Appendix 4.1.A – Mott MacDonald flood risk assessment

Wessex Water

September 2018

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Flood Risk Assessment and Mitigation Strategy

Wessex Water PR19 Flooding Resilience Assessments

19 July 2017

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Flood Risk Assessment and Mitigation Strategy

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Contents

1 Introduction and Scope of Work

Mott MacDonald has been commissioned by Wessex Water Services Ltd. to conduct flooding resilience assessments at 63 Wessex Water sites, including water treatment works, sewage treatment works, sewage pumping stations, source and supply sites. The objective of this project is to undertake high level flood risk assessments for sites specified by Wessex Water, taking into account flood risk up to the 1 in 1000 year event and climate change impacts. The flood risk assessments will inform a recommendation of flood mitigation strategy and an accompanying cost estimate for improving asset flood resilience to inform the PR19 Business Plan.

The Scope of Work as defined in the Technical Scope includes:

- Phase 1: Preliminary Assessment
  - Data collection and review
  - Gap analysis
  - Workshop with Wessex Water project team and site operators
  - Site visits to identify critical equipment
  - High level assessment of flooding at each site
  - Screening assessment
  - Prepare Preliminary Assessment Report and Site Summary Sheets
  - Attend intermediate review meeting
- Phase 2: Flood Risk Assessment and Mitigation Strategy
  - Confirm scope of additional topographical survey
  - Update existing surveys where applicable
  - Indicative site specific flood risk assessment including
    - Fluvial flood risk (1 in 100 year, 1 in 1000 year event, present day and climate change)
    - Tidal flood risk (1 in 200 year, 1 in 1000 year event, present day and climate change)
    - Surface water flood risk (1 in 30 year, 100 year and 1000 year event)
  - Assessment of site operation in time of flood
  - Assessment of impact to flood risk elsewhere
  - Recommendation for potential options to manage the flood risk for each site, with indicative cost
  - Prepare Flood Risk Assessment Report
  - Final presentation

1.1 Outcome of Phase 1

The report *Preliminary Assessment Report, Wessex Water PR10 Flooding Resilience Assessments, Revision B* (Mott MacDonald, March 2017) summarises the output of Phase 1.

The purpose of the screening exercise undertaken in Part 1 was to identify the number of sites that are at risk of flooding to progress to Phase 2 (Flood Risk Assessment and Mitigation Strategy) and the estimated complexity of the assessment for each site.

An excerpt from the screening assessment is summarised in the table below.

Table 1: Outcome from Phase 1 Screening Assessment

Description		Number of Sites	
Sites in Phase 1			
		63	
Sites progressing to Phase 2			
		56	
Estimated FRA complexity (for sites progressing to Phase 2)			
	Low	9	
	Medium	31	
	High	16	*Total= 56*

1.2 Phase 2 Scope of Work

This report covers work undertaken as part of Phase 2.

Based on the results of the screening assessment, a high-level flood risk assessment and mitigation strategy was conducted for the 56 sites identified in Phase 1 as in the table below. Their locations are shown in Figure 1.

Table 2: Phase 2 Site List

Site Name	Wessex Water Site ID	NGR
Admiralty	12001	
Ashford	12004	
Balls Hill P.S.	11678	
BATH	14002	
BATH	17142	
Black Lane	12008	
Bournemouth	15019	
Briantspuddle	12015	
Bristol (Ashton Ave)	14016	
Brixton Deverill	12017	
Burnham on Sea	15341	
Burrowbridge	13040	
Bushfield P.S.	11467	
Charlton P.S.	12026	
Chitterne	12030	
Compton P.S.	12036	
Corfe Mullen	12038	

Site Name	Wessex Water Site ID	NGR
Corscombe	11729	
Crewkerne	13084	
Dewlish	12043	
Durleigh	12049	
Durrington	12050	
East Lyng	18714	
Ferndown	15078	
Fivehead P.S.	17220	
Fiveways Valve Rotork chamber	11371	
Haselbury Plucknett	13144	
Heytesbury	12063	
Highbridge	14374	
Ivyfields P.S.	12068	
Lytchett Minster	13190	
Malmesbury	14205	
Merriott	13208	
Newton Meadows	12090	
Newton Toney	12089	
Poole	15263	
Poole	15383	
Poole	15270	
Poole	15240	
Poole	15273	
Poole	15235	
Rodbourne	12103	
Sherborne	13268	
Sutton Bingham	12111	
Sutton Poyntz	12112	
Taunton (Ham)	13305	
Trowbridge	14510	

Site Name	Wessex Water Site ID	NGR
Warmwell	13326	
Washpool	12118	
West Grimstead P.S.	11648	
West Wick	19833	
Weston-Super-Mare	15681	
Weston-Super-Mare (Black Rock)	13340	
Whychurch Tower & GT	11344	
Wickwar	13347	
Worle	15588	

Figure 1: Site Locations of Assets

Source: Mott MacDonald

2 Summary of Available Data

The table below summarises the data used in Phase 2 – Flood Risk Assessments. The data specific to each site is included in page 3 of each Site Summary Sheet in Appendix A.

Table 3: Data Used for this Assessment

Data Type	Source of Data	Comment
Site topographical survey	Wessex Water	Ground elevation data at the site. Provided for 31 of 56 sites
Site schematic	Wessex Water	Shows schematic operation of the site. Provided for 22 of 56 sites.
Historical flooding information	Wessex Water	1) NFFR Data Collection Template 2) STW Flood Resilience Review Database 3) WTW Flood Resilience Review Database 4) Flood Surveys North, South and West
Critical Equipment Drawings	Wessex Water	Marked up plans from Wessex Water site operators indicating the location of critical equipment
LIDAR data	Environment Agency	Publicly available data on ground level information, available in 1 and 2m grid resolution. Downloaded for all sites where available (54 of 56 sites).
OS Terrain 50 Data	Ordnance Survey	For two sites (Haselbury Plucknett and Corscombe), LIDAR data was unavailable. Terrain 50 Data is a free dataset from Ordnance Survey, providing terrain data with a 50m grid resolution.
Ordnance Survey 1:10,000 Mapping Tiles	Wessex Water	For background mapping
Flood Zone Mapping	Environment Agency	Publicly available
Hyder Flood Risk Assessment Reports	Wessex Water	1) 002-DV01482-DVR-00 Sewage Treatment Works and Pumping Stations Flood Vulnerability Assessments, Hyder, 2008 2) 5001-DV53311-DVR-01 Water Treatment Works Asset Resilience to Flooding – Summary Report and Site Specific Flood Risk Assessments, Hyder, 2008 Hyder Flood Risk Assessments and associated modelling files were available for 9 of the 56 sites. Some of these FRAs were accompanied by hydrological assessment and hydraulic modelling (HEC-RAS or ISIS software). Only some of the hydrological analysis and modelling files were made available for this assessment. Please see the site specific summary sheets for further information.
Data collected during site visits	Wessex Water	Location of critical equipment Photographs of critical equipment and surrounding site Historical flooding information
Risk of flooding from surface water	Environment Agency	https://flood-warning-information.service.gov.uk/long-term-flood-risk/
Risk of flooding from reservoirs	Environment Agency	https://flood-warning-information.service.gov.uk/long-term-flood-risk/
Watercourse Survey	Wessex Water	For the 9 sites where Hyder FRAs were available, watercourse survey was undertaken to inform the Hyder hydraulic modelling. The watercourse survey was available for 2 of these 9 studies.
Limited data on watercourse channel and structures	Obtained by Mott MacDonald during site visits	See Section 3.2

Data Type	Source of Data	Comment
Hydraulic Flood Models	Environment Agency	Flood models or data outputs from flood models were available from the Environment Agency for 20 of 56 sites.
Coastal Flood Boundary Data	Environment Agency	Used to inform flood risk for sites at risk of tidal flooding
Previous Flood Risk Assessments	Wessex Water	Previous flood risk assessments were available for 4 of the 56 sites. One of the FRAs (Durleigh) also had hydraulic modelling available.
Section 10 Reservoir Inspection Reports	Wessex Water	Section 10 reservoir reports were provided for 3 of the sites (Ashford, Sutton Bingham and Durleigh). The data from these were used to inform the hydrology. Further details can be found in the site summary sheets.
Hydrological Assessments	Mott MacDonald	35 ReFH hydrology assessment were conducted to inform the flood risk assessments. These were used to either compare against existing hydrological analyses or to estimate hydrology for sites where no hydrological information was available.
New Hydraulic Modelling	Mott MacDonald	24 new hydraulic models were constructed (1D and/or 2D) to inform the flood risk assessments. These were required for sites where no existing modelling was available, or the existing modelling was found to be unsuitable for the assessment.

Source: Mott MacDonald

3 Site Visits

3.1 Phase 1 Site Visits

Site visits were conducted at all 63 sites between 23 November and 14 December 2016. The purpose of the site visits was to:

- Accompany the site operator in identifying critical equipment at the site
- Record location and photographs of critical equipment
- Measure height above ground (or finished flood level) of critical equipment
- Collect other flood related information such as previous flooding history from the site operator
- Confirm recent or future works at the site

The resulting critical asset dataset produced during the site visits is summarised in each individual Site Summary Sheet in Appendix A.

3.2 Phase 2 Site Visits

Additional site visits were conducted in April 2016 at eight sites. The purpose of these site visits was to observe, and where possible, take rough measurements or make observations of key hydraulic features that may affect the assessment of flood risk at each site, for instance, river crossings or embankments. The data collected during these site visits were then incorporated into the hydraulic modelling to better understand flooding mechanisms.

Please note that the data collected during these visits does not constitute a formal watercourse survey but were important and considered appropriate given the high-level nature of the flood risk assessments.

Table 4: Phase 2 Site Visits

Site Name	Wessex Water Site ID
Corscombe	11729
Crewkerne	13084
Haselbury.Plucknett	13144
Balls Hill P.S.	11678
Heytesbury	12063
Rodbourne	12103
Charlton P.S.	12026
Wickwar	13347

4 Flood Risk Assessment

4.1 Summary of Flood Risk Assessment Approach

The flood risk assessment conducted at each site assessed the source of flooding from all potential sources for the following return periods:

- Fluvial flood risk (1 in 100 year, 1 in 1000 year event, present day and climate change)
- Tidal flood risk (1 in 200 year, 1 in 1000 year event, present day and climate change)
- Surface water flood risk (1 in 30 year, 100 year and 1000 year event)
- Risk of flooding from reservoirs

A more detailed description of the methods is provided in the following section and on page 3 and 4 of the Site Specific Summary Sheets in Appendix A.

4.2 Flood Risk Assessment Method

The method for conducting the flood risk assessment at each site was specifically tailored approach based on the data available for each site. A detailed summary of the methods is provided on page 3 and 4 of the Site Specific Summary Sheets in Appendix A.

The table below provides a high-level summary of the different categories of sites, and the methods used for each category.

Table 5: Summary of Flood Risk Assessment Method

Primary Source of Flood Risk	Assessment Method
Fluvial	Option 1: Use existing modelling results (provided by Wessex Water or Environment Agency), update/extrapolate to account for climate change or other updates such as hydrology. Use results to estimate flood levels on site.
	Option 2: Where no existing models are available, build simple 1D or 2D model to estimate flood risk at site.
Tidal	Coastal Flood Boundary data provided by the Environment Agency (upper bound) used to estimate extreme flood levels. Where required, an additional allowance for wave and tidal overtopping was applied as appropriate.
Surface water	Option 1: Where the surface water risk is the primary source of flooding, produce a simple 2D model to estimate flood levels on site.
	Option 2: Where the surface water risk is not the primary source of flooding, use existing Environment Agency Surface Water Flood Risk Mapping to estimate risk. https://flood-warning-information.service.gov.uk/long-term-flood-risk/
Groundwater	Environment Agency Area Susceptible to Groundwater Flooding Mapping
Reservoir	https://flood-warning-information.service.gov.uk/long-term-flood-risk/

Source: Mott MacDonald

4.3 Assessment of the impact of climate change

The base year for the flood risk assessment is set at 2025. This was defined by Wessex Water Ltd as it represents the end of Asset Management Programme (AMP) 7 and it is assumed that the proposed measures would be constructed by this time. The climate change horizon as defined by Wessex Water Ltd is 25 years, to 2050.

The impacts of climate change have been estimated using the latest Environment Agency guidelines, as provided in the National Planning Policy Framework Guidance (last updated 12 April 2016).

An assessment of the impact of climate change was made for both the Central and Upper End estimates for climate change allowances (for surface water and fluvial risk sites). For sites with influence from the sea and/or estuaries both the median bound and upper bound Coastal Flood Boundary data has been considered during the flood risk assessment as agreed with Wessex Water.

4.4 Assumptions and Limitations

The results from these high-level flood risk assessments are an indicative estimate only and are suitable to support the flood mitigation cost estimate for the PR19 Business Plan. The flood levels obtained in this assessment are not suitable for detailed design.

A list of assumptions and limitations specific to each site are provided in the Site Specific Summary Sheets in Appendix A.

5 Proposed Flood Mitigation Measures and Cost Estimate

5.1 General Approach

Based on the flood levels derived, a flood defence mitigation measure or measures have been proposed at each site to protect the site from extreme events up to and including the 1 in 1000 year return period event, under climate change conditions to 2050. It is assumed that the proposed mitigation measures would be constructed by 2025 (end of AMP7) with climate change horizon of 25 years.

In several instances, the estimated depth of flooding on site is so extreme that it would be difficult or extremely costly to defend the site to this standard of protection. In this instance, alternative measures have been proposed. Please see the individual site summary sheets for more detail.

Given the high-level nature of this project and lack of site specific data, the proposed mitigation options were filtered to a range of potential mitigation options are outlined that could be considered plausible for use to protect the sites.

5.2 Derivation of Flood Defence Crest Level

As per the instruction from Wessex Water, the flood defence threshold level of the proposed mitigation measure was determined from the larger of the two:

- 1 in 1000 year return period event under climate change conditions to 2050 (Upper End Allowance), not including freeboard
- 1 in 1000 year return period event under climate change conditions to 2050 (Central Allowance), including 300mm freeboard

For sites where the primary risk is from tidal sources, there is a single climate change allowance with no distinction between Upper End and Central allowance. Therefore, at tidal sites, the flood defence crest level of the proposed mitigation measure was determined from the larger of the two:

- 1 in 1000 year return period event under climate change conditions to 2050, using Upper Bound Coastal Flood Boundary data, not including freeboard
- 1 in 1000 year return period event under climate change conditions to 2050, using Median Bound Coastal Flood Boundary data, including 300mm freeboard

5.3 Choice of Flood Mitigation Measures

In order to meet the target level of flood resilience, an assessment of existing onsite flood risk was conducted at each site. The flood levels determined in this assessment have been used to inform the preferred flood resilience measures at each site.

A sequential approach was used to identify and develop suitable flood resilience measures, also with the aim of minimising impact to third parties:

- Can the site be relocated away from flood risk?
- Can the existing equipment be raised above flood levels?

- Can the existing equipment and key apparatus be protected locally?
- If a flood defence must be built to protect the entire site, can it be designed in such a way with the minimum footprint?
- Access and egress were taken into consideration, as well as operability of the site, to ensure that site operators and staff can safely and efficiently operate the site while also benefiting from increased flood resilience.

In all cases, it was assumed that the assets at each site would not be relocated to a lower risk site.

Therefore, a tiered approach to determine a cost-effective solution that also minimises impact to third parties was used to determine the preferred solution or combination of solutions with the following options. Any preference noted by the site operator was taken into account where possible.

<u>Raising Equipment</u>

- Raise control panel or kiosk
- Raise other equipment

<u>Local Protection</u>

- Building waterproofing (treatment to existing buildings- height varies)
- Localised cabinet protection (max 1m height)
- Localised cabinet protection (max 2.1m height)
- Flood doors
- Flood gate up to 1m
- Flood gate up to 2m

<u>Whole Site Protection</u>

- Earth bunding up to 2m height
- Walling up to 1m height
- Walling up to 2m height
- Walling up to 3m height
- Movable/demountable defence

<u>Other</u>

- Replace equipment with IP68 rating (low, medium or high complexity site banding)
- Other (site specific bespoke solution)

5.4 Cost Estimate for Flood Defences

A unit cost was developed for each of the flood mitigation options. An estimate was made for the sizing and number of the mitigations required, based on information from site layout plans, aerial photography and site visit photographs.

A list of assumptions and limitations for the cost estimate is provided in Section 6.3.

A table summarising the estimated flood defence costs are provided in Appendix 0.

5.5 Exceptions

Some unique sites are noted as follows:

Table 6: Sites with no proposed flood mitigation measures

Description	Number of Sites	Comment
Site not at risk of flooding	3 (Brianspuddle, Sutton Bingham, Ivyfields)	Based on our flood risk assessment, the site is not at risk of flooding. No mitigation measures proposed.
No ground level data available	2 (Corscombe, Haselbury Plucknett)	Ground level data in the form of topographical survey or LIDAR data not available. Terrain50 data was used as an alternative; this does not provide adequate resolution to estimate flood levels on site. Therefore, no mitigation measures are proposed. Further detailed study recommended to include commission of topographical survey.
Sites with extreme levels of flooding >2m depth	10 (Bath [2 sites], Burnham on Sea, Highbridge, Newton Meadows, West Wick, Weston Super Mare, Black Rock, Wickwar, Worle)	Our flood risk assessments indicate that some sites are at risk of flooding to extreme depths over 2m. In this case, based on Wessex Water guidance, it is unlikely that flood defences over 2m would meet operational, visual impact and safety requirements. Therefore, a reduced standard of protection or no flood mitigation measures have been proposed at these sites.

5.6 Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences

When permanent defences are proposed within a floodplain, it is possible that the obstruction to flow and reduction of floodplain storage due to the proposed defences may have a significant or even detrimental impact on flood risk elsewhere.

An estimate has been made on the likelihood and anticipated impact on flood risk to third parties due to the proposed defences. This is based on a qualitative estimate depending upon the source of flooding, likely floodplain extent and storage volume and the size of the proposed flood mitigation measures. It is not possible to quantify the potential impact to adjacent areas, especially the third parties for different magnitude events without detailed modelling. Therefore, our estimate is qualitative only.

This is an indicative estimate suitable for the level of assessment in this study. It is recommended that if further modelling is undertaken for detailed design of flood defence measures at these assets, that a quantitative assessment of the potential impact to third parties is assessed. If impacts to third parties are expected, mitigation measures such as flood compensation storage may be necessary to satisfy regulatory requirements.

6 Summary and Conclusion

6.1 Summary and Conclusion

Based on the results from the Flood Risk Assessment and proposed mitigation measures at each site, an indicative cost for the proposed flood mitigation measures has been developed for each site, to protect the site from extreme flood events. This indicative cost will feed into the Wessex Water Services Ltd PR19 Business Plan.

