concept.

2.6 Summary of Stage 1 results

- **Option 1 – Optimise eastern flow route and extent.**
  - (1.1) A large eastern development extent with east flow route fully open resulted in no increase of flood hazard.
  - (1.2) A larger eastern development extent with only the north strand of the east flow route open resulted in no increase of flood hazard.
  - (1.3) An even larger eastern development extent with only the north strand of the east flow route open and a route created by lowering a strip of the tip resulted in no increase of flood hazard.
- **Option 2 – Hard defences.**
  - (2.1) Total development of the east side with hard defences on the Witham resulted in no increase of flood hazard.
  - (2.2) Medium development extent C with hard defences on the Fossdyke gave a slight improvement compared with zero mitigation, however there was still an increase of flood hazard so the EA's requirement is not met.
- **Option 3 – Raised defences on Coulson Road.**
  - Adding 1m high flood walls to both north and south banks of the Main Drain from Tritton Rd to the Witham gave a slight increase of flood hazard in the retail park/Siemens north of the drain. No increase of flood hazard in the residential area.
  - The modeller speculates that by extending the flood walls west to WGC/railway might completely eliminate flooding at this location (betterment compared with existing).
- **Option 4 – Flood storage in Fossdyke.**
  - Till contribution is very low into the Fossdyke due to upstream storage.
  - Witham backflows through the Fossdyke during a flood – Witham is main driver of flood risk.
  - Low storage volume in Fossdyke.
  - Overall there is low scope for mitigation with this option.
- **Option 5 – Compartmentalisation.**
  - The idea is to raise defences along the north bank of the Main Drain through the WGC to increase water storage prior to overtopping into the Main Drain.
  - The option did provide more storage however it produced a worse result than existing because breach flood water was more effectively directed into the Main Drain through the connection of the two Main Drains.
  - This option may still provide a solution but much more work is needed than just one run to optimise and stop unintended consequences.

Given the limited benefits arising from hard defences, the low likelihood of an effective solution through Fossdyke storage and time constraints to pursue the flood compartmentalisation, the decision of the Technical Working Group was to pursue Option 1 and Option 3, referred to as 'Option E2'.

3.0 Stage 2 – Development extent E2 with preferred mitigation

- Eastern flow route open, but with the south of the 2 east flows closed (see Section 2.1.2).
- Option 1.3 applied to the east development extent (see Section 2.1.3).
- West development extent based on May 2013 extent E but with alterations to the shape around Decoy Farm based on new constraints in that area.
- 50m breach on both the Fossdyke and Witham (separate runs).
- Partial lowering of the tip to assist the east flow route.
- Extended Option 3 applied – i.e. raised defences along the Main Drain from the railway line at the west to the Witham at the east.

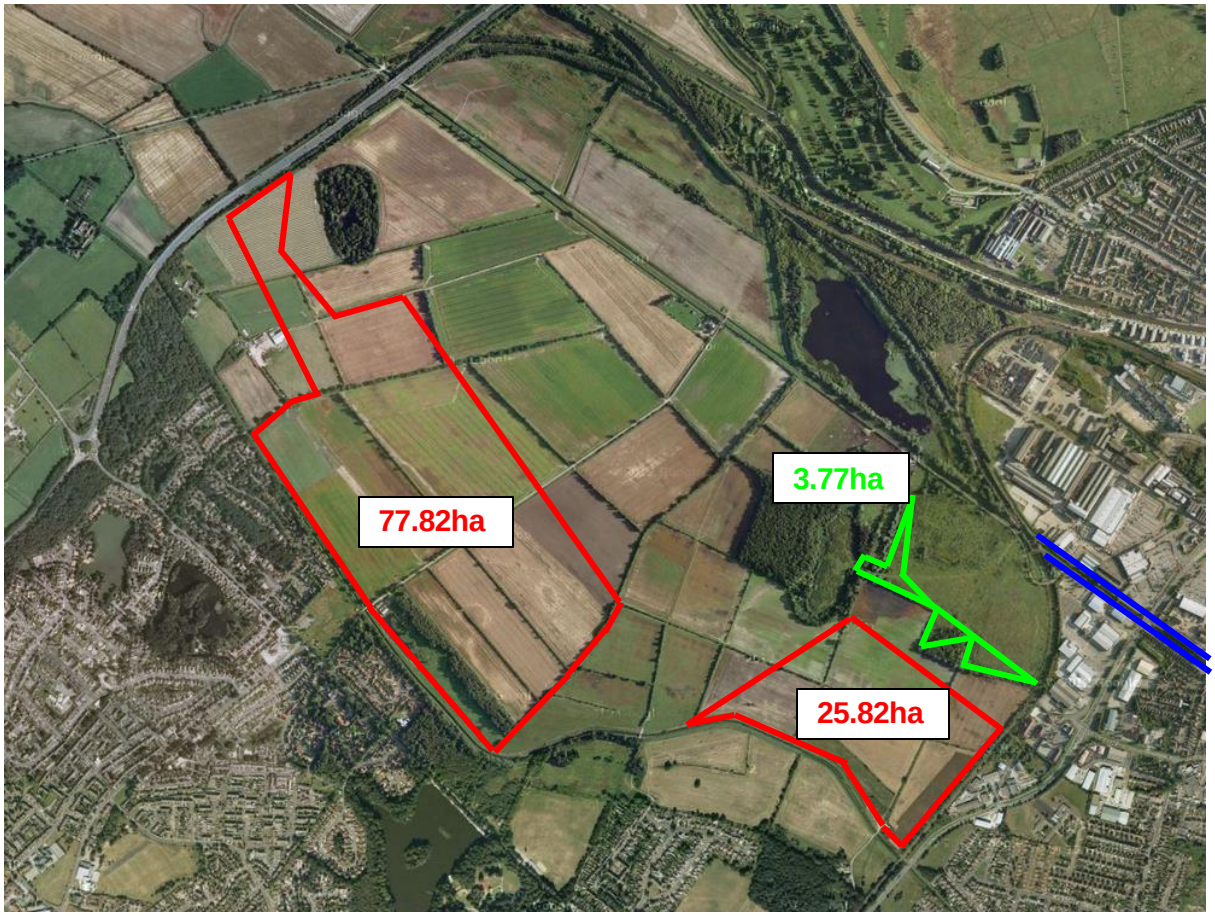


FIGURE 19 DEFINITION OF OPTION E2. RED LINES SHOW THE AREA OF GROUND RAISING, GREEN LINES SHOW GROUND LOWERING TO ADJACENT GROUND LEVELS AND BLUE LINES SHOW THE MAIN DRAIN FLOOD DEFENCE SUPERIMPOSED ONTO A SCREENSHOT FROM GOOGLE MAPS TAKEN ON 08/05/2013.

