Bristol City Council

River Avon Tidal De Facto Flood Defences Investigation

Visual Walkover Structural Assessment

REP/042/16

Rev1 | 03 May 2016

Job number 248369-00

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Document Verification

ARUP

Job title	River Avon Tidal De Facto Flood Defences Investigation	**Job number**	248369-00
Document title	Visual Walkover Structural Assessment	**File reference**	
Document ref	REP/042/16		

Revision	**Date**	**Filename**			
Draft 1	21 Mar 2016	**Description**	Final draft for Client comment.		
			Prepared by	Checked by	Approved by
		Name	Gwion Parri	Tracey Williamson	Richard Brown
		Signature			
Issue	24 Mar 2016	**Filename**	AvonDeFactoDefencesReport_Issue.docx		
		Description	Issue		
			Prepared by	Checked by	Approved by
		Name	Gwion Parri	John Philip	Richard Brown
		Signature			
Rev 1	03 May 2016	**Filename**	AvonDeFactoDefencesReport_Rev1.docx		
		Description	Re issued following comments from client		
			Prepared by	Checked by	Approved by
		Name	Gwion Parri	John Philip	Richard Brown
		Signature			

Issue Document Verification with Document ✓

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CAFRA Workstream 3 Report

1 Introduction

1.1 Background

The flood event with the potential for most severe damage to Bristol’s city centre is tidal. Low spots along the river banks are potential flood pathways for water to inundate properties, disrupt infrastructure and cause the Floating Harbour to inundate other parts of the city centre. Although there has been no recent widespread tidal flood event, there have been many ‘near misses’ including a series of surges in January 2014 estimated as between a 1 in 5 and 1 in 10 annual chance tidal event (Hyder, 2015).

The Central Area Flood Risk Assessment (CAFRA) was a collection of technical studies commissioned by Bristol City Council (BCC) between 2010 and 2013 to investigate flood risk from tidally-influenced watercourses within Bristol. BCC and the Environment Agency have agreed that Workstream 3 model is an appropriate representation of flood risk in Bristol at catchment level. Hyder compared predicted and observed flood levels found a good confidence in predicted in-channel levels (within ±0.1m) and concluded:

‘The model is considered to be generally capable of matching the in-channel gauged levels, however it does not match observed flood extents well where existing walls and buildings form de-facto defences and restrict flood flow on the floodplain.’

1.2 Scope

Ove Arup and Partners Ltd (Arup) were commissioned by BCC in January 2016 to complete a visual condition assessment of identified buildings, walls and other raised structures to estimate the likely depth of water that these can resist, based on identified assumptions and recommendations for ongoing management measures.

Structures were identified, during a walkover with BCC and the Environment Agency of predicted areas of overtopping from the River Avon to the Floating Harbour. Consideration was given to whether the structure could be considered a prospective de-facto defence based on its proximity to the defined ‘top of bank’ (see Section 1.3).

The areas covered by this report are shown in Figures 1 to 3 below.

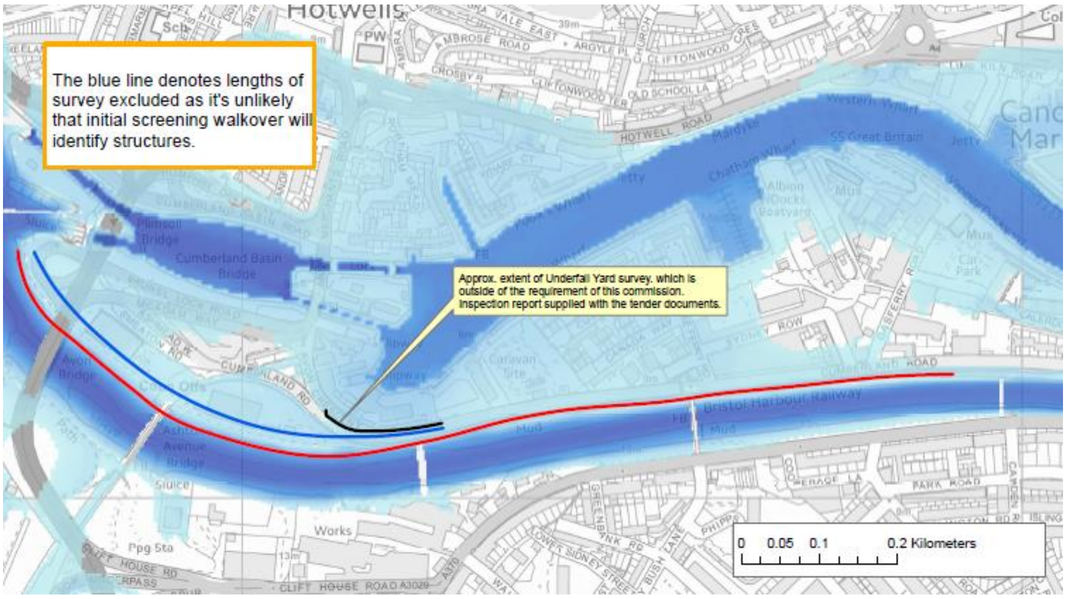


Figure 1 - Approx. survey requirement along Cumberland Road shown in red (Section 3)

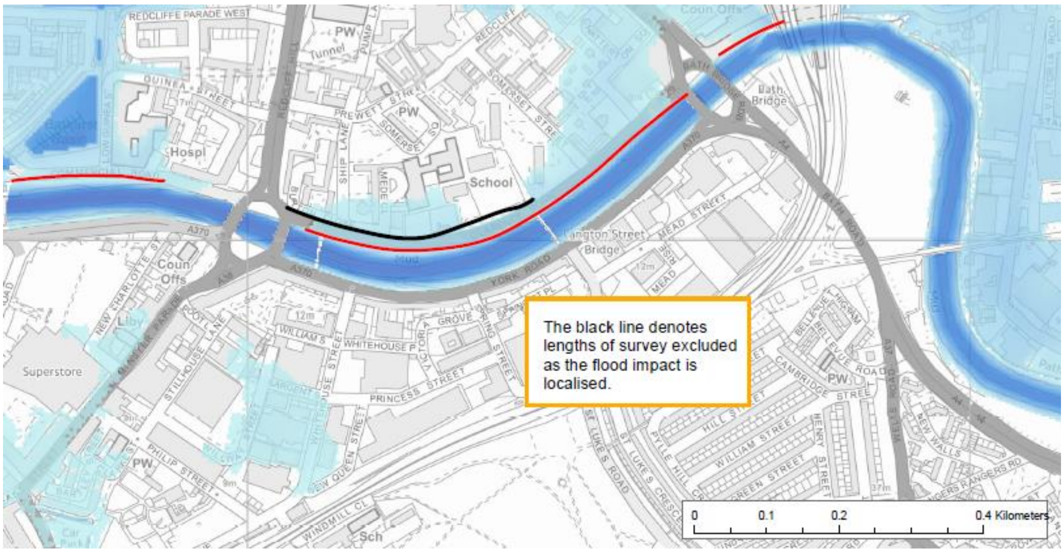


Figure 2 - Approx. survey requirement along Clarence Road, Commercial Road and Cattle Market Road shown in red (Section 4)

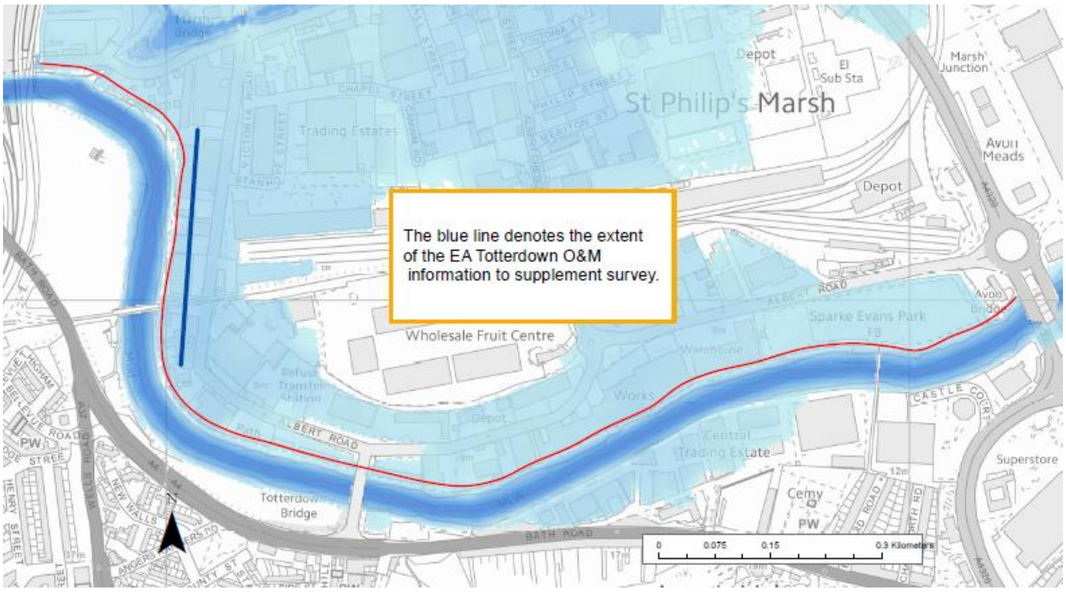


Figure 3 - Approx. survey requirement in St Philip's shown in red (Section 5)

The estimates of the likely depth of water that the walls can withstand before collapsing is based on a visual inspection of the outside only, i.e. the water side of the walls. No buildings were entered, this has resulted in some conservative assumptions being made in their analysis and it is possible that some buildings can resist water substantially deeper than the levels presented in this report. No intrusive investigation was carried out.

The conclusions of this report are estimates of the likely depth of water that the walls can resist in March 2016. Where practically possible to do so, comments have been included on how long the walls are likely to continue to be able to act as defacto defences.

Based on the estimates of the allowable depth of water, the current Standard of Protection (SoP) provided by each wall was estimated based on the CAFRA Workstream 3 report.

1.3 Legislative Background

A flood defence is a structure that alters the natural flow of water or flood water for the purpose of flood risk management. A defence may be 'formal' or 'defacto. A 'formal' flood defence is a structure that is maintained by its respective owner for flood risk management purposes. A 'defacto' flood defence is a structure not built and/or maintained for the primarily purpose of flood defence but which limits the spread of flooding as a secondary or indirect purpose, for example a boundary wall.

BCC and the Environment Agency are investigating the betterment from defacto flood defences in Bristol. If the defacto defences are shown to be of value, further investigation will be carried out into how any such structures could be brought within the necessary control of a suitable risk management authority.

The Environment Agency has no statutory responsibility to maintain flood defences. This remains the responsibility of the riparian land owner. However they retain 'permissive powers' which they use to monitor and maintain their formal flood defences.

The Environment Agency also supervises and works with other organisations to manage the risk of flooding and coastal erosion in England. Development on or near main rivers, and works affecting watercourses, flood and sea defences and other structures are protected by its byelaws through Schedule 25 Section 5(1) of the Water Resources Act 1991, and also Section 34 of the Land Drainage Act 1976. An Environmental Permit may be required for any proposed works or structures, in, under, over or within 8 metres of the top of the bank of a main river. As such Environmental Permitting Regulation provide a permitting system for changes to structures within 8m from top of bank, including defacto defences.

Section 30 and Schedule 1 of the Flood and Water Management Act 2010 (FWMA) give the Environment Agency the power as a "Designating Authority" to designate assets owned by others on main rivers as flood/coastal erosion risk management assets, subject to certain conditions. The "Asset" can be either a structure or a feature of the environment (whether natural or manufactured). Once the asset has been designated, it must not be altered, removed or replaced without the consent of the Designating Authority and a Local Land Charge on the property freehold title is recorded. The designation of the asset does not create an obligation on its owner to actively maintain and repair it. Designation does not prevent subsequent changes or removal of structure, only that property owner needs to apply for consent (assumed as free). This is nationally untested for main river risk management structures and duplicate many of the provisions of the Environment Agency byelaws.

The Environment Agency have advised they would not wish to consider defacto defence structures beyond the extent of the control of their existing byelaws. The Environment Agency defined the top of bank during a site walkover on 27th January 2016, see below. Our scope therefore excludes consideration of structures more than 8m from top of bank.

2 Methodology

2.1 Comparing flood levels with ground levels

The predicted flood levels in a 1 in 200 annual chance event in 2010, 2060 and 2110 were reviewed compared to the existing ground levels.

Flood levels were based on 2012 CAFRA reporting, and interpolated along the river bank where necessary.

2.2 Initial Site Meeting

This was held on 27th January 2016 and attended by:

- Melvin Wood of the Environment Agency
- Matthew Sugden and Robin Campbell of BCC
- Jason Drummond of AECOM
- Gwion Parri of Arup

At this meeting, Melvin Wood advised where the point that the Environment Agency considered to be the top of the riverbank in each location. It was also collectively agreed which walls / buildings had potential value as a defacto flood defences and would be included in this survey. Both of these are shown in detail in Sections 3-5.

2.3 Visual Inspection

All walls identified as being of potential value as defacto defences during the site visit were visually inspected by Gwion Parri CEng MICE and John Philip CEng MICE MCIWEM of Arup on the afternoon of January 27th and on February 18th, 2016. Visible parts of the walls were photographed and measured, and a general assessment made of their condition. Visible signs of ground movement were also recorded, but no research of historical land slippages, etc. was carried out.

Condition grade deterioration curves offer a standardised approach to assess and quantify the deterioration of flood defence assets. Condition grades are based on the Condition Assessment Manual, CAM, (Environment Agency 2006) definitions of condition grades per asset type as shown below.

Condition Grade	Description of condition	Extent of defects
1	Very good	Cosmetic defects that will have no effect on performance.
2	Good	Minor defects that will not reduce overall performance of asset.
3	Fair	Defects that could reduce performance of asset.
4	Poor	Defects that would significantly reduce performance of asset.
5	Very poor	Severe defects resulting in complete performance failure.

2.4 Analysis

The walls were analysed for compliance with the relevant BS design codes, BS5628 for masonry and BS8002 for stability. Possible methods of failure were:

- the wall snapping, applying a safety factor of 1.4 to the loads and 3.0 to the materials
- the whole wall overturning, normally a safety factor of 2.0 is considered acceptable in this case
- the whole wall sliding, normally a safety factor of 1.5 is considered acceptable in this case.

Due to the short length of the walls and hence low pressure they applied on the ground, ground failure was not likely to be a failure mechanism and so was not considered in the analysis.

Due to the geometry of the channel in a flood event and the depths of water involved immediately adjacent to the walls, it is very unlikely that a wall will be struck by floating debris that is large, heavy and moving fast enough to damage it. Therefore impact loading on the walls has not been considered in the analysis.

All walls were analysed assuming that gaps within them for gates, etc. were blocked up in a flood using sandbags or other temporary barriers.

The analysis is heavily influenced by factors that cannot be determined from a site walkover, most significantly the geometry of the wall's foundation and the properties of the soil. Because of this, each wall has been analysed twice based on a different set of assumptions:

- Worst realistic case: conservative assumptions are made for all unknown parameters, based on industry standards (where they exist) and experience of analysing walls of this type. The conclusions from this analysis can be relied on immediately.
- Most likely case: all unknown parameters are assumed to be 'typical' for walls of this type and age, based on experience of analysing similar walls. The conclusions from this analysis should not be relied on without carrying out further intrusive investigation to confirm the validity or otherwise of these assumptions.

The intention is that the difference in the likely allowable depth of water between the two cases is used to inform a decision on whether or not intrusive investigations of the walls should be carried out.

The foundation geometry and other assumed parameters are described in detail in each section.

Due to the geometry of the river in the area and that most walls have considerable freeboard, wave action is unlikely to be an issue and has not been considered. Observations by BCC personnel during past surge tides in St Philips confirmed that even sections of the river that were exposed to the wind did not have significant waves.

Although the walls are not formal flood defence assets, they have been given a condition grade in accordance with EA guidance report SC060078/R1, noting their potential to function as a flood defence structure.

The current Standard of Protection (SoP) provided by each wall was estimated based on the results for 2010 from the CAFRA Workstream 3 report, included in Appendix B for reference. This estimated the water levels during 1 in 20, 1 in 75, 1 in 100, 1 in 200, 1 in 500 and 1 in 1000 flood events. The locations used were:

- Entrance Lock Confluence for Cumberland Road
- Mylnes Culvert / Malago Old Course for Commercial Road
- DS Netham for St Philips Marsh

Each wall was assigned a SoP based on the highest return period where the allowable water level exceeded the predicted level e.g. for the wall in section 3.2.1 the allowable water level is 9.3m. This exceeds the level of the 1 in 200 event (9.25) but not the in 500 event (9.39) and so the estimated SoP for this wall is 1 in 200. The SoP's assigned do not account for leaking through cracks, joints, etc. and so should be used with caution for walls of condition grade 3 or 4.

3 Cumberland Road

The lengths of wall considered to be potential defacto flood defences are shown below.

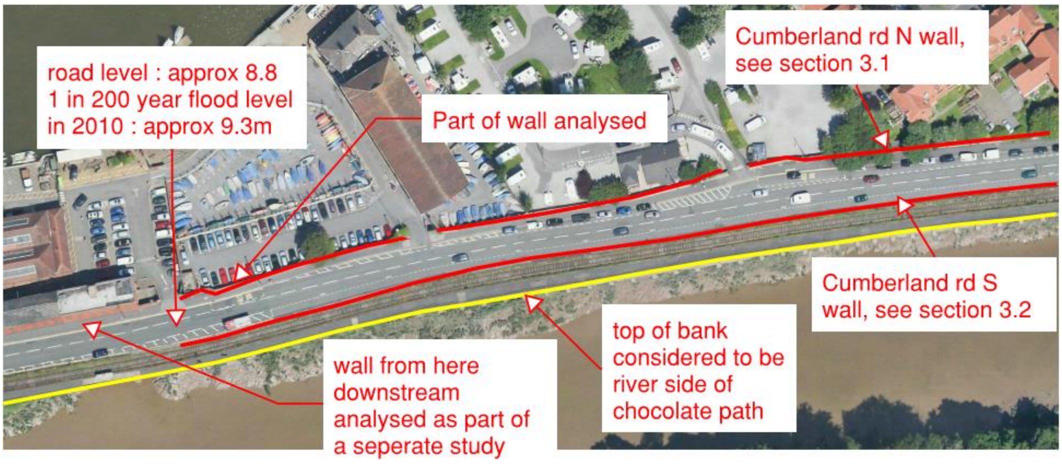


Figure 4 - West section of Cumberland Road, aerial image © Blom 2012

Walls to the (west) downstream are excluded from the scope. They include:

- North – Underfall Yard boundary walls were the subject of a visual structural assessment as part of the CAFRA Harbour Study by Mott MacDonald.
- South – Construction works as part of Metrobus as ongoing and the former masonry highway retaining wall is currently being replaced and raised with a formal reinforced masonry flood defence wall, owned and maintained by BCC.