6.2 Recommendations for Future Work

It should be pointed out that the flood levels estimated for each site would requiring updating when the proposed mitigation measures move to detailed design stage. At this stage, we recommend the following additional work to inform the detailed design:

- Topographical survey of the site and surrounding area where required to confirm the levels of critical equipment
- Watercourse survey where required to inform detailed hydraulic modelling
- Detailed hydrological analysis and hydraulic modelling
- Quantitative assessment of impact to third parties to ensure proposed mitigation measures have no detrimental impact on flood risk to third parties
- Options appraisal and cost benefit analysis of potential flood mitigation solutions

6.3 Assumptions and Limitations

- Identification of critical equipment on site was made by Wessex Water Ltd site operators. Height of critical equipment above ground was estimated during site visits. The ground level at critical equipment was estimated from topographical survey where available, or from LIDAR data when not available.
- Flood level estimates are based on a high-level flood risk assessment using publicly available data and engineering judgement. When no flood modelling data was available, a simple 1D or 2D model was developed to estimate flood risk on site. The results from this assessment are not suitable for detailed design.
- All prices are based on 2017 costs.
- Cost estimates for building waterproofing, localised cabinet protection, flood doors, flood gates and demountable defences were provided by Total Flood Solutions Ltd (http://www.totalfloodsolutions.com/) in May 2017.
- Cost estimates for earth bunding and flood walls are based on estimates made by Mott MacDonald Ltd. quantity surveyors in May 2017.
- Unit costs include design, preliminaries, construction management and overhead. It does not include any OPEX operational or maintenance costs.
- No information is available with regard to the current ground conditions. An assumption of 1m foundation depth has been made for earth bunding and flood walls.
- All temporary works are assumed to be allowed within the x2 Indirect cost uplift
- It is assumed that all costs for surveys and as built drawings are included in the indirect percentages.
- No allowance has been made for piling or any ground stabilisation works

- No allowance has been made for the cost of any discharge licenses
- No allowance has been made for dewatering
- No allowance has been made for meeting any planning or environmental costs
- No allowance has been made for dealing with any hard material or soft ground
- No allowance has been made for dealing with any impact that the proposed works may have on any existing or proposed assets plant or foundations
- No allowance has been made for dealing with any contaminated material and that all arisings are of inert material.
- This work is assumed to be required as a stand-alone operation and not part of any wider scheme
- All works are assumed to be carried out during midweek day time working hours
- It is assumed that the working area is not impacted in any way by hazardous working conditions
- It is assumed that no working at height is required
- It is assumed that there are no restrictions to the works from overhead power or telephone lines
- It is assumed that the works will be carried out during 2017/18
- It is assumed that there are no restrictions to access
- No allowance has been made for any accommodation or temporary works
- Material prices are based on current market rates; no allowance has been made for future fluctuations in material supply costs
- It is assumed that suitable access is available to all the areas needed to carry out the works and no confined space or hazardous working conditions are present
- No allowance has been made for any restrictions placed on the works due to adverse weather conditions
- It is assumed that the works can be completed in one continuous visit to site.
- Please note that based on the current level of information the estimate is subject to plus or minus 0-60% uncertainty.
- Please note that no allowance has been made for any service diversions
- Building waterproofing does not include any cost for cable duct sealing
- For all prices on local cabinet protection, flood doors, gates, demountable defence: delivery price is included for 100miles from Llanelli as is the installation, assuming shared welfare is provided and that a minimum order value of £20k for each site or group of sites within a 10-mile radius.
- Cost estimate does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within the proposed flood mitigation measures.
- Building waterproofing surface area is calculated from Finished Flood Level.
- Costs for waterproofing of air vents, cable duct sealing or other potential entrance points are not included.
- Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties due to the construction of proposed defences. This is not included in the cost estimate.

- No detail is available on land ownership at each site. Proposed flood defences have been assumed to be within the site boundary. Additional costs for land purchase have not been included in the cost estimate.
- During detailed design, an assessment of the appropriate freeboard allowance should be made.
- In the event of inundation of open tanks, clean-up operations may be required. No allowance has been made for the cost of clean-up.
- It is assumed that cables and ducts on site are already sealed and that waterproofing sealing will be maintained. No allowance is made in our costs for cable/duct sealing.
- The cost estimates for raising equipment are based on a high level estimate. An assumption has been made for labour and cabling length, size, complexity of requirements.
- IP68 (submersible) rated equipment is only rated at IP68 for a period of time, with different equipment having different periods. Most are testing up to 24 or 48 hours. The equipment might still work after those durations but they have not been tested to that extent; the supplier will not be liable after that duration. The duration of flooding will vary from site to site.
- For the cost banding for replacement of IP68 rated (submersible) equipment, the following assumptions have been made:

		Typical Range	
Site Category	**Banded cost**	**Low Bound**	**High Bound**
small site, 1-2 pieces kit to be replaced which may include pumps, junction boxes, emergency stops, cabling. Not including replacement for any large motors, actuators, etc.	£7-15k	1 pump £3k junction box and emergency stop £1k cabling £2k 1 day labour £1000	2 pumps £10k junction boxes and emergency stops £1k cabling £2k 2 days labour £2000
medium site, 3-4 pieces kit to be replaced which may include pumps, junction boxes, emergency stops, cabling. Not including large motors, actuators	£23-40k	3 pumps £9k junction boxes and emergency stops £1k cabling £10k 3 days labour £3k	4 pumps £20k junction boxes and emergency stops £1k cabling £10k 8 days labour £8k
large site, 5+ pieces kit to be replaced which may include pumps, junction boxes, emergency stops, cabling. Potentially including specialised motors, actuators, etc.	£41-70k	3 pumps £9k 1 actuator £7k junction boxes and emergency stops £2k cabling £18k 5 days labour £5k	3 pumps £15k 1 specialised motor £15 1 actuator £7k junction boxes and emergency stops £2k cabling £18k 13 days labour £13k
Note: These are broad range estimates used to provide a typical banded cost for a typical site.			

7 References

- National Planning Policy Framework, Department for Communities and Local Government UK (2012). ISBN 978-1-4098-3413-7.
- Planning Practice Guidance web portal, Department for Communities and Local Government UK http://planningguidance.planningportal.gov.uk
- National Planning Policy Framework Guidance, "Flood risk assessments: climate change allowances", published 19 February 2016, last updated 12 April 2016. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
- Coastal flood boundary conditions for UK mainland and islands, Project: SC060064/TR4: Practical guidance design sea levels. ISBN: 978-1-84911-214-7, © Environment Agency – February 2011.
- 002-DV01482-DVR-00 Sewage Treatment Works and Pumping Stations Flood Vulnerability Assessments, Hyder, 2008
- 5001-DV53311-DVR-01 Water Treatment Works Asset Resilience to Flooding – Summary Report and Site Specific Flood Risk Assessments, Hyder, 2008.
- Long term flood risk assessment for locations in England: https://flood-warning-information.service.gov.uk/long-term-flood-risk/

Appendices

A. Flood Risk Assessment Summary Sheets

Table 7: List of Site Summary Sheets

Site Name	Mott MacDonald Site Code	Wessex Water Site ID	Site Type
Admiralty	SO_AD	12001	Source
Newton Meadows	SO_NM	12090	Source
BATH	SP_BA	14002	Sewage Pumping Station
BOURNEMOUTH	SP_BO	15019	Sewage Pumping Station
Bristol (Ashton Ave)	SP_BR	14016	Sewage Pumping Station
BURNHAM ON SEA	SP_BS	15341	Sewage Pumping Station
BATH	SP_BW	17142	Sewage Pumping Station
FERNDOWN	SP_FD	15078	Sewage Pumping Station
HIGHBRIDGE	SP_HB	14374	Sewage Pumping Station
MALMESBURY	SP_MA	14205	Sewage Pumping Station
POOLE	SP_PB	15240	Sewage Pumping Station
POOLE	SP_PF	15263	Sewage Pumping Station
POOLE	SP_PL	15273	Sewage Pumping Station
POOLE	SP_PS	15235	Sewage Pumping Station
POOLE	SP_PT	15270	Sewage Pumping Station
POOLE	SP_PW	15383	Sewage Pumping Station
TROWBRIDGE	SP_TB	14510	Sewage Pumping Station
WARMWELL	SP_WA	13326	Sewage Pumping Station
WESTON-SUPER-MARE	SP_WE	15681	Sewage Pumping Station
WORLE	SP_WO	15588	Sewage Pumping Station
Weston-Super-Mare (Black Rock)	SP_WS	13340	Sewage Pumping Station
WEST WICK	SP_WW	19833	Sewage Pumping Station
Burrowbridge	ST_BU	13040	Sewage Treatment Works
Crewkerne	ST_CR	13084	Sewage Treatment Works
East Lyng	ST_EL	18714	Sewage Treatment Works
Taunton (Ham)	ST_HA	13305	Sewage Treatment Works
Haselbury Plucknett	ST_HP	13144	Sewage Treatment Works
Lytchett Minster	ST_LM	13190	Sewage Treatment Works
Merriott	ST_ME	13208	Sewage Treatment Works
Sherborne	ST_SH	13268	Sewage Treatment Works
Wickwar	ST_WI	13347	Sewage Treatment Works
Bushfield P.S.	SU_BC	11467	Supply
Balls Hill P.S.	SU_BH	11678	Supply

Site Name	Mott MacDonald Site Code	Wessex Water Site ID	Site Type
Corscombe	SU_CC	11729	Sewage Pumping Station
Compton P.S.	SU_CO	12036	Supply
Charlton P.S.	SU_CT	12026	Supply
Fivehead P.S.	SU_FH	17220	Supply
Fiveways Valve Rotork chamber	SU_FW	11371	Supply
Ivyfields P.S.	SU_IF	12068	Supply
West Grimstead P.S.	SU_WG	11648	Supply
Whychurch Tower & GT	SU_WT	11344	Supply
Ashford	WT_AS	12004	Water Treatment Works
Brixton Deverill	WT_BD	12017	Water Treatment Works
Black Lane	WT_BL	12008	Water Treatment Works
Briantspuddle	WT_BP	12015	Water Treatment Works
Chitterne	WT_CH	12030	Water Treatment Works
Corfe Mullen	WT_CM	12038	Water Treatment Works
Dewlish	WT_DE	12043	Water Treatment Works
Durleigh	WT_DL	12049	Water Treatment Works
Durrington	WT_DU	12050	Water Treatment Works
Heytesbury	WT_HE	12063	Water Treatment Works
Newton Toney	WT_NT	12089	Water Treatment Works
Rodbourne	WT_RB	12103	Water Treatment Works
Sutton Bingham	WT_SB	12111	Water Treatment Works
Sutton Poyntz	WT_SP	12112	Water Treatment Works
Washpool	WT_WP	12118	Water Treatment Works

Wessex Water Site ID	Site Name	Admiralty	Post Code		
12001					
Site Type	NGR				
Source	Division	South	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Robert William Rawlings			
SO_AD	Contact Number	07825401068 S/D 602			

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Stour	EA Flood Warning Area	Parley, Corfe Mullen, Hampreston, Ferndown, Throop, Hurn, Bournemouth and Christchurch
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
22.27 (LIDAR) to 22.61 (LIDAR)	22.40 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	22.20	0.00	N/A	0.00			
			1 in 200 year (0.5%)	22.23	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	22.28	0.00	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	22.33	0.00	N/A	N/A			
			1 in 200 year (0.5%)	22.37	0.00					
			1 in 1000 year (0.1%)	22.43	0.06	N/A	N/A			
22.37			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Note: although the EA surface water map indicates surface water risk on site, our assessment indicates that fluvial risk is the primary risk at the site.

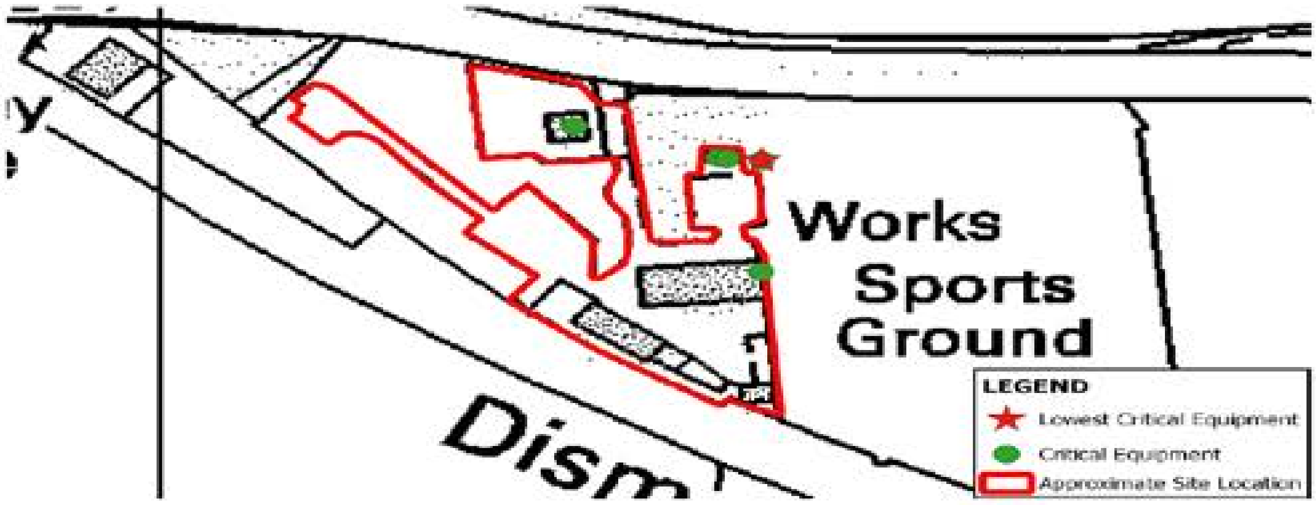
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Jeffrey Mail	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	28/11/2016	Attendees	Carrie Eller (MM) and Rob Rawlings (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Generator	22.37	22.43	22.53	22.53	0.16
Borehole pump 1 and 2 MCC	22.47	22.43	22.53	22.53	0.07
ICAs mains incomer	22.61	22.43	22.53	22.53	-0.08
Borehole isolator	23.27	22.43	22.53	22.53	-0.74
Borehole 2	23.37	22.43	22.53	22.53	-0.84

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. Water comes up through basement, but not necessarily direct from river. It would be good to have facility to pump out. Even under extreme flood conditions, this ingress was experienced. (Kieron Sloan, WW). 2. As per STW and WTW Flood Resilience Database, boreholes are strategically important sources of supply at times of heavy rain because other boreholes would have been lost to turbidity. 3. Road pollution is a concern for fissures leading to boreholes. Headwater plates are not raised to the required 300mm standard above ground. (Rob Rawlings, Site visit 28/11/2016)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. The brick building containing boreholes MCC is at risk of flooding 7cm above finish floor level. Revisions to the building to raise the building threshold, raise any air vents or other pathways of flooding into the site to be provided to a level 7cm above FFL.
2. The generator is located on a plinth covered with metal siding and is at risk of flooding 16cm above ground level. The critical equipment threshold level has been assumed as ground level, however it is noted by the site operator that some flooding is likely to be possible without flooding the generator. Therefore, flood mitigation measures have not been proposed at the generator. Please see comments box below for alternative options.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

22.53 mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	1

Comments

1. The following mitigation measures were considered:
a) raising of the generator on a concrete plinth. Given the low levels of flooding and the high cost of raising the generator, this solution has not been proposed.
b) localised cabinet protection is proposed for the areas affected. This method of protection should be considered together with an allowance for pumps to remove rainfall which falls within the footprint of the cabinet itself.
c) waterproofing of the existing building was considered, but given the low level of flooding (7cm above FFL) it was considered more cost effective to provide a simpler solution of a ramped flood protection around the building and raising of the door thresholds.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Waterproofing of the building and raising equipment will have a minor affect on floodplain storage and therefore the impacts are likely to be minimal.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

A previous FRA was undertaken for the site in 2008 by Hyder, based on 1D modelling of the Lower Stour with ISIS v3 software.

Site Topographical Survey

No site topographical survey is available for the site. Limited spot heights at locations within the site bounds are available from the previous Hyder FRA report.

Watercourse Survey

The cross sections used in the previous Hyder FRA are availabe, however no watercourse survey was provided for this assessment.

Environment Agency / Local Authority Existing Studies

The Lower Stour Model and Flood Study (2006) was supplied by the Environment Agency for the review and use in this Flood Risk Assessment.

Details of Existing Study

Fluvial Hydrology

1. Hyder Study
The hydrological assessment was carried out using ReFH, Gauged donors and pooled catchment descriptors, with the pooled catchment descriptors selected as a most conservative estimate.
2. Lower Stour Study
The Lower Stour modelling used a combination of FEH Statistical, Rainfall Runoff and urban drainage methods to generate hydrology for the catchment. The hybrid methodology was used to best represent both the urban and non-urban portions of the catchment.

Tidal Hydrology

1. Hyder Study
This model extent was local to the area surrounding the Wessex Water site and did not extend to the tidal portion of the Lower Stour.
2. Lower Stour Study
Spring tidal curves for Christchurch Harbour were applied at Priory Quay with sensitivity testing of tidal surge completed on the model. The limit of influence of the tidal boundary on the model performance is far downstream of the site, at the A338 Bridge. Therefore the risk of tidal flooding at the site is minimal.

Study Extent

Hydraulic Model Construction

1. Hyder Study
A detailed 1-D unsteady hydraulic model has been built using ISIS V3 for the catchment upstream and downstream of the site. The extent of the model is approximately 400m upstream of the site and 1km downstream of the site. The inflow to the model is included as an unsteady flow/time boundary, and the downstream boundary was included as the Normal/Critical Depth Boundary.
2. Lower Stour Study
The Lower Stour model copmrises a TUFLOW-ESTRY 1D-2D schematisation, with varying 2D grid sizes depending on the area modelled. Urban areas were assigned smaller grid sizes than typically flatter, open areas. The river channel consists of 1d cross sections, surveyed between 2005 and 2006, including structures.

Return Periods Assessed in Model

1. Hyder Study
25, 50, 100 year return periods with 100 year climate change scenario.
2. Lower Stour Study
2, 5, 10, 25, 50, 75, 100, 200, 1000 year return periods with 100 year climate change scenario.

Comments

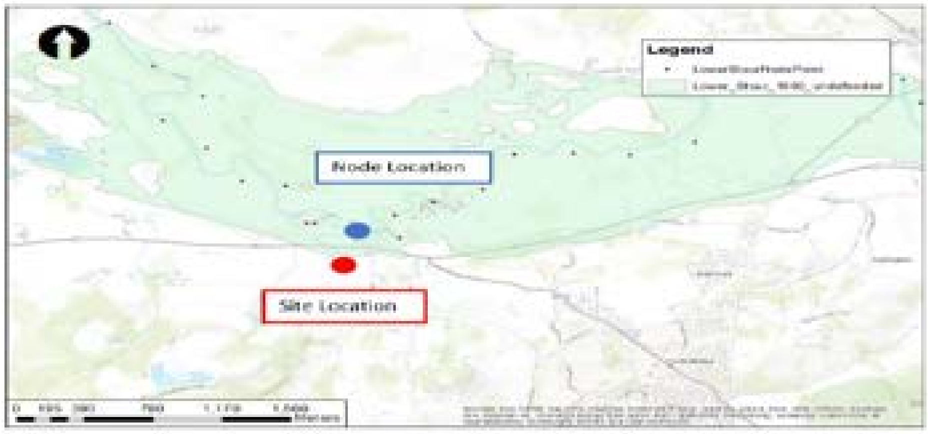
1. Hyder Study
The study made an assessment of climate change limited to a 20% increase in catchment inflows. The model was also sensitive to the manning's n parameter adopted, with sensitivity checks revealing large variations in flow. This modelling is limited, without calibration and validation of the results due to the lack of data available.
2. Lower Stour Study
The existing analysis of the hydrology was judged to be an accurate representation of the catchment, and suitable for use in this risk assessment. The modelling results from this Lower Stour study were used in our analysis of flooding at Admiralty.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial, from the River Stour

Supporting Figure



Fluvial Hydrology

The hydrological calculations summarised in the Lower Stour Hydraulic Model and Flood Study Report to the Environment Agency were reviewed and found to be an appropriate representation of the catchment for the purpose of this flood risk assessment.

Tidal Hydrology

N/A

Summary of Approach

1. The Lower Stour Model is reviewed to find previously modelled flood levels in the vicinity of the site.
2. The schematisation of hydraulic structures within the existing model, which could influence flooding in the area, is assessed.
3. The previously modelled results are extracted from the model and compared with other sources of flooding information such as EA flood maps.
4. Extrapolation of the results from the previous modelling is made to reveal likely flooding for return periods not included in previous assessment.
5. The latest guidance from climate change projections is applied to model results to reveal likely flood levels in the future.

Hydraulic Modelling

The relationship between fluvial flood flow and the water level was reviewed by hydraulic modellers. Engineering judgement was used in the extrapolation of these results to yield future climate change results, based on the known response of the area to increases in fluvial flows, informed by the Lower Stour modelling. Further hydraulic modelling was not undertaken for this study.

Results

Results indicate that the site and critical equipment are at risk of flooding. Resulting flood levels are shown on pages 1 and 2.

Comparison to previous studies / data

The results from the Hyder 2008 study are generally quite similar to the EA supplied model results. The Hyder results indicate slightly increased flood levels with respect to the Lower Stour EA model. The EA model was considered a more appropriate indication of flood levels as it considers the wider river system and is not a localised model which relies on assumptions of boundary conditions in the vicinity.