3.1 Preliminary results to identify the required Main Drain bank height

Initially, the peak contained flood level was found by applying infinitely high Main Drain banks.

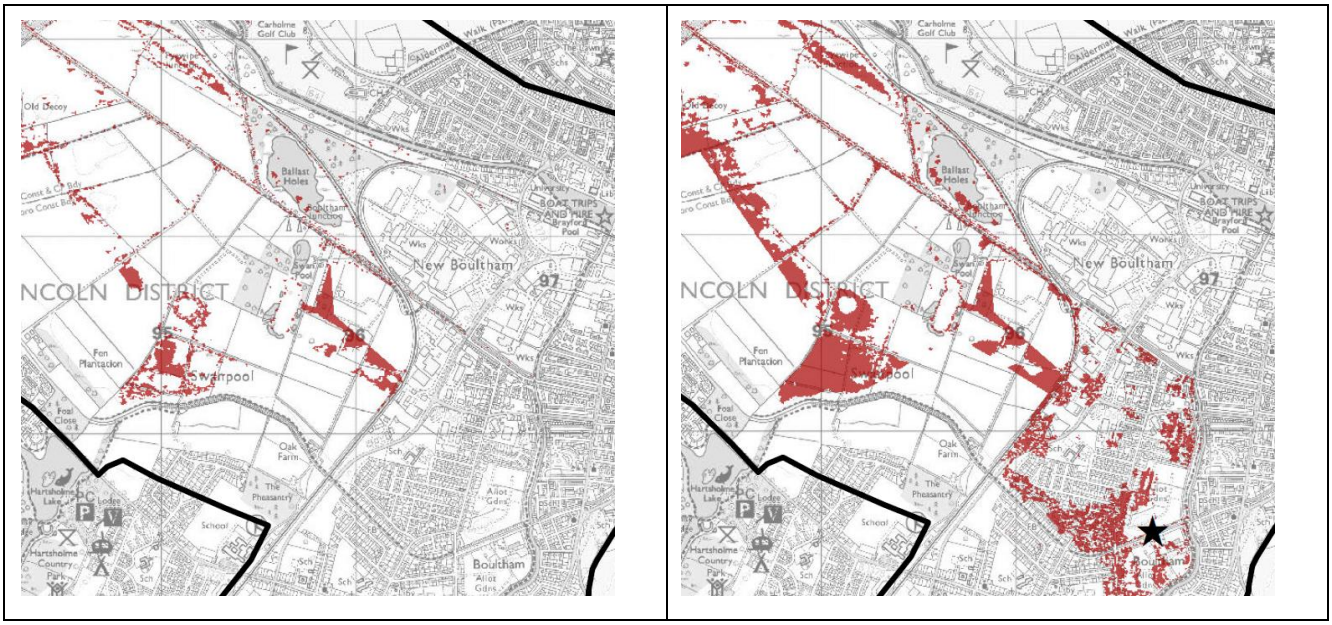


FIGURE 20 RESULTS FROM PRELIMINARY E2 TESTING USING INFINITELY HIGH BANKS ALONG BOTH NORTH AND SOUTH SIDE OF THE MAIN DRAIN. RED COLOURATION SHOWS WHERE FLOOD HAZARD CATEGORY HAS INCREASED. LEFT IMAGE IS FROM FOSSDYKE BREACH, SHOWING NO INCREASE OF FLOOD HAZARD. RIGHT IMAGE IS FROM WITHAM BREACH WHICH SHOWS (AS EXPECTED) FLOOD WATER BEING TRAPPED BY THE INFINITELY HIGH WALLS.

Summary of results for Option E2 with infinitely high banks on both north and south side of the Main:

- No increase of flood hazard rating with a Fossdyke breach.
- Widespread increase of flood hazard rating with a Witham breach, as expected, as flood water is trapped in the Witham area by the infinitely high flood banks.
- A long section of the Main Drain flood results (Figure 21) reveals only a modest increase of water level with Option E2 ground raising during a Fossdyke breach compared with the baseline – 4.65mAOD flood level with Option E2 versus 4.50mAOD for the baseline (red dotted line and purple dotted line in respectively).
- The Main Drain south bank height would need raising only in certain locations to manage an increased water level of 4.65mAOD with Option E2 during a Fossdyke breach (Figure 22 and Figure 23).
- A long section of the Main Drain flood results (Figure 21) reveals a reduced water level with Option E2 ground raising during a Witham breach compared with the baseline - 4.90mAOD flood level with Option E2 versus 5.25mAOD flood level for the baseline (blue dotted line and green dotted line in respectively). This is because flood water is trapped in the Witham area by the infinitely high flood banks, and cannot enter the Main Drain, unlike with the baseline.