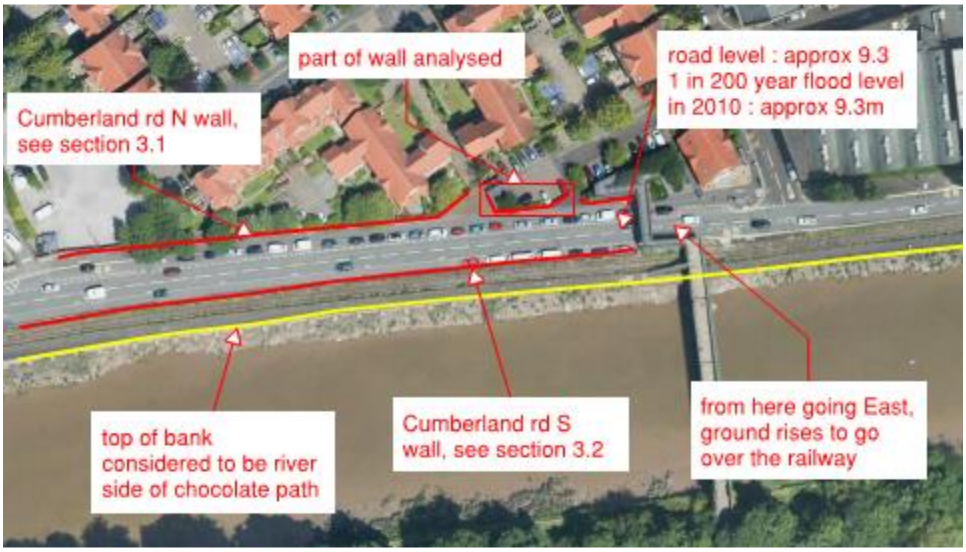


Figure 5 – East section of Cumberland Road, aerial image © Blom 2012

3.1 Cumberland Road North Wall

3.1.1 General Description

Material	Clay bricks / random stone masonry
Min height	Approx. 1.88m
Max height	Approx. 3m
Min thickness	215mm
Max thickness	Approx. 450mm

Most of the wall is a combination of random stone masonry and clay bricks. The wall is not continuous and has 4 gaps in it, these can be seen on figures 4 and 5 above. There are several places where former doors have been in-filled and a few where vegetation is growing on the wall. There are some signs of cracking and movement in the wall. While none of these suggest the wall is likely to collapse in the near future, there is a possibility that during a flood a small amount of water could seep through. It was also noted that particularly at the west end, there were numerous potholes in the adjacent road that could indicate soft ground in the area.

Figure 6 - Photo of the wall taken between the entrance to Underhill Yard and Cottage Inn car parks

Heading east towards Vauxhall Bridge, the wall becomes a clay brick wall. This wall has several cracks in it that could allow water to pass through in a flood. It is also narrower and shorter than the random stone masonry walls.

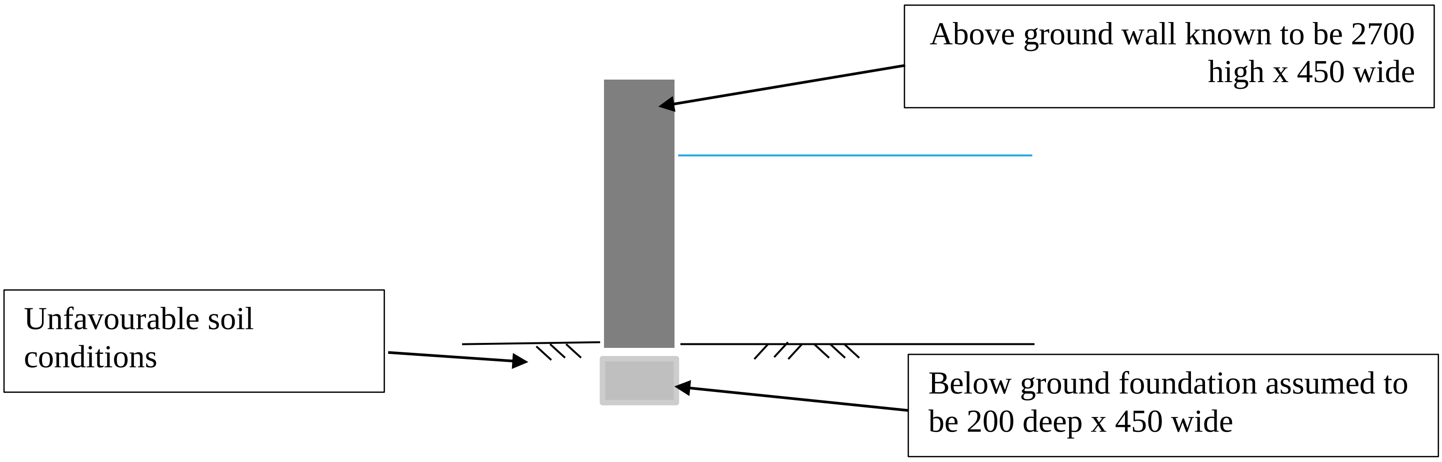
Figure 7 - Photo of the clay brick wall close to Vauxhall Bridge

In terms of height of water above ground needed to put the wall at risk of collapse, the weak link is likely to be the clay brick wall in the east. However the ground at the base of the wall rises going east, from around 8.8m to around 9.2m. This makes is possible that the first part of the wall to collapse during a flood will be the stone wall in the west. Both walls have been analysed, see below.

Because of the cracks, condition of the wall is considered to be condition grade 4.

3.1.2 Worst Realistic Case

For the stone wall, the worst realistic case is assumed to be:

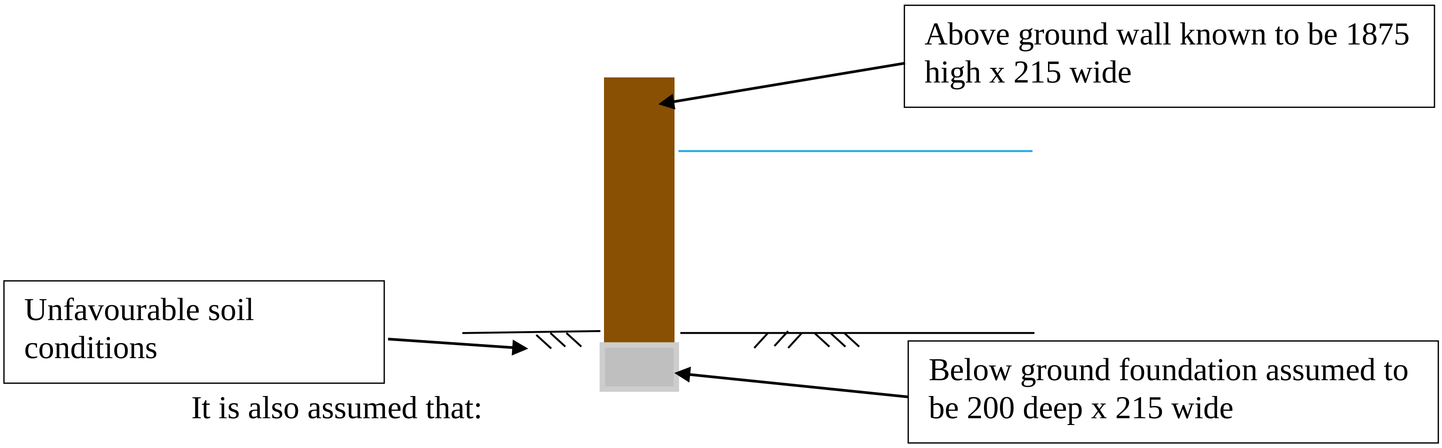


It is also assumed that:

- Stones were not selected based on strength and the weakest type of mortar was used, so fkx = 0.1 N/mm^2.
- Density of the stones is 16 kN/m^3
- Passive pressure from the soil on the landside is included i.e. there will be no excavation during a flood

In this situation, it can be expected that the wall will remain stable up to a water height of around 0.85m, or 9.65m AOD. Above this point the wall is at risk of failure by sliding. This would lead to rapid inundation of the Floating Harbour.

For the clay brick wall, the worst realistic case is assumed to be:



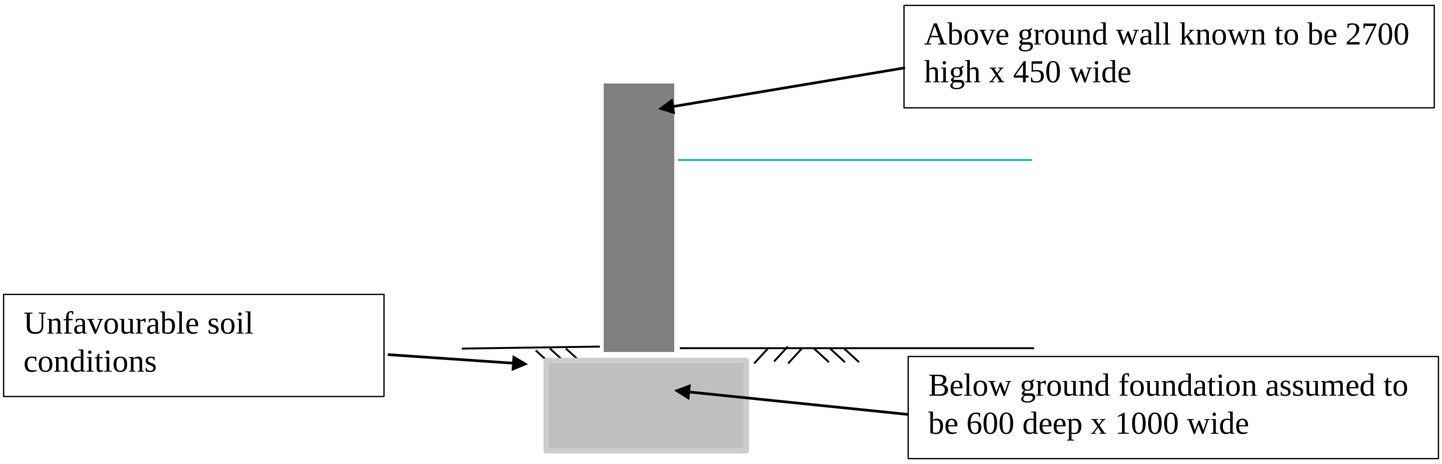
It is also assumed that:

- Mortar is M2, and the bricks have a water absorption > 12% i.e. the wall has been constructed with the weakest type of materials commonly used
- Density of the bricks is 20 kN/m^3 i.e. lighter than average
- Passive pressure from the soil on the landside is included i.e. there will be no excavation during a flood

In this situation, it can be expected that this wall will remain stable up to a water height of around 0.45m, or 9.65m AOD. Above this height the wall is at risk of overturning, this would again lead to rapid inundation of the Floating Harbour.

3.1.3 Most Likely Case

From experience of analysing freestanding random stone masonry walls, a mid-range estimate of the foundation dimensions is:

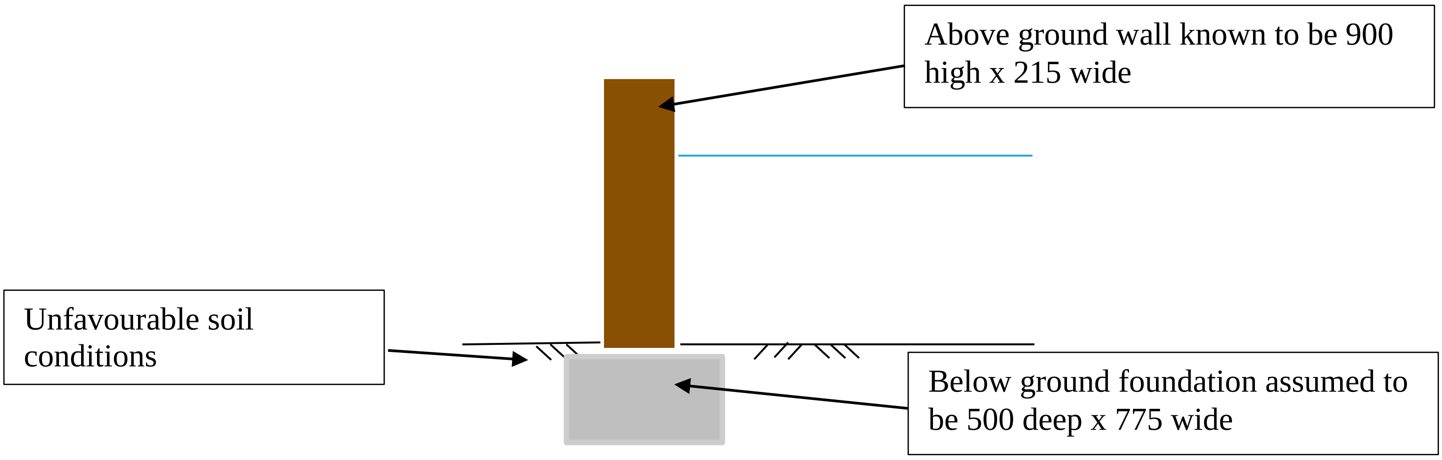


It is also assumed that:

- Stem failure will not be critical
- Density of the stones is 20 kN/m^3
- Passive pressure from the soil on the landside is included i.e. there will be no excavation during a flood

In this situation the wall can be expected to remain stable up to a water height of 1.05m, or 9.85m AOD, with sliding again the most likely mode of failure.

For the brick wall, it is likely that the foundations are constructed to be in accordance with a rule of thumb, such as those from BRE Good Building guide 14 (1994). This document gives rules of thumb for constructing freestanding masonry walls similar to this one. The most likely case is assumed to be:



It is also assumed that:

- Stem failure will not be critical
- Density of the bricks is 22 kN/m^3
- Passive pressure from the soil on the landside is included i.e. there will be no excavation during a flood

In this situation the wall can be expected to remain stable up to a height of 0.65m, or 9.85m AOD. Above this height failure by sliding and overturning are both possible.

3.1.4 Conclusions and Recommendations

In any flood, there is a realistic possibility of a small amount of water passing through the cracks in the walls. The likely water level that the wall can resist before being at risk of collapse is approximately:

Wall	**Condition Grade**	Worst realistic case			Most likely case			**Comments**
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 3.1.1	4	0.85 stone, 0.45 brick	9.65	1 in 1000	1.05 stone, 0.65 brick	9.85	1 in 1000	Not a continuous structure

Table 2.3 of the EA guidance report SC060078/R1 suggests that for a masonry wall in a coastal environment, the expected time for deterioration to progress from CG4 to CG5 is 10-20 years. This wall is not subject to the same forces from waves, etc. as some walls in a coastal environment would be, but is showing signs of movement and it is possible that movement is continuing at a slow rate. It is not possible to say with confidence that the wall can continue to act as a defacto defence for more than 5-10 years.

If the wall is to be relied on to act as a defacto flood defence asset, it would be advisable to inspect it annually.

3.2 Cumberland Road South Wall

3.2.1 General Description

Material	random stone masonry
Min height	Approx. 0.9m
Max height	Approx. 1m
Min thickness	Approx. 100mm locally
Max thickness	Approx. 450mm

The wall is adjacent to ongoing construction works as part of Metrobus to replace and raise the former masonry retaining wall with a reinforced masonry formal flood defence wall. Because of the road / construction site on one side of the wall and the railway on the other, safe access to this wall was not available. All measurements and comments are estimates based on observations from 5-10m away.

The main function of this wall appears to be to act as a retaining wall, the road on the land side is around 0.9m higher than the railway on the river side. Some parts of the wall appear very thin for this type of wall (see immediately to the left of the herras fencing below) and it is likely that these panels span horizontally between the panels adjacent to them.

Figure 8 - Photo of the wall from the Chocolate path on the riverside

The top of the wall extends above the road level by 150-250mm.

Best estimate as to the condition of the wall is condition grade 3.

3.2.2 Analysis

There are 2 ways that loading from flood water could adversely affect the wall:

- The flood water could push the wall into the soil behind it. By inspection the resultant force pushing the wall inland in a flood will not exceed the resultant force pushing the wall towards the river in its current state, and so this is not considered an issue.
- The flood water could knock the coping stone onto the road. However, the width of the coping stone is more than twice its height and the forces involved here make this unlikely.

It is therefore likely that this wall would not be damaged by flood water overtopping.

3.2.3 Conclusions and Recommendations

In a flood, the possibility of a small amount of water seeping through cracks in the coping cannot be ruled out.

Wall	**Condition Grade**	Worst realistic case			Most likely case			**Comments**
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 3.2.1	3	0.15m above road	9.3	1 in 200	0.15m above road	9.3	1 in 200	Can resist water up to the top

Table 2.3 of the EA guidance report SC060078/R1 suggests that for a masonry wall in a coastal environment, the expected time for deterioration to progress from CG3 to CG5 is 30-60 years. However, if the wall is to be relied on to act as a defacto flood defence asset, it would be advisable to inspect it annually at the same time as the Cumberland Road North walls are inspected.

It should also be noted that the wall is currently functioning as a highway structure, and is likely to be subject to regular inspections from BCC Highways. If this is the case it would be advisable to co-ordinate these inspections.

4 Clarence Road, Commercial Road and Cattle Market Road

The only length of wall in this area considered to be a potential defacto defence is located adjacent to Commercial Road.

4.1 Commercial Road

4.1.1 Location

The length of wall considered to be potential defacto flood defences is shown below.