Assumptions and Limitations

1. Calibration of the Lower Stour model was based mainly on events between 5 and 10 year return period events.
2. The results indicate flooding from a single duration storm. Further modelling of varying storm durations and analysis of the results to create a composite dataset would be required to ensure that the results indicate the worst case flooding in all portions of the model.
3. The impact of surface water flooding was not incorporated into the modelling.
4. LIDAR accuracy varies around the urban portions of the modelling.
5. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

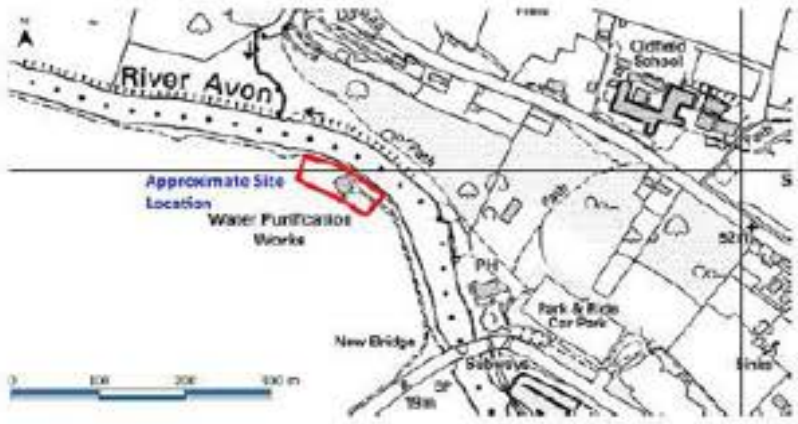
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

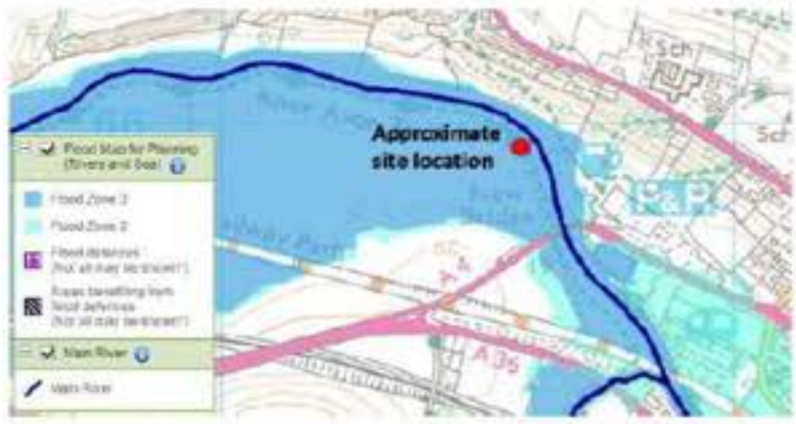
Wessex Water Site ID	Site Name	Newton Meadows	Post Code	
12000				
Site Type	NGR			
Source	Division	North	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Marc Hodgson		
SO_NM	Contact Number	07768036421		

Site Plan

Location Plan



Environment Agency Flood Map

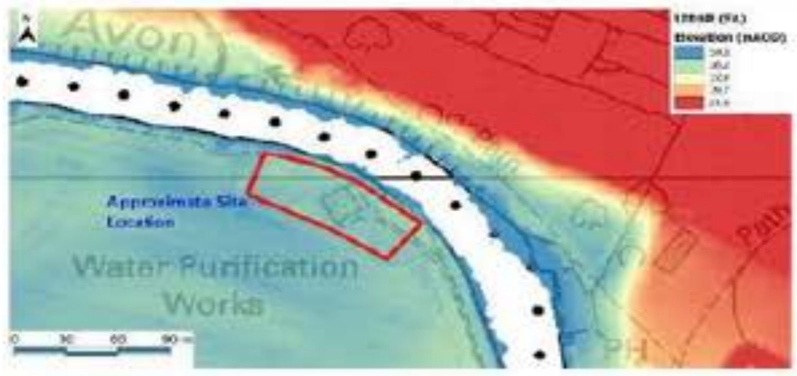


Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Avon	EA Flood Warning Area	Bristol Avon from New Bridge to Netham
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal Level (mAOD)	Fluvial / Coastal Depth (m)	Surface Water Level (mAOD)	Surface Water Depth (m)	Ground Water Flooding Susceptibility	Reservoir Level (mAOD)	Reservoir Depth (m)
15.07 (LIDAR) to 15.60 (LIDAR)	15.3 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	16.97	1.68	N/A	0.00			
			1 in 200 year (0.5%)	17.30	2.01					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	17.87	2.58	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	17.26	1.97	N/A	N/A			
			1 in 200 year (0.5%)	17.58	2.29					
15.29			1 in 1000 year (0.1%)	18.00	2.79	N/A	N/A			
			Groundwater flooding					Low		
			Reservoir							0.3-2.0

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

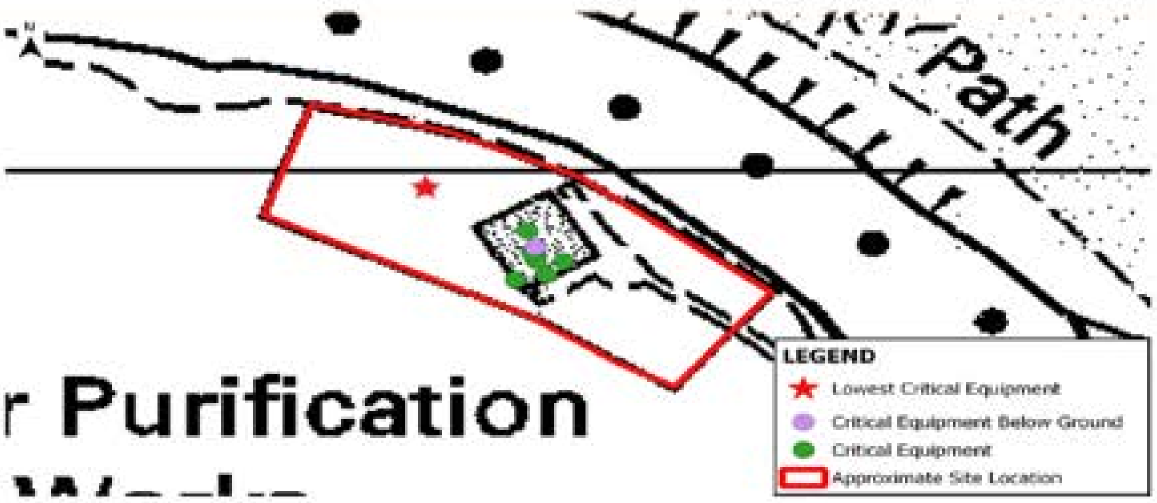
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Bill O'Leary	Kelsey Plech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	30/11/2016	Attendees	David Tinning (MM) and Kieron Sloan (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Mains Pipe (Bristol Water Inlet)	15.39	18.08	18.11	18.11	2.72
Septic Tank	15.29	18.08	18.11	18.11	2.82
Piping	15.32	18.08	18.11	18.11	2.79
Chlorine Dosing	15.58	18.08	18.11	18.11	2.53
Actuator	15.83	18.08	18.11	18.11	2.28
Chlorine Gas Store	17.69	18.08	18.11	18.11	0.42
Control Panel Room	17.72	18.08	18.11	18.11	0.39
Treatment Room	17.95	18.08	18.11	18.11	0.16

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
None	1. Both piping and Mains pipe, are below ground level. 2. The mains pipe is 1.50m below ground level. Its lowest critical equipment level is at 13.88 mAOD.

Phase 2 Mitigation Assessment

Flood Defence Description

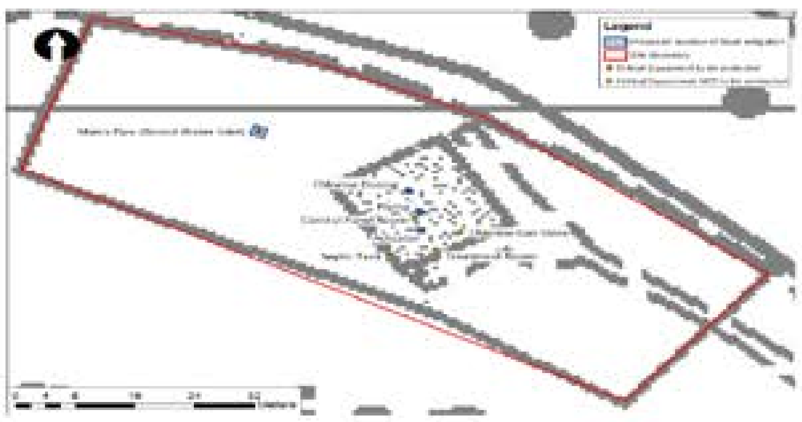
NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event.

1. Equipment to be replaced with IP68 rated equipment where possible (Mains Pipe (Bristol Water Inlet), Piping, Chlorine Dosing and actuator, inclusive of junction boxes, emergency stops, instrumentation).
2. Equipment already raised within the existing building including the Chlorine gas store, Control panel room and the Treatment room will not receive protective measures due to already being raised and the difficulty in providing protection to non ground floor structures.
3. Equipment not to be protected includes the septic tank. Wessex Water has confirmed the septic tank is not critical.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

N/A - varies

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	High
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation options were considered but not chosen as the preferred solution for the following reasons:
a) whole site protection with a 2m high wall (Wessex Water maximum practical height) was considered but not preferred as this wall height will not protect to the design crest level for the 1000yr event including climate change.
b) raising or waterproofing the building (Chlorine gas store, Control Panel room and Treatment room) was considered but not preferred due to the complexity of modifying the building. The existing building is unsuitable for raising these items up to 0.42m in height.
2. The proposed mitigation provides a standard of protection less than the 1000yr+CC flood event. However the IP68 rating of replacement electrical equipment will speed up recovery time after the occurence of flooding.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligible. The IP68 rated upgrades do not reduce the storage available to the floodplain, and impacts to the flooding will be limited.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

None Available

Site Topographical Survey

TOPO is available in .dwg
Name of the file:
SO_NM_12090 NEWTON MEADOWS topo_20161122.dwg

Watercourse Survey

No watercourse survey was commissioned for either the 2006 or 2013 models. Instead cross-sectional information was obtained from a previous model, the Bristol Avon Flood Forecasting Model.

Environment Agency / Local Authority Existing Studies

Environment Agency models Avon (2006) and Bath (2013) were provided for the study, both 1D/2D ISIS/TUFLOW models cover the site.
As the 2013 study is more recent, this model has been used to derive flood levels at the site.

Details of Existing Study

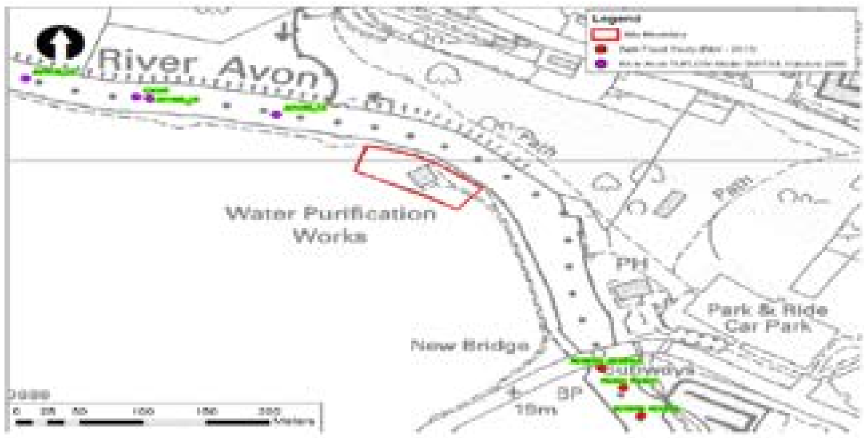
Fluvial Hydrology

Hydrology in the models were based on a previous 1D ISIS model created in (2004). This model used gauged flows where available and for ungauged tributaries the flow was scaled according to the ungauged catchment area.

Tidal Hydrology

None

Study Extent



Hydraulic Model Construction

EA Avon (2006) Model is a 1D/2D ISIS/TUFLOW model of the River Avon which passes the site with the downstream boundary at Avonmouth and the upstream extent at Bathford.
The Avon (2006) Model is based on survey data used in previous modelling studies.
Manning's n values in the 1D section of the Avon (2006) model were 0.04 in the Channel and 0.07 on the floodplain.

EA Bath (2013) Model is a 1D/2D ISIS/TUFLOW Model based on the Avon (2006) model but with reduced extents to cover only the River Avon through Bath.
The downstream boundary of the model is located at New Bridge which is approximately 225m upstream of the site.

Neither of these models include the bridge downstream of the site where the disused railway line crosses the River Avon.
There is an error in some of the information provided by the EA in that cross-section CS135 appears to be close to the site in the Geo-referenced information which has been provided. This cross-section actually represents a location close to Bristol.

Return Periods Assessed in Model

EA Avon (2006) Model assessed the 10yr, 25yr, 50yr, 75yr, 100yr, 100yrCC, 200yr and 1000yr.
EA Bath (2013) Model assessed the: 2yr, 5yr, 10yr, 20yr, 20yrCC(+20%), 30yr, 50yr, 75yr, 100yr, 100yrCC(+20%), 100yrCC(+30%), 200yr and 1000yr

Comments

The closest River Avon (2006) model node is located approximately 80m downstream of the site.
The Bath (2013) model ends approximately 225m upstream of the site.
Results have been interpolated and extrapolated between these two models to determine flood levels at the site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

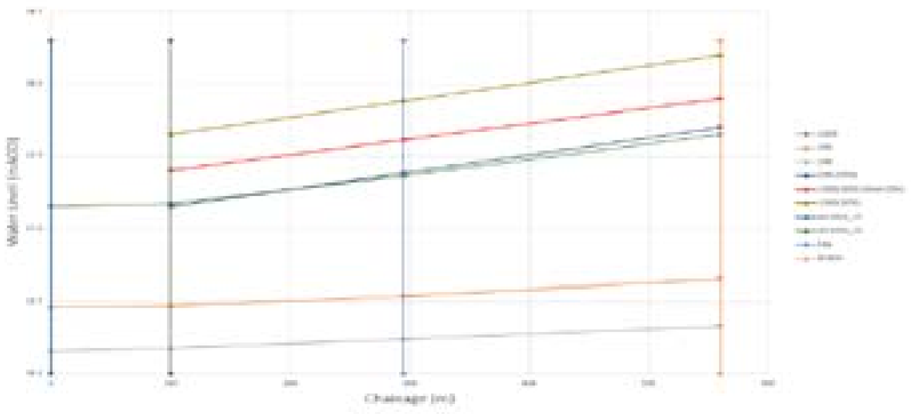
Fluvial Hydrology

Climate change allowance accounted for by adding 25% (2025) and 40% (2050) to design flows from the previous EA Bath (2013) Model.

Tidal Hydrology

N/A

Supporting Figure



Summary of Approach

1. Modelled levels were interpolated in order to obtain 100yr, 200yr and 1000yr water levels at the site.
2. A Level/Flow comparison was carried out to identify how peak water level increases with increased flow in the existing (modelled) return periods.
3. Extrapolations of this relationship were made in order to estimate the peak water level for the design flows.
4. The extrapolation was amended taking into account water levels from the 2D model results from the Avon (2006) Model at the site.

Hydraulic Modelling

The relationship between fluvial flood flow and the water level was reviewed by hydraulic modellers. Engineering judgement was used in the extrapolation of these results to yield future climate change results, based on the known response of the area to increases in fluvial flows, informed by the EA Bath (2013) modelling. No further hydraulic modelling was undertaken for this assessment.

Results

The results indicate that the site is at risk of flooding under the 1 in 1000yr plus climate change (to 2050) conditions. The resulting flood levels are shown on page 1 and 2.

Comparison to previous studies / data

1. This assessment was carried out with reference to the EA Avon (2006) Model and Bath (2013) Model.
2. Based on the EA flood zone map, the 1000yr flood level is approximately 17.0mAOD in the vicinity of the site. Based on the updated assessment, the 1000yr level is 17.56mAOD, about 0.50m higher than the flood zone mapping results. The EA flood zone map is a catchment wide study and is not site specific.

Assumptions and Limitations

Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
The approach assumes a linear relationship between peak water levels in upstream and downstream 1D nodes taken from two separate models nodes.
The design peak water levels at the 1D nodes (upon which the levels at the site are based), are derived by extrapolating the flow/level curve.
In excluding the bridge for the disused railway line downstream of the site, the model does not capture any potential backing up of water level from this bridge. This is considered acceptable as a large proportion of the length of the railway embankment is below 18mAOD in level and therefore there will be significant alternative flow routes during flooding of this magnitude.

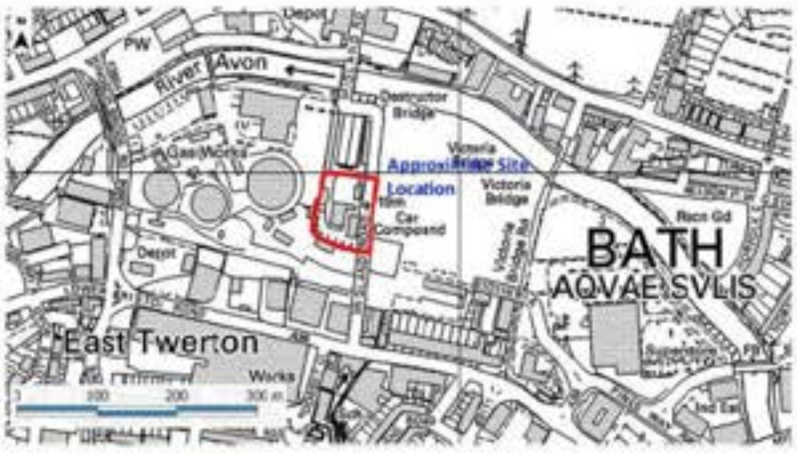
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	BATH	Post Code		
14002					
Site Type	NGR				
Sewage Pumping Station	Division	North	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Steven David Coombs			
SP_BA	Contact Number	07500128066			

Site Plan

Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Avon	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
18.16 (LIDAR) to 21.55 (LIDAR)	18.75 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	19.72	1.56	N/A	0.00			
			1 in 200 year (0.5%)	20.11	1.95					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	20.77	2.61	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	20.05	1.89	N/A	N/A			
			1 in 200 year (0.5%)	20.42	2.26					
18.16			1 in 1000 year (0.1%)	21.17	3.01	N/A	N/A			
			Groundwater flooding					Medium susceptibility		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	David Tinning (MM), Julian Collins (WW) and Russ Burgham (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Substation	18.16	21.17	20.96	21.17	3.01
Transformer	19.37	21.17	20.96	21.17	1.80
Main Control Room	19.28	21.17	20.96	21.17	1.89
Liquid Oxygen Panels	19.86	21.17	20.96	21.17	1.31
Actuator	19.74	21.17	20.96	21.17	1.43
	0.00				

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. Site has not flooded recently. Flood defences have helped. (Julian Collins and Russ Burgham, Site visit 02/12/2016) 2. This is located in Western Riverside which has built flood defences (Julian and Stephen, 27/01/2017).	NONE

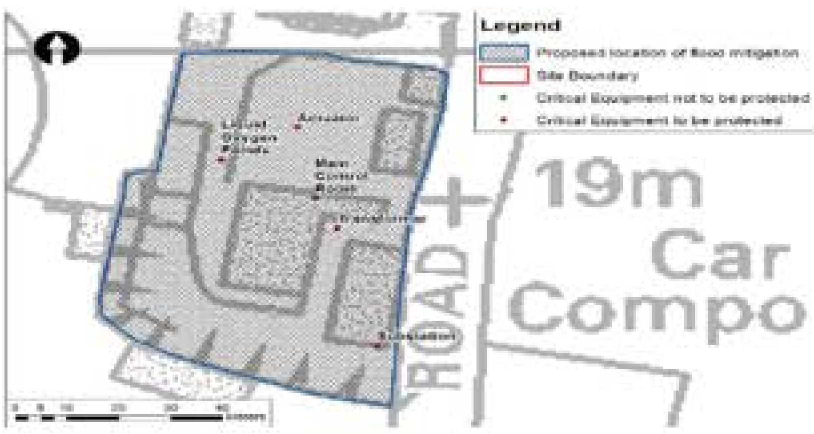
Phase 2 Mitigation Assessment

Flood Defence Description

NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event.

1. The transformer, Western Power substation, liquid oxygen panels, actuator and building housing the main control room should be protected by a wall of 2m height including a flood gate for access.
2. Equipment to be replaced with IP68 rated equipment where possible (actuator and liquid oxygen panels, inclusive of junction boxes, emergency stops, instrumentation).

Flood Defence Layout



Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

Note: the proposed measures provide a standard of protection less than the 1000yr+CC event.

Maximum Defence height of 2.00m. Crest Level of Defences varies with ground level, minimum defence level of 20.16mAOD

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	280
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	1
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation options were considered but not chosen as the preferred solution for the following reasons:
a) whole site protection with a 3m wall was considered but not preferred due to advice from Wessex Water on a practical maximum wall height of 2m.
b) raising or waterproofing the building (control room) was considered but not preferred due to the complexity of modifying the building. The existing building is unsuitable for raising of the control panel by over 1.5m.