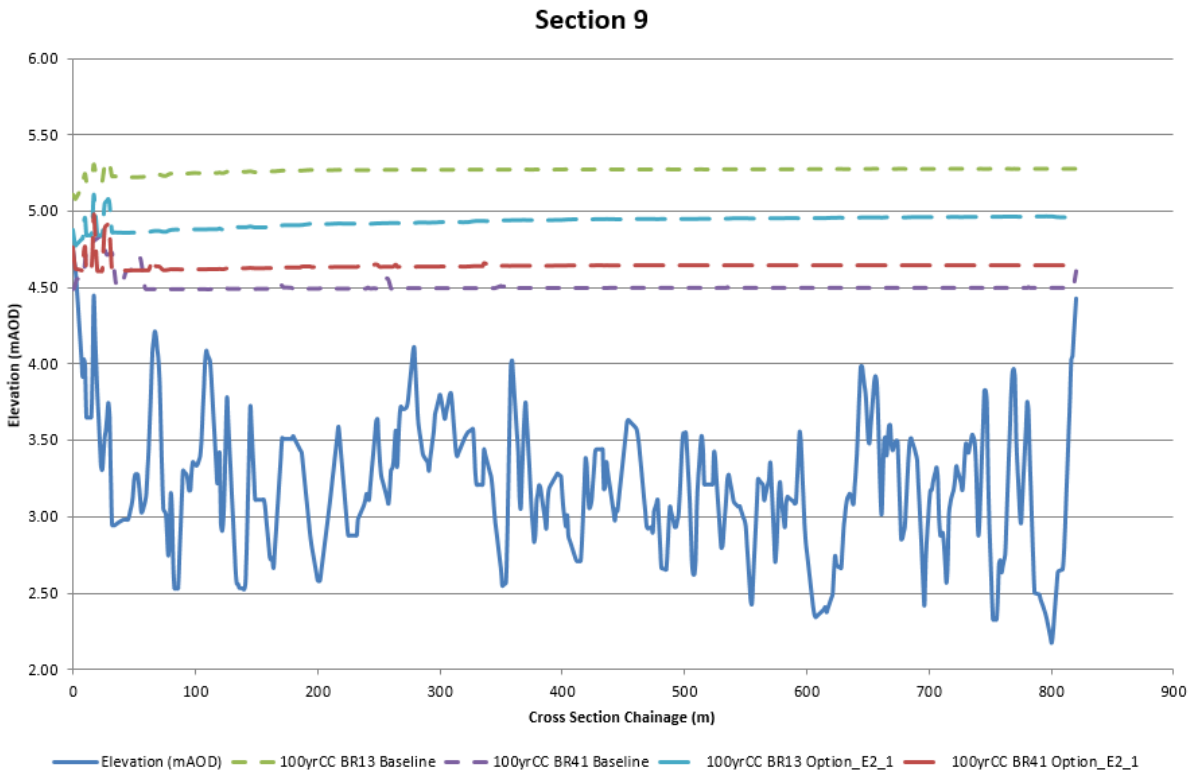


FIGURE 21 LONG SECTION FLOOD RESULTS. THE RED DOTTED LINE SHOWS THE CONTAINED FOSSDYKE BREACH LEVEL TO BE 4.65MAOD. THE SOLID BLUE LINE DEFINES THE SUBMERGED BED LEVEL.

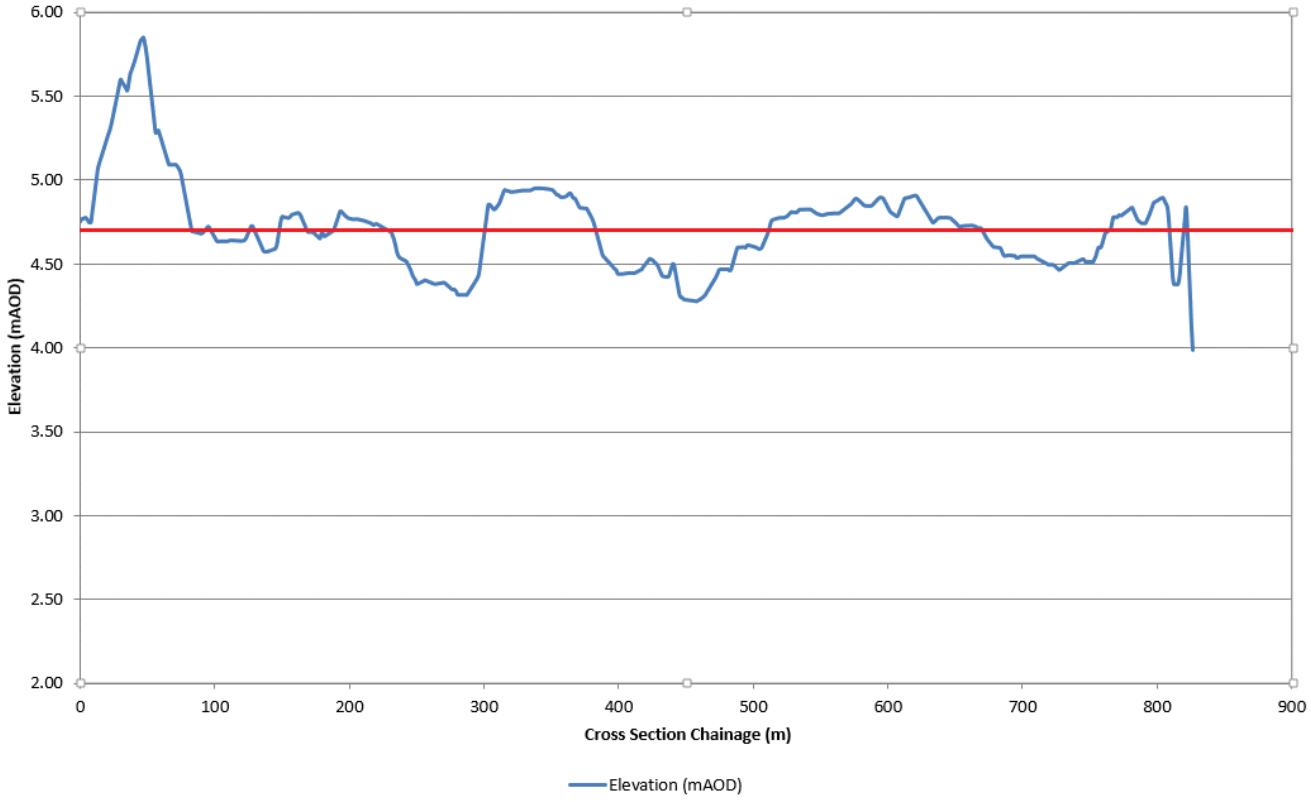
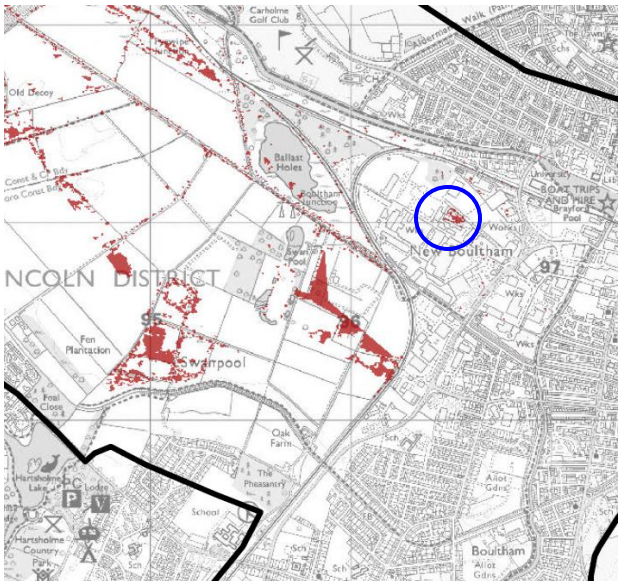