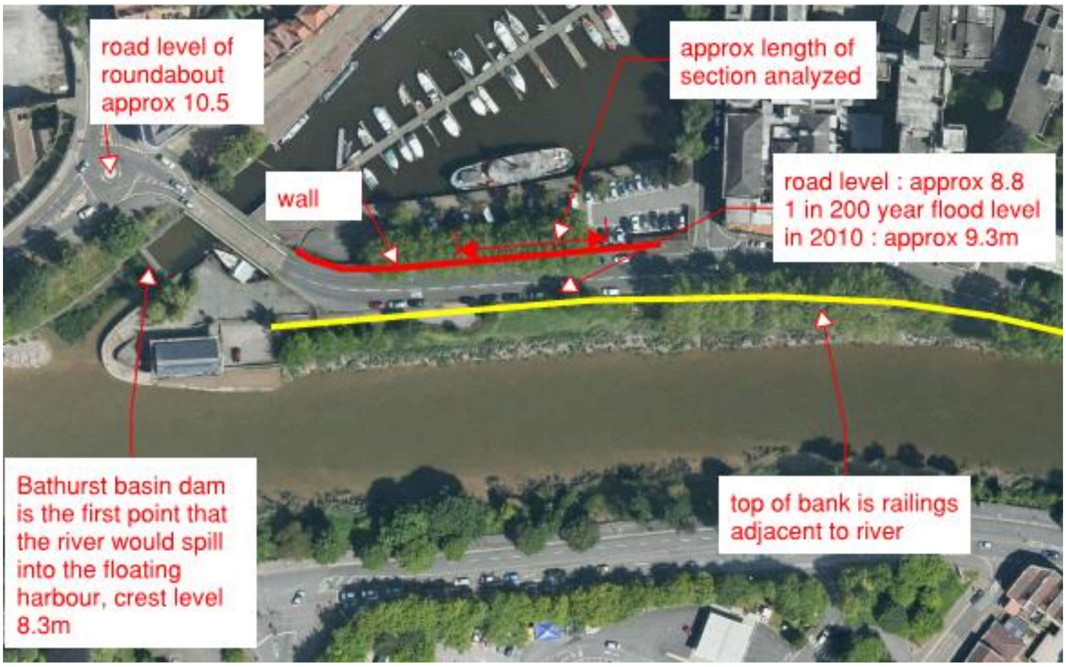


Figure 9 – Location of wall along Commercial Road, aerial image © Blom 2012

4.1.2 General Description

Material	Clay bricks
Min height	Approx. 0.9m
Max height	Approx. 2.4m
Min thickness	215mm
Max thickness	440mm

Figure 10 - Photo taken near the west end of the wall, looking east. The railing on the right of the road are on the alignment of the Environment Agency’s definition of top of the bank.

The wall has several vertical or near vertical cracks, probably caused by the lack of movement joints in the masonry. The lengths of wall with no vertical cracks in them vary from approximately 6m to approximately 20m, and some of them pass all the way through the wall. These cracks are wide enough to allow a small amount of water to flow through in a flood. There is also a narrow joint that is not filled in, this joint could also allow a small amount of water to flow through in a flood.

Figure 11 – typical vertical crack in the wall

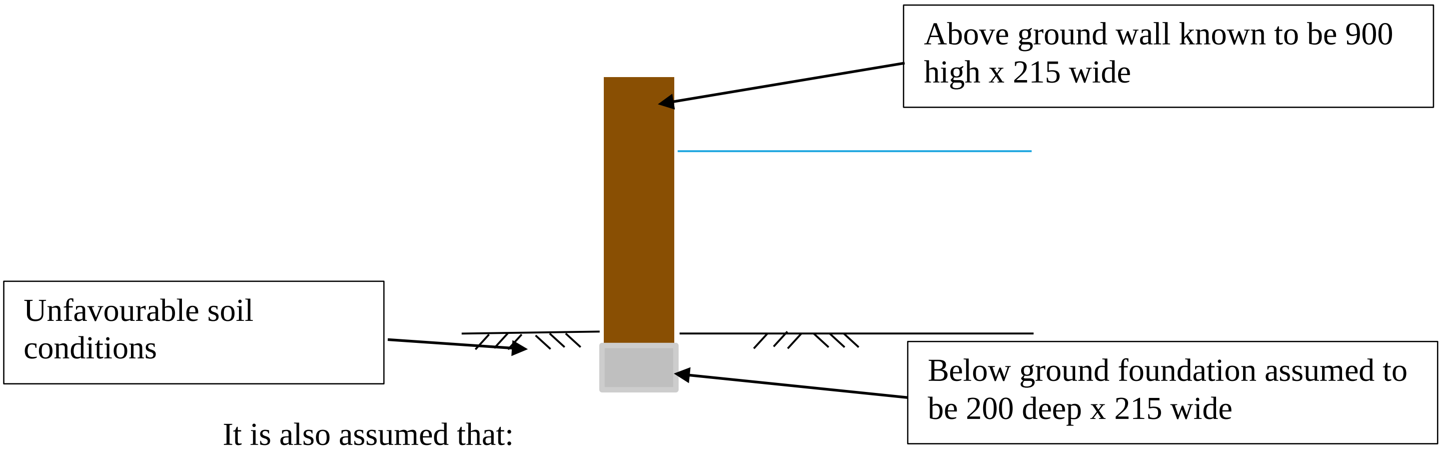
In a flood, the first section to fail is likely to be the lowest and most narrow section of the wall, where it is approximately 0.9m high x 215mm thick. This section is approximately 25m long and shown below.

Figure 12 - The lowest part of the wall is on the right of this photo, this photo also shows the only gap in the wall

Because of the cracks, condition of the wall is considered to be condition grade 4.

4.1.3 Worst Realistic Case

The worst realistic case is assumed to be:



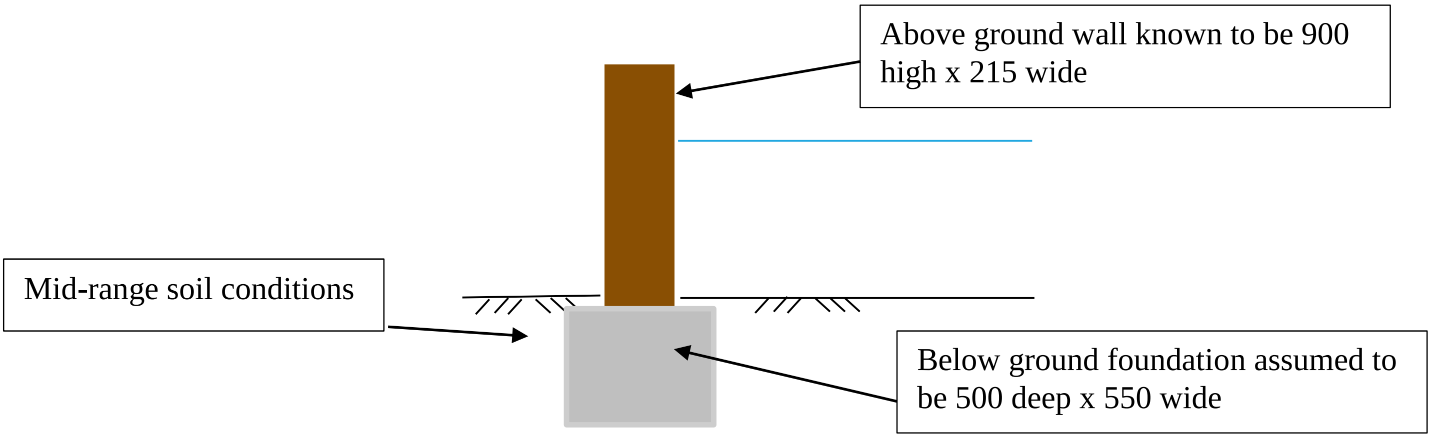
It is also assumed that:

- Mortar is M2, and the bricks have a water absorption > 12% i.e. the wall has been constructed with the weakest type of materials commonly used
- Density of the bricks is 20 kN/m^3 i.e. lighter than average
- Passive pressure from the soil on the landside is included i.e. there will be no excavation during a flood

In this situation, it can be expected that the wall will remain stable up to a water height of around 0.3m above ground level. If the water rises above this level, failure could be by the wall sliding or overturning, or the stem failing. The calculations show that none of these failure modes will happen at 0.3m, but any could happen at 0.4m. Any of these failure modes will lead to rapid inundation of the Floating Harbour.

4.1.4 Most Likely Case

It is more likely that the foundations are constructed to be in accordance with a rule of thumb, such as those from BRE Good Building guide 14 (1994). This document gives rules of thumb for constructing freestanding masonry walls similar to this one. The most likely case is assumed to be:



It is also assumed that:

- Mortar is M4, and the bricks have a water absorption <7% i.e. the wall has been constructed with the type of materials most commonly used for external walls similar to this one
- Density of the bricks is 22 kN/m3
- Passive pressure from the soil on the landside is included i.e. there will be no excavation during a flood

In this situation, it can be expected that the wall will remain stable up to a water height of around 0.45m above ground level. Again failure could be caused by sliding, overturning or stem failure. The calculations show that none of these failure modes will happen at 0.45m, but any could happen at 0.55m. Again, any of these failures will lead to rapid inundation of the Floating Harbour.

4.1.5 Conclusion and Recommendations

In any flood, a small amount of water would pass through the cracks in the wall. To prevent this, the cracks and joints should be filled with a suitable waterproof sealant.

The likely depth of water that the wall is able to withstand before being at risk of collapse is approximately:

Wall	**Condition Grade**	Worst realistic case			Most likely case			**Comments**
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 4.1.2	4	0.3	9.2	1 in 100	0.45	9.35	1 in 200	Wall has a gap

Table 2.3 of the EA guidance report SC060078/R1 suggests that for a masonry wall in a coastal environment, the expected time for deterioration to progress from CG4 to CG5 is 10-20 years. While it is possible that the wall could last considerably longer, particularly given that the wall will not be subjected to wave forces, at this stage it is not possible to say with any confidence that the wall could continue to act as defacto flood defence for more than around 10 years.

If the wall is to be relied on to act as a defacto defence, it would be advisable to inspect it annually.

It should be noted that a new bridge will soon be constructed over Bathurst Basin dam very near to this wall, and it would be advisable that any planned works in this area should be co-ordinated with the works planned for the bridge.

5 St Philips Marsh

5.1 Cattle Market Road

5.1.1 Location

The length of wall considered to be potential defacto flood defences is shown below.

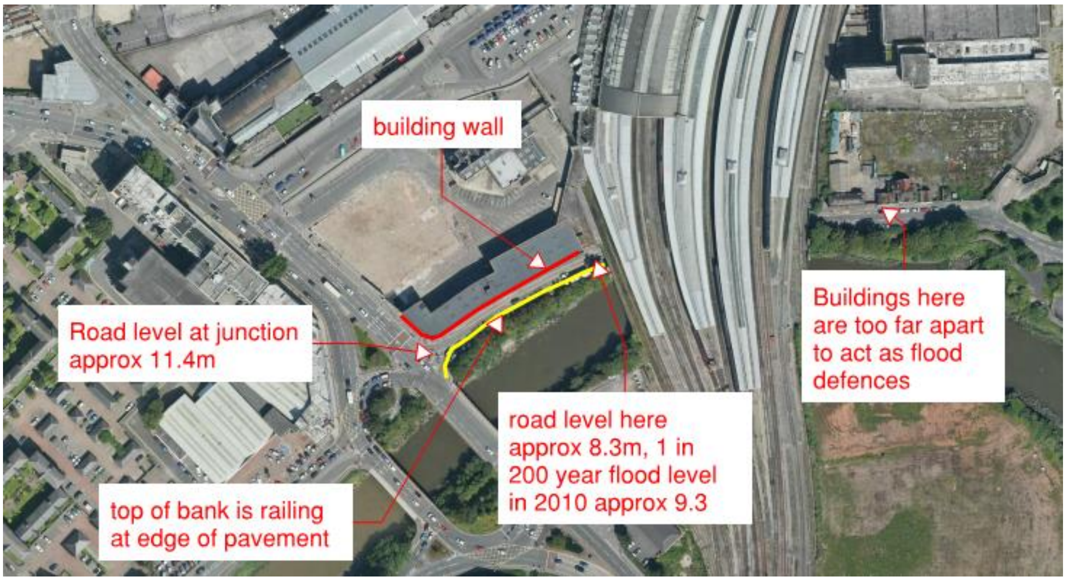


Figure 13 – Location of wall in Cattle Market Road, aerial image © Blom 2012

5.1.2 General Description

Material	Clay bricks
Min height	Approx. 12m
Max height	Approx. 12m
Min thickness	100mm
Max thickness	unknown

This is the wall of a building that is currently unoccupied. The lowest window, that would probably be a weak link in terms of flood defence, is around 2.4m above ground level. The wall is in a reasonable condition with no major defects visible. To comply with BS requirements on panel sizes it is likely that the wall is buttressed by either piers or internal walls at approx. 6m c/c, it is also likely that the wall is a cavity wall. These could not be confirmed without entering the building.

Figure 14 - Photo taken looking east along Cattle Market Road

The wall is considered to be condition grade 2.

5.1.3 Worst Realistic Case

In the worst realistic case, the building could have a basement and so the wall could be currently acting as a retaining wall supporting the road. In this case it is possible that the wall is already loaded close to its capacity, and so flood water could cause a section of wall to collapse leading to the flood water entering the building.

5.1.4 Most Likely Case

It is unlikely that a building of this type in this location would have been built with a basement. Outline calculations were carried out assuming that:

- The wall is subdivided into panels 6m wide x 4m tall by internal floors and walls
- The wall is a cavity wall constructed with 100mm engineering bricks on the outer leaf and 140mm dense concrete blocks in the inner leaf, both held in place with M4 mortar

In this situation, it can be expected that the wall will remain in place up to a water height of around 1m.

5.1.5 Conclusions and Recommendations

The level that the water can rise to before the wall in this section is at risk of collapse is approximately:

Wall	**Condition Grade**	Worst realistic case			Most likely case			**Comments**
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 5.1.2	2	minimal	8.3	Less than 1 in 20	1	9.3	1 in 100	

If the wall is to be relied on to act as a defacto flood defence, it is recommended that further investigation of the building is carried out to determine its geometry and rule out the possibility that the wall in its current state is loaded close to its capacity.

5.2 Cattle Market Road to Bristol Electric Centre

5.2.1 Location

The lengths of wall considered to be potential defacto flood defences are shown below.

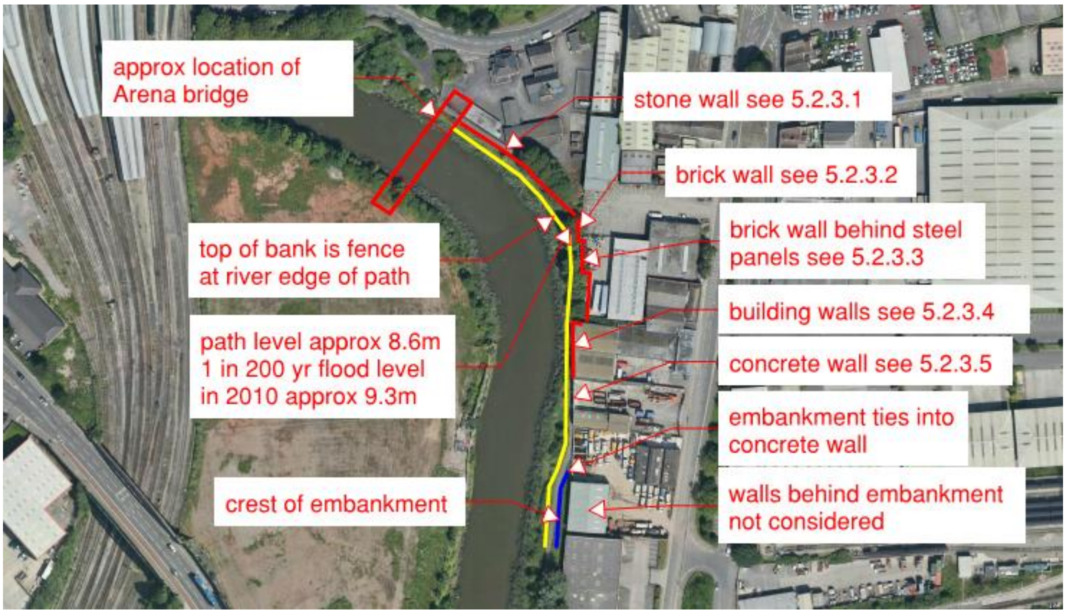


Figure 15 - Walls from Cattle Market Road to Bristol Electric Centre, aerial image © Blom 2012

5.2.2 Environment Agency Flood Defence Scheme

The area forms part of the Environment Agency's Totterdown flood defence. The elements of the scheme run for approximately 300m north (downstream) of the Victor Street railway bridge. The defences were constructed in 1984 following inundation of properties during a tidal surge in 1981, with a design flood level of 9.0mAOD (EA Totterdown Operation and Maintenance Manual, 2014). The scheme consists of:

- raised existing bank;

- raised existing walls and new defence walls;
- cut-off walls between existing boundary walls;
- waterproof rendered boundary walls;
- tidal flapped outfalls.

The scheme relies on privately-owned defacto defence walls, investigated as part of this study, and formal defences not included in this study.

The EA identified a number of failed structures (2014) summarised below;

- Low wall (Section 2 in Figure 16 and the wall in Section 5.2.3.3) is damaged.
- Low wall (Section 3 in Figure 16) inspection is prevented as access is blocked by fencing and the wall is surrounded by vegetation.
- A pathway for outflanking is present to the south of the concrete wall (Section 5 in Figure 16 and the wall in Section 5.2.3.5) as the wall does not tie into the adjacent formal flood defence embankment.
- The asphalt ramp (Section 8 in Figure 16) is below the defence design level.
- The earth embankment (Section 9 in Figure 16) is in poor condition, with erosion, brambles and exposed patches with low grass cover.
- The concrete ramp (Section 11 in Figure 16) is also lower than the flood defence design level.