2. Assuming that walls cannot be constructed over a maximum height of 2m, the proposed mitigation provides a standard of protection less than the 1000yr+CC flood event.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Significant. This site is located in a residential area, is at risk from fluvial flooding and blocks a significant cross-sectional area of the floodplain on the south bank of the River Avon. Defences are therefore likely to have a significant impact on peak water levels.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

None Available

Site Topographical Survey

No site topographical survey is available for the site.

Environment Agency / Local Authority Existing Studies

Environment Agency models Avon (2006) and Bath (2013) were provided for the study, both 1D/2D ISIS/TUFLOW models cover the site.
As the 2013 study is more recent, this model has been used to derive flood levels at the site.

Watercourse Survey

No watercourse survey was commissioned for either the 2006 or 2013 models. Instead cross-sectional information was obtained from the Bristol Avon Flood Forecasting Model.

Details of Existing Study

Fluvial Hydrology

Hydrology in the models were based on a previous 1D ISIS model created in (2004). This model used gauged flows where available and for ungauged tributaries the flow was scaled according to the ungauged catchment area.

Study Extent

Tidal Hydrology

Not Applicable

Hydraulic Model Construction

Environment Agency Bath (2013) model:
Schematisation: 1D/2D ISIS/TUFLOW Models
Upstream Extent: Bathford
Downstream Extent: Newbridge Road Bridge
1D Sections: Based on previous modelling
2D Domain: Based on LIDAR
Fluvial Flows: Taken from the Corston to Avonmouth Flood Zone Compliance Project (Halcrow (2007)

Return Periods Assessed in Model

EA Bath (2013) assessed the: 2yr, 5yr, 10yr, 20yr, 20yr+CC(20%), 30yr, 50yr, 75yr, 100yr, 100yr+CC(20%), 100yr+CC(30%), 200yr and 1000yr

Comments

1D and 2D modelling results (levels and flows) have been provided for the range of return periods. These results have been used to carry out the site specific Flood Level Assessment.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

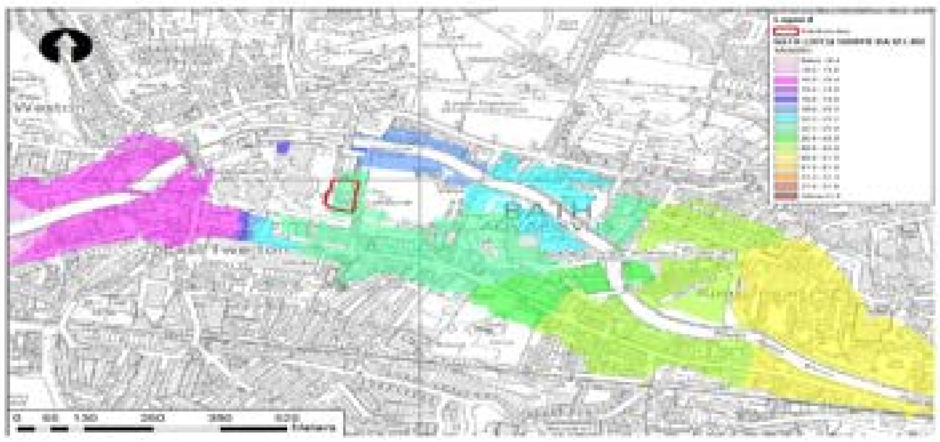
Fluvial Hydrology

Climate change allowance accounted for by adding 25% (2025) and 40% (2050) to design flows from the previous EA Bath (2013) Model.

Tidal Hydrology

N/A

Supporting Figure



Summary of Approach

1. A Level/Flow comparison is carried out to identify how peak water level increases with increased flow in the existing (modelled) return periods. Then interpolation/extrapolation is conducted in order to esstimate the peak water level for the design flows. This is performed for multiple 1D model nodes in the vicinity of the site. Similarly, Level/Flow comparison is completed on 2D levels in the vicinity of the site.
2. The above comparisons are compared to adopt the most consistent relationship between the increase of flows in the channel and peak water levels on the site. The most reliable relationship is selected to interpolated/extrapolate peak water levels on the site for the design flows.
3. A third approach is carried out comparing modelled 1000yr level at the site and the level obtained by conveyance testing, applying a constance level difference along the whole watercourse. This provides an estimated long-section along the River Avon through Bath. The soffits and deck heights of all the bridges (modelled and not modelled) are then included and the long-section amended using engineering judgement in order to estimate the impact of the bridges on water levels. A similar process is then undertaken using a long-section along the floodplain, following the route of the flooded Lower Bristol Road from the bottom of the Wells Road downstream to the junction with Twerton High Street.

Hydraulic Modelling

Additional hydraulic modelling not undertaken at this site. The existing EA Bath (2013) model was used to inform the assessment.

Results

The results indicate that the site is at risk of flooding under the 1 in 1000yr plus climate change (to 2050) conditions. The resulting flood levels are shown on page 1 and 2.

Comparison to previous studies / data

This assessment was carried out with reference to two previous 1D/2D modelling studies (the Bath (2013) model and the Avon (2006) model). The design levels in this assessment are extrapolated from the levels in the Bath (2013) Model.

Assumptions and Limitations

1. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
2. It is assumed that the Environment Agency approved models (Bath (2013), Avon (2006)) which have been referenced in this assessment are reasonable and the information used in these models is representative.
3. Up-to-date EA guidance has been used in order to estimate the potential impact of climate change on flows in the River Avon.
4. LIDAR data has been used to estimate the Ground Levels on the site. Typically this data is accurate to approximately +/-150mm.
5. The pieces of critical equipment identified in the summary sheet are limited to those which were identified by Wessex Water. The summary sheet is not intended to assess what equipment is critical.
6. Where available, information regarding the geometry of the bridges on the River Avon has been drawn from the existing modelling. Where there was no information, estimates have been carried out using photographic evidence and reviewing LIDAR.
7. There has been widespread development on the banks of the River Avon in Bath surrounding this site which may mean that the modelling is out-of-date and the flow routes shown in the modelling may be incorrect.

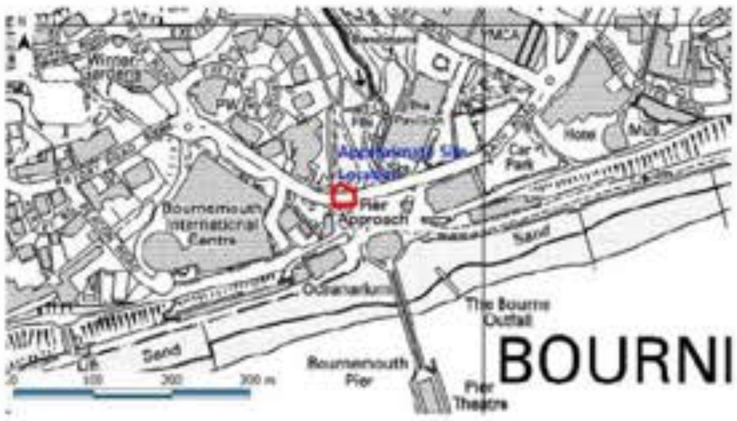
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

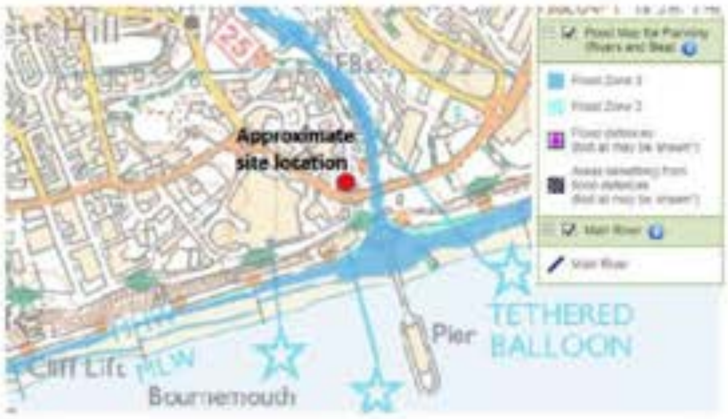
Wessex Water Site ID	Site Name	BOURNEMOUTH	Post Code		
15019					
Site Type	NGR				
Sewage Pumping Station	Division	South	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Mark Bailey			
SP_BO	Contact Number	07884234605 (329)			

Site Plan

Location Plan

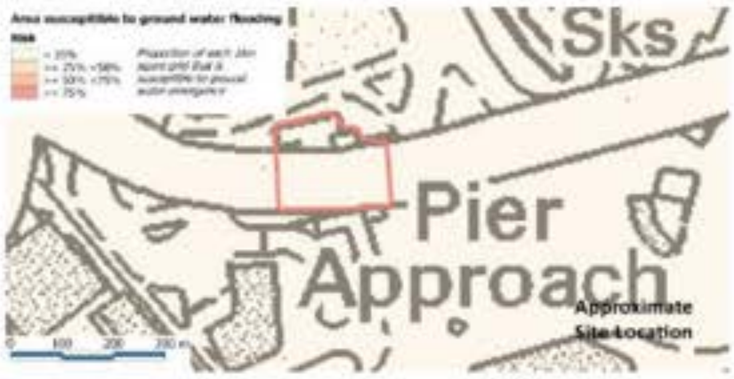


Environment Agency Flood Map



Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Poole Bay and the Bourne	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
5.25 (LIDAR) to 6.4 (LIDAR)*	5.8 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	5.50	0.24	N/A	0.00			
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 200 year (0.5%)	5.53	0.27					
			1 in 1000 year (0.1%)	5.60	0.34	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	5.52	0.26	N/A	N/A			
			1 in 200 year (0.5%)	5.54	0.28					
			1 in 1000 year (0.1%)	5.63	0.37	N/A	N/A			
5.26			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 2, 3 and 4 of this summary sheet.
Flood levels are based on fluvial risk from the River Bourne. Fluvial risk exceeds coastal risk at this site.
*Note: topographical survey not available. Because site is located partly beneath a bridge, LIDAR data is not representative of ground levels. Based on the site visit and engineering judgment, ground levels have been estimated but have a high degree of uncertainty.

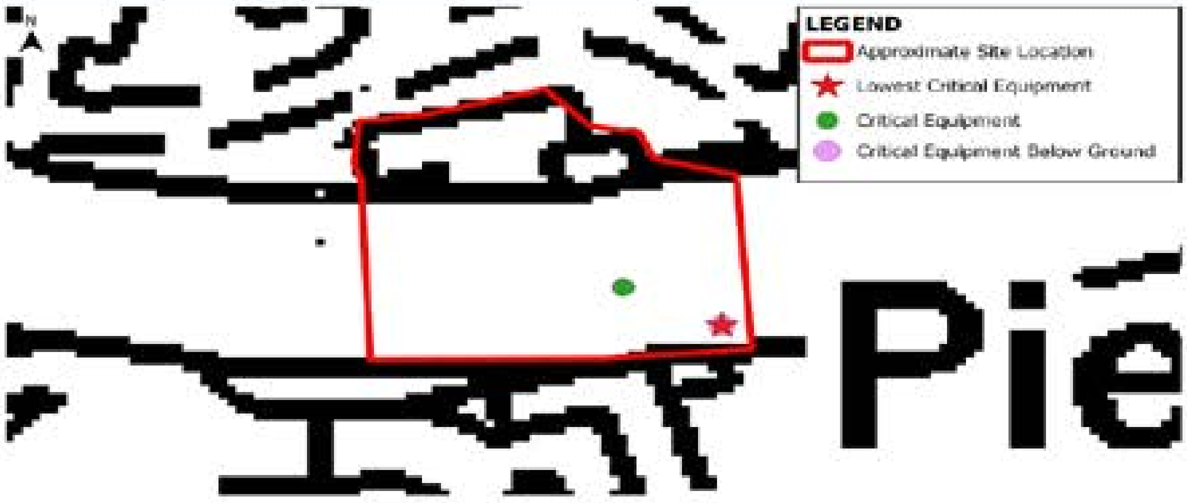
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Enrique Flores Diaz	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	Carrie Eller (MM) and Dave Whitelock (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Pumps in basement. Transformer would knock it out	5.26	5.63	5.90	5.90	0.64
Control panels, mains incomer, pumps and screens	5.26	5.63	5.90	5.90	0.64

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. River through gardens around the back of the site gets high and floods in heavy rain. (Dave Whitelock, Site visit 01/12/2016)	1. Pump is in basement and its level is at -1.88mAOD. If the electrical joining boxes, which are located in the basement (having approx. level as -0.88mAOD), get flooded then pump would stop working. Therefore, electrical joining boxes for pumps should be considered as lowest critical equipment. (Dave Whitelock, Site visit 01/12/2016) 2. As per our assessment, the electrical joining boxes would start to inundate once the flood water reaches the ground level (5.17m).

Phase 2 Mitigation Assessment

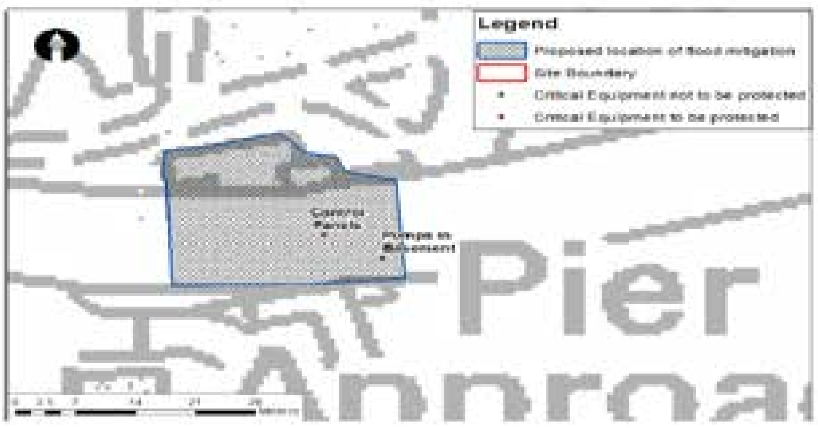
Flood Defence Description

Building waterproofing and flood doors are proposed as flood mitigation measures for the building which contains control panels, mains incomer, pumps and screen and the pumps in the basement.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

5.90mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The area of waterproofing proposed for the buildings containing the critical equipment was calculated assuming flat ground whereas (based on LIDAR) the ground is sloping up to ~1.5m.

2. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection was not preferred given the location of the building beneath a road bridge.
b) local protection would be difficult given that the lowest critical equipment is located in the basement.
c) raising equipment was considered but dismissed as the required height for raising could cause headroom issues in the basement room.

General caveat: Indicated scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within the proposed flood mitigation measures. Building waterproofing surface area is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigation impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent the site.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

No FRA was available for this site.

Site Topographical Survey

No site topographical survey is available for the site.

Watercourse Survey

Cross-sectional data was extracted from LIDAR

Environment Agency / Local Authority Existing Studies

Not available

Details of Existing Study

Fluvial Hydrology

Not available

Tidal Hydrology

Not available

Study Extent

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

n/a

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

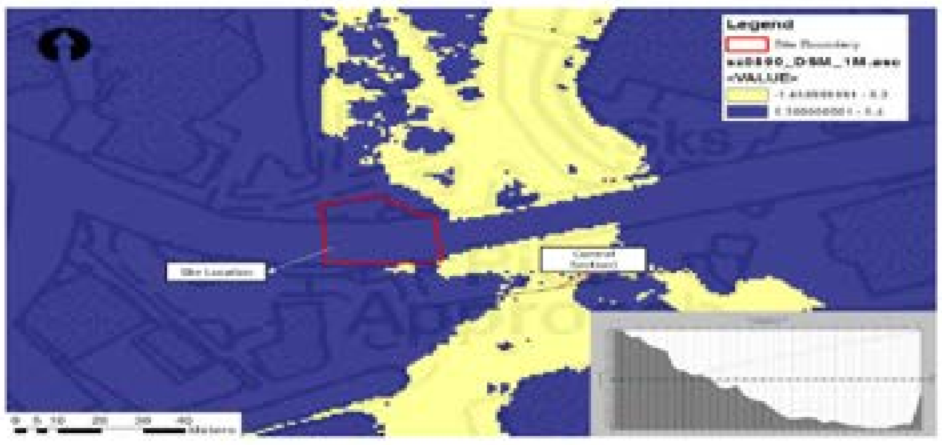
Fluvial Hydrology

Derived by Mott MacDonald using ReFH method.

Tidal Hydrology

Site ground levels were compared against CFB data (1000yr under 2050 climate change + upper bound = 2.59mAOD) and the risk was found lower than the fluvial risk.

Supporting Figure



Summary of Approach

1. The control section was identified analysing LIDAR and using engineering judment.
2. The stage-discharge relationship in the control section was calculated using the conveyance function in the ISIS software.
3. The Manning's values (0.045) were obtained from recommended literature (Chow, 1989).
4. The water levels for all the return periods were obtained using the hydrology obtained using ReFH.

Hydraulic Modelling

Not carried out

Results

Levels were obtained using a stage-discharge relationship. The results show shallow flooding for the larger events and no flooding that would affect the critical equipment.The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. No other studies were available. EA flood maps information was discarded as it was found it did not match with the LIDAR contours.
2. The gardens at the north of the site have elevations below 5mAOD, as per our assessment they would have over 1m depth of flooding for the 1000yr plus Climate Change return period event. This corroborates information obtained during the sites visit about this gardens flooding during high intensity events.

Assumptions and Limitations

1. The impact of hydraulic structures is not considered in this assessment.
2. The selected section is considered a control section to the floodplain.
3. Cross section (channel and floodplain) are extracted from the latest EA LiDAR (1m resolution).
4. No hydraulic model was available and thus the EA flood map was taken as a reference.
5. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Bristol (Ashton Ave)	**Post Code**	
14016				
Site Type	**NGR**			
Sewage Pumping Station	**Division**	North	**Flood Resilience Design Life (years)**	25
Mott MacDonald Site Code	**Controller**	Mark James Cooper		
SP_BR	**Contact Number**	07776226970		

Site Plan

Location Plan

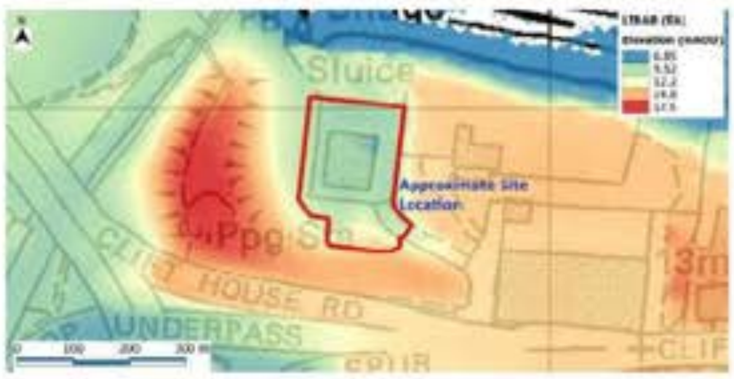
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Tidal	**Existing Flood Defence**	No
Main Flooding Source	River Avon	**EA Flood Warning Area**	Low lying property and roads along the River Avon from Sea Mills to Conham including Sea Mills Road
Current Site Flood Zone	Flood Zone 1*	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
9.13 to 9.63 (TOPO)	9.26 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	9.42	0.00	N/A	0.00			
			1 in 200 year (0.5%)	9.60	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	9.98	0.32	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	9.60	0.00	N/A	N/A			
			1 in 200 year (0.5%)	9.78	0.12					
9.66			1 in 1000 year (0.1%)	10.17	0.51	N/A	N/A			
			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Bill O'Leary	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	08/12/2016	Attendees	Carrie Eller (MM) and Chris D (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Control panels for mains incomer, pumps	9.66	10.17	10.02	10.17	0.51
Control panels in secondary room	9.66	10.17	10.02	10.17	0.51
Storm pump joining boxes	10.63	10.17	10.02	10.17	-0.46
Sewage pump junction box	10.72	10.17	10.02	10.17	-0.55

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. The site has not observed any recent flooding. Sewers have inlet valves into the site that automatically shut-off if it gets full. (Chris D., Site visit 08/12/2016)	NONE

Phase 2 Mitigation Assessment

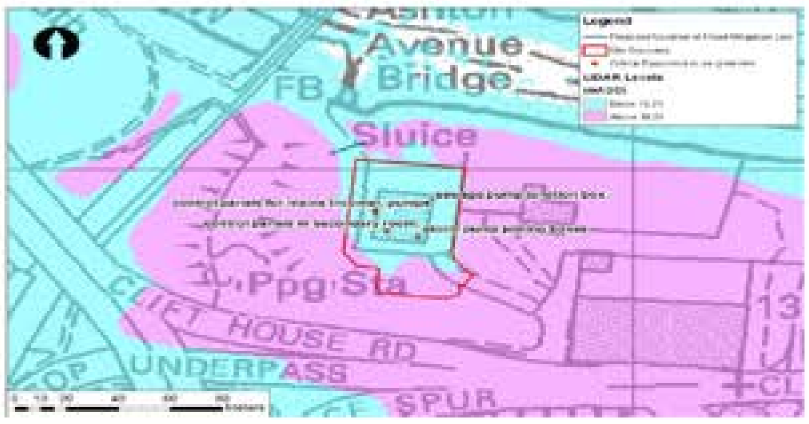
Flood Defence Description

1. The entire site should be protected by a wall of 2m height connecting two areas of higher ground. Blocking off the narrow section of localised low ground prevents water entry to the site from fluvial flooding.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

10.17mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	
Walling up to 1m height	linear m	15	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	1. The following mitigation options were considered but not chosen as the preferred solution for the following reasons: a) raising or waterproofing the building was considered but not preferred due to the relative complexity of modifying the building in comparison with the flood cutoff wall.
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	
Localised cabinet protection (max 1m height)	linear m	0	2. The storm pump joining boxes and sewage pump junction box do not require protection based on the flood level assessment but will receive protection due to the whole site approach.
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	0	General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	0	
Raise other equipment	number	0	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The site experiences tidal flooding and defending this area will remove a very small proportion of the floodplain storage. Consequently impact on flood levels is minor.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Not Available

Watercourse Survey

Not Available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency provided details of a hydraulic modelling study, the Bristol City Council Central Area Flood Risk Assessment. This is a 1D/2D ISIS-TUFLOW model which covers the site.