FIGURE 22 LONG SECTION OF THE MAIN DRAIN SOUTH BANK LEVELS (BLUE) COMPARED WITH AN EXPECTED REQUIRED BANK HEIGHT OF 4.70MAOD (RED).

FIGURE 23 LIDAR GROUND LEVEL DATA HIGHLIGHTING REGIONS OF THE MAIN DRAIN THAT WOULD REQUIRE THE BANK INCREASING TO AN EXPECTED LEVEL OF 4.70M AOD.

3.2 Option E2 – Just south bank level set to 4.7mAOD



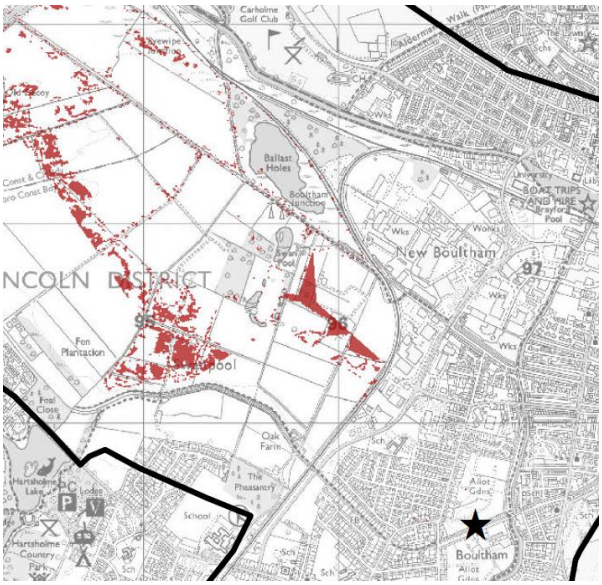


FIGURE 24 RESULTS FROM OPTION E2 WITH THE SOUTH BANK OF THE MAIN DRAIN SET TO 4.7MAOD. THE BLUE CIRCLE SHOWS A SMALL REGION OF HAZARD CLASS INCREASE AT JOSEPH BANKS LABORATORIES.

Summary of results for Option E2 with south bank of Main Drain set to 4.7mAOD:

- No increase of flood hazard rating with a Witham breach.
- No increase of flood hazard rating in the existing residential areas with a Fossdyke breach.
- A small area of increased flood hazard rating at Joseph Banks Laboratories did however occur with a Fossdyke breach. The affected area is mainly located on the grassed area just to the north of the buildings (Figure 25), in a local low spot (Figure 26). Comparing the baseline results with those of Option E2 (Figure 27), shows pixels of flood hazard increase that were wet in the 'baseline' have typically experienced an increased water depth of 0.1m as a result of ground raising. This is increasing flood hazard from approx. 0.6 to approx. 1.15. It can also be seen that, in this area, some pixels of flood hazard increase were in fact dry in the 'baseline' and have become wet due to a slight increase of flood extent. These are the pixels at the perimeter of the wet area. For these, the depth of water has jumped from zero up to approx. 0.03m as a result of the ground raising. This is increasing flood hazard from 0 to approx. 0.5.