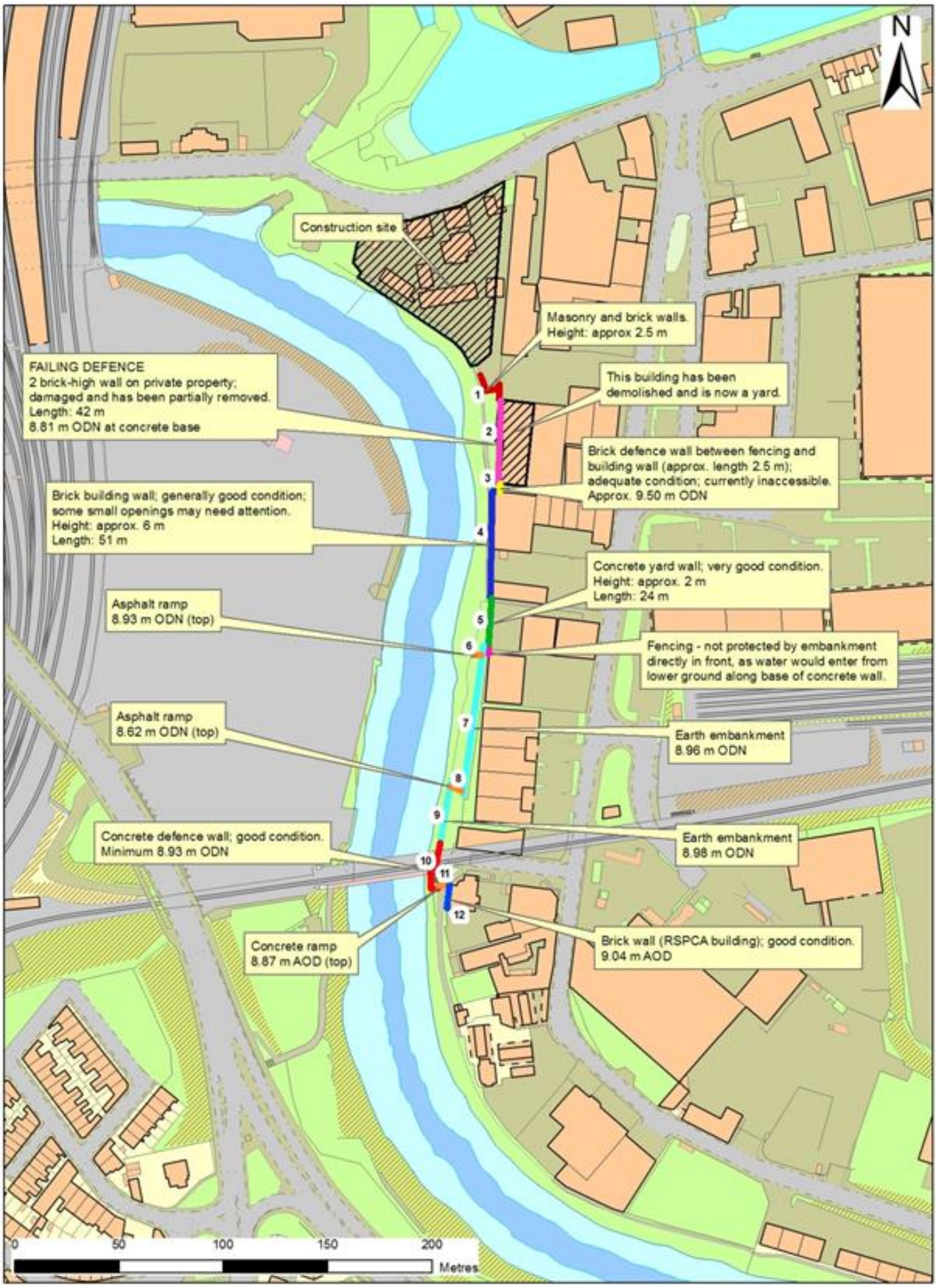


Figure 16 - Extent and condition of the current flood defences (source: EA)

5.2.3 General Description

5.2.3.1 Stone wall

Material	Random sized stone
Min height	Approx. 1.3m
Max height	Approx. 2.5m
Min thickness	Approx. 450mm
Max thickness	Approx. 450mm

Due to the construction of the Arena bridge no direct access was available to this wall and the observations are estimated from viewing from a few metres away. In some places this wall is heavily overgrown and is some others the mortar in the joints is in poor condition. Because of this, the wall is considered to be condition grade 4.

Figure 17 – Photo showing stone wall looking downstream.

5.2.3.2 Brick wall

Material	Clay bricks
Min height	1.88m
Max height	1.88m
Min thickness	215mm
Max thickness	215mm

This wall has no obvious major defects and is considered to be condition grade 2.

Figure 18 – Photo showing brick wall

5.2.3.3 Brick wall behind steel panels

Material	Clay bricks
Min height	unknown
Max height	Approx. 225mm
Min thickness	215mm
Max thickness	215mm

This wall is difficult to see due to being obscured behind steel panels and tyres. In some places the steel panels are in very poor condition, and in some places the wall is also in a poor condition with bricks having been knocked off.

Figure 19 - The brick wall can be seen immediately behind the steel panels

Figure 20 – Removed brick wall (source: EA 2014)

Due to bricks visibly falling off, the wall is considered to be condition grade 5 (failed).

5.2.3.4 Building walls

Material	Clay bricks
Min height	3.68m
Max height	6.08m
Min thickness	490mm
Max thickness	unknown

This wall is partly covered with render and also graffiti, making it very difficult to estimate its condition. There are several cracks in the render but it was impossible to determine if these are only in the render or a result of cracking in the walls. Condition grade of the wall could be considered grade 2, 3 or 4.

Figure 21 – Wall of building, looking upstream.

The wall had several service ducts and an access door observed in poor condition, presenting potential pathways for flood water.

It was also noted that the path in this area has several longitudinal cracks suggesting that the fence might be at risk of 'falling off' within the next few years, an example of such a crack can be seen on the right of the Figure above. In the long term, it is possible that the river bank could erode/slip leading to the building foundations becoming undermined.

5.2.3.5 Concrete wall

Material	Concrete
Min height	1.8m
Max height	1.8m
Min thickness	300mm
Max thickness	300mm

This wall also has a large amount of graffiti on it making it difficult to accurately assess. It appeared to be in reasonable condition so it is likely to be condition grade 2, but could possibly be grade 3 or 4.

Figure 22 - Concrete wall, the tie in to the embankment can be seen on the right

5.2.4 Analysis

It is clear that the weak link in this area in terms of flood defence is the brick wall behind the steel panels, see Section 5.2.3.3. This wall cannot be relied on to act as a defence against any level of water.

For the other walls in this area:

- The stone wall in section 5.2.3.1was analysed using similar parameters for the worst realistic and most likely cases as for the stone wall in Cumberland Road, see section 3.1
- The brick wall in section 5.2.3.2 was analysed using similar parameters for the worst realistic and most likely cases as for the brick wall in Cumberland Road, see section 3.1
- The building wall in section 5.2.3.4 was analysing as a free standing wall, using the same parameters as for the brick wall in section 5.2.3.2. Given that the worst realistic case gives a higher allowable flood level than the most likely case for the other walls, there is very little value in calculating accurately the allowable flood level in the most likely case for this wall.
- The concrete wall in section 5.2.3.5 is slightly higher, slightly thicker and built using a stronger material than the brick wall in 5.2.3.2. Therefore, it can be concluded by inspection that the allowable water level is slightly higher

All of these walls can be expected to resist the forces imposed on them by water 0.45m deep in the worst realistic case, or 0.65m deep in the most likely case.

5.2.5 Conclusions and Recommendations

The brick wall behind the steel panels described in Section 5.2.3.3 cannot be relied on to have any capacity to resist flood water. This wall should be repaired and heightened to be suitable to resist flood water.

The wall described in Section 5.2.3.4 also has a number of significant defects which further investigation and remedial work would be required.

Elsewhere, the level that the water can rise to before the remaining walls in this section are at risk of collapse are estimated as below:

Wall	Condition Grade	Worst realistic case			Most likely case			Comments
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 5.2.3.1	4	0.55	8.95	Less than 1 in 20	0.75	9.15	1 in 20	Wall has a gap
Section 5.2.3.2	2	0.45	8.85	Less than 1 in 20	0.65	9.05	1 in 20	
Section 5.2.3.3	5 (failed)	0	8.4	Less than 1 in 20	0	8.4	Less than 1 in 20	
Section 5.2.3.4	4	1.2	9.6	1 in 200	>1.2	>9.6	At least 1 in 200	Wall has door and numerous access ducts that are potential pathways for flood water
Section 5.2.3.5	Most likely 2	>0.45	>8.85	Less than 1 in 20	>0.65	>9.05	1 in 20	Condition grade could be 3-4, impossible to see due to render

With all the various walls in the area of various ages and in various states of repair, it would be impractical to attempt a prediction as to how long the walls can continue to function as defacto defences.

If the walls are to be relied on to function as defacto defences, it is recommended that all the walls in the area are inspected annually. The path on the river side of the wall should also be inspected annually.

5.3 RSPCA Bristol Dogs and Cats Home

5.3.1 Location

The length of wall considered to be of flood defence value is shown below.

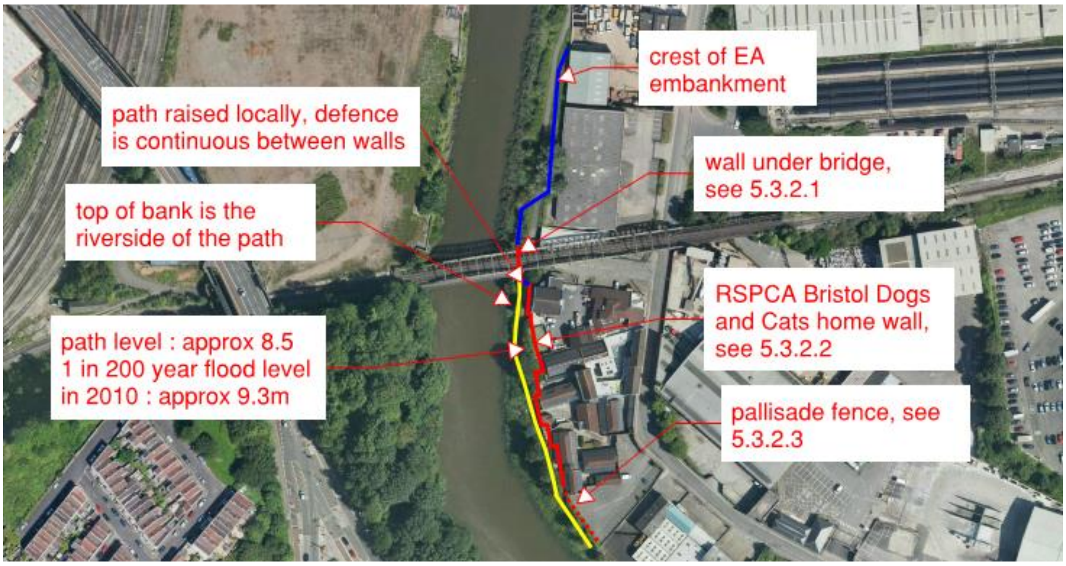


Figure 23 – Plan showing walls around RSPCA Bristol Dogs and Cats home, south of Victor Street. Aerial image © Blom 2012

5.3.2 General Description

5.3.2.1 Wall under bridge

Material	Concrete
Min height	0.8m
Max height	0.8m
Min thickness	300mm
Max thickness	300mm

This wall appears to be in good condition. The sealant between the wall and the pier also appears to be in good condition. Condition is considered to be condition grade 1.

The wall may be considered a formal flood defence (see Section 5.2.2).

5.3.2.2 RSPCA Bristol Dogs and Cats Home Wall

Material	Clay bricks
Min height	1.13m
Max height	2.7
Min thickness	215mm
Max thickness	450mm

The wall has movement joints at approx. 6m spacing that are sealed. This wall also appears to be in good condition, condition is considered to be condition grade 1.

Figure 24 - Wall of RSPCA Bristol Dogs and Cats Home, adjacent to the flood defence asphalt ramp can be seen on the left

5.3.2.3 Hedge and Palisade Fence

In terms of flood defences the hedge / palisade fence is the weak link in this area and will not act as a defacto defence. The ground here is around 0.2m higher than the ground adjacent to the walls described above.

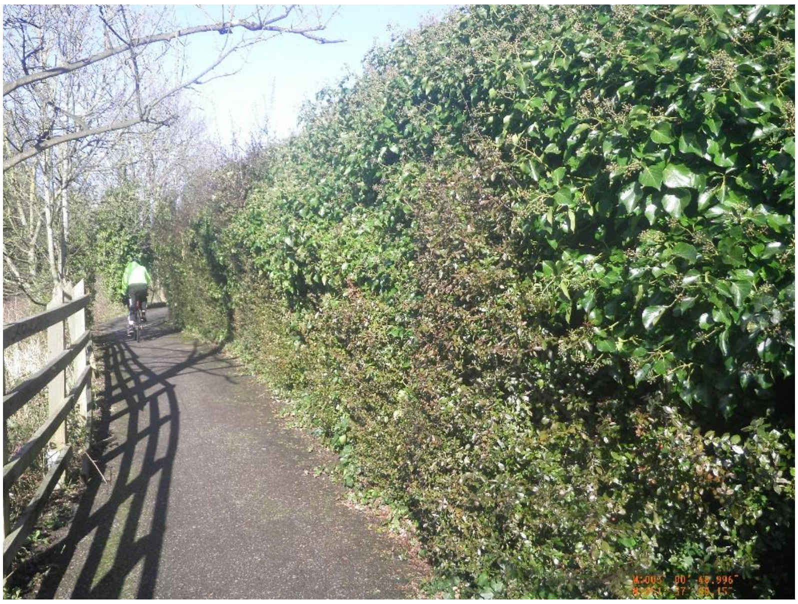


Figure 25 - Hedge and palisade fencing

5.3.3 Analysis

In a flood water would pass through the hedge/ palisade fence. This water would then flow through the car park to Albert road, and from there flood the area on the land side of the walls. It is unlikely that either wall in this section would be under pressure from water more than 0.2m deep for a significant length of time.

For the wall in 5.3.2.1, it can be concluded by inspection that stem failure will not occur, Stability was analysed using the same parameters for the foundation as the wall in Commercial Road, described in section 4.1.

The brick wall in 5.3.2.2 was also analysed assuming similar parameters in both the worst realistic and most likely cases.

5.3.4 Conclusions and Recommendations

The hedge/palisade fence cannot be relied on to have any capacity to resist flood water. If this was replaced with a wall suitable to resist flood water, the level that the water can rise to before the remaining walls in this section are at risk of collapse are estimated as below:

Wall	**Condition Grade**	Worst realistic case			Most likely case			**Comments**
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 5.3.3.1	1	0.3	8.6	Less than 1 in 20	0.45	8.75	Less than 1 in 20	
Section 5.3.3.2	1	0.6	8.9	Less than 1 in 20	0.75	9.05	1 in 20	
Section 5.3.3.3	5 (no wall)	0	8.5	Less than 1 in 20	0	8.5	Less than 1 in 20	Allowable flood level is ground level

With all the various walls in the area of various ages and in various states of repair, it would be impractical to attempt a prediction as to how long the walls can continue to function as defacto defences.

If the walls are to be relied on to function as defacto defences, it is recommended that all the walls in the area are inspected annually. The path on the river side of the wall should also be inspected annually.

5.4 RSPCA Bristol Dogs and Cats Home to Albert Road Bridge

5.4.1 Location

The length of wall considered to be of flood defence value is shown below.

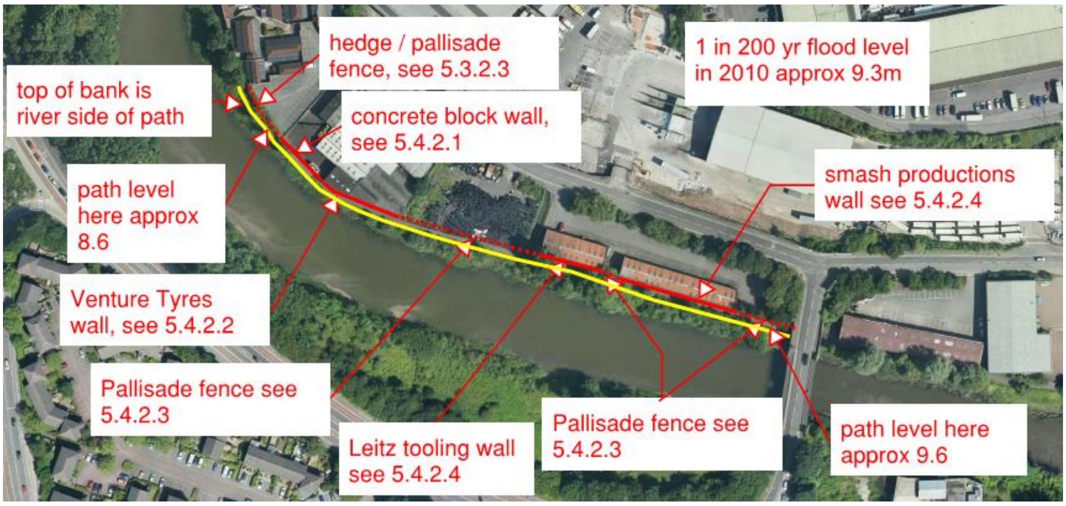


Figure 26 - Walls from RSPCA Bristol Dogs and Cats Home to Albert Road Bridge, aerial image © Blom 2012

5.4.2 General Description

5.4.2.1 Concrete block wall

Material	Concrete blocks
Min height	1.8m
Max height	1.8m
Min thickness	200mm
Max thickness	200mm

The wall also has graffiti on it making assessment of its condition difficult. In general condition appears to be good, there are small vertical cracks on the upper part of the wall. Because of these cracks, condition is considered to be condition grade 3.

Figure 27 - Concrete block wall

5.4.2.2 Venture Tyres wall

Material	Clay bricks / random size stone
Min height	3.23m
Max height	5.1m
Min thickness	430mm
Max thickness	unknown

The downstream end of this wall is mostly in reasonable condition, but there are several cracks that could pass all the way through the wall and let water through. The upstream end of wall is random size stone and appears to be considerably older. This part has considerably more cracks that also could pass through the wall and let water in. There are also 3 small circular holes of dia. approx. 60mm that could pass all the way through the wall, a stick approx. 35cm long could be pushed all the way into a hole without meeting any resistance. Because of the cracks and holes, this wall is considered to be condition grade 4.

Figure 28 - Venture Tyres Wall

There are several longitudinal cracks in the path, indicating that the riverside of the path is settling and in the long term could be at risk of 'falling off' into the river. Some of these cracks can be seen above. In the long term this could cause the riverbank to erode away and undermine the foundations of the wall.

5.4.2.3 Palisade fencing

There are several areas of palisade fencing, these are all similar enough to each other to be described in the same section here. None of these fences have any value as flood defences.

Figure 29 - Palisade fencing adjacent to Venture Tyres building

5.4.2.4 Workshop buildings

The buildings used currently used by Leitz tooling and Smash productions are very similar and so are described in the same section here

Material	Clay bricks
Min height	4.8m
Max height	6.4m
Min thickness	unknown
Max thickness	unknown

The walls appeared to be in good condition with no visible defects, and are considered to be condition grade 1.

Figure 30 - Leitz tooling building

5.4.3 Analysis

The lowest area of land in this area with palisade fencing, or with no wall, is at a level of around 8.9m AOD. This makes is unlikely that any of the other walls in this area would have flood water higher than this on one side only.

For the other walls in the area:

- For the concrete block wall in 5.4.2.1, the same parameters were assumed for the foundations as for the other walls of a similar height e.g. the brick wall in 5.2.3.2. Density of the blocks was assumed to be 15 kN/m^3 in the worst realistic case and 18 kN/m^3 in the most likely case. Allowable water depth was 0.35m in the worst realistic case and 0.6m in the most likely case.

- The Venture Tyres wall was analysed using the same parameters as for the building wall described in 5.2.3.4

- The ground adjacent to the workshop buildings is higher than 9.6m AOD and is considerably higher than the ground in the rest of this area. By inspection, failure of these walls in highly unlikely to be the critical case for flood defence.