Details of Existing Study

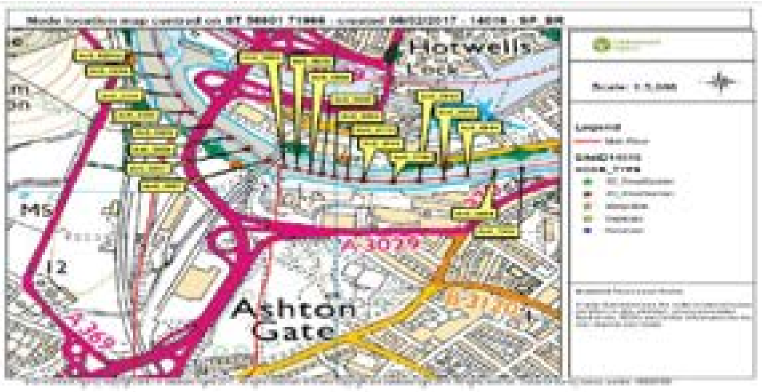
Fluvial Hydrology

Fluvial hydrology in existing model is based on ReFH and FEH statistical analysis.

Tidal Hydrology

The downstream boundary is a head time (HT) boundary using coastal flood boundary conditions for Avonmouth.

Study Extent



Hydraulic Model Construction

A 1D/2D ISIS-TUFLOW hydraulic model of the River Avon with the downstream boundary at Avonmouth.
The CAFRA (2012) model is largely based on survey data used in previous modelling studies. However, new survey data was also obtained for the CAFRA (2012) modelling.
The model includes a reach of the Avon from Hanham in the south-west of Bristol (approximately 7km to the east of the site) downstream to the Clifton Suspension Bridge which is approximately 1km downstream from the site.
Manning's n values in the 1D section of the CAFRA (2012) model were obtained from observations made on site visitsthe previous Frome Model

Return Periods Assessed in Model

20yr, 20yr+CC(+20%), 75yr, 100yr, 100yr+CC(+20%), 200yr, 200yr+CC(+20%), 500yr & 1000yr.

Comments

The model covers the River Avon as it passes the site. The results indicate that tidally influenced flooding is dominant at the site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal, from the River Avon

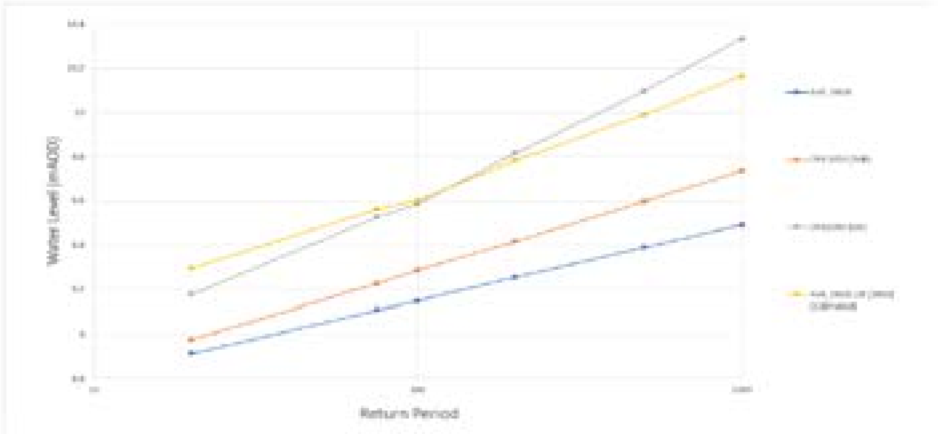
Fluvial Hydrology

Not applicable as the primary risk of flooding is from tidal sources.

Tidal Hydrology

Coastal Flood Boundary information has been used to estimate the impact of climate change and using Upper Confidence Bound figures at the site

Supporting Figure



Summary of Approach

1. Peak water levels at the site from the existing model have been compared to peak water levels at Avonmouth from Coastal Flood Boundary data during the same magnitude event.
2. The relationship between increasing water levels at the coast and water levels at the site was then estimated using this information.
3. The impact of the addition of the upper confidence bound and climate change to 2025 and 2050 was estimated by extrapolating the relationship.

Hydraulic Modelling

Additional hydraulic modelling not undertaken at this site.

Results

Results indicate that two pieces of critical equipment are at risk of flooding for the 1000yr+CC(2050) event.
Resulting water levels are provided on pages 1 and 2.
Note: The 2050 Central climate change levels on page 2 use the median bound CFB Data.

Comparison to previous studies / data

The Environment Agency's flood zone mapping shows the site to be within Flood Zone 1 (outside of the 1 in 1000yr floodplain)
The Bristol CC CAFRA study shows the 1000yr flood level close to the site of 9.24mAOD. However, this does not include the impact of climate change to 2050 and is based on the median (50%) confidence bound tidal boundary conditions.

Assumptions and Limitations

Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

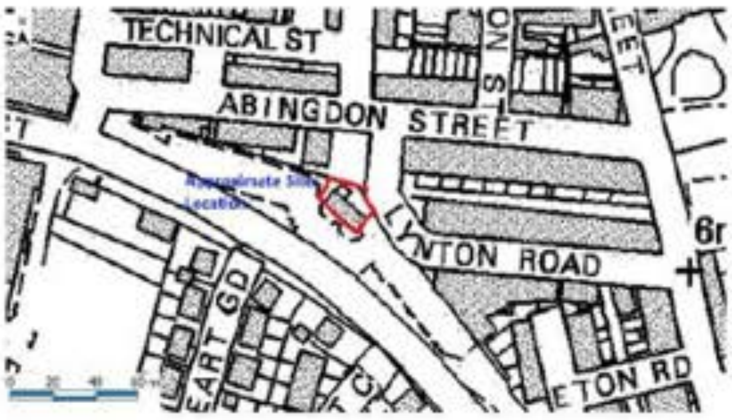
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	BURNHAM ON SEA	Post Code	
15341				
Site Type	NGR			
Sewage Pumping Station	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark James Cooper		
SP_BS	Contact Number	07776226970		

Site Plan

Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Coastal	Existing Flood Defence	Yes
Main Flooding Source	River Parrett and Bristol Bay	EA Flood Warning Area	Burnham-on-Sea Holiday Village, Maple Drive, Steart Avenue, Lynton Road, Adam Street, and High Street
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
5.88 (LiDAR) to 6.70 (LiDAR)	6.29 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	8.27	2.03	N/A	0.00			
			1 in 200 year (0.5%)	8.38	2.14					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	8.86	2.62	N/A	< 0.30			
6.24		2050 (Upper End Allowance)	1 in 100 year (1%)	8.47	2.23	N/A	N/A			
			1 in 200 year (0.5%)	8.58	2.34					
			1 in 1000 year (0.1%)	9.06	2.82	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

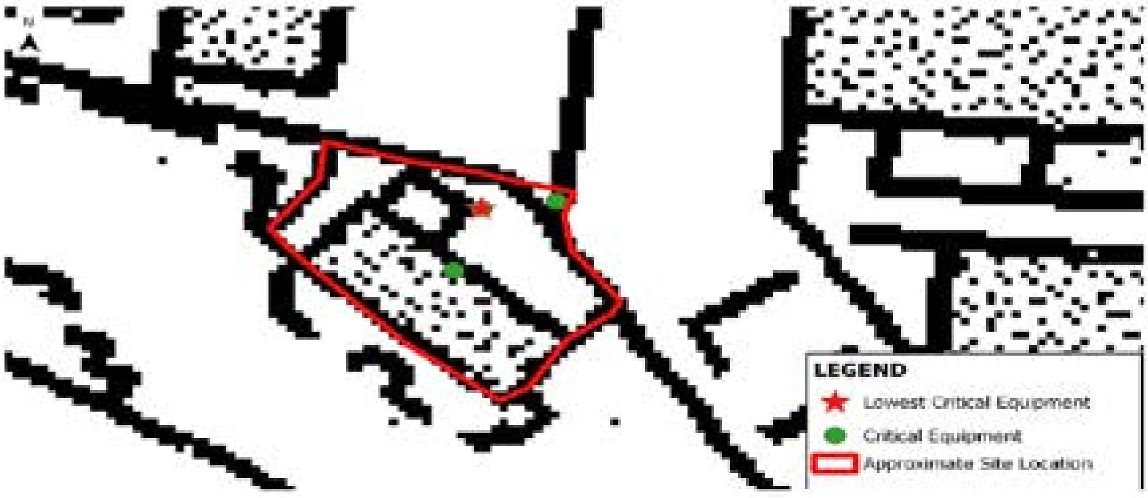
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	06/12/2016	Attendees	Domenico Santoro (MM) and Lee Weller (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Western Power substation	6.25	9.06	8.86	9.06	2.82
Pump control panel	6.45	9.06	8.86	9.06	2.61
Generator control panel	6.56	9.06	8.86	9.06	2.50

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
Emergency access is located at the opposite side of the building than the main (front) one. More information can be obtained from Gerald Turner regarding this. (Lee Weller, Site visit 06/12/2016)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

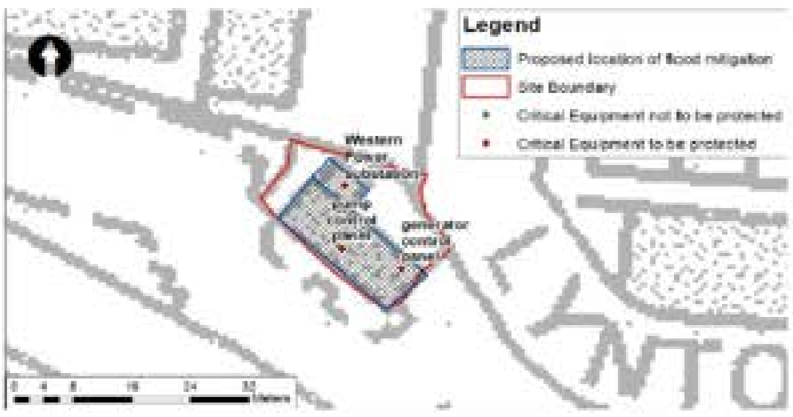
NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event.
1. The building housing the Pump control panel and the Generator control panel should be hardened to 0.9m height (the maximum practical on advice from suppliers).
2. The Western Power substation should be raised by as much as is permitted by the asset owner, and at least 1.5m. This equipment will require stair access/working platform at the new height.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

8.75mAOD

Note: this level is determined by the assumption that the existing substation cannot be raised above a maximum height of 1.5m. The proposed mitigation measures provide a standard of protection less than the 1000yr+CC event.

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	3
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	1
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred given the cost and depth of flooding at site. Although this option could protect three pieces of equipment together, it is not practical to build a 3m wall to satisfy the 1000yr climate change resilience level.
b) Localised protection (cabinets or flood walls) were considered at various individual pieces of equipment however this may cause access issues and therefore raising the equipment is preferred.
2. The 1000yr Upper Bound flood level inclusive of climate change is 9.06mAOD, almost 3m above the ground level at the substation. Noting it is likely not practical to raise to this level, a minimum 1.5m raise is suggested to meet the level of protection of the equipment inside the building.
3. Although the waterproofing to 0.9m height does not meet the 1000yr climate change resilience level, it will protect the equipment to a higher level and ensure function for the portion of the community not already inundated by floodwaters.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. No changes to the flood storage available and limited impact on flood levels as a result.

MOTT MACDONALD

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the EA website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Topographic survey is not available

Environment Agency / Local Authority Existing Studies

Data and model files were requested from Environment Agency in the vicinity of the site. Five result data sets, as provided by Environment Agency, are listed below:
1. Somerset Levels and Moors - Brue: Report and model files in Flood Modeller Pro are not available but results of peak levels and peak flows for 2, 5, 10, 20, 30, 50, 75, 100, 100CC20, 100CC30, 200 and 1000 yr return periods defended scenario are available (Model date: 01/12/2015).
2. Somerset Levels and Moors - Parrett Lowlands: Report and model files in Flood Modeller Pro are not available but results of peak levels and peak flows for 2, 5, 10, 20, 30, 50, 75, 100, 100CC, 100CC30, 200 and 1000 yr return periods defended scenario are available (Model date: 30/09/2016).
3. Coastal boundary data which contains extreme sea levels with confidence interval is available.
4. Steart-Brean_Q200_Defended_2016_Update_Tide_H.asc tidal flood level file for 200yr return period for defended scenario.

Watercourse Survey

Not available

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent

Tidal Hydrology

Not available

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

The Coastal Flood Boundary Extreme Sea Levels are available for 1, 2, 5, 10, 20, 25, 50, 75, 100, 150, 200, 250, 300, 500, and 1000-year return periods.

Comments

Data source A. Coastal Flood Boundary:
1. After estimating the levels from Coastal Flood boundary (CFB) for 200yr tidal event, the extreme sea level is 8.02m and confidence interval is 0.3m. So, the total sea level rise is 8.32m.
2. For 1000yr tidal event, sea level rise is 8.8m (including confidence interval 0.5m).
3. The defence elevation from the EA LiDAR is approximately 8.5mAOD. It is to be noted that the defence crest elevation is not available from the spatial flood defences shapefile wherein there is only a mention that the defences have a standard of protection for 200yr return period tidal event.
4. The 200yr return period tidal event standard of protection information from spatial flood defences shapefile is confirmed from a separate analysis that was performed using the elevation of crest as 8.5mAOD as compared to 8.32mAOD 200yr return period water level calculated using Coastal Flood Boundary database.
5. For 1000yr tidal event, our assessment of data and defence elevations indicates that site may be at risk. To verify, we don't have any water level map with defences.

Data source B. Somerset Levels and Moors - Brue:
1. Node BRUE_02858u is closer to the site.
2. Fluvial water level doesn't reach to ground elevation (8.5mAOD) and there is no possibility of flooding for all the return periods including climate change allowances.

Data source C: Somerset Levels and Moors - Parrett Lowlands:
River Parrett is not a direct flowpath to our site and it does not represent tidal flooding at the site; therefore, it is not accounted in our study.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Coastal

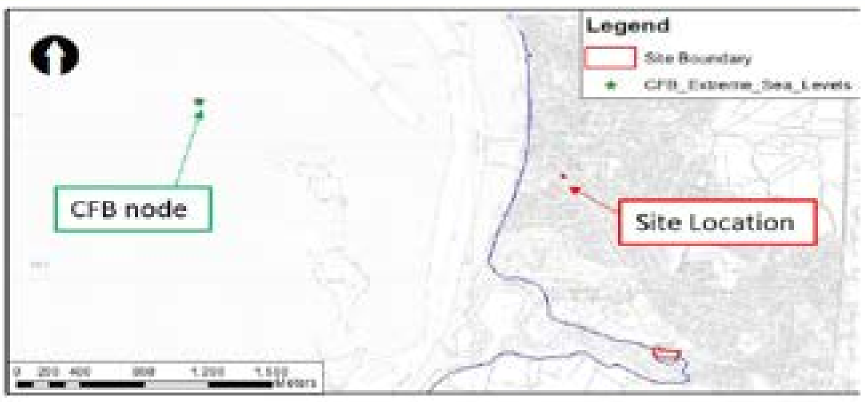
Fluvial Hydrology

Not available

Tidal Hydrology

Not available

Supporting Figure



Summary of Approach

1. Available data sets have been reviewed and compared to assess the 100yr and 1000yr flood levels at the site for climate change allowances as explained in the comments section of page 3 in this summary sheet.
2. The Coastal Flood Boundary is used for the assessment of flooding at the site.
3. Area -Elevation-Volume relationship is extracted for the areal extent that will be possibly flooded when the site floods. This relationship is established using LiDAR data.
4. Spill level and spill length are assumed to compute the volume of water that will be accumulated in the vicinity of the site. In this volume assessment, high tide experiencing the surge was assumed spilling over the River Brue right bank and into the lower area behind the site.
5. The flood level corresponding to this volume is estimated using Area -Elevation-Volume relationship.

Hydraulic Modelling

Not applicable

Results	Comparison to previous studies / data
As per this assessment, the water level for 1 in 1000 including upper bound (2025) climate change shows flooding at the site.	As per this assessment, the site doesn't flood due to fluvial flooding but it gets flooded due to tidal flooding with a depth of over 2m for extreme return periods. It is to be noted that the level of the top of defence adjacent to the site is about 8.4m as estimated using the 1m resolution EA LiDAR (downloaded from the EA website in December 2016). Tidal flood levels above this cause inundation of the lower portions of land to the west of the site.