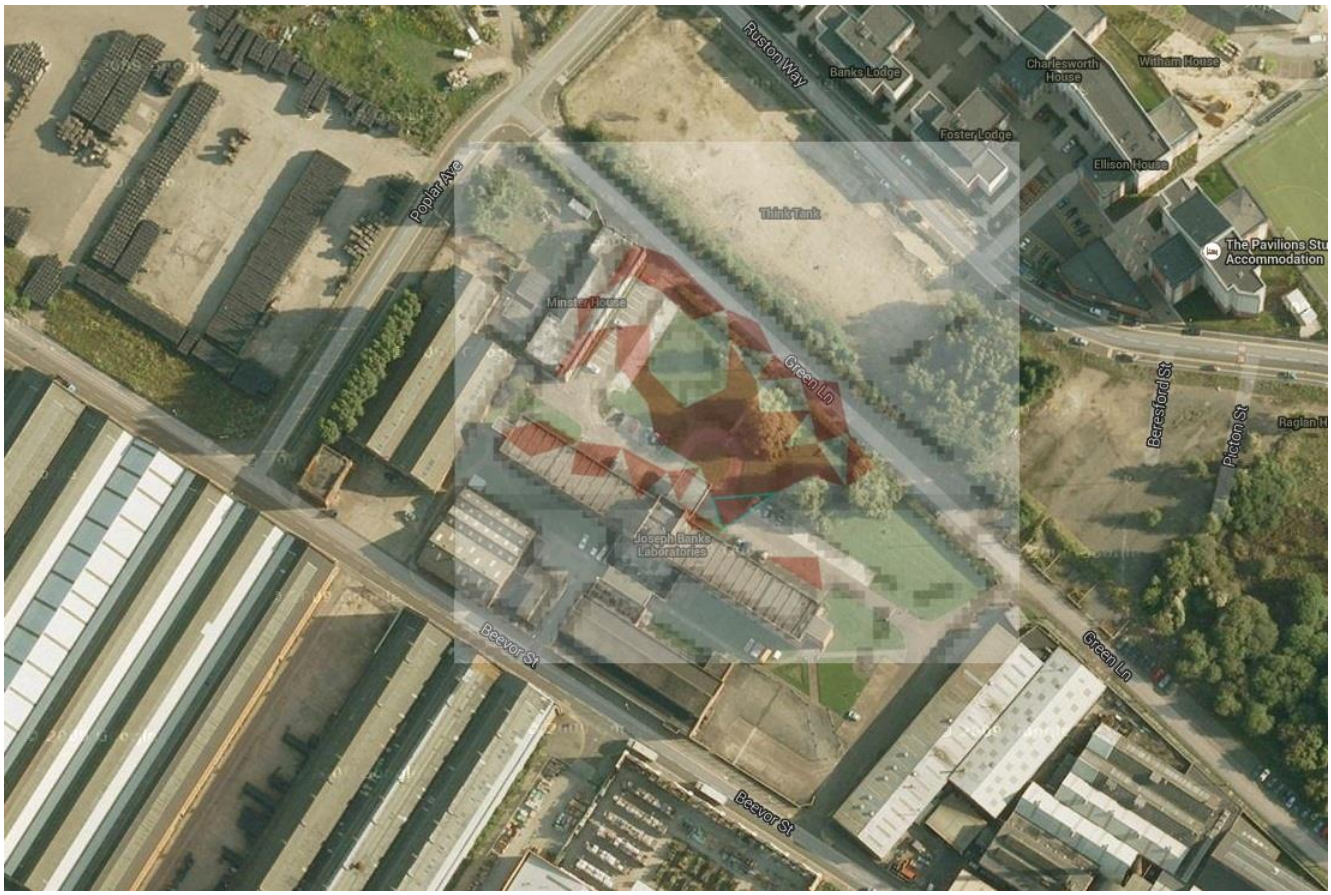


FIGURE 25 MAGNIFIED OVERLAY IMAGE INDICATING THE LOCATION OF FLOOD HAZARD INCREASE. N.B. GIVEN THE UNCERTAINTIES OF MODELLING THIS IS INDICATIVE ONLY.

FIGURE 26 LIDAR DATA SHOWING A LOCAL LOW SPOT AT JOSEPH BANKS LABORATORIES

		Baseline				With Land Raised			
Location	GIS Object ID	Depth	Water Level	Velocity	Hazard	Depth	Water Level	Velocity	Hazard
1	41667	0.18	3.89	0.01	0.59	0.28	3.99	0.01	1.14
2	31086	0.24	3.89	0.03	0.62	0.35	3.99	0.04	1.18
3	29467	0.19	3.89	0.01	0.60	0.30	3.99	0.01	1.15
4	37998	0.00	0.00	0.00	0.00	0.01	3.99	0.00	0.51
5	34731	0.00	0.00	0.00	0.00	0.04	3.99	0.00	0.52
6	5463	0.19	3.89	0.01	0.60	0.30	3.99	0.01	1.15