5.4.4 Conclusions and Recommendations

The hedge/palisade fence cannot be relied on to have any capacity to resist flood water. If this was replaced with a wall suitable to resist flood water, the level that the water can rise to before the remaining walls in this section are at risk of collapse are estimated as below:

Wall	**Condition Grade**	Worst realistic case			Most likely case			**Comments**
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 5.4.2.1	3	0.3	8.95	Less than 1 in 20	0.65	9.25	1 in 75	
Section 5.4.2.2	4	1	9.6	1 in 200	>1	>9.6	At least 1 in 200	Several potential paths for flood water entry
Section 5.4.2.3	5 (no wall)	0	8.9	Less than 1 in 20	0	8.9	Less than 1 in 20	
Section 5.4.2.4	1	NA	>9.6	At least 1 in 200	NA	>9.6	At least 1 in 200	

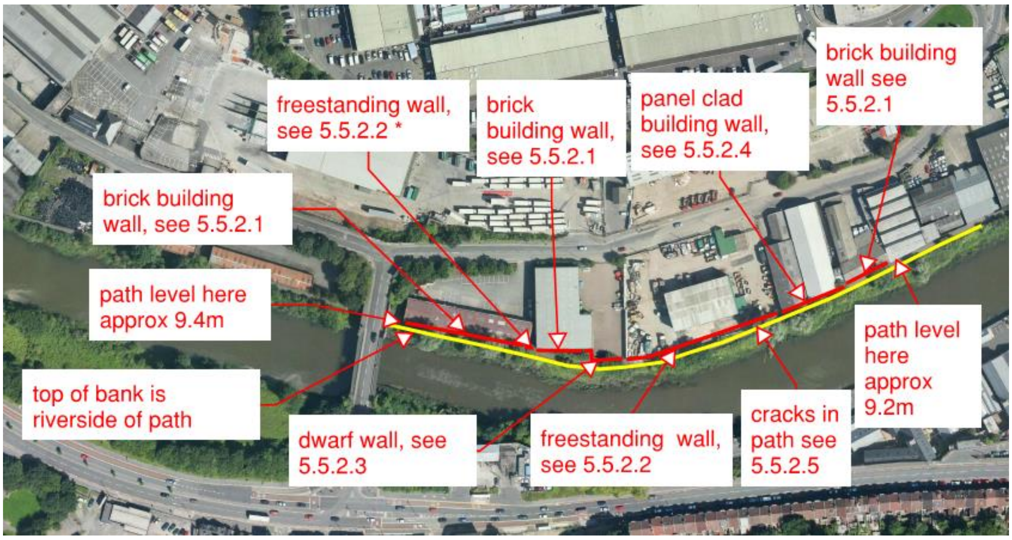
With all the various walls in the area of various ages and in various states of repair, it would be impractical to attempt a prediction as to how long the walls can continue to function as defacto defences.

If the walls are to be relied on to function as defacto defences, it is recommended that all the walls in the area are inspected annually. The path on the river side of the wall should also be inspected annually.

5.5 Albert Road bridge to Travis Perkins building

5.5.1 Location

The length of wall considered to be of flood defence value is shown below.



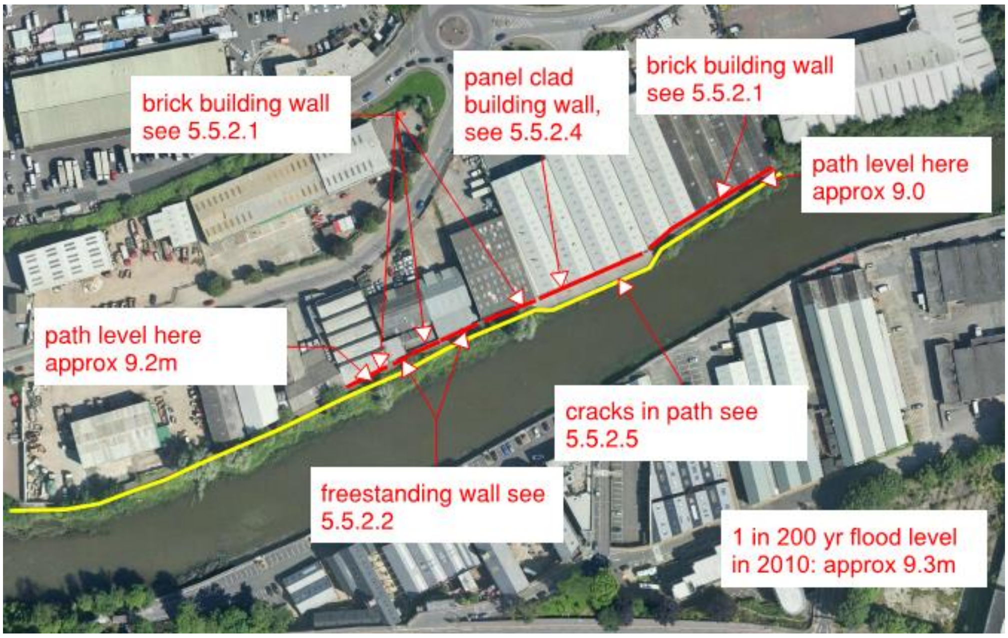


Figure 31 - Walls from Albert Road bridge to Travis Perkins building, aerial image © Blom 2012

5.5.2 General description

Due to the large number of walls in this area, walls of similar types have been grouped together for description and analysis

5.5.2.1 Brick building wall

Material	Clay bricks
Min height	Approx. 4m
Max height	Approx. 6.7m
Min thickness	unknown
Max thickness	unknown

Several of these walls have doors, these doors all appear to be robust but they are probably not completely watertight. Some of them also have windows or vent blocks that could allow a path for flood water. Condition of the walls varies, from condition grade 2 to condition grade 4.

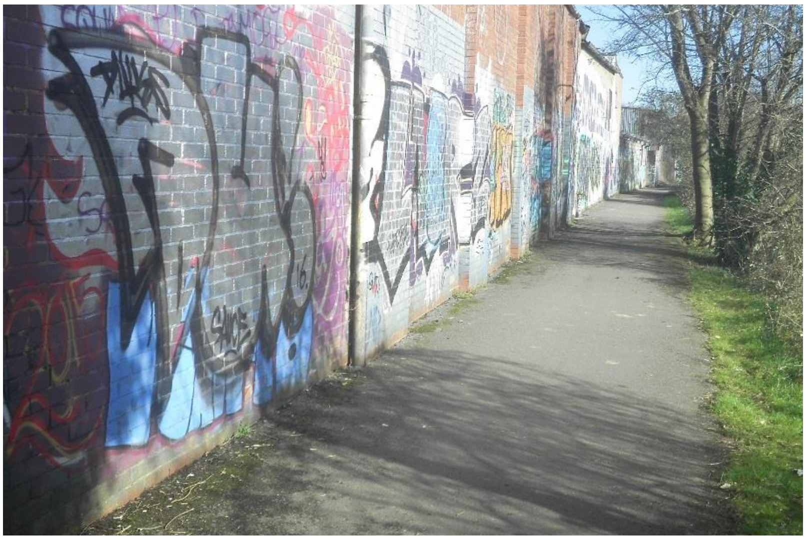


Figure 32 - Example of a wall considered to be condition grade 2

Figure 33 - Example of a wall considered to be condition grade 4

5.5.2.2 Freestanding walls

All freestanding walls higher than 1m are grouped together in this category.

Material	Clay bricks, concrete blocks
Min height	1.65m
Max height	Approx. 3.5m
Min thickness	215mm
Max thickness	350mm

The condition of many of these walls was difficult to determine because of a combination of render and graffiti. Some of the walls appear to be in very good condition, while others have cracks and unfilled joints that would allow flood water to pass through. Condition grade of these walls varies from condition grade 2 to condition grade 4.

One of the walls, marked * on fig. 31, is leaning towards the river. The gap between this wall and the adjacent building varies from around 15mm at the top to 0mm at the bottom.

Figure 34 - Wall marked *, condition grade 4

5.5.2.3 Dwarf wall

This wall is the weak link in the area in terms of flood defence and so is described and analysed separately to the other walls. There is a palisade fence on top of the wall that has no value as a flood defence.

Material	Clay bricks
Min height	0.4m
Max height	0.4m
Min thickness	215mm
Max thickness	215mm

This wall is generally in a good condition, condition grade 2.

Figure 35 - Dwarf wall

5.5.2.4 Panel clad building wall

Material	Prefabricated cladding panels
Min height	Approx. 3.5m
Max height	Approx. 6m
Min thickness	unknown
Max thickness	unknown

These generally appear to be in a reasonable condition. Some of them contain doors that appear robust but are probably not 100% waterproof, because of the doors they are considered to be condition grade 3.

It is understood (from discussions between the EA and the building occupiers) that for extreme tidal events, the occupiers of the buildings put temporary flood resilience measures in place.

Figure 36 – Panel clad wall

5.5.2.5 Cracks in path

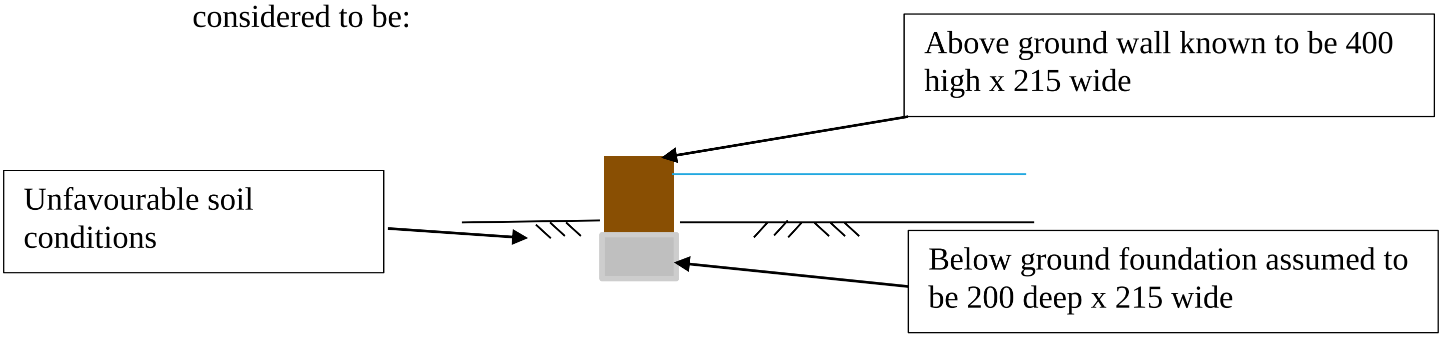
There are numerous longitudinal cracks in the path in this area, indicating that ground movement is causing the river side of the path to ‘fall off’ into the river.

In some places this coincided with a location where the riverbank appears to be kept stable by the roots of trees. If these trees were damaged or removed, there is a risk that parts of the path could fall into the river within a short timeframe, in geomorphological terms. This could lead to the foundations of the walls being undermined.

Figure 37 - Cracks in path

5.5.3 Worst Realistic Case

For the dwarf wall described in section 5.5.2.3, the worst realistic case is considered to be:



It is also assumed that:

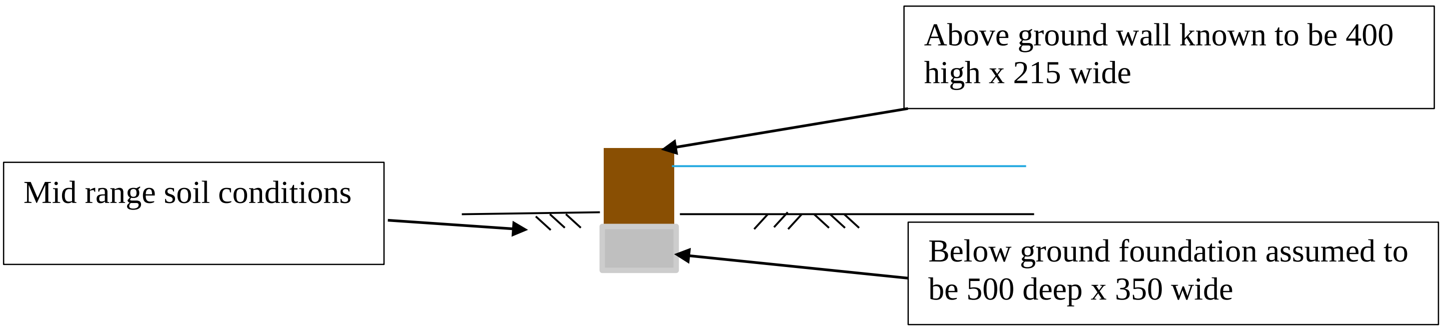
- Mortar is M2, and the bricks have a water absorption > 12% i.e. the wall has been constructed with the weakest type of materials commonly used
- Density of the bricks is 20 kN/m^3 i.e. lighter than average
- Passive pressure from the soil on the landside is included i.e. there will be no excavation during a flood

In this situation, it can be expected that the wall will remain stable up to a water height of around 0.2m above ground level. The ground level in this area is approx. 9.1, so this corresponds to a water level of 9.3m AOD. If the water rises above this level, failure could be by the wall sliding or overturning. This will allow flood water to access Albert rd and from there to eventually reach the Floating Harbour, though further investigation would be needed to confirm that this would happen and the timescale involved.

By inspection, all the other walls in the area will be able to resist the forces imposed on them by the water rising to this level.

5.5.4 Most Likely Case

It is more likely that the foundations are built in accordance with a document such as the BRE Good Building Guide 14, and the typical section of the wall is:



It is also assumed that:

- Stem failure will not be critical

- Density of the bricks is 22 kN/m^3 i.e. lighter than average
- Passive pressure from the soil on the landside is included i.e. there will be no excavation during a flood

In this situation, it can be expected that the wall will remain stable up to a water height of around 0.25m above ground level. The ground level in this area is approx. 9.1, so this corresponds to a water level of 9.35m AOD. Failure in this case is likely to be by overturning.

5.5.5 Analysis of the other walls

For the building walls in sections 5.5.2.1 and 5.5.2.4 it would be impractical to attempt to analyse each component (i.e. wall, supporting frame, foundations) to estimate its capacity. It is known that the walls are able to resist the wind loads currently acting on them, and so these walls have been analysed by estimating the wind load, and then calculating the depth of flood water that places the wall under the same load. It is noted that during a flood, the bricks or cladding panels will be subjected to higher shear forces than they currently are subjected to by wind load, but walls of this type can be shown to have a large amount of spare capacity to resist shear forces and by inspection this will not cause failure.

In the worst realistic case, the wall is assumed to be designed to resist a wind load of 0.5 kN/m^2, this is the lower end of the wind load that buildings of this type and size in this location would be designed for. In the most likely case the walls is assumed to resist 0.8 kN/m^2. The allowable depth of flood water is approximately 0.7m in the worst realistic case and 0.9m in the most likely case.

The other freestanding walls described in 5.5.5.2 are analysed using the same parameters as walls of a similar type and height e.g. the brick wall described in 5.2.3.2.

5.5.6 Conclusions and Recommendations

The level that the water can rise to before the types of walls in this section are at risk of collapse are estimated as below:

Wall	Condition Grade	Worst realistic case			Most likely case			Comments
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 5.5.2.1	2-4	0.7	10.1	1 in 1000	0.9	10.3	1 in 1000	Several potential paths for flood water entry
Section 5.5.2.2	2-4	0.45	9.55	1 in 200	0.65	9.75	1 in 500	Several potential paths for flood water entry
Section 5.5.2.3	2	0.2	9.3	1 in 100	0.25	9.35	1 in 100	
Section 5.5.2.4	3	0.7	9.1 - 9.7	1 in 20	0.9	9.3 - 9.9	1 in 100	Contain several doors that could allow flood water entry

There are multiple walls in this area where cracks and gaps in the walls would allow water to pass through in a flood.

With all the various walls in the area of various ages and in various states of repair, it would be impractical to attempt a prediction as to how long the walls can continue to function as defacto defences.

If the walls are to be relied on to function as defacto defences, it is recommended that all the walls in the area are inspected annually. The path on the river side of the wall should also be inspected annually.

6 Conclusion

Specific recommendations on actions to be taken for each wall are described in the relevant sections above.

The estimated height of flood water that each section of wall can resist are summarised in this section, along with the current SoP. It should be noted that the estimate of current SoP does not account for cracks or joint openings in the wall, and so these estimates should be used with caution for walls of Condition Grade 3 or 4.

6.1 Cumberland Road

Wall	**Condition Grade**	Worst realistic case			Most likely case			**Comments**
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 3.1.1	4	0.85 stone, 0.45 brick	9.65	1 in 1000	1.05 stone, 0.65 brick	9.85	1 in 1000	Not a continuous structure
Section 3.2.1	3	0.15m above road	9.3	1 in 200	0.15m above road	9.3	1 in 200	Can resist water up to the top

6.2 Commercial Road

Wall	**Condition Grade**	Worst realistic case			Most likely case			**Comments**
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 4.1.2	4	0.3	9.2	1 in 100	0.45	9.35	1 in 200	Wall has a gap

6.3 St Philips Marsh

Wall	Condition Grade	Worst realistic case			Most likely case			Comments
		Allowable flood level (m above ground)	**Allowable flood level (mAOD)**	**Current SoP**	**Allowable flood level (m above ground)**	**Allowable flood level (mAOD)**	**Current SoP**	
Section 5.1.2	2	minimal	8.3	Less than 1 in 20	1	9.3	1 in 100	
Section 5.2.3.1	4	0.55	8.95	Less than 1 in 20	0.75	9.15	1 in 20	Wall has a gap
Section 5.2.3.2	2	0.45	8.85	Less than 1 in 20	0.65	9.05	1 in 20	
Section 5.2.3.3	5 (failed)	0	8.4	Less than 1 in 20	0	8.4	Less than 1 in 20	
Section 5.2.3.4	4	1.2	9.6	1 in 200	>1.2	>9.6	At least 1 in 200	Wall has door and numerous access ducts that are potential pathways for flood water
Section 5.2.3.5	Most likely 2	>0.45	>8.85	Less than 1 in 20	>0.65	>9.05	1 in 20	Condition grade could be 3-4, impossible to see due to render
Section 5.3.3.1	1	0.3	8.6	Less than 1 in 20	0.45	8.75	Less than 1 in 20	
Section 5.3.3.2	1	0.6	8.9	Less than 1 in 20	0.75	9.05	1 in 20	
Section 5.3.3.3	5 (no wall)	0	8.5	Less than 1 in 20	0	8.5	Less than 1 in 20	Allowable flood level is ground level
Section 5.4.2.1	3	0.3	8.65	Less than 1 in 20	0.65	9.25	1 in 75	
Section 5.4.2.2	4	1	9.6	1 in 200	>1	>9.6	At least 1 in 200	Several potential paths for flood water entry
Section 5.4.2.3	5 (no wall)	0	8.9	Less than 1 in 20	0	8.9	Less than 1 in 20	
Section 5.4.2.4	1	NA	>9.6	1 in 200	NA	>9.6	1 in 200	
Section 5.5.2.1	2-4	0.7	10.1	1 in 1000	0.9	10.3	1 in 1000	Several potential paths for flood water entry

Section 5.5.2.2	2-4	0.45	9.55	1 in 200	0.65	9.75	1 in 1000	Several potential paths for flood water entry
Section 5.5.2.3	2	0.2	9.3	1 in 100	0.25	9.35	1 in 100	
Section 5.5.2.4	3	0.7	9.1 - 9.7	1 in 20	0.9	9.3 - 9.9	1 in 100	Contain several doors that could allow flood water entry

6.4 RAG Analysis

In view of the number and potential interaction of the structures through Cumberland Road, Commercial Road and St Philips, Red/Amber/Green (RAG) analyses have been prepared for these sections and are presented on the summary plans attached in Appendix A1 and A2 for:

- The structural condition of the walls/structures visually inspected between Cumberland Road and St Philips Causeway, and
- The status of the defacto defences in these sections in a current 0.5%AEP flood event, taking into account the depth of water to which each section would be subject.