Assumptions and Limitations

1. Reports and model files of River Brue study are not available for analysis.
2. Defence crest elevation is estimated from 1m resolution EA LiDAR (downloaded from the EA website in December 2016) and not from a detailed survey.
3. Climate change allowances are based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	BATH	Post Code	
17142				
Site Type	NGR			
Sewage Pumping Station	Division	North	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Richard Peter Downing		
SP_BW	Contact Number	07884 234594 s/d 339		

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Avon	EA Flood Warning Area	Upstream at Bathampton Bridge and Sports Fields to riverside properties at Twerton and Locksbrook.
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
17.91(Min)(LIDAR) 18.18(Max)(LIDAR)	18.00 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	18.71	0.57	N/A	< 0.30			
			1 in 200 year (0.5%)	19.20	1.06					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	19.94	1.80	N/A	0.30 - 0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	19.21	1.07	N/A	N/A			
			1 in 200 year (0.5%)	19.60	1.46					
18.14			1 in 1000 year (0.1%)	20.20	2.06	N/A	N/A			
			Groundwater flooding					Medium susceptibility		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

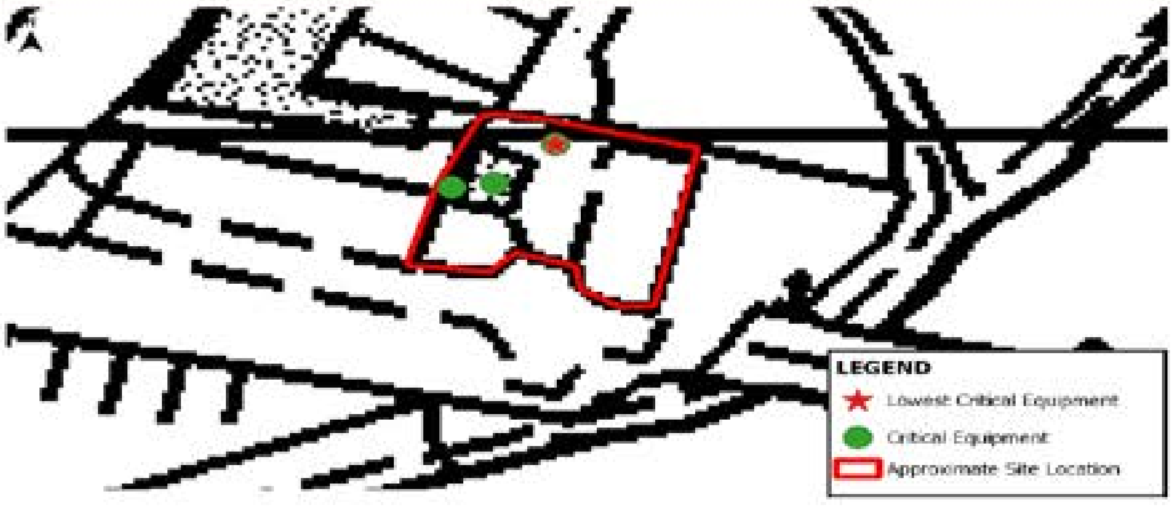
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Bill O'Leary	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	David Tinning (MM), Julian Collins (WW) and Russ Burgham (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Nitrate dosing room	18.16	20.20	20.15	20.20	2.04
Main Control Room	18.22	20.20	20.15	20.20	1.98
Transformer	18.14	20.20	20.15	20.20	2.06

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. This site was built in 2005 as part of the Bath Storm Overflow (CSO) scheme. (Julian Collins and Russ Burgham, Site visit 02/12/2017)	NONE

Phase 2 Mitigation Assessment

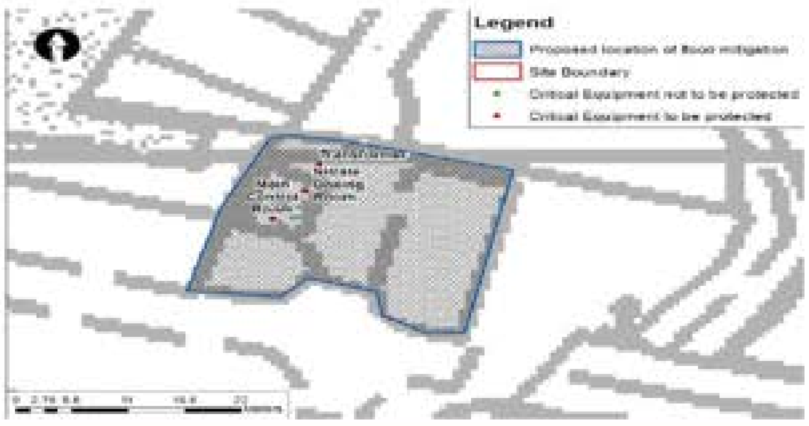
Flood Defence Description

NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event.
1. Whole site protection with flood wall to 2m maximum height, including flood gate for access.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

Maximum Defence height of 2.00m. Height of defence varies with ground level, minimum defence level of 20.00mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	101
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	1
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation options were considered but not chosen as the preferred solution for the following reasons:
a) whole site protection with a 3m wall was considered but not preferred due to advice from Wessex Water on a practical maximum wall height of 2m.
b) raising or waterproofing the building (control room) was considered but not preferred due to the complexity of modifying the building. The existing building is unsuitable for raising of the control panel by over 1.5m.
c) a lesser site protection by 2m wall, to the existing building and transformer area only, could effectively halve the length of wall required. Not considered due to access issues and negative impacts on the accessibility of the site for maintenance vehicles.

2. Assuming that walls cannot be constructed over a maximum height of 2m, the proposed mitigation provides a standard of protection less than the 1000yr+CC flood event.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Significant. This site is located in a residential area, and is at risk from fluvial flooding and blocks a proportion of hte cross-sectional area of the floodplain on the north bank of the River Avon. Defences are therefore likely to have a significant impact on peak water levels.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

None available

Site Topographical Survey

No site topographical survey is available for the site.

Watercourse Survey

No watercourse survey was commissioned for either the 2006 or 2013 models. Instead cross-sectional information was obtained from the Bristol Avon Flood Forecasting Model.

Environment Agency / Local Authority Existing Studies

Environment Agency models Avon (2006) and Bath (2013) were provided for the study, both 1D/2D ISIS/TUFLOW models cover the site.
As the 2013 study is more recent, this model has been used to derive flood levels at the site.

Details of Existing Study

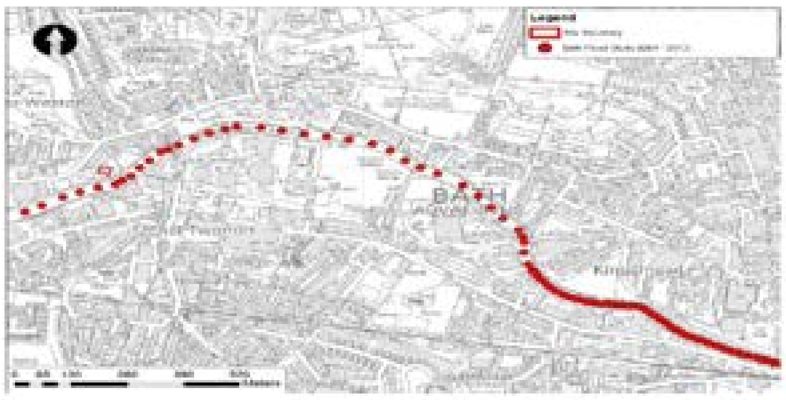
Fluvial Hydrology

Hydrology in the models were based on a previous 1D ISIS model created in (2004). This model used gauged flows where available and for ungauged tributaries the flow was scaled according to the ungauged catchment area.

Tidal Hydrology

Not Applicable

Study Extent



Hydraulic Model Construction

Environment Agency Bath (2013) model:
Schematisation: 1D/2D ISIS/TUFLOW Models
Upstream Extent: Bathford
Downstream Extent: Newbridge Road Bridge
1D Sections: Based on previous modelling
2D Domain: Based on LIDAR
Fluvial Flows: Taken from the Corston to Avonmouth Flood Zone Compliance Project (Halcrow (2007)

Return Periods Assessed in Model

EA Bath (2013) assessed the: 2yr, 5yr, 10yr, 20yr, 20yr+CC(20%), 30yr, 50yr, 75yr, 100yr, 100yr+CC(20%), 100yr+CC(30%), 200yr and 1000yr

Comments

1D and 2D modelling results (levels and flows) have been provided for the range of return periods. These results have been used to carry out the site specific Flood Level Assessment.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

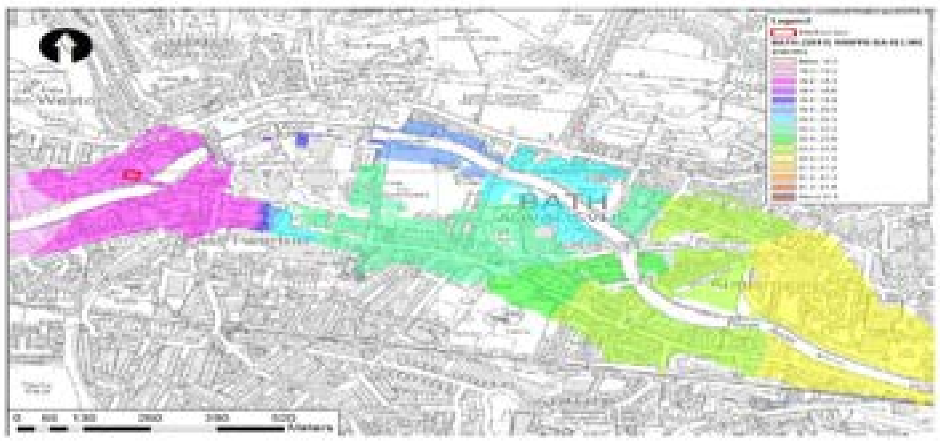
Fluvial Hydrology

Climate change allowance accounted for by adding 25% (2025) and 40% (2050) to design flows from the previous EA Bath (2013) Model

Tidal Hydrology

N/A

Supporting Figure



Summary of Approach

1. A Level/Flow comparison was carried out to identify how peak water level increases with increased flow in the existing (modelled) return periods. Then interpolation/extrapolation was conducted in order to estimate the peak water level for the design flows. This was performed for multiple 1D model nodes in the vicinity of the site. Similarly, Level/Flow comparison was completed on 2D levels in the vicinity of the site.
2 The final Level/Flow curve was selected for the modelled results up to the 1 in 1000yr water levels. For events in excess of this magnitude the mid-point between these two curves is used based on engineering judgement.

Hydraulic Modelling

Additional hydraulic modelling not undertaken at this site. The existing EA Bath (2013) model was used to inform the assessment.

Results

The results indicate that the site is at risk of flooding under the 1 in 1000yr plus climate change (to 2050) conditions. The resulting flood levels are shown on page 1 and 2.

Comparison to previous studies / data

This assessment was carried out with reference to two previous 1D/2D modelling studies (the Bath (2013) model and the Avon (2006) model). The design levels in this assessment are extrapolated from the levels in the Bath (2013) Model.

Assumptions and Limitations

1. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
2. It is assumed that the Environment Agency approved models (Bath (2013), Avon (2006)) which have been referenced in this assessment are reasonable and the information used in these models is representative.
3. Up-to-date EA guidance has been used in order to estimate the potential impact of climate change on flows in the River Avon.
4. LIDAR data has been used to estimate the Ground Levels on the site. Typically this data is accurate to approximately +/-150mm.
5. The pieces of critical equipment identified in the summary sheet are limited to those which were identified by Wessex Water. The summary sheet is not intended to assess what equipment is critical.
6. Where available, information regarding the geometry of the bridges on the River Avon has been drawn from the existing modelling. Where there was no information, estimates have been carried out using photographic evidence and reviewing LIDAR.
7. There has been widespread development on the banks of the River Avon in Bath surrounding this site which may mean that the modelling is out-of-date and the flow routes shown in the modelling may be incorrect.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	FERNDOWN	**Post Code**	
15078				
Site Type	**NGR**			
Sewage Pumping Station	**Division**	South	**Flood Resilience Design Life (years)**	25
Mott MacDonald Site Code	**Controller**	Mark Bailey		
SP_FD	**Contact Number**	07884234605 (329)		

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	Uddens Water	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

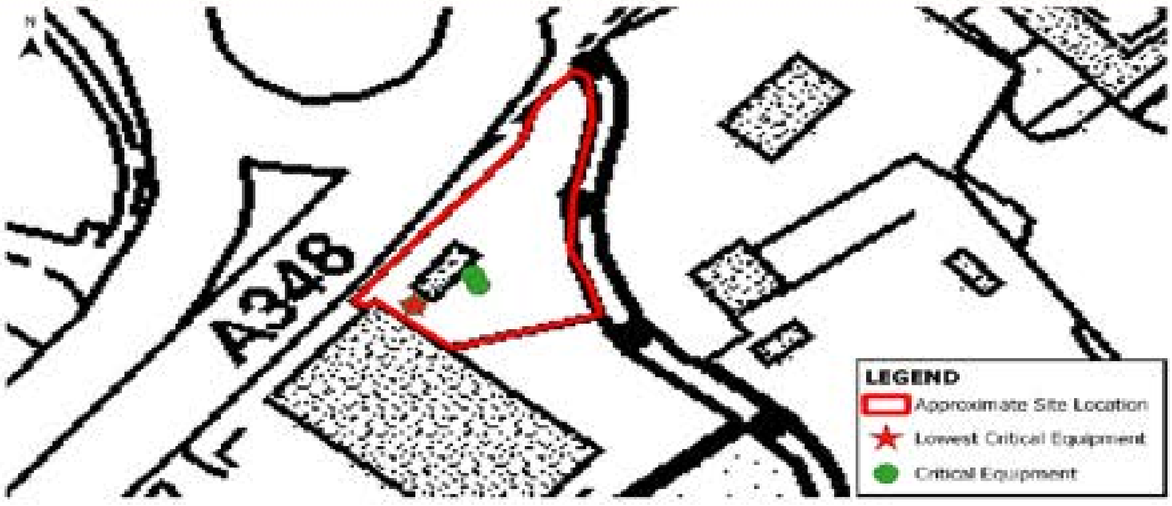
Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
12.53 to 12.84 (LIDAR)	12.65 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	13.18	0.53	N/A	0.00			
			1 in 200 year (0.5%)	13.22	0.57					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	13.42	0.77	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	13.28	0.63	N/A	N/A			
			1 in 200 year (0.5%)	13.32	0.67					
12.65			1 in 1000 year (0.1%)	13.51	0.86	N/A	N/A			
			Groundwater flooding					Data not available*		
			Reservoir							0.00

Comments

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	Carrie Eller (MM) and Dave Whitelock (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
SEE sub station	12.65	13.51	13.68	13.68	1.03
Mains incomer control panel	12.84	13.51	13.68	13.68	0.84
Generator	13.00	13.51	13.68	13.68	0.68

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. SEE sub-station, identified as the lowest critical equipment, is not a Wessex Water asset but powers WW site and if it floods then the site is going to be out of action. Therefore it is considered as lowest critical equipment even though it is not a WW asset. (Dave Whitelock, Site visit 01/12/2016) 2. There is history of flooding up to the site boundary from watercourse but not the site itself. In fact, the river floods yearly during heavy rain. The flooding has not affected the operation of the site. (Dave Whitelock, Site visit 01/12/2016) 3. Dry-well and wet well are underground while MCC is above ground. (Dave Whitelock, Site visit 01/12/2016)	NONE

Phase 2 Mitigation Assessment

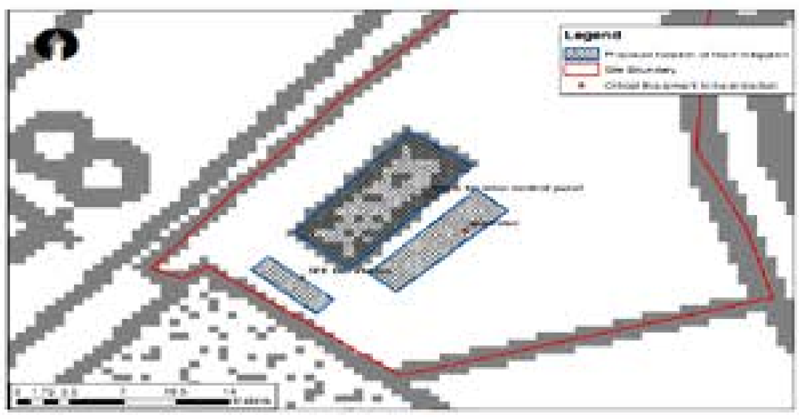
Flood Defence Description

1. The building housing the mains incomer control panel and other electrical equipment to be waterproofed, with two flood doors.
2. The generator is to be raised 68cm.
3. The SEE substation is to be raised 1.03m. This method of protection will require approval from the asset owner, and be subject to the operational requirements for the substation.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

13.68 mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	2
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred given the relative cost given the few number of critical equipment on site.
b) the building housing the control panel could be reconstructed and raised to allow for raising for the control panel and other electrical equipment. This option is not preferred due to cost and likely increased construction time.
c) localised protection in the form of flood proofed cabinets could be installed at the generator and SEE substation. This may have operational constraints, and therefore it is preferred to completely raise the critical equipment above the estimated flood level.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. As the proposed mitigation comprises waterproofing an existing building and raising equipment, the impacts are likely to be small.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

No site topographical survey was provided for this assessment.

Watercourse Survey

Cross-sectional information is available from the River Moors HEC-RAS model (Environment Agency, 2002)

Environment Agency / Local Authority Existing Studies

River Moors Modelling and Flood Risk Mapping Study (2002)

Details of Existing Study

Fluvial Hydrology

The hydrological calculations were based on the FEH statistical method using a pooled group, generating the flood growth curve for the catchment.

Tidal Hydrology

Not applicable. The site is not within the influence of tidal flooding.

Study Extent

Hydraulic Model Construction

1-dimensional HEC-RAS modelling was conducted for the Moors River system, including its tributaries, from just south of Verwood to just East of Ferndown. The watercourse survey data was collected for the development of the Moors River Modelling and Flood Risk Mapping commission. Structures were represented based on visual inspection and engineering judgement regarding structure coefficients. The hydrological flows have been applied to the model using cumulative flows along the River Moors, estimated using linear interpolation so that the maximum distance between flow changes in the model is approximately 1km. A normal water surface has been assumed using the gradient of the bedslope (estimated at 0.003) at the downstream extent.

Return Periods Assessed in Model

2, 5, 10, 15, 25, 50, 75, 100, 200 year.

Comments

The modelling report notes that limited information is available for the calibration of the model, with calibration carried out to anecdotal evidence.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial, from Uddens Water tributary of Moors River

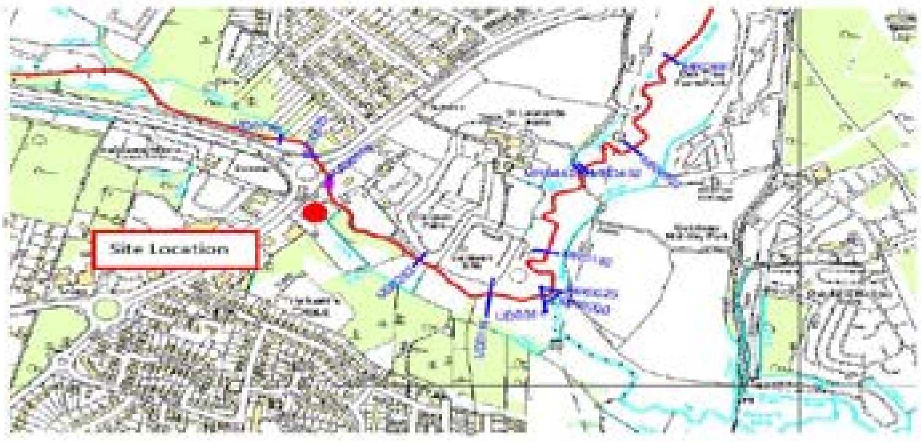
Fluvial Hydrology

The hydrological calculations summarised in the Moor River Modelling and Flood Risk Mapping commission for the Environment Agency were reviewed and found to be an appropriate representation of the catchment for the purpose of this flood risk assessment. The 1000yr hydrology was determined through extrapolation of the data for the smaller return periods. Climate change flows were determined by applying the factors to Environment Agency guidance. The largest inflow for the 1000yr return period including the higher end estimate for climate change (40%) increase in flows was $70.5m^3/s$.

Tidal Hydrology

The site is not within the influence of tidal flooding.

Supporting Figure



Summary of Approach

1. The Moors River modelling informing the 2002 Flood Risk Study provides relevant information on fluvial flooding to the site due the proximity of the site to the watercourse and the results of this modelling were used.
2. The culvert structure upstream of the site was investigated for influence on water levels during flood events in the watercourse. The results indicate the culvert is drowned in events greater than the 2 year return period.
3. Extrapolation of flood levels was made based on the relationship between flood level and flow for the results for return periods greater than the 2 year, representing flooding where the structure upstream is already drowned.
4. Increase in flows due to climate change were then determined based on the latest guidance.
5. Flood levels for the climate change scenarios were determined from examination of the level-flow relationship.

Hydraulic Modelling

The relationship between fluvial flood flow and the water level was reviewed by hydraulic modellers. Engineering judgement was used in the extrapolation of these results to yield future climate change results, based on the known response of the area to increases in fluvial flows, informed by the River Moors modelling. Structures in the vicinity were reviewed to ensure that results used in the extrapolation considered the affects on water level of the drowned structures. Further hydraulic modelling was not undertaken for this study.

Results

Results indicate that the site and critical equipment are at risk of flooding. Resulting flood levels are shown on pages 1 and 2.

Comparison to previous studies / data

No previous studies for the Ferndown site are available for comparison. The results are lower than the Environment Agency flood zone mapping by approximately 0.2m, however the flood zone mapping is not a site specific study.