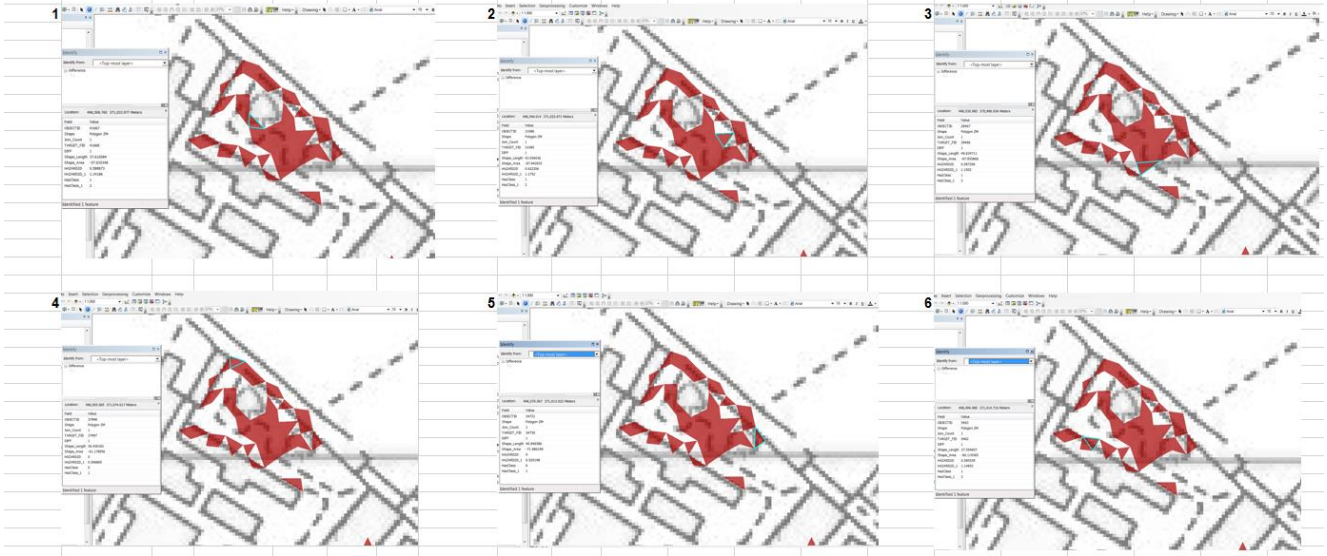


FIGURE 27 MODELLED BREACH RESULTS AT 6 SPECIFIC CELL LOCATIONS AT JOSEPH BANKS LABORATORIES

3.3 Option E2 – Both north and south bank levels set to 4.7mAOD

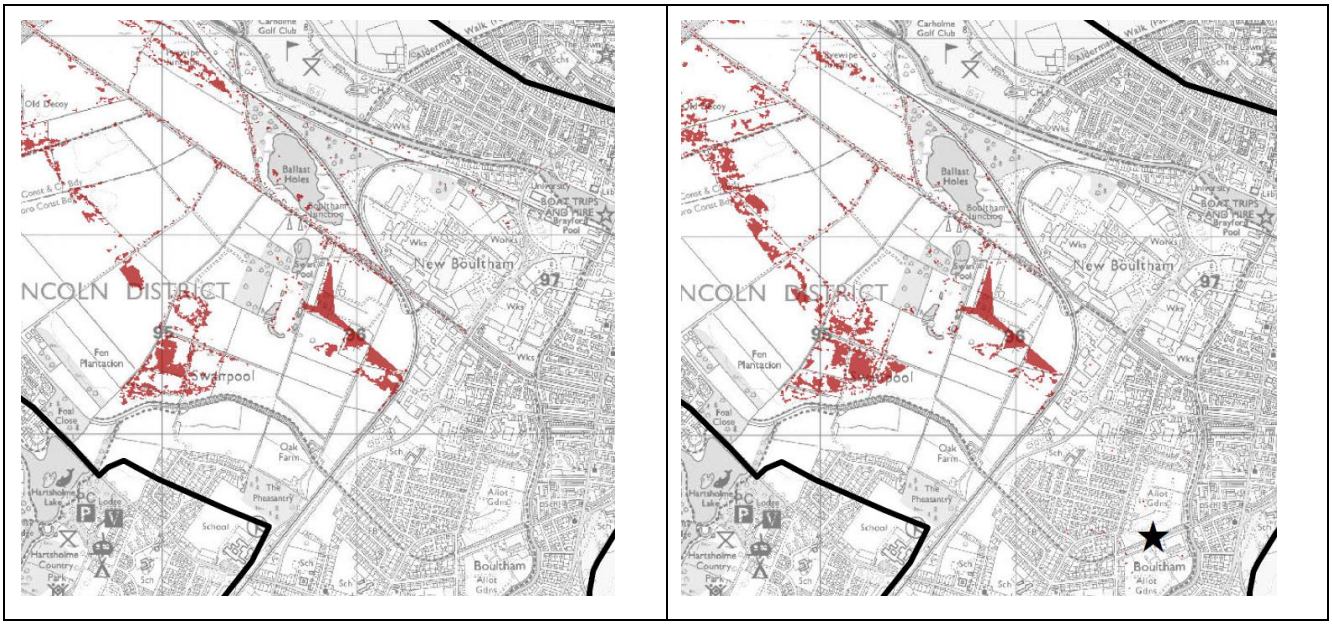


FIGURE 28 RESULTS FROM PRELIMINARY E2.

Summary of results for Option E2 with both north and south bank of Main Drain set to 4.7mAOD:

- No increase of flood hazard rating with either a Fossdyke or Witham breach.

4.0 Conclusion and recommendations arising from the breach modelling work

The four partner authorities of the Central Lincolnshire Joint Planning Committee have identified the need for sustainable growth in Central Lincolnshire with a significant proportion within the Lincoln area. An assessment of flood risk and risk management options is needed to understand the contribution that the Sustainable Urban Extension site referred to as the Western Growth Corridor (WGC) could bring. A report was published in May 2013 (Appendix A) by the WGC Technical Working Group to provide supporting evidence to Central Lincolnshire Joint Planning Unit to assist with determining, in principle, the safe sustainable quantum of development. Since then, financial viability constraints have been revealed that change assumptions made within the original report, which has prompted this update work.

This update work has indicated the extent of land raising (which is an increase on previous work) that can be achieved without significantly impacting on third parties, when considering breaches in either the Fossdyke or Witham, which is deemed to be the primary flood risk. It should be noted that the criterion used to make judgements is based on there being an increase of hazard class. Where no increase of hazard class has occurred, there might still have been an increase of hazard, just not so significant as to increase the class.

The importance of maintaining the eastern breach flow route onto the site has been confirmed again, however the mechanism has been investigated in more detail here in order to optimise the extent of development at the east side. As previously though, if the eastern flow route is entirely closed, by extending land beyond both of the east flow route strands, then New Boultham will experience an increase of flood hazard category during a breach on the Witham.

This update work shows that ground raising to extent E (similar in scope to that defined in the May 2013 work, which is the area considered necessary for viable development) is feasible when flood defence improvements are applied to the south bank of the Main Drain, to mitigate the effects of the change. No increase of flood hazard class occurs throughout the existing residential areas of Lincoln with a breach of either the Witham or Fossdyke flood defences. The change does introduce a localised area of increased hazard, but this is considered acceptable as it is confined to an open space area within the commercial zone. The required change to the Main Drain flood defence would be limited to 3 areas, increasing the bank height by a maximum of 0.5m and typically 0.25m.

The results and conclusions were discussed by the WGC Technical Working Group with technical representation from Taylor-Wimpey. In the absence of cost-benefit analysis, an initial view was taken regarding the expected viability based on the available information.

- *A significant ground raising extent (and hence 'more vulnerable' development extent) of approximately 104ha is feasible at the WGC, if mitigation is provided by increasing the Main Drain south bank height and keeping an open flow route at the east side.*

This 'in principle' conclusion has been reached after considering just breaches in either the Fossdyke or Witham, which is deemed to be the primary flood risk. There remains however a significant amount of assessment work needed to determine impacts to / from the Upper Witham Internal Drainage Board systems and surface water, for example the WGC entirely depends on pumps evacuating

surface water because the Witham and Fossdyke are high level carriers, with water levels higher than the ground level all year round.

Any further mitigation works which may involve for example attenuation storage ponds has the potential to interfere with water levels in the local drainage systems and may reduce the flood storage capacity of the WGC in the event of a main river breach. In any case, the complexity of the drainage system in this area and the potential impact on urban as well as rural areas will need careful consideration.

The Technical Group therefore again recommend to the JPC that the determining authorities should require a developer to provide:

- *A Detailed Flood Risk Assessment and Water Level Management Plan to accompany any planning proposal at the Western Growth Corridor in line with the brief given in Section 5.1 of this report.*

There are a number of physical works that both the Environment Agency and Upper Witham Internal Drainage Board would wish to see put in place to provide greater flood resilience to the site and wider area. This is needed to meet the Exception Test as required by the National Planning Policy Framework.

The Technical Group therefore further recommend to the JPC that the determining authorities should require a developer to provide:

- *Additional physical works as part of any development at the Western Growth Corridor to provide greater flood resilience to the site and the wider area, in line with the brief given in Section 5.2 of this report.*

It should be noted that the Upper Witham Internal Drainage Board cannot recommend any development in the floodplain, in principle, and its objection to the development as a whole will be sustained on that principle alone. It will be up to the developer and the planning authority to determine if development is required on floodplain.