Appendix A

RAG Analysis Summary Plans

A1 Structural Condition of De Facto Defences

See sheet 1 for station co-ordinate schedule.

M.J. REES & COMPANY LIMITED
Chartered Land Surveyors
LAND, ENGINEERING AND BUILDING SURVEYS
UNIT A1 VANTAGE OFFICE PARK
OLD GLOUCESTER ROAD
HAMBROOK
BRISTOL BS16 1GW
TELEPHONE 01454 252930 FAX 01454 776832

BRISTOL RAPID TRANSIT
TOPOGRAPHICAL SURVEY
LINE 2

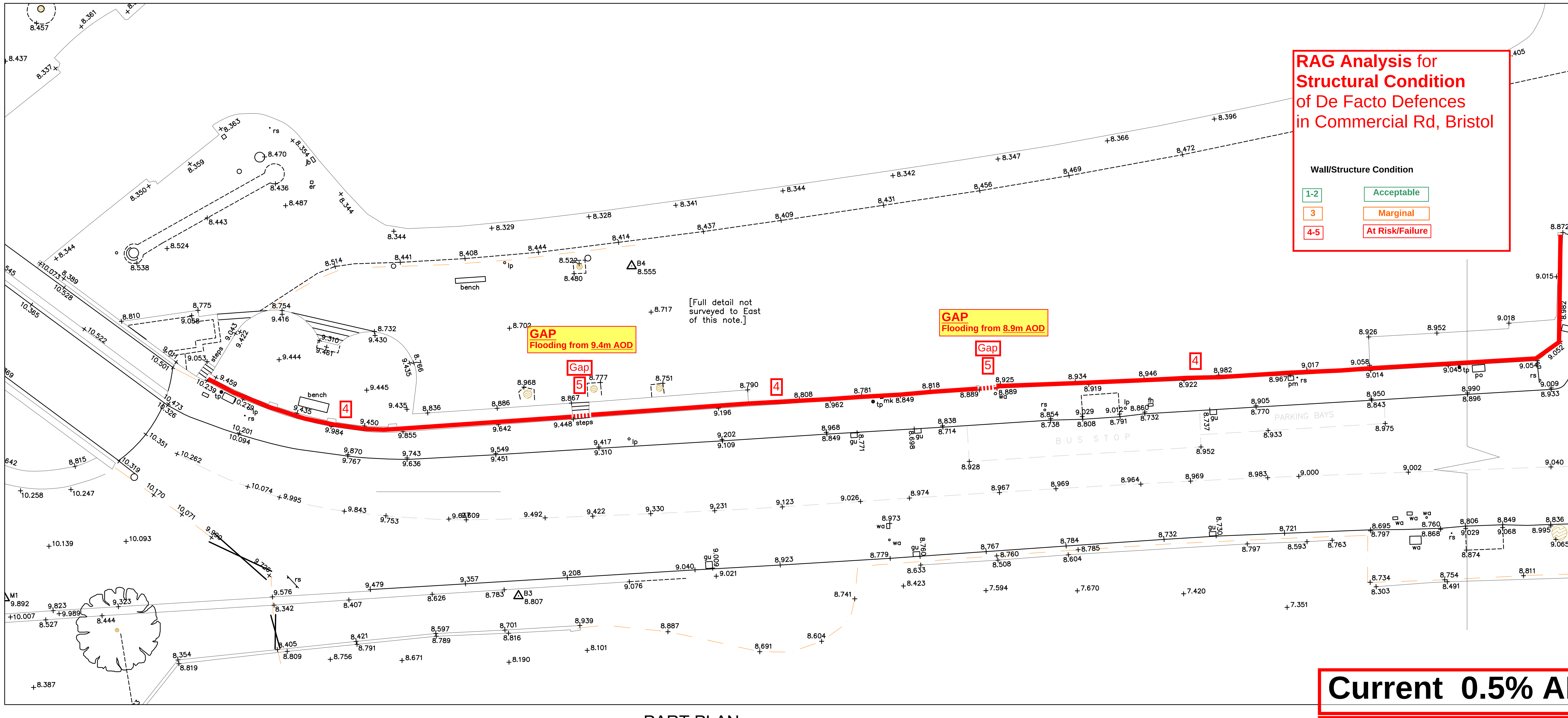
Job No	7652	Date	October 2009
Drawn By :	M.P.S.	Checked	R.M.
Scale :	1/200	Sheet	14 of 21

Client
Bristol City Council
Wilder House
Wilder Street
Bristol
BS2 8PH

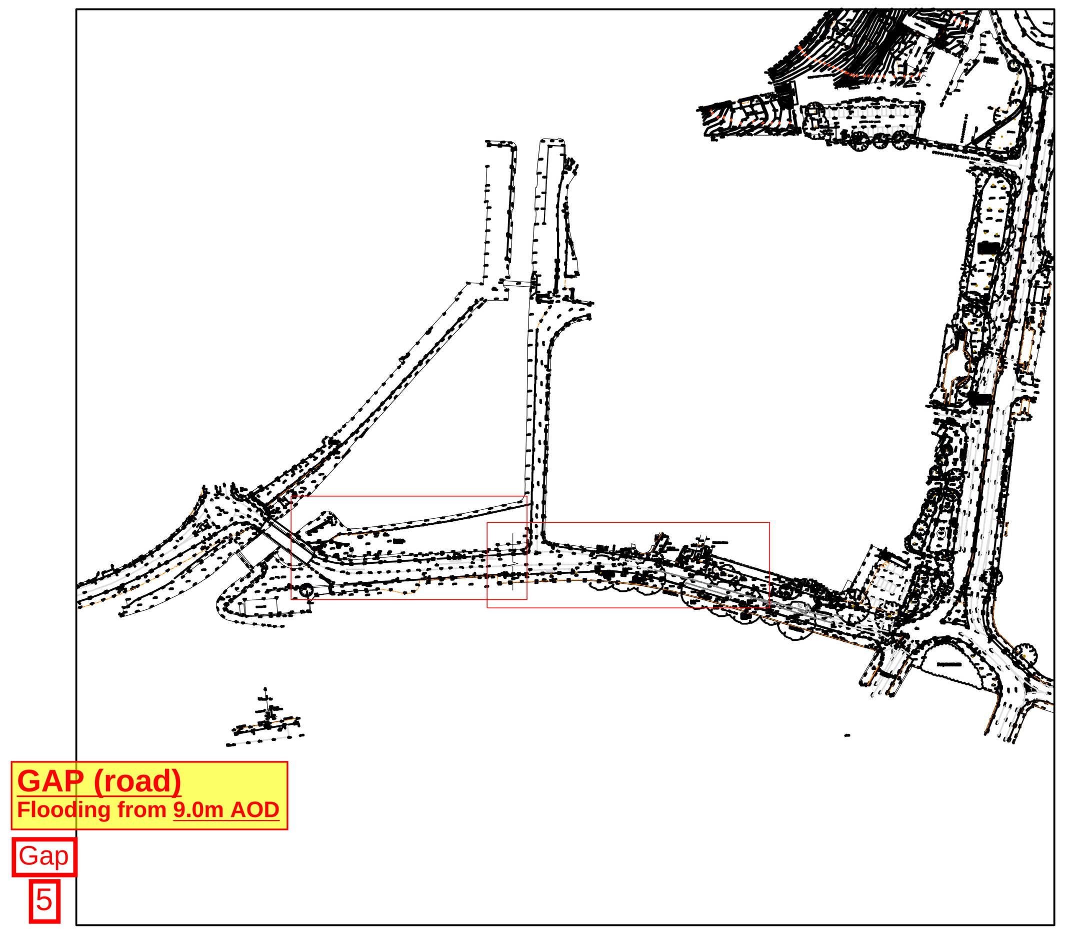
All levels are based on OS datum related to O.S.B.M.s situated at :-

See sheet 1 for a full list of benchmarks used.


RAG Analysis for Structural Condition
of De Facto Defences
in Cumberland Rd, Bristol
Wall/Structure Condition
1-2 Acceptable
3 Marginal
4-5 At Risk/Failure
Not in survey
Gap
5
4
CUMBERLAND ROAD
RIVER AVON (NEW CUT)
Current 0.5% AEP 9.3m AOD
2060 0.5% AEP 9.5m AOD
2110 0.5% AEP 10.2m AOD
Sheet Layout
Sheet 14
Sheet 15
Sheet 16
Sheet 17
See sheet 1 for station co-ordinate schedule.
M.J. REES & COMPANY LIMITED
Chartered Land Surveyors
LAND, ENGINEERING AND BUILDING SURVEYS
UNIT A1 VANTAGE OFFICE PARK
OLD GLOUCESTER ROAD
HAMBROOK
BRISTOL BS16 1GW
TELEPHONE 01454 252930 FAX 01454 776832
BRISTOL RAPID TRANSIT
TOPOGRAPHICAL SURVEY
LINE 2
Job No 7652
Date October 2009
Drawn By : M.P.S.
Checked R.M.
Scale : 1/200
Sheet 15 of 21
Client
Bristol City Council
Wilder House
Wilder Street
Bristol
BS2 8PH
All levels are based on OS datum
related to O.S.B.M.s situated at :-
See sheet 1 for a full list of benchmarks used.



PART PLAN
Scale 1:200 (at A1)

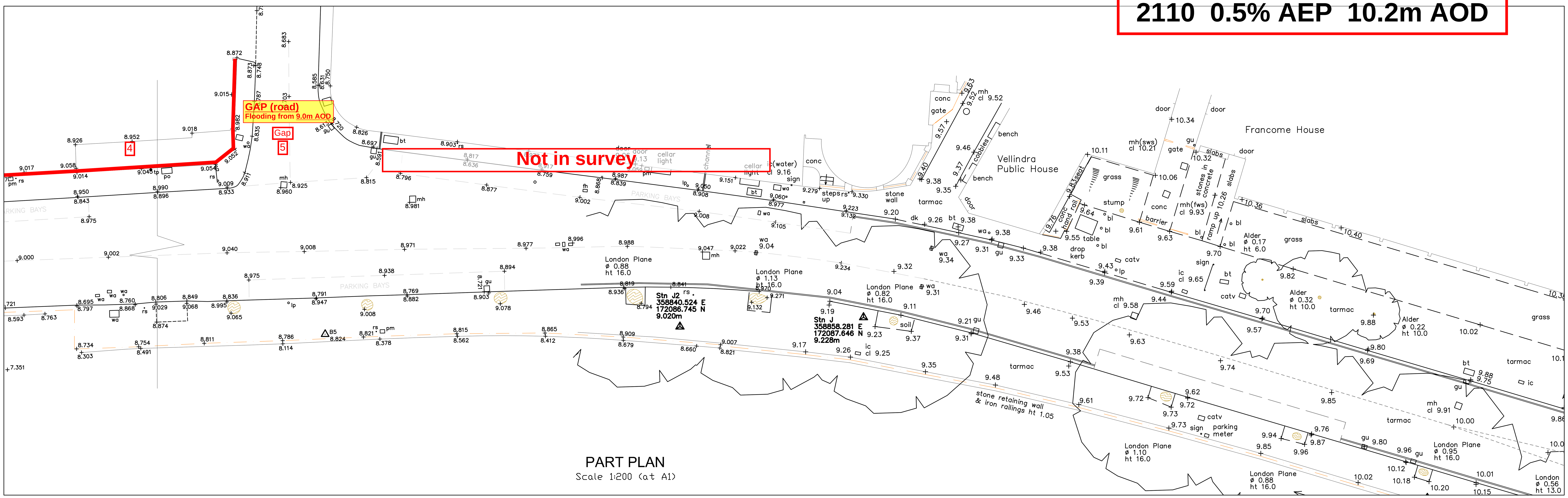


KEY PLAN
N.T.S.

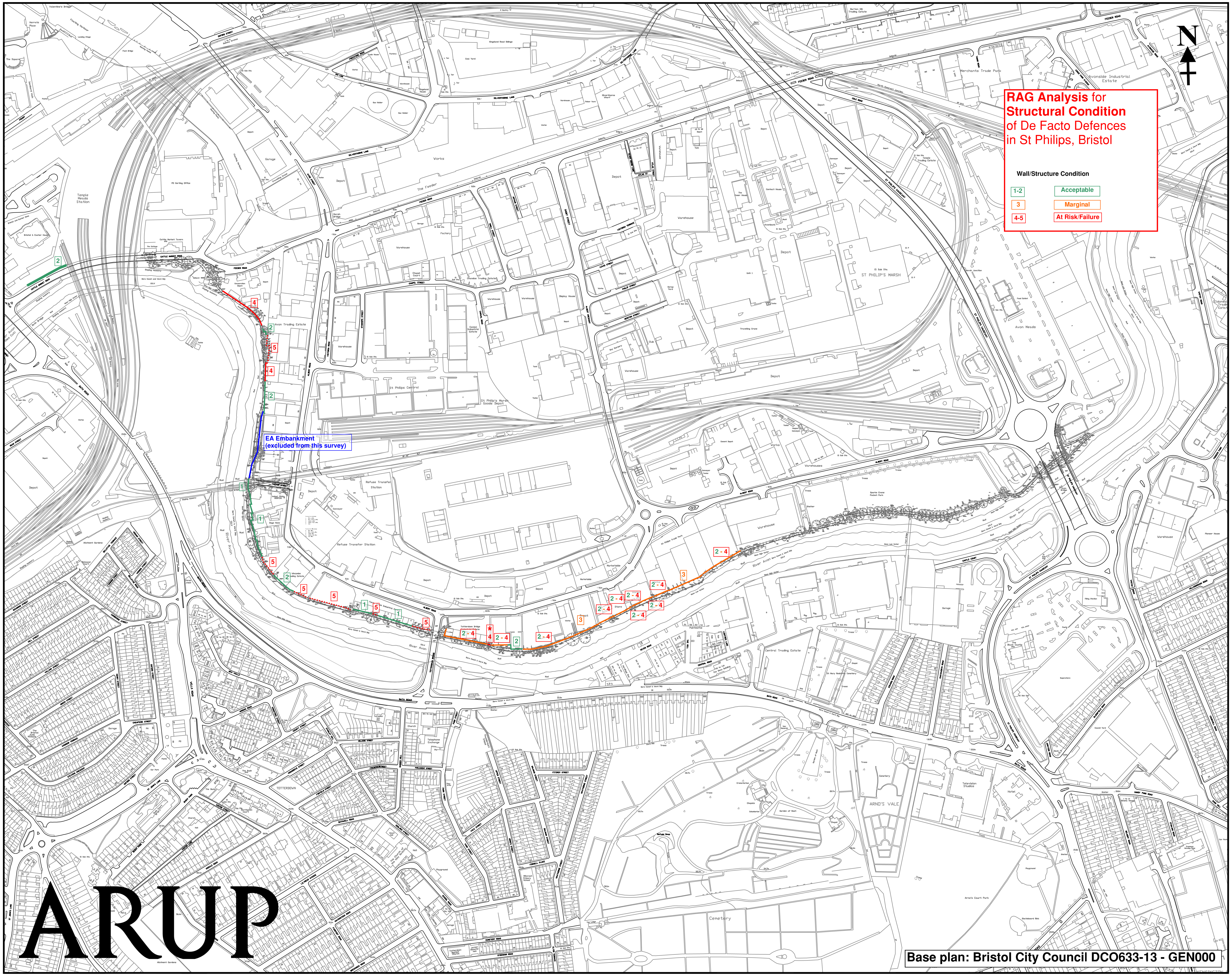
Current 0.5% AEP 9.3m AOD

2060 0.5% AEP 9.5m AOD

2110 0.5% AEP 10.2m AOD



PART PLAN
Scale 1:200 (at A1)



RAG Analysis for
Structural Condition
of De Facto Defences
in St Philips, Bristol
Wall/Structure Condition
1-2 Acceptable
3 Marginal
4-5 At Risk/Failure
EA Embankment
(excluded from this survey)
N
ARUP
Base plan: Bristol City Council DCO633-13 - GEN000

A2 Status of De Facto Defences in a current 0.5% AEP event (RAG Analysis)

See sheet 1 for station co-ordinate schedule.