Assumptions and Limitations

Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

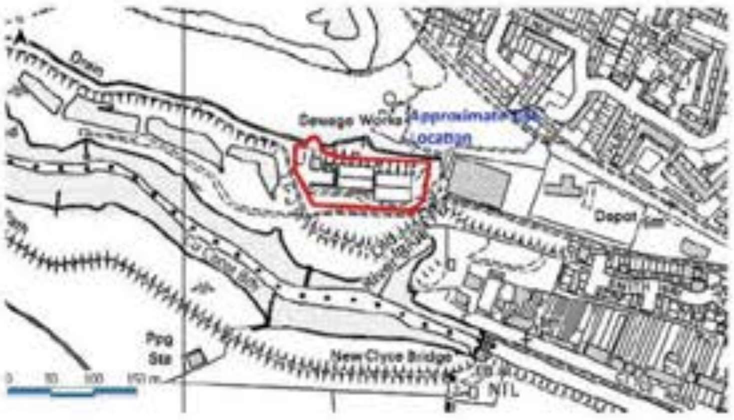
WESSEX WATER PR19 FLOODING RESILIENCE ASSESSMENTS
PHASE 2 SITE SUMMARY SHEET

MOTT MACDONALD

Wessex Water Site ID	Site Name	HIGHBRIDGE	Post Code		
14374					
Site Type	NGR				
Sewage Pumping Station	Division	West	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Philip Leslie Strange			
SP_HB	Contact Number	07919111912			

Site Plan

Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Coastal	Existing Flood Defence	Yes
Main Flooding Source	River Brue and Bridgwater Bay	EA Flood Warning Area	West Huntspill, Highbridge, Burnham-on-Sea and Berrow to the west to Mark in the east
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
5.20 to 7.78 (LIDAR)	6.50 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	8.77	2.10	N/A	0.00			
			1 in 200 year (0.5%)	8.88	2.21					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	9.36	2.69	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	8.97	2.30	N/A	N/A			
			1 in 200 year (0.5%)	9.08	2.41					
6.67			1 in 1000 year (0.1%)	9.56	2.89	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

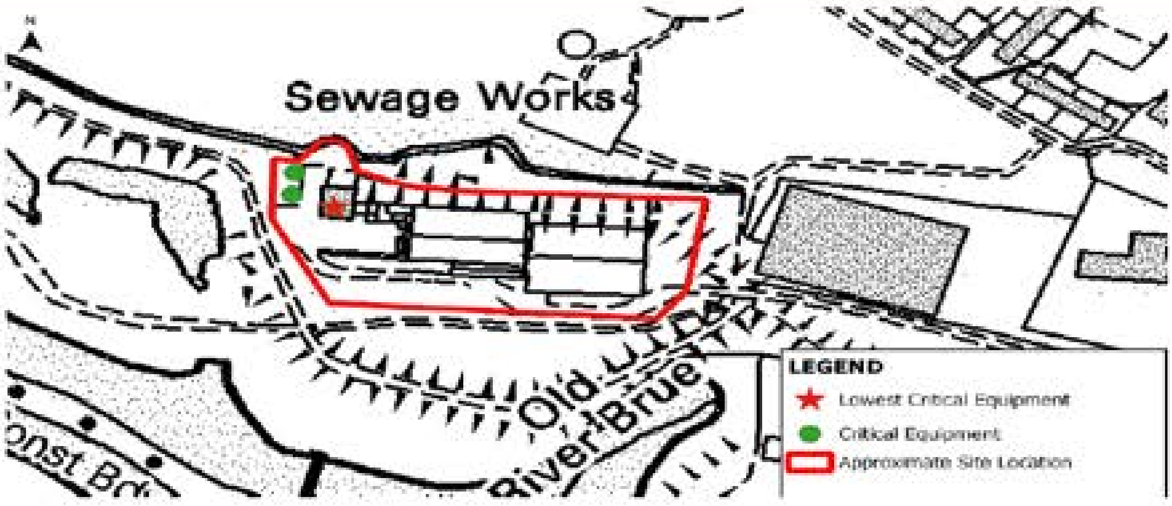
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Mayuresh Padalkar	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	Domenico Santoro (MM) and Philip Strange (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Mains and generator incomer, screw pumps MCC feeder	6.67	9.56	9.36	9.56	2.89
Western Power transformer	7.05	9.56	9.36	9.56	2.51
Generator	8.07	9.56	9.36	9.56	1.49

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. As per site operator, lowest critical equipment is the screwed MCC. All other equipment is raised (excluding a transfomer which belongs to Western Power). (Philip Strange, Site visit 01/12/2016) 2. As per the site operator, no flooding has been observed at this site. (Philip Strange, Site visit 01/12/2016)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

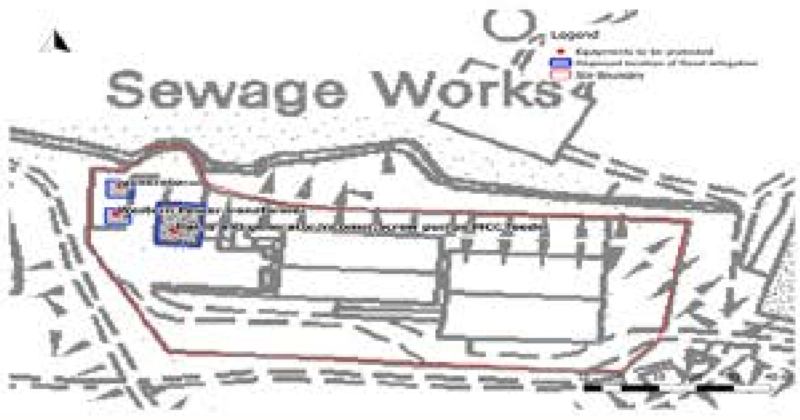
NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event.
1. Building waterproofing and hardening up to 2m height, with 1 flood door, to protect the mains and generator incomer, screw pumps MCC feeder.
2. Wester Power transfomer to be raised 1.6m to meet defence level of building protection (8.67mAOD).
3. Generator to be raised 0.6m to meet defence level of building protection (8.67mAOD).

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

8.67mAOD

Note: this level is determined by the assumption that the existing building cannot be waterproofed/hardened above a maximum height of 2m. The proposed mitigation measures provide a standard of protection less than the 1000yr+CC event.

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	1
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	2
Other	linear m	0

Comments

1. The following mitigation options were considered but not chosen as the preferred solution for the following reasons:
a) whole site protection was considered but not preferred due to cost as this would require a flood wall over 2m in height. In addition, in the event of extreme flooding at this site, the surrounding area will also be flooded.
b) raising the building (mains and generator incoming, screw pumps MCC feeder) was considered but not preferred due to cost.

2. It is assumed that the existing building cannot be waterproofed/hardened above a maximum height of 2m. Therefore, the proposed mitigation provides a standard of protection less than the 1000yr+CC flood event.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligable. Given the small foot print of the proposed measures, and the relative large floodplain storage of the sea, the impact is likely to be very small.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the EA website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Topographic survey is not available
Site schematic is available: SP_HB_Highbridge_14374101_20161122

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

Data and model files were requested from Environment Agency in the vicinity of the site. Five result data sets, as provided by Environment Agency, are listed below:
1. Somerset Levels and Moors - Brue: Report and model files in Flood Modeller Pro are not available but results of peak levels and peak flows for 2, 5, 10, 20, 30, 50, 75, 100, 100CC20, 100CC30, 200 and 1000 yr return periods defended scenario are available (Model date: 01/12/2015).
2. Somerset Levels and Moors - Parrett Lowlands: Report and model files in Flood Modeller Pro are not available but results of peak levels and peak flows for 2, 5, 10, 20, 30, 50, 75, 100, 100CC, 100CC30, 200 and 1000 yr return periods defended scenario are available (Model date: 30/09/2016).
3. Coastal boundary data which contains extreme sea levels with confidence interval is available.
4. John Southwell (EA) provided anecdotal information mentioning rule of thumb of 5.5mAOD upstream of the tidal sluice (Highbridge Clyce) as a theoretical maximum fresh water level in the Brue at Highbridge.
5. Steart-Brean_Q200_Defended_2016_Update_Tide_H.asc tidal flood level file for 200yr return period for defended scenario.

Details of Existing Study

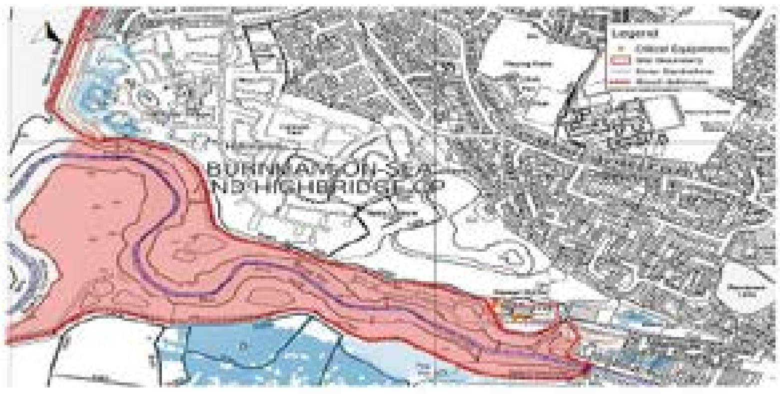
Fluvial Hydrology

Not available

Tidal Hydrology

Not available

Study Extent



Hydraulic Model Construction

Not available

Return Periods Assessed in Model

The Coastal Flood Boundary Extreme Sea Levels are available for 1, 2, 5, 10, 20, 25, 50, 75, 100, 150, 200, 250, 300, 500, and 1000-year return periods.

Comments

Data source A. Coastal Flood Boundary:
1. After estimating the levels from Coastal Flood boundary (CFB) for 200yr tidal event, the extreme sea level is 8.02m and confidence interval is 0.3m. So, the total sea level rise is 8.32m.
2. For 1000yr tidal event, sea level rise is 8.8m (including confidence interval 0.5m).
3. The defence elevation from the EA LiDAR is approximately 8.5mAOD. It is to be noted that the defence crest elevation is not available from the spatial flood defences shapefile wherein there is only a mention that the defences have a standard of protection for 200yr return period tidal event.
4. The 200yr return period tidal event standard of protection information from spatial flood defences shapefile is confirmed from a separate analysis that was performed using the elevation of crest as 8.5mAOD as compared to 8.32mAOD 200yr return period water level calculated using Coastal Flood Boundary database.
5. For 1000yr tidal event, our assessment of data and defence elevations indicates that site may be at risk. To verify, we don't have any water level map with defences.

Data source B. Somerset Levels and Moors - Brue:
1. Node BRUE_02858u is closer to our site.
2. Fluvial water level doesn't reach to ground elevation (6.5mAOD) and there is no possibility of flooding for all the return periods including climate change allowances.

Data source C. Anecdote from John Southwell (EA):
John Southwell (EA) applied a thumb rule of 5.5mAOD upstream of the tidal sluice (Highbridge Clyce) as a theoretical maximum fresh water level in the Brue at Highbridge. Therefore, as per John's assessment, the site is not going to be flooded due to fresh water (fluvial) levels.

Data source D: Somerset Levels and Moors - Parrett Lowlands:
River Parrett is not a direct flowpath to our site and it does not represent tidal flooding at the site therefore, it is not accounted in our study.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Coastal

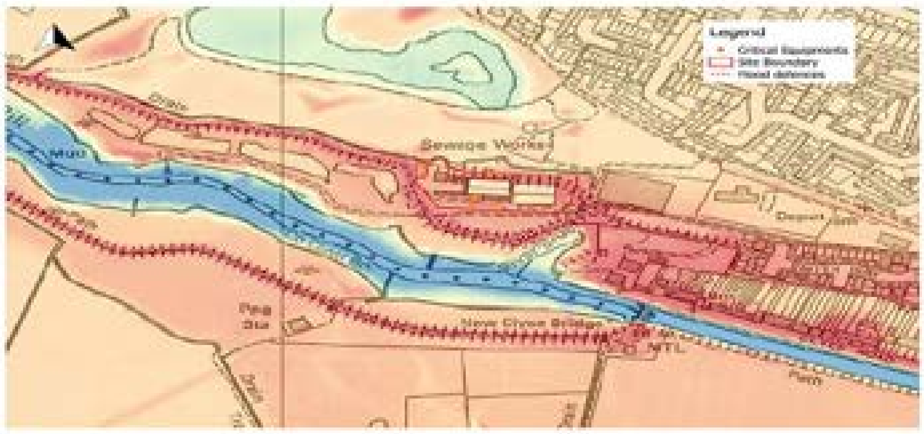
Fluvial Hydrology

Not available

Tidal Hydrology

Not available

Supporting Figure



Summary of Approach

1. Four data sets have been reviewed and compared to assess the 100yr and 1000yr flood levels at the sites for climate change allowances as explained in the comments section of page 3 in this summary sheet.
2. The Coastal Flood Boundary is used for the assessment of flooding at site.
3. The flood level is estimated by adding the sea level rise due to climate change corresponding to 2025 and 2050 for the critical return periods.
4. An additional 0.2m has been added to the flood level to account for the funnelling of water travelling up the river channel.
5. An additional 0.3m has been added to the flood level to account for the wave action within the river channel.
6. These allowances should be reviewed during further design stages, and a full wave analysis completed to inform detailed design.

Hydraulic Modelling

Not applicable

Results

As per this assessment, the water level for 1 in 200 including upper bound (2050) climate change shows flooding at the site, and the water level for 1 in 1000 including upper bound (2025) climate change shows flooding at the site.

Comparison to previous studies / data

The site operator has commented that the site has not flooded previously. As per this assessment, the site doesn't flood due to fluvial flooding but it gets flooded due to tidal flooding with a depth of over 2m for extreme return periods. It is to be noted that the level of the top of defence adjacent to the site is about 8.5m as estimated using the 1m resolution EA LiDAR (downloaded from the EA website in December 2016).

Assumptions and Limitations

1. 1 in 1000 defended tidal flood levels was not available for review and comparison during this study, and only 1in 200 defended tidal flood level information was available from Environment Agency.
2. Reports and model files of River Brue study are not available.
3. Defence crest elevation is estimated from 1m resolution EA LiDAR (downloaded from the EA website in December 2016) and not from a detailed survey.
4. Climate change allowances are based on Environment Agency (2017) Climate Change Guidance.

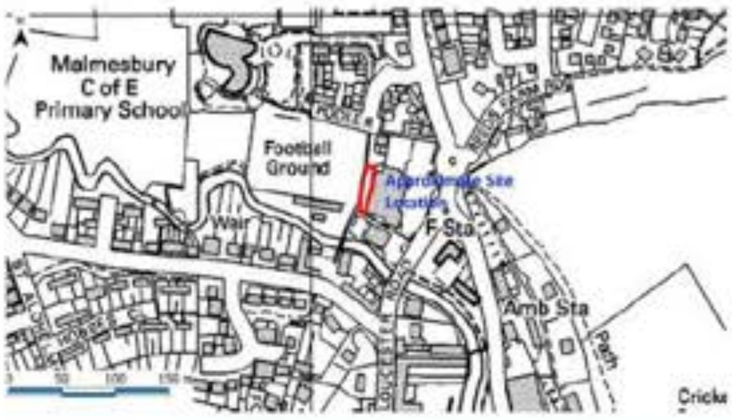
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	MALMESBURY	Post Code	
14205				
Site Type	NGR			
Sewage Pumping Station	Division	North	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark James Cooper		
SP_MA	Contact Number	07776226970		

Site Plan

Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	River Avon (Tetbury Branch)	**EA Flood Warning Area**	Park Road, Poole Road, Gloucester Road, Mill Lane and Baskerville
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal Level (mAOD)	Fluvial / Coastal Depth (m)	Surface Water Level (mAOD)	Surface Water Depth (m)	Ground Water Flooding Susceptibility	Reservoir Level (mAOD)	Reservoir Depth (m)
71.50-72.27 (LIDAR)	71.70(LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	71.85	0.00	N/A	0.00			
			1 in 200 year (0.5%)	72.07	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	72.81	0.47	N/A	0.30-0.90*			
		2050 (Upper End Allowance)	1 in 100 year (1%)	72.03	0.00	N/A	N/A			
			1 in 200 year (0.5%)	72.19	0.00					
			1 in 1000 year (0.1%)	73.05	0.71	N/A	N/A			
72.34			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

*The impact of local topographic character to surface water run-off combined with the sites close proximity to the River Avon indicate that flooding occuring from surface water ostensibly represents the the same source of flooding as the fluvial factor. In this regard the fluvial risk is considered to be more accurate and of high impact to the site.

Revision Record

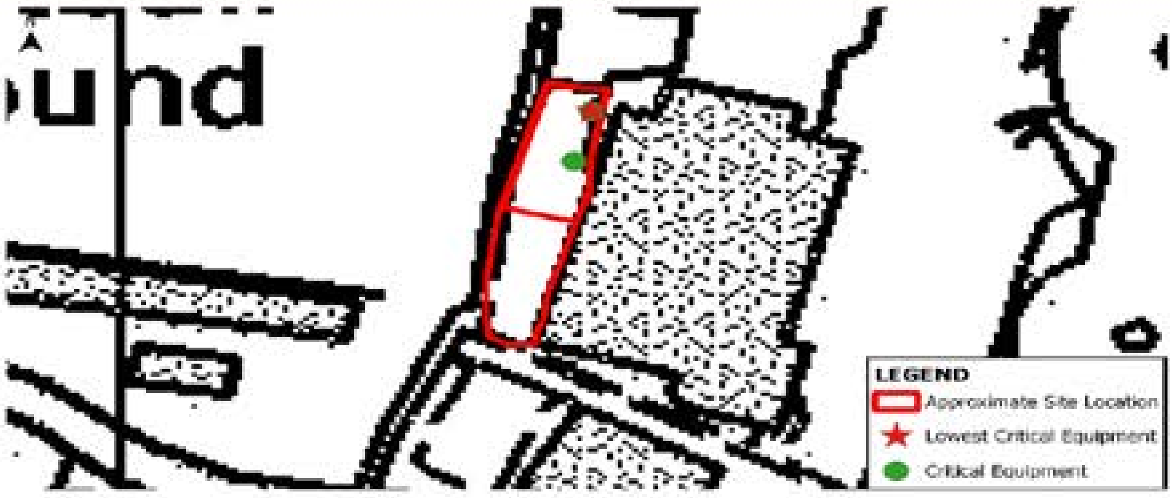
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Lisha Parambath	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	07/12/2016	Attendees	Carrie Eller (MM) and Tim (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
control panel for mains incomer, pumps	72.34	73.05	72.78	73.05	0.71
pump joining boxes and wet well joining box	73.02	73.05	72.78	73.05	0.03

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. This site floods every year, however the depth of flood is close to puddling. (Tim, Site visit 07/12/2017) 2. The adjacent football field receives minor flooding during heavy rain. (Tim, Site visit 07/12/2017) 3. As per STW and WTW Flood Resilience Database, sludge treatment equipment was flooded by surface water. No additional information was provided in the database.	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. The metal cabinet/building housing the control panel for mains incomer and pumps is to be raised 0.71m. Suitable access platform included in the cost estimate.
2. Pump joining boxes and wet well joining box to be replaced with suitable IP68 rated equipment. Costing based on 'low' complexity cost banding.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

73.05mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	1. The following mitigation measures were considered but not preferred for the following reasons: a) whole site protection not preferred due to cost and limited amount of critical equipment at the site. b) localised flood proofed cabinet protection considered but not preferred due to access and operational restrictions. General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	0	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low	
Raise control panel or kiosk	number	0	
Raise other equipment	number	1	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The proposed measures include raising and replacement of equipment, which are unlikely to have an impact on floodplain storage.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in Dec, 2016 from the Environmental Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Not available

Watercourse Survey

Not Available

Environment Agency / Local Authority Existing Studies

1. The existing model of the River Avon at Malmesbury (Malmesbury Flood Modelling Study) was built by JacksonHyder in 2016 as part of WEM Lot 1 Modelling.
2. The site is in the vicinity of this model. Existing model files and the modelling report "WEM Lot 1 Modelling, Mapping and Data Malmesbury Flood Modelling Study" (June, 2016) is available.

Details of Existing Study

Fluvial Hydrology

Fluvial hydrology for critical return periods is available from Malmesbury Flood Modelling Study (June, 2016).

Tidal Hydrology

Tidal hydrology is not applicable since the site is not tidally influenced.

Study Extent

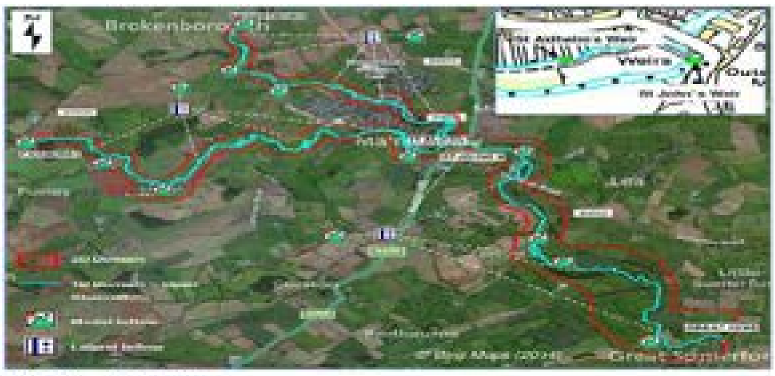


Figure 5-1 Model extents

Hydraulic Model Construction

1. A 1D-2D hydraulic model of the River Avon, covering the Tetbury and Sherston Arms through Malmesbury was developed for this study.
2. The model was constructed as a linked 1D-2D ISIS-TUFLOW hydraulic model, updated with survey data collected in 2012, 2014 and 2015.
3. Rating curve (Stage-Discharge relationship) was adopted as the downstream boundary condition.