5.0 Further work

A Detailed Flood Risk Assessment (DFRA) with Surface Water Drainage Strategy will be required to accompany a planning application for the site. The Technical Working Group recommends that a Water Level Management Plan (WLMP) should form part of the Flood Risk Assessment, detailing exactly how water levels in the channels and groundwater behaves in the existing condition and how this will be managed both during and post- development. A brief for the Detailed Flood Risk Assessment, Surface Water Drainage Strategy and Water Level Management Plan is given below in Section 5.1 (updated from the report of May 2013). The brief provides a starting point, based on the information currently available. It is expected that as the detailed assessment progresses the brief will evolve. It is therefore important that the developer consults regularly with the Technical Working Group as the work progresses.

In addition to providing a DFRA with WLMP, the Exception Test will need to be passed as prescribed by the National Planning Policy Framework:

'It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared.'

To assist with the Exception Test, the Technical Working Group has provided a list of flood resilience measures that a developer should address to increase resilience to the development and provide flood risk mitigation to the wider community (Section 5.2, reproduced from the report of May 2013). It is expected that the need for the further flood resilience measures will be clearly demonstrated in the DFRA and WLMP.

5.1 The Brief for DFRA and WLMP

5.1.1 General requirements for DFRA and WLMP

The Detailed Flood Risk Assessment and Water Level Management Plan should be progressed in consultation with the Technical Working and in accordance with the National Planning Policy Framework, considering all potential flood sources including:

- Environment Agency watercourses (including the River Till etc.).
- Environment Agency flood banks (including the River Till etc.).
- UWIDB watercourses.
- UWIDB flood banks.
- UWIDB pumping stations and catchments.
- Third party flood banks.
- Riparian water courses.
- Hartsholme Lake.
- The River Trent (where appropriate and in consultation with the Environment Agency who are finalising the outputs from an updated River Trent model).
- Surface water, groundwater and ordinary watercourses.

- Regular consultation with the Technical Working Group.
- A flood warning and evacuation plan to mitigate residual risk to the non-residential zone, as this will not be set on the raised development platform.

5.1.2 Flood risk model improvements

- Consult with the Environment Agency, who are just finalising a review of the Upper Witham model.
- Consult UWIDB. Review the HECRAS model results for the pumped system and compare with the boundary conditions used in the main river breach model. Revise the breach model as necessary.
- Any proposed changes to Decoy and Fen Lane pumping station will need to be demonstrated within the model.
- Show the impact of increased flows through the site if sewage from the site is treated at Skellingthorpe sewage treatment works.
- Consider the effect of WGC development on other Lincoln watercourses. This may best be done as a separate exercise by utilising UWIDB's 1D HECRAS model.
- The work of Technical Working Group has shown that it is critical to maintain the eastern flow route on to the WGC site to prevent increased flood hazard to Boultham. Once the masterplan has been produced, this point should be proven by including the commercial buildings and highway / railway crossing into the breach model. It is expected that commercial buildings will be represented as 300mm raised stubs with increased Manning's n.
- Determine the optimum use for Junction Sluice on the UWIDB Main Drain in the post development scenario.
- Establish the number of properties affected by an increase of flood hazard class for each scenario run.

5.1.3 Sensitivity testing

Additional breach modelling work is required to:

- Test the effect of the latest climate change estimates. The standard test for climate change is based on estimates from 2002 as per PPS25. More recent estimations have been made (2009). Although the later estimates have not yet been adopted as a standard, sensitivity testing should be undertaken to record the effect. Climate Change should be applied to the fluvial flows and sea level as boundary condition.
- Test the effect of having all UWIDB pumps off.

- Test summer/winter UWIDB water levels. The IDB raises the water level to 3mAOD west of the Junction Sluice during the summer months to satisfy abstraction demand for irrigation. Winter levels are 2.7mAOD.
- Test the effect of removing the 'tunnel' below the Fossdyke Navigation at Pyewipe Pumping Station. There is a legacy connection that allows water to pass freely between the north and south sides of the Fossdyke. This asset is no longer needed by UWIDB, however it may provide an important flow route that contributes to the mitigation of the ground raising scheme. In which case its future ownership and maintenance will need to be considered.
- Demonstrate the effect on normal UWIDB operating regimes (summer and winter) and main river breach scenario of all flood resilience measures proposed as part of the development.
- Show that no houses are affected by an increase of flood hazard class.

The development does not necessarily have to be designed for the worst result under sensitivity testing. It is for the planning authority to decide what level of risk is acceptable and what level of risk requires mitigation.

5.1.4 Establish the 1 in 20 annual probability functional floodplain

The model has been re-run by the Environment Agency without breaches to establish the functional floodplain. There should be no development in this zone.

Likewise, review the UWIDB functional floodplain outline as defined by the model of the pumped system to also ensure no development in this zone.

A 9m easement will also apply to all watercourses.

5.1.5 Additional breach analysis

It is understood that there is a raised bank protecting land to the south of Boultham Catchwater, at the eastern side of the WGC (near Westwood Drive). This risk will need to be determined and managed. It may be appropriate to raise a strip of land along this bank.

The breach risk from Hartsholme Lake should be considered and the appropriateness of the breach flow corridor demonstrated. The existing Hartsholme Lake inundation maps are based on an extremely conservative hydrological analysis. It would be prudent to carry out further dam-break analysis using realistic parameters.

5.1.6 Review of flood defences

Assess the flood defences on the south side of the Coulson Road Main Drain from the railway line to the River Witham and demonstrate the viability of the mitigation works.

Produce a comprehensive map detailing ownership / responsibility / level of protection of all flood risk assets protecting the site, including any additional relevant information (for example, the railway line along the Fossdyke right bank is subject to the Great Northern Railway Act 1848 which stipulates the standard of protection to be provided).

Assess the level of the development platform relative to flood levels in the Environment Agency gravity drainage systems particularly with regard to available funding to maintain and improve the required flood defences.

5.1.7 Free movement of fish/eels

Consider fish and eel regulations on any proposed mitigation / resilience works.

5.1.8 Surface water drainage strategy

Understand surface water overland flow routes to and from the development with particular attention given to the interaction of flow routes with watercourses and the Hartsholme Lake system.