M.J. REES & COMPANY LIMITED
Chartered Land Surveyors
LAND, ENGINEERING AND BUILDING SURVEYS
UNIT A1 VANTAGE OFFICE PARK
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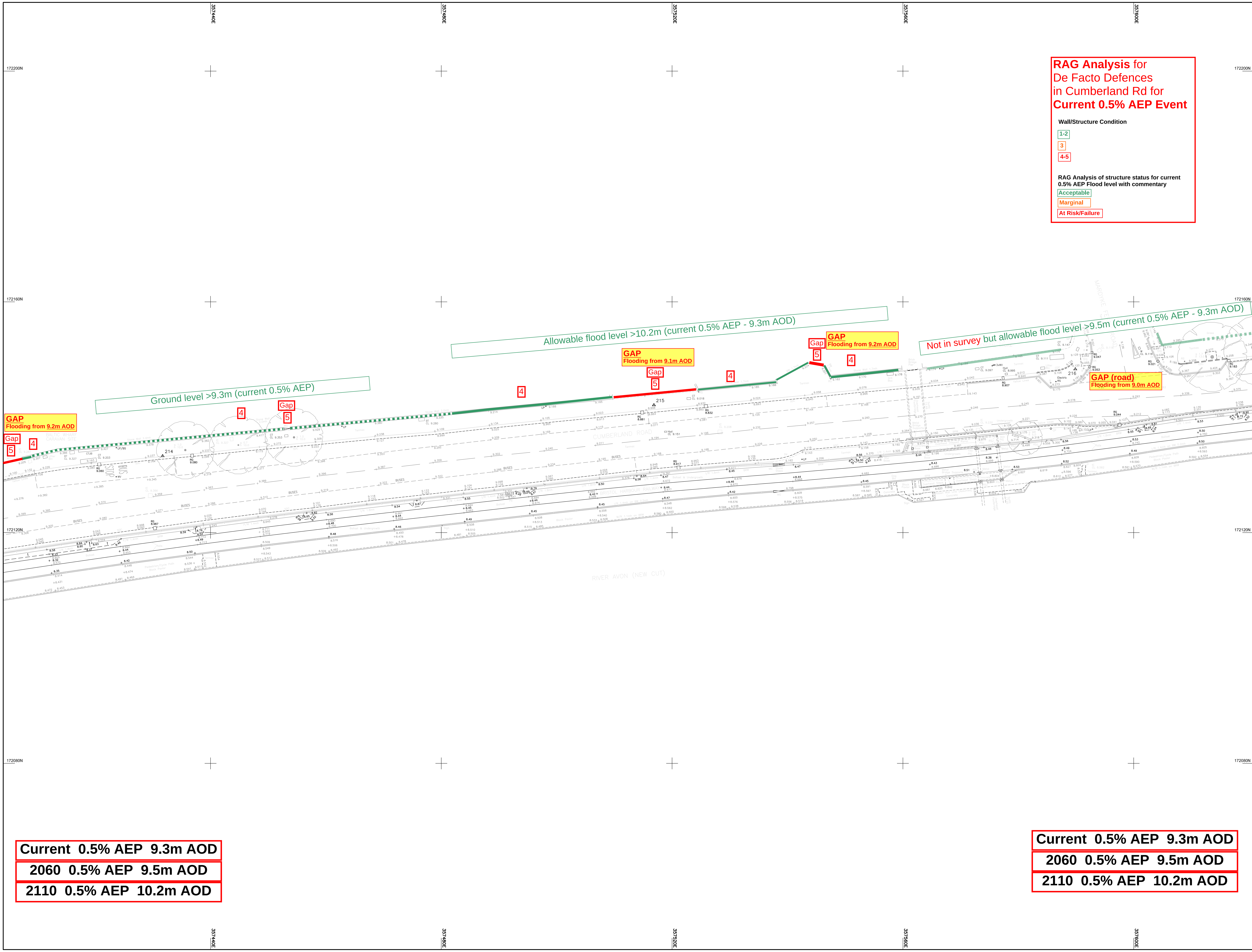
BRISTOL RAPID TRANSIT
TOPOGRAPHICAL SURVEY
LINE 2

Job No	7652	Date	October 2009
Drawn By :	M.P.S.	Checked	R.M.
Scale :	1/200	Sheet	14 of 21

Client
Bristol City Council
Wilder House
Wilder Street
Bristol
BS2 8PH

All levels are based on OS datum related to O.S.B.M.s situated at :-

See sheet 1 for a full list of benchmarks used.



See sheet 1 for station co-ordinate schedule.

M.J. REES & COMPANY LIMITED
Chartered Land Surveyors
LAND, ENGINEERING AND BUILDING SURVEYS
UNIT A1 VANTAGE OFFICE PARK
OLD GLOUCESTER ROAD
HAMBROOK
BRISTOL BS16 1GW
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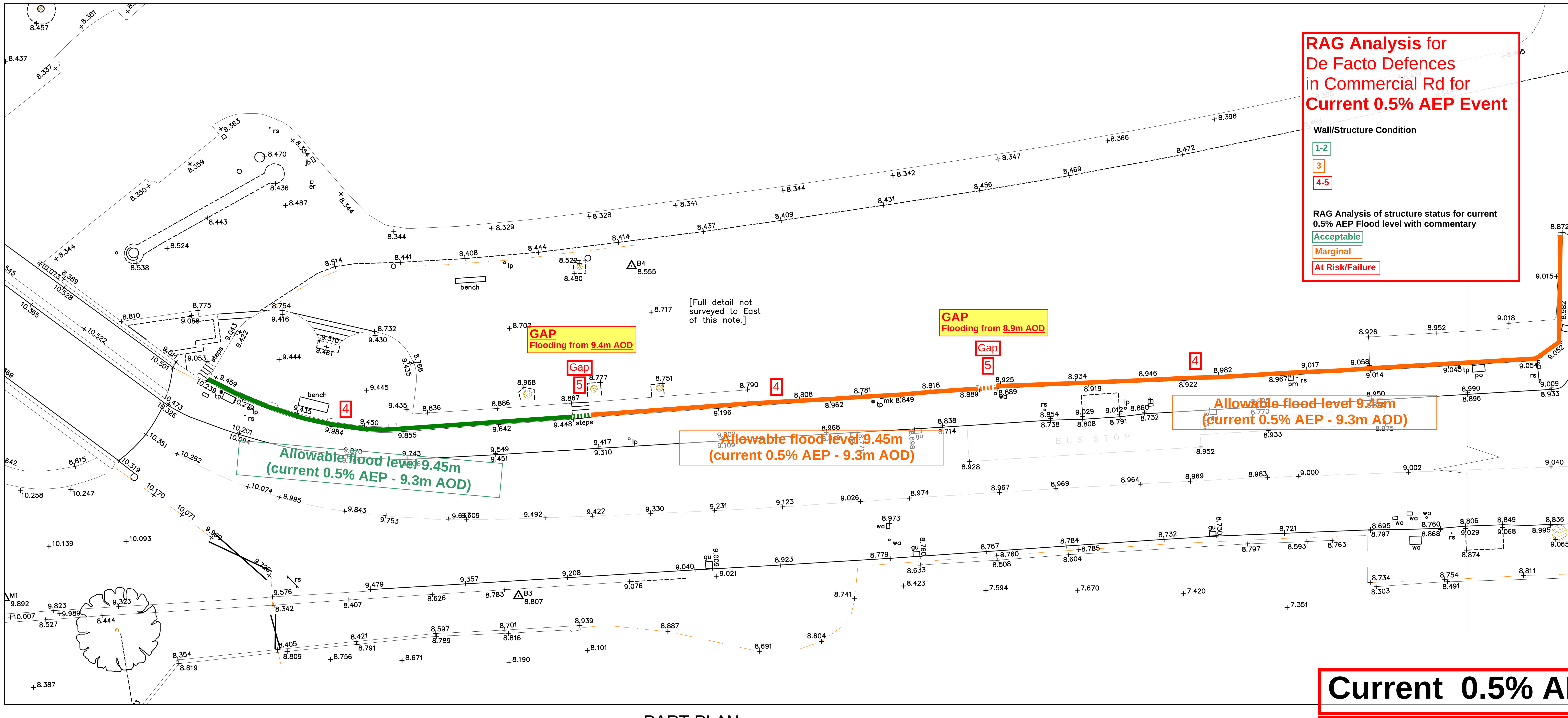
BRISTOL RAPID TRANSIT
TOPOGRAPHICAL SURVEY
LINE 2

Job No	7652	Date	October 2009
Drawn By :	M.P.S.	Checked	R.M.
Scale :	1/200	Sheet	15 of 21

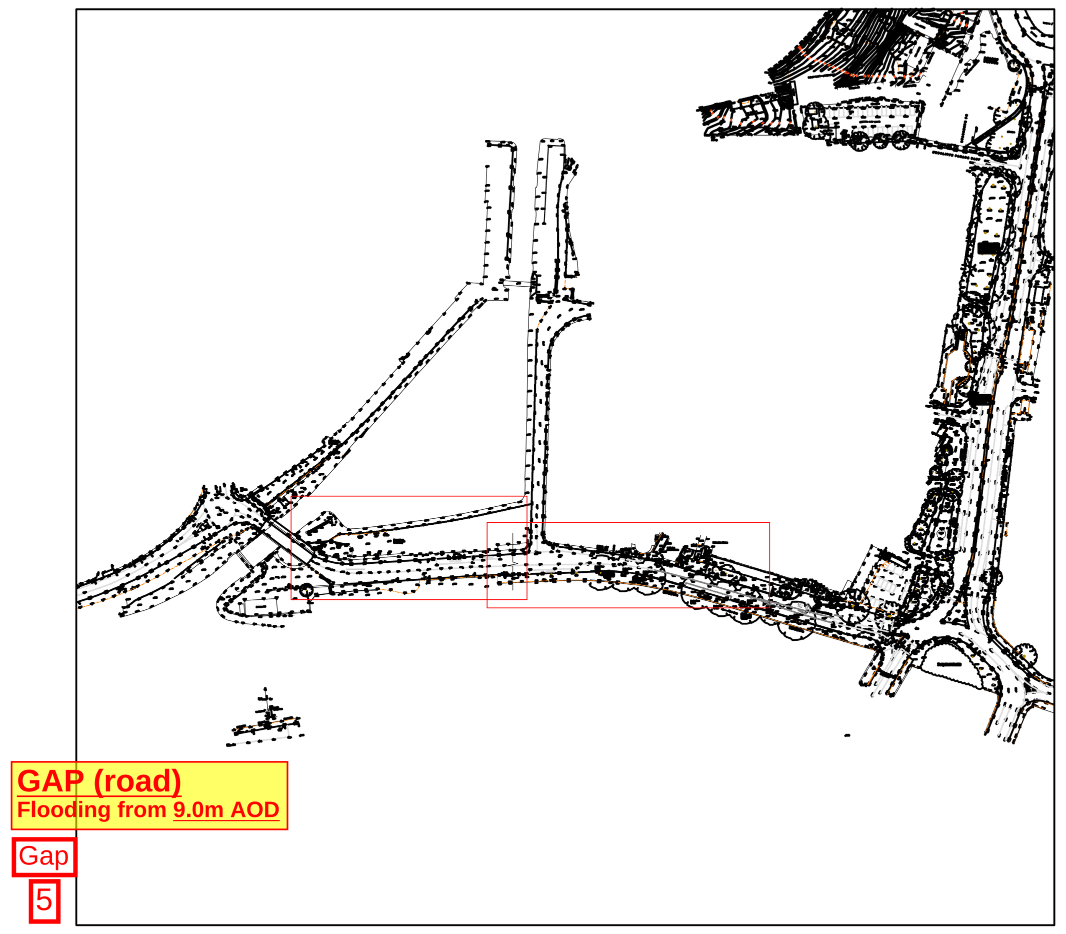
Client
Bristol City Council
Wilder House
Wilder Street
Bristol
BS2 8PH

All levels are based on OS datum related to O.S.B.M.s situated at :–

See sheet 1 for a full list of benchmarks used.

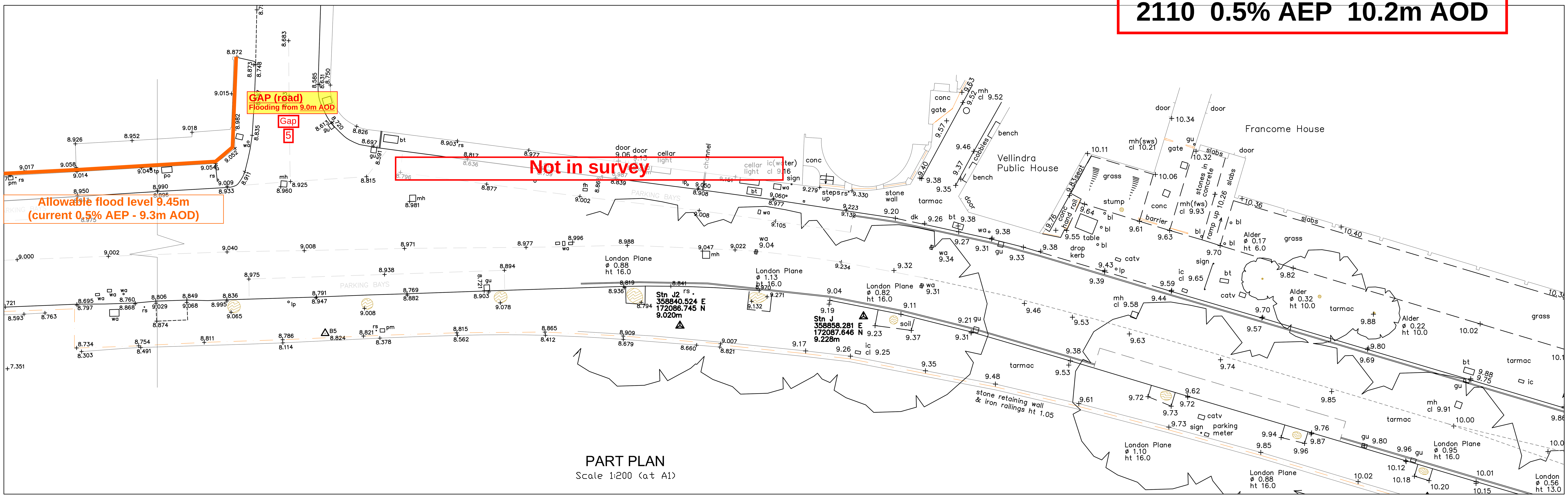


PART PLAN
Scale 1:200 (at A1)

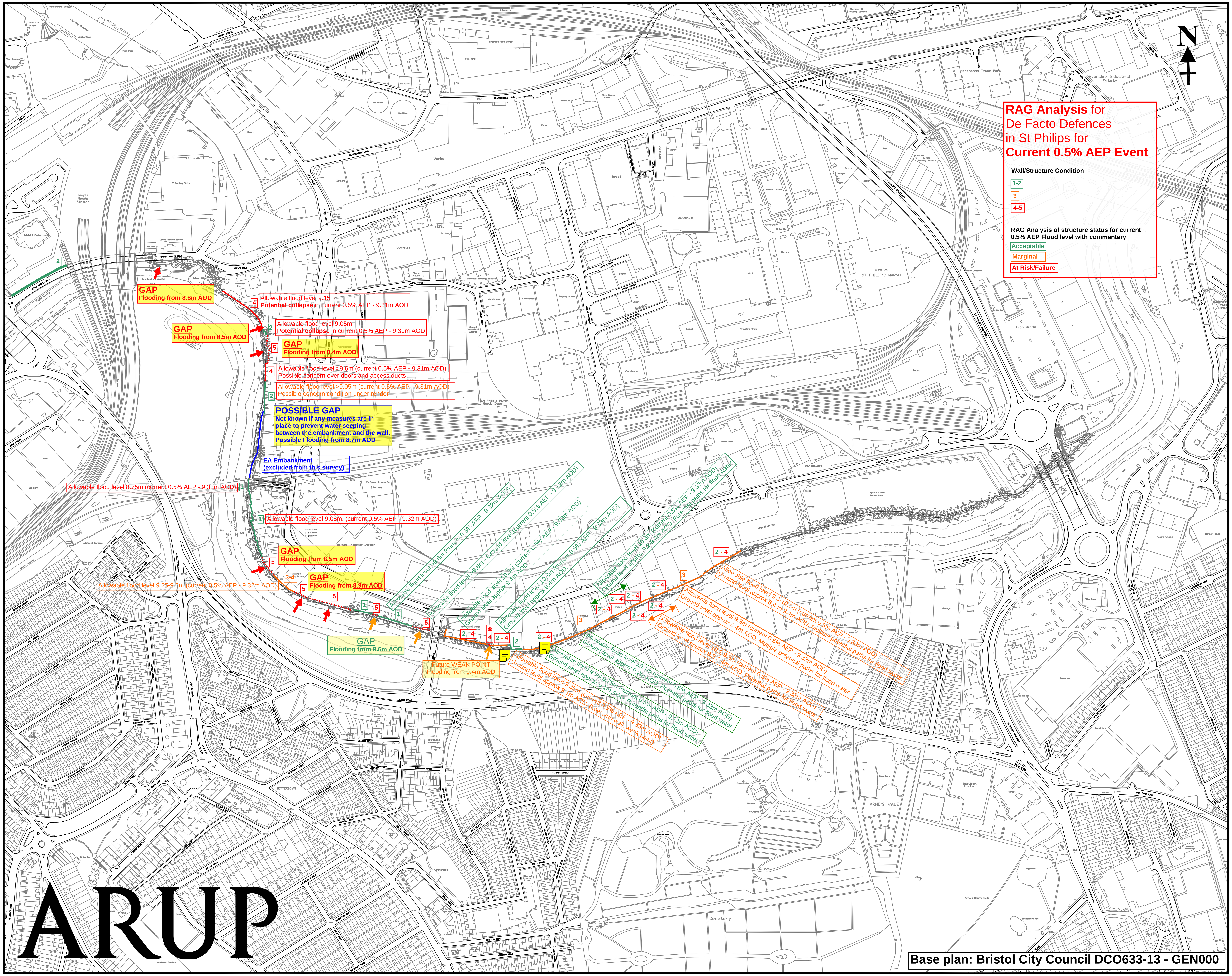


KEY PLAN
N.T.S.