Return Periods Assessed in Model

The existing ISIS-TUFLOW model was run for 10 return periods, plus a number of climate change scenarios as follows: 2, 5, 10, 20, 30, 50, 75, 100, 200, 1000, 20 with climate change allowance of 20%, 20 with climate change allowance of 30%, 100 with climate change allowance of 20%, 100 with climate change allowance of 30%.

Comments

A number of flood events recorded at Fosseway and Great Somerford gauging stations were selected for use in calibration and verification of the hydraulic model. The results from this model were used for the analysis of flood level assessment at the site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

Fluvial Hydrology

The hydrological data from the existing model (June, 2016) is used for the flood level assessment.

Tidal Hydrology

Tidal hydrology is not applicable since the site is not tidally influenced.

Supporting Figure

Summary of Approach

1. The existing model nodes are identified in the vicinity of the site boundary that will represent the stage levels at the site location.
2. Model node "Section17" represents the cross-section of the river Avon near the site boundary which is considered as the representative node for the flood level assessment at the site.
3. Since there is a bridge at section 17, the stage-discharge curve is plotted from merged data of the ISIS rating curve and orifice calculations, just upstream of the bridge to obtain slightly conservative results.
4.The stage corresponding to the flow at critical return periods with climate change allowances are extracted from this stage-discharge relationship.

Hydraulic Modelling

The existing hydraulic model is used for the assessment of flood levels at the site.

Results

1. The flood levels are estimated from the Stage-Discharge relationship obtained at cross section 17 for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The site operator has commented that the site floods almost every year and the depth of flooding is close to "puddling" (assumed to be 0.05 - 0.2m).
2. This assesment concludes that there is flooding above the typical ground level for 1000-year return period with 40% climate change allowance, to a depth of 0.71m.
3. The results of this assessment correlate with those of the previous Malmesbury study. Modelled flood Levels at the road bridge south-east of the site are 71.78mAOD for the 1000 year event. This assessment determined a flood level of 73.05mAOD when including a 40% increase in flows due to climate change and a 0.25m allowance to account for the hydraulic gradient between the road bridge and an upstream section closest to the site.
4. Comparison of the assessed flood level for the 1000 year Upper Limit (including climate change allowance for 2050) with the Environment Agency Flood Zone 3 extents (>0.1% AEP) demonstrate a good correlation.

Assumptions and Limitations

1. This assessment is based upon a review of the exisitng Malmesbury model results, specifcally in-channel water levels at sections near to the site (Section 17 and 18).
2. Section 18 (a road bridge structure) was identified to have the greatest impact on flood levels at the site. The bridge is overtopped during the 1 in 1000 year event (including climate change to 2025 and 2050) so a new rating curve was constructed incorperating orifice flow to more accurately represent the hydraulic behaviour of the structure and extrapolate the flood levels.
3. A 0.25m allowance is included in the 1000 year (+CC) results to account for the hydraulic gradient between section 18 and the next upstream section comprised a 0.25m difference in flood level.
4. Climate change allowances are based upon current guidelines from the Environment Agency at the time of the writting.

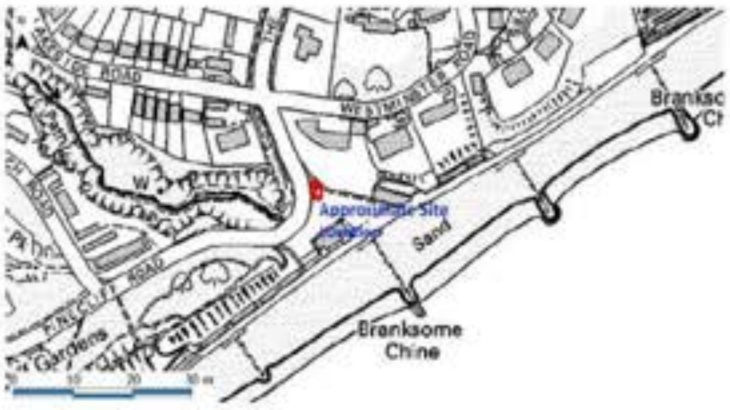
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	POOLE	Post Code		
15240					
Site Type	NGR				
Sewage Pumping Station	Division	South	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Mark Bailey			
SP_PB	Contact Number	07884234606 (329)			

Site Plan

Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	Poole Bay and Drainage ditch	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
5.07-7.74 (LiDAR) The minimum value found on LiDAR is 4.11mAOD - However it is assumed that the LiDAR picked the elevation of the staircase going down the basement.	7.00 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	5.63	0.00	N/A	< 0.30			
			1 in 200 year (0.5%)	5.66	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	5.77	0.00	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	5.64	0.00	N/A	N/A			
			1 in 200 year (0.5%)	5.67	0.00					
5.87			1 in 1000 year (0.1%)	5.97	0.10	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

1. Although the EA surface water map indicates that the site is at risk from this source, our assessment indicates that the primary risk to the site is from fluvial flooding.
2. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

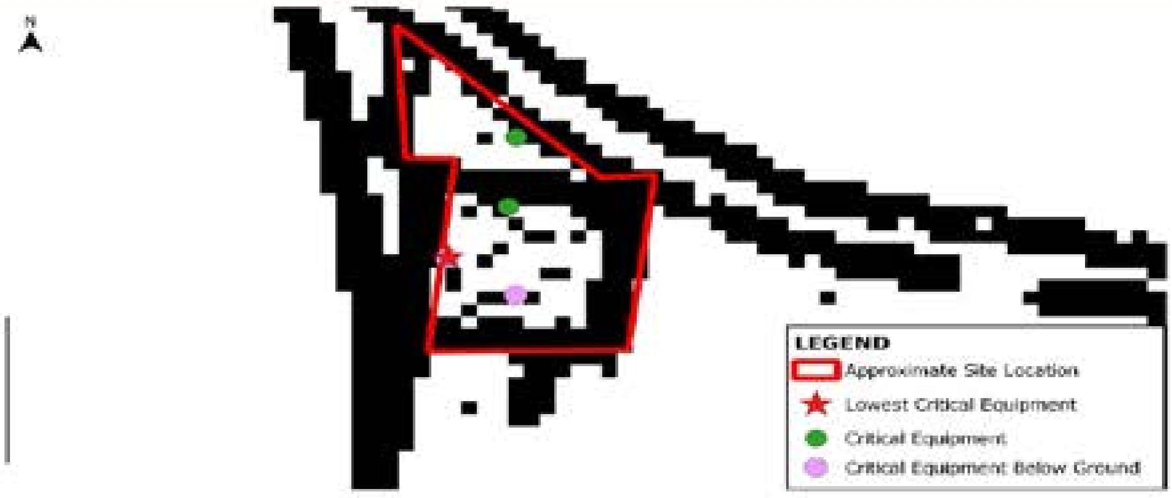
Revision	Issue Date	Originator	Checker	Approver
A	04/05/2017	Enrique Flores Diaz	Christian Hetmank	Kelsey Piech

MOTT MACDONALD

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	Carrie Eller(MM) and Dave Whitelock(WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Pumps	5.87	5.97	5.97	5.97	0.10
Pump joining box	5.87	5.97	5.97	5.97	0.10
Control panel for mains incomer, pumps	6.41	5.97	5.97	5.97	-0.44
Generator	6.41	5.97	5.97	5.97	-0.44

Summary of Key Client Comments

1. No recent flooding has been observed at this site. (Dave Whitelock, Site visit 01/12/2016)
2. Wet well/dry well is underground, and MCC kiosk is above ground. Highway adjacent to site has flooded in the past, affecting site access. (Critical Equipment Drawing)

Comments on Below Ground Equipment (if any)

1. Pumps are located in the lower basement. The pump would start to inundate once the flood water reaches the ground level (5.87mAOD) and begins to flood the ground floor of the building. The equipment level is at 2.21mAOD.
2. The pump joining box is also located in the basement, which has the critical level as 5.36mAOD which is 0.88m above from the basement finished floor.

Phase 2 Mitigation Assessment

Flood Defence Description

1. It is proposed to build a curb or similar feature around the wooden fence at the stairs, with a ramp up the entrance. This feature should have a crest level 10cm above ground leve to stop the water the water entering the stair/basement.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

5.97mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	1

Comments

1. It is observed that the flood risk occurs when the water level on the surface reaches a level sufficient to reach the entrance (staircase) to the underground room leading to the critical equipment. The level calculated on the road is 7.11mAOD, using engineering judgement it was assessed a shallow flood level at the entrance of the site of 0.10m. The proposed defence measures intends to stop the water to enter the stairs/basement.

2. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection was considered but not preferred due to cost, given the minimal flood depths at the site.
b) waterproofing the building was considered but requires significant work compared to the proposed measure.
c) raising the equipment was not preferred given the likely cost.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent the site.

Source Data

LiDAR Data

LIDAR data for use in this Flood Risk Assessment has been obtained from the UK Government's national coverage lidar.

Existing FRA and accompanying model files

Not Available

Site Topographical Survey

No site topographical survey is available for the site.

Watercourse Survey

Cross-sectional data was extracted from LIDAR

Environment Agency / Local Authority Existing Studies

1. Preliminary Flood Risk Assessment produced by Borough of Poole Unitary Authority, June 2011
2. Strategic Flood Risk Assessment Level 1 by Borough of Poole Unitary Authority, January 2009
3. Strategic Flood Risk Assessment Level 2 by Borough of Poole Unitary Authority, April 2011

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent

PIC(SP_PB\P1_SP_PB_MODEL.png)(500,270)

Tidal Hydrology

Not available

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

n/a

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

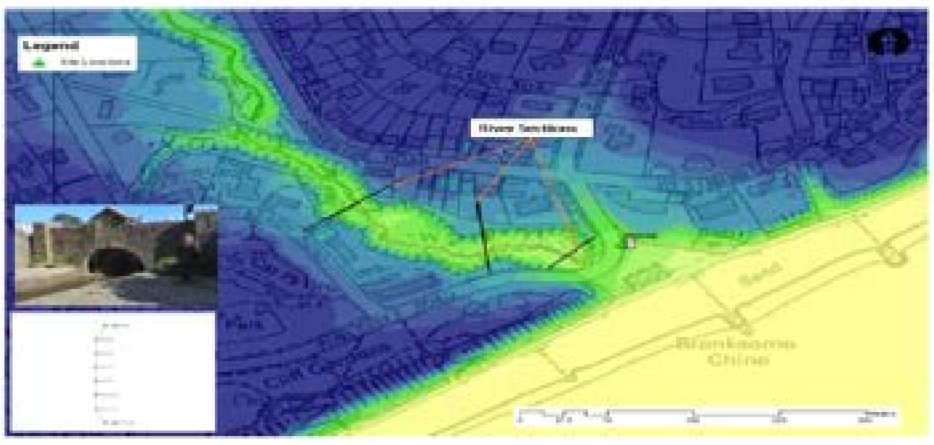
Fluvial Hydrology

Derived by Mott MacDonald using ReFH method.

Tidal Hydrology

Extreme Sea Levels from Coastal Flood Boundary (CFB) data, including upper bound confidence interval

Supporting Figure



Summary of Approach

A simple 1D ISIS hydraulic model was built to obtain the water levels in Pinecliff Road, engineering judgment was used to estimate the equivalent flooding on site. Information from the EA map was discarded as it does not match with LIDAR contour lines.

Hydraulic Modelling

1. Cross-section data obtained from LIDAR.
2. Hydrology obtained using ReFH methodology.
3. Downstream boundary using Extreme Sea level values from CFB.

Results

The result show the critical equipment would be subject to flooding for the 1 in 1000yr under Climate Change to 2025 and 2050 flood events.

Comparison to previous studies / data

No other studies were available. EA flood maps information was discarded as it was found it did not match with the LIDAR contours.

Assumptions and Limitations

1. The dimentions of the culvert under Pinecliff Road were obtained from google street images.
2. Floodplain is represented within the 1D domain of the model.
3. Cross sections (channel and floodplain) are extracted from the latest EA LiDAR (1m resolution).

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	POOLE	Post Code	
15263				
Site Type	NGR			
Sewage Pumping Station	Division	South	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark Bailey		
SP_PF	Contact Number	07884234605 (329)		

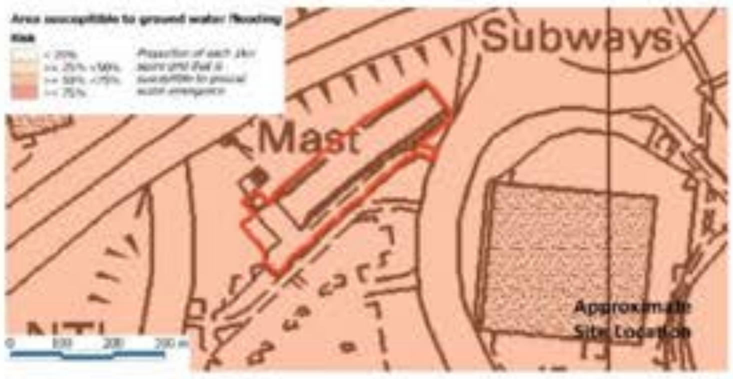
Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Tidal	Existing Flood Defence	No
Main Flooding Source	Upton Lake and Holes Bay	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 2	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
1.80 - 2.37 (LIDAR)	2.00 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	2.61	0.26	N/A	0.00			
			1 in 200 year (0.5%)	2.67	0.32					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	2.89	0.54	N/A	<0.30*			
		2050 (Upper End Allowance)	1 in 100 year (1%)	2.81	0.46	N/A	N/A			
			1 in 200 year (0.5%)	2.87	0.52					
2.35			1 in 1000 year (0.1%)	3.09	0.74	N/A	N/A			
			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

*The EA surface water flood map was found to be innacurate as the LIDAR shows errors at the location of the site. S
Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

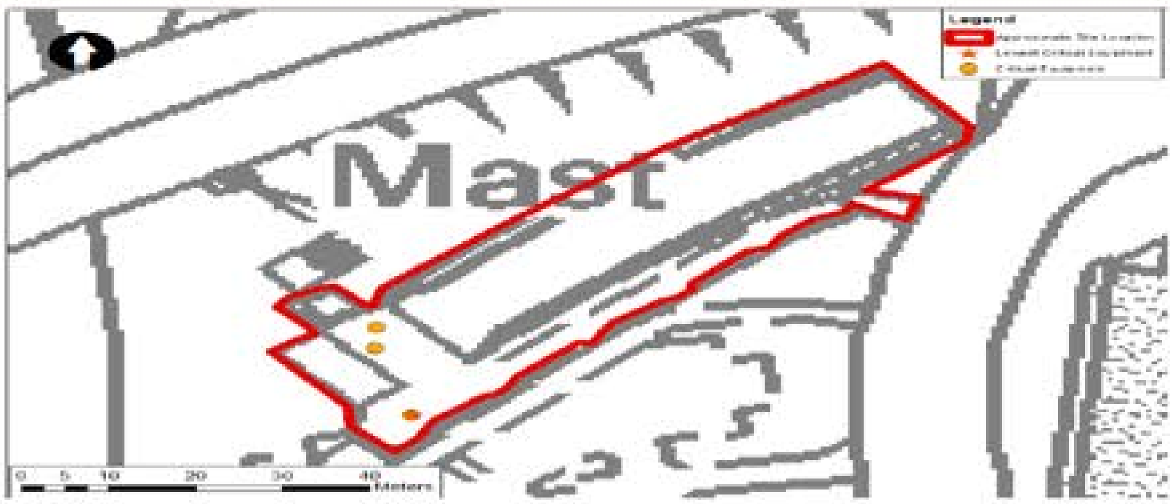
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Enrique Flores Diaz	Kelsey Plech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	Carrie Eller(MM) and Dave Whitelock(WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Generator	2.35	3.09	3.09	3.09	0.74
Mains incomer control panel	2.59	3.09	3.09	3.09	0.51
Control panel for pumps, 2 panels 1 for each pump	2.62	3.09	3.09	3.09	0.47

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. Flood water backs up sewer network during severe rainfall events which causes the site to flood, therefore flooding due to surface water is observed at the site. (Dave Whitelock, Site visit 02/12/2016)	NONE

Phase 2 Mitigation Assessment

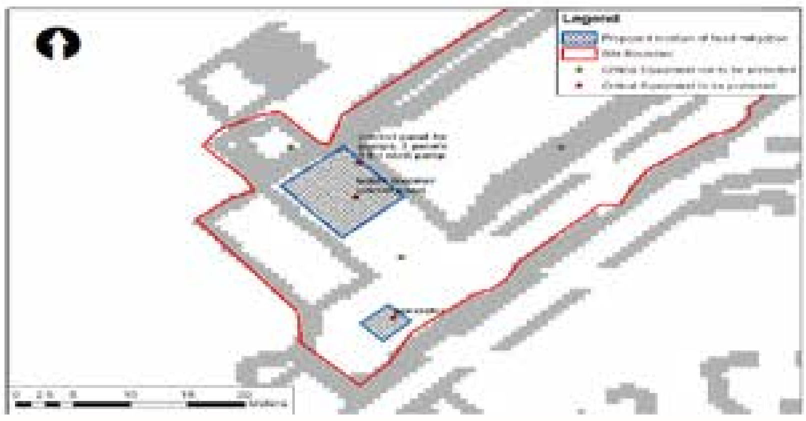
Flood Defence Description

1. Building waterproofing and flood doors are proposed as flood mitigation measures for the building which contains the control panels for the pumps (2 panels, 1 for each pump) and the mains incomer control panel.
2. Generator cabinet to be raised 0.74m.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

3.09mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	1. The following mitigation measure was considered but not preferred for the following reasons: a) Localised cabinet protection for the generator cabinet; this option was tested, but these works are far more expensive and not justifiable. General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	2	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	0	
Raise other equipment	number	1	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent to the site.

Source Data

LiDAR Data

LIDAR data for use in this Flood Risk Assessment has been obtained from the UK Government's national coverage. LIDAR data was downloaded on December 2016.

Existing FRA and accompanying model files

No FRA was avaiable for this site.

Site Topographical Survey

Not available

Watercourse Survey

N/A

Environment Agency / Local Authority Existing Studies

1. Preliminary Flood Risk Assessment produced by Borough of Poole Unitary Authority, June 2011
2. Strategic Flood Risk Assessment Level 1 by Borough of Poole Unitary Authority, January 2009
3. Strategic Flood Risk Assessment Level 2 by Borough of Poole Unitary Authority, April 2011

Details of Existing Study

Fluvial Hydrology

Not available

Tidal Hydrology

Not available

Study Extent

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

N/A

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

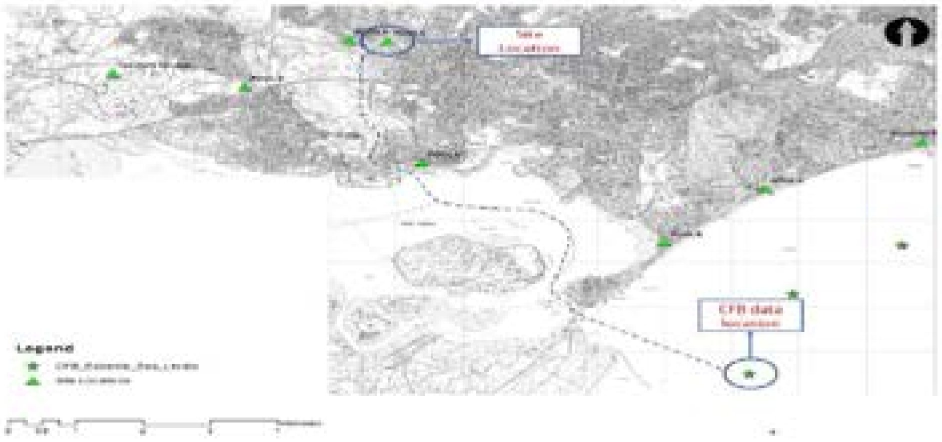
Fluvial Hydrology

Not applicable

Tidal Hydrology

Extreme Sea Levels from Coastal Flood Boundary (CFB) data, including upper bound confidence interval

Supporting Figure



Summary of Approach

The site and critical equipment levels (LIDAR) were compared against the Extreme Sea Levels from the Coastal Flood Boundary (CFB) data.
The latest Environment Agency Climate Change Guidance (2017) was followed for climate change allowances.

Hydraulic Modelling

Not carried out

Results

The results show flooding in the site and critical equipment for all the assessed events.

Comparison to previous studies / data

Results are around 20cm more conservative compared to the EA flood maps projected to the ground elevations from LIDAR.

Assumptions and Limitations

1. Report or hydraulic models were not available for the area.
2. The approach does not take into account the possible flowpaths to the site, it represents the most conservative approach using CFB data (uses the Upper Bound confidence interval).
2. The assessment does not consider the impact of wind and/or waves in the area.

Caveat