It is expected that all the surface water from the developed area will discharge into UWIDB's higher level pumped system, i.e. Skellingthorpe Pumped Drain or Boultham Pumped Drain.

It is expected that the design catchment divide between UWIDB's Pyewipe system and Boultham/Coulson Road system will be restored. Currently local farmers have recut watercourses to take advantage of the lower pumped levels in the Decoy system.

It is expected that a sustainable, gravity driven, solution to surface water drainage will be sought, to comply with the NPPF, reflect good SuDS principles and minimise the use of UWIDB pumping. Therefore prevention, source control and site control should significantly feature on the raised platform in the drainage strategy.

Assess the impact of the proposed raised platform (material and construction) on the ability of the ground to effectively infiltrate rainwater.

It is expected that attenuation storage will also be required. It is acceptable to locate a proportion of this off the raised platform, in for example widened drainage ditches. Flood water must not compromise the site's ability to drain (particularly given the Coulson Road pumping station will stop pumping when the River Witham is high), therefore demonstrate safe drainage from the site for 1:1 year, 1:30 year and 1:100 year plus climate change storms, utilising the UWIDB flood model outputs as downstream boundary condition. Surface water outflow should be restricted to the IDB pumped discharge rate, which is nominally 1.4l/s/ha for this area.

The drainage strategy should be tested under both summer and winter IDB water levels.

There are at least 2 drains that cross land south of the catchwater (near Westwood Drive and Oak Farm Hall). This drainage route should be maintained.

A Water Level Management Plan should demonstrate how drainage operates across the site in combination with the surrounding watercourses and how drainage will be maintained during the development phase and within the proposed new development.

Complete a full review the existing drainage infrastructure, particularly the pumping stations and establish the required upgrades to provide a suitable level of service and resilience for the drainage of the proposed development.

5.2 Brief for further flood resilience measures

There are a number of physical works that both the Environment Agency and UWIDB would wish to see put in place to provide greater flood resilience to the site and wider area. These are required due to the increased impact of flooding in the post development scenario.

1 Works connected with Coulson Road Pumping Station

1.1 The pumping station has two pumps (each with capacity 0.67cumecs) but was constructed with capacity for a third to deal with any future development in the catchment. A third pump of 0.67cumecs capacity will need to be installed as part of this development.

1.2 With increased development upstream, the pumping station will be more prone to blockage from debris. An automated weedscreen cleaner would be required to deal with this risk to reduce flood risk to the site and the wider area.

1.3 There is a redundant culvert under the River Witham at Coulson Road, which allowed the Main Drain to discharge direct to Great Gowts Drain on the right bank of the Witham. This was blocked some time ago, however its use may provide a more sustainable gravity discharge at lower flows. The DFRA should consider re-opening / replacing this culvert and installing automated penstocks at either end to close the culvert during higher flows and thus divert water to the pumping station. Works would be required to Great Gowts Drain to receive the culvert. This should provide a more sustainable means of draining the site and would also have benefits to the wider area. Increased base flows in Great Gowts Drain would provide improvements in water quality downstream, especially during the summer and for lower reaches where Canwick sewer treatment works discharges.

1.4 Consider whether the existing culvert under Coulson Road is large enough and upgrade if required.

2 Works connected with Pyewipe Pumping Station

2.1 Vehicular access to Pyewipe pumping station will be required through the site and over the railway line. Current access is via the bank top of the Fossdyke Canal though this cannot be guaranteed and would not be possible in the event of a breach. Alternative vehicular access through the site would provide greater resilience, reducing risk to the site and wider area.

2.2 With increased development upstream the pumping station will be more prone to blockage from debris. An automated weedscreen cleaner would be required to deal with this risk, reducing the flood risk to the site and wider area.

3 Floodplain Compartmentalisation

3.1 There are a number of siphons / culverts across or adjacent to the WGC site that currently allow the spread of floodwater onto or from the site. These flow routes should be closed off through the installation of penstocks to compartmentalise the floodplain, resulting in increased flood resilience to the site and the wider area. This includes:

- The culvert under Coulson Road from the Main Drain to the pumping station.
- The culvert under the Fossdyke Canal connecting Pyewipe pumping station with the UWIDB system to the north of the canal.
- The culvert under Burton Catchwater Drain immediately upstream of the Pyewipe culvert.

- The culvert under Boultham Catchwater outfall.
- The culvert under Pike Drain outfall.
- The culvert from the university to Coulson Road.

3.2 Water levels in the main rivers around the site are relatively flat. A failure in any of the raised defences would lead to significant volumes of water entering the floodplain. A series of pointing doors will be required at each open outfall to prevent backflow and significantly reduce the volume of water that can flow though potential breaches on certain main rivers. Pointing doors are required at the outfalls of the following watercourses:

- Boultham Catchwater Drain to the River Witham.
- Burton Catchwater Drain to the Fossdyke Canal.

3.3 It will need to be shown that the proposed compartmentalisation has no impact on flood risk elsewhere as part of the DFRA and WLMP.

4 Other Resilience Measures

4.1 The embankments of the Boultham Catchwater should be incorporated into any development platform, such that they are no longer simple raised embankments but are part of a wider development platform and maintained as part of the development, e.g. as public open spaces, whilst maintaining 9m byelaw distance for access.

4.2 Include a controlled overspill from the Boultham Catchwater as part of the Hartsholme reservoir overflow arrangement. This will reduce the likelihood of a breach in other (downstream) reaches of the watercourse thus reducing risk to the site and the wider area. It would also reduce / remove the required maintenance expenditure provided by the Environment Agency, saving money for use in the wider area.

4.3 Installation of telemetry on key watercourses to assist with flood monitoring and warning.

4.4 Installation of a screen on the outlet from Hartsholme Lake to reduce the risk of blockage of the overflow culvert which is the most likely trigger for a breach of the reservoir embankment.

4.5 Taking ownership of and maintaining land to the north of Skellinghthorpe Road, where the downstream face of Hartsholme Lake dam is located, would enable effective surveillance for the early signs of dam failure and provide easy access for repair.

5 Cost recovery for any additional pumping including sewage discharge.

Appendix A – Report from May 2013

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