Current	0.5% AEP	9.3m AOD
2060	0.5% AEP	9.5m AOD
2110	0.5% AEP	10.2m AOD



PART PLAN
Scale 1:200 (at A1)



N
RAG Analysis for
De Facto Defences
in St Philips for
Current 0.5% AEP Event
Wall/Structure Condition
1-2
3
4-5
RAG Analysis of structure status for current 0.5% AEP Flood level with commentary
Acceptable
Marginal
At Risk/Failure
GAP
Flooding from 8.8m AOD
Allowable flood level 9.15m
Potential collapse in current 0.5% AEP - 9.31m AOD
GAP
Flooding from 8.5m AOD
Allowable flood level 9.05m
Potential collapse in current 0.5% AEP - 9.31m AOD
GAP
Flooding from 8.4m AOD
Allowable flood level >9.6m (current 0.5% AEP - 9.31m AOD)
Possible concern over doors and access ducts
Allowable flood level >9.05m (current 0.5% AEP - 9.31m AOD)
Possible concern condition under render
POSSIBLE GAP
Not known if any measures are in place to prevent water seeping between the embankment and the wall, Possible Flooding from 8.7m AOD
EA Embankment
(excluded from this survey)
Allowable flood level 8.75m (current 0.5% AEP - 9.32m AOD)
Allowable flood level 9.05m. (current 0.5% AEP - 9.32m AOD)
GAP
Flooding from 8.5m AOD
GAP
Flooding from 8.9m AOD
Allowable flood level 9.25-9.6m (current 0.5% AEP - 9.32m AOD)
GAP
Flooding from 9.6m AOD
Future WEAK POINT
Flooding from 9.4m AOD
Allowable flood level >9.6m (current 0.5% AEP - 9.32m AOD)
Allowable flood level >9.6m - Ground level.(current 0.5% AEP - 9.32m AOD)
Allowable flood level 10.3m (current 0.5% AEP - 9.33m AOD)
Ground level approx 9.4m AOD.
Allowable flood level 10.3m (current 0.5% AEP - 9.33m AOD)
Ground level approx 9.4m AOD.
Allowable flood level 10.3m (current 0.5% AEP - 9.33m AOD)
Ground level approx 9.2-9.4m AOD. Potential paths for flood water
Allowable flood level 9.3-10.3m (current 0.5% AEP - 9.33m AOD)
Ground level approx 8.4 to 9.4m AOD. Multiple potential paths for flood water
Allowable flood level 9.3m (current 0.5% AEP - 9.33m AOD)
Ground level approx 8.4m AOD. Multiple potential paths for flood water
Allowable flood level 10.1-9.3m (current 0.5% AEP - 9.33m AOD)
Ground level approx 9.2-8.4m AOD. Potential paths for flood water
Allowable flood level 10.1m (current 0.5% AEP - 9.33m AOD)
Ground level approx 9.2m AOD. Potential paths for flood water
Allowable flood level 9.75m (current 0.5% AEP - 9.33m AOD)
Ground level approx 9.1m AOD. Potential paths for flood water
Allowable flood level 9.35m (current 0.5% AEP - 9.33m AOD)
Ground level approx 9.1m AOD. (Low stub wall, weak point)
River Avon
ST PHILIP'S MARSH
ARNO'S VALE
TOTTERDOWN
ARUP
Base plan: Bristol City Council DCO633-13 - GEN000

Appendix B

CAFRA Workstream 3 Report

Appendix E - Part 1 - Flow (m^3/s)

		2010						2060						2110					
Node location	Node	1 in 20	1 in 75	1 in 100	1 in 200	1 in 500	1 in 1000	1 in 20	1 in 75	1 in 100	1 in 200	1 in 500	1 in 1000	1 in 20	1 in 75	1 in 100	1 in 200	1 in 500	1 in 1000
DS Hanham Weir	Av5_6016	297.60	355.72	368.93	406.74	462.60	509.37	361.14	435.19	453.73	501.79	574.42	632.04	376.85	456.60	476.03	529.53	608.27	662.16
Brislington Boat Screen Outfall	Av5_2536d	281.86	327.88	337.92	369.99	411.53	453.44	331.87	389.00	403.53	443.81	489.71	530.32	346.63	405.52	420.37	464.50	512.25	552.12
Brislington Outfall	Av5_0672d	287.32	339.66	350.80	391.84	432.99	483.30	341.13	403.86	418.25	479.24	499.25	516.96	359.08	422.96	437.98	493.59	512.32	521.36
US Netham	Av5_0100	289.37	339.98	352.41	398.38	435.00	476.50	343.51	405.96	418.99	469.61	477.52	498.79	362.05	423.04	434.24	476.89	485.24	507.75
DS Netham	Av6_6270	289.37	339.98	352.41	398.38	435.00	476.50	343.51	405.96	418.99	469.61	477.52	498.79	362.05	423.04	434.24	476.89	485.24	507.75
Mylnes Culvert/ Malago Old Course Confluence	Av6_2378d	329.23	377.82	407.94	458.24	494.36	527.77	384.98	443.80	468.44	511.53	580.69	663.12	416.26	476.47	524.77	590.63	677.01	764.14
Entrance Lock Confluence	Av6_0075d	439.68	490.48	536.41	591.76	664.14	733.38	495.23	555.61	602.93	670.18	811.12	926.87	563.57	720.91	781.01	866.43	981.22	1129.60
NSWI Outfall	Av7_6060d	583.86	661.26	716.60	769.14	845.64	914.37	645.38	724.58	794.80	855.69	991.38	1087.11	771.98	933.16	967.09	1050.20	1162.42	1287.22
Trym Confluence	Av7_4087d	758.89	844.28	899.54	950.71	1028.11	1100.56	827.31	919.97	984.00	1053.96	1186.35	1266.33	1004.58	1153.51	1209.96	1292.12	1378.95	1453.64
US Eastville Intake	FRneg51U	55.29	68.50	71.90	84.60	90.86	99.69	65.52	81.83	86.35	87.97	97.40	99.35	68.57	85.77	87.82	89.87	97.65	98.71
Boiling Wells Outfall	fr750D	33.22	41.10	43.97	48.48	54.21	55.64	39.56	47.00	47.09	54.04	55.06	56.29	43.46	48.78	52.26	53.69	55.18	56.21
Wade Street Culvert	fr0_wade	33.45	40.36	41.78	48.08	51.28	54.85	39.48	45.97	47.91	50.01	53.67	55.33	41.46	48.39	49.79	50.95	52.72	55.43
US of Stonegate Weir	FC377U	3.01	4.93	5.43	8.09	12.17	13.48	4.59	6.78	9.38	12.16	13.51	14.06	6.76	9.77	11.24	12.98	13.76	14.23
US Brislington Boat Screen	BRIS_1230	16.81	28.76	31.98	44.94	74.84	138.42	20.19	33.60	38.84	57.06	97.72	181.74	21.05	35.02	41.03	60.21	105.34	191.50
US Chapel Way	BRIS_0465	2.62	5.94	6.68	8.11	8.98	9.20	4.14	7.10	7.55	8.68	9.12	9.21	3.89	7.28	7.76	8.74	9.11	9.49
US Crox Bottom Interceptor	PIGE01_0823	11.48	19.76	22.34	29.86	44.45	62.18	15.36	23.72	26.81	35.93	53.34	74.61	14.43	24.70	27.91	37.44	55.56	77.71
US Malago Interceptor	MALA01_3162	9.66	16.50	18.64	25.06	28.94	29.42	13.03	19.76	22.35	27.34	29.00	30.33	12.07	20.53	23.26	26.59	30.31	31.41
US Bedminster Road	01.012	0.91	1.23	1.32	5.19	12.02	12.70	1.13	1.41	1.50	8.66	12.50	12.60	1.07	1.45	1.55	8.80	12.57	12.58
Confluence of Longmoor and Colliters New Channel	LONG_1475D	7.14	9.19	11.77	13.84	15.42	16.01	9.34	11.34	13.44	14.98	15.65	15.67	10.80	13.11	13.79	14.93	15.17	15.97
Ashton Gate Stadium	COL_754D	1.08	1.12	1.18	1.12	1.14	1.15	1.11	1.14	1.13	1.14	1.10	1.15	1.11	1.12	2.26	2.39	2.61	2.68
Aylesbury Mill	BWS01_1330	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Mina Road Park	BWS01_0449	0.77	0.77	0.68	0.61	1.42	0.86	0.72	0.57	0.56	0.58	0.90	0.93	0.51	0.59	0.63	0.68	0.94	0.89

Appendix E - Part 2 - Level (mAOD)

		2010						2060						2110					
Node location	Node	1 in 20	1 in 75	1 in 100	1 in 200	1 in 500	1 in 1000	1 in 20	1 in 75	1 in 100	1 in 200	1 in 500	1 in 1000	1 in 20	1 in 75	1 in 100	1 in 200	1 in 500	1 in 1000
DS Hanham Weir	Av5_6016	10.17	10.66	10.77	11.11	11.47	11.81	10.70	11.23	11.35	11.71	12.11	12.51	10.86	11.39	11.50	11.91	12.33	12.71
Brislington Boat Screen Outfall	Av5_2536d	9.24	9.72	9.94	10.30	10.62	11.01	9.79	10.30	10.41	10.89	11.29	11.70	10.04	10.49	10.72	11.16	11.57	11.93
Brislington Outfall	Av5_0672d	9.05	9.26	9.51	9.78	10.04	10.49	9.26	9.64	9.87	10.36	10.77	11.18	9.57	9.97	10.28	10.72	11.13	11.45
US Netham	Av5_0100	9.03	9.19	9.33	9.53	9.73	9.81	9.24	9.45	9.63	9.74	10.05	10.39	9.56	9.82	10.04	10.30	10.59	10.88
DS Netham	Av6_6270	9.04	9.20	9.25	9.44	9.61	9.68	9.25	9.41	9.53	9.63	9.94	10.28	9.56	9.79	10.03	10.30	10.58	10.80
Mylnes Culvert/ Malago Old Course Confluence	Av6_2378d	8.92	9.10	9.14	9.28	9.39	9.50	9.16	9.30	9.33	9.50	9.70	9.86	9.54	9.74	9.90	10.11	10.37	10.65
Entrance Lock Confluence	Av6_0075d	8.91	9.11	9.15	9.25	9.39	9.49	9.18	9.35	9.40	9.48	9.68	9.84	9.64	9.86	9.90	10.17	10.38	10.55
NSWI Outfall	Av7_6060d	8.88	9.10	9.14	9.24	9.38	9.49	9.17	9.36	9.41	9.50	9.65	9.80	9.68	9.90	9.94	10.14	10.34	10.47
Trym Confluence	Av7_4087d	8.85	9.07	9.12	9.22	9.36	9.49	9.15	9.35	9.41	9.51	9.67	9.79	9.71	9.93	9.98	10.13	10.34	10.49
US Eastville Intake	FRneg51U	10.72	11.40	11.56	12.00	12.40	12.68	11.29	11.86	11.95	12.39	12.72	13.18	11.55	12.03	12.21	12.49	12.96	13.27
Boiling Wells Outfall	fr750D	9.96	10.38	10.46	10.79	11.12	11.45	10.32	10.70	10.77	11.09	11.49	11.77	10.45	10.80	10.97	11.28	11.63	11.87
Wade Street Culvert	fr0_wade	9.21	9.57	9.65	10.03	10.69	11.16	9.53	9.92	10.05	10.65	11.22	11.51	9.65	10.25	10.48	10.95	11.39	11.63
US of Stonegate Weir	FC377U	8.57	8.70	8.73	8.88	9.31	9.55	8.68	8.81	9.02	9.44	9.76	9.98	9.39	9.70	9.93	10.18	10.44	10.61
US Brislington Boat Screen	BRIS_1230	14.95	15.61	15.93	16.97	17.62	17.87	15.35	16.34	16.73	17.32	17.83	17.88	15.40	16.52	16.84	17.39	17.86	17.88
US Chapel Way	BRIS_0465	9.79	10.91	11.02	11.13	11.18	11.20	10.21	11.06	11.10	11.17	11.21	11.30	10.52	11.07	11.11	11.18	11.28	11.49
US Crox Bottom Interceptor	PIGE01_0823	21.33	21.80	21.94	22.97	23.58	24.01	21.56	22.00	22.12	23.33	23.82	24.27	21.51	22.05	22.59	23.39	23.88	24.33
US Malago Interceptor	MALA01_3162	17.97	18.52	18.77	20.28	21.10	21.25	18.18	18.90	19.19	20.99	21.20	21.34	18.12	19.01	19.52	21.04	21.24	21.38
US Bedminster Road	01.012	9.65	9.94	10.01	9.69	11.44	12.08	9.90	10.11	10.19	11.05	11.80	12.43	9.82	10.15	10.24	11.22	11.99	12.57
Confluence of Longmoor and Colliters New Channel	LONG_1475D	7.47	7.70	7.96	8.15	8.32	8.43	7.60	7.85	8.16	8.32	8.46	8.57	7.85	8.06	8.28	8.42	8.54	8.64
Ashton Gate Stadium	COL_754D	7.30	7.33	7.42	7.51	7.59	7.70	7.33	7.44	7.50	7.59	7.73	7.83	7.39	7.49	7.55	7.69	7.86	8.17
Aylesbury Mill	BWS01_1330	19.05	19.05	19.05	19.05	19.06	19.06	19.05	19.05	19.05	19.06	19.06	19.06	19.05	19.05	19.05	19.05	19.06	19.06
Mina Road Park	BWS01_0449	9.85	10.14	10.20	10.39	10.83	11.37	10.04	10.33	10.38	10.75	11.43	11.79	10.12	10.38	10.42	11.08	11.62	11.90

Appendix E - Part 3 - Flow (m^3/s) Sensitivity

Node location	Node	Base model	Mn +20%	Difference	Mn -20%	Difference	Q +20%	Difference	Q -20%	Difference
DS Hanham Weir	Av5_6016	368.93	354.96	13.96	387.17	-18.25	453.56	-84.63	292.31	76.61
Brislington Boat Screen Outfall	Av5_2536d	337.92	335.45	2.48	344.03	-6.11	403.40	-65.48	278.58	59.34
Brislington Outfall	Av5_0672d	350.80	349.32	1.47	354.67	-3.88	416.82	-66.02	290.67	60.13
US Netham	Av5_0100	352.41	352.19	0.22	355.25	-2.85	416.55	-64.14	292.69	59.72
DS Netham	Av6_6270	352.41	352.19	0.22	355.25	-2.85	416.55	-64.14	292.69	59.72
Mylnes Culvert/ Malago Old Course Confluence	Av6_2378d	390.72	378.77	11.95	400.13	-9.41	451.23	-60.51	332.48	58.24
Entrance Lock Confluence	Av6_0075d	507.04	485.03	22.01	521.56	-14.52	566.23	-59.19	443.52	63.52
NSWI Outfall	Av7_6060d	649.74	616.88	32.86	670.53	-20.79	702.82	-53.08	585.22	64.52
Trym Confluence	Av7_4087d	788.44	748.83	39.60	810.64	-22.21	840.49	-52.05	719.76	68.67
US Eastville Intake	FRneg51U	71.90	70.78	1.12	73.32	-1.42	86.19	-14.30	58.26	13.63
Boiling Wells Outfall	fr750D	43.97	43.05	0.92	43.78	0.19	47.01	-3.04	34.71	9.26
Wade Street Culvert	fr0_wade	41.78	40.98	0.80	42.87	-1.10	47.21	-5.43	35.05	6.73
US of Stonegate Weir	FC377U	5.43	5.16	0.27	5.78	-0.35	7.17	-1.74	3.02	2.41
US Brislington Boat Screen	BRIS_1230	31.98	31.73	0.25	32.39	-0.40	38.83	-6.85	26.00	5.98
US Chapel Way	BRIS_0465	6.68	6.21	0.46	7.88	-1.20	7.55	-0.88	5.06	1.61
US Crox Bottom Interceptor	PIGE01_0823	22.34	22.34	0.01	22.35	0.00	26.81	-4.46	17.87	4.48
US Malago Interceptor	MALA01_3162	18.64	18.65	0.00	18.64	0.00	22.36	-3.71	14.94	3.70
US Bedminster Road	01.012	1.32	1.30	0.02	1.32	0.00	1.48	-0.16	1.13	0.19
Confluence of Longmoor and Colliters New Channel	LONG_1475D	9.64	8.97	0.66	10.44	-0.80	10.80	-1.17	4.63	5.01
Ashton Gate Stadium	COL_754D	1.17	1.04	0.13	1.30	-0.13	1.17	0.00	1.11	0.06
Aylesbury Mill	BWS01_1330	0.48	0.48	0.00	0.49	-0.01	0.48	0.00	0.48	0.00
Mina Road Park	BWS01_0449	0.36	0.29	0.07	0.49	-0.13	0.29	0.07	0.77	-0.41

Appendix E - Part 4 - Level (mAOD) Sensitivity

Node location	Node	Base model	Mn +20%	Difference	Mn -20%	Difference	Q +20%	Difference	Q -20%	Difference
DS Hanham Weir	Av5_6016	10.77	11.17	-0.40	10.40	0.37	11.35	-0.58	10.14	0.64
Brislington Boat Screen Outfall	Av5_2536d	9.83	10.20	-0.37	9.57	0.26	10.38	-0.56	9.23	0.59
Brislington Outfall	Av5_0672d	9.18	9.48	-0.31	9.10	0.08	9.68	-0.51	8.67	0.51
US Netham	Av5_0100	8.86	9.12	-0.26	8.86	0.01	9.30	-0.44	8.40	0.46
DS Netham	Av6_6270	8.74	9.01	-0.28	8.41	0.33	9.15	-0.41	8.32	0.42
Mylnes Culvert/ Malago Old Course Confluence	Av6_2378d	7.52	7.58	-0.05	7.43	0.09	7.59	-0.07	7.42	0.10
Entrance Lock Confluence	Av6_0075d	7.32	7.33	0.00	7.30	0.02	7.33	0.00	7.29	0.03
NSWI Outfall	Av7_6060d	7.28	7.27	0.00	7.25	0.03	7.27	0.01	7.25	0.03
Trym Confluence	Av7_4087d	7.23	7.22	0.01	7.21	0.02	7.21	0.01	7.21	0.02
US Eastville Intake	FRneg51U	11.56	11.67	-0.11	11.43	0.13	11.89	-0.33	10.86	0.70
Boiling Wells Outfall	fr750D	10.46	10.66	-0.20	10.29	0.18	10.74	-0.28	10.06	0.41
Wade Street Culvert	fr0_wade	9.65	9.62	0.04	9.71	-0.06	9.99	-0.33	9.29	0.37
US of Stonegate Weir	FC377U	8.73	8.72	0.01	8.74	-0.01	8.83	-0.10	8.60	0.13
US Brislington Boat Screen	BRIS_1230	15.93	16.08	-0.15	15.79	0.14	16.73	-0.80	15.51	0.42
US Chapel Way	BRIS_0465	11.02	11.07	-0.05	10.96	0.05	11.10	-0.08	10.64	0.37
US Crox Bottom Interceptor	PIGE01_0823	21.94	21.94	0.00	21.94	0.00	22.12	-0.18	21.70	0.23
US Malago Interceptor	MALA01_3162	18.77	18.77	0.00	18.77	0.00	19.19	-0.42	18.34	0.43
US Bedminster Road	01.012	10.01	10.01	-0.01	10.00	0.01	10.19	-0.18	9.82	0.19
Confluence of Longmoor and Colliters New Channel	LONG_1475D	7.52	7.55	-0.03	7.49	0.04	7.65	-0.13	7.20	0.32
Ashton Gate Stadium	COL_754D	7.35	7.35	0.00	7.34	0.01	7.44	-0.09	7.31	0.04
Aylesbury Mill	BWS01_1330	19.05	19.05	0.00	19.06	-0.01	19.05	0.00	19.05	0.00
Mina Road Park	BWS01_0449	10.20	10.22	-0.02	10.17	0.02	10.37	-0.18	9.92	0.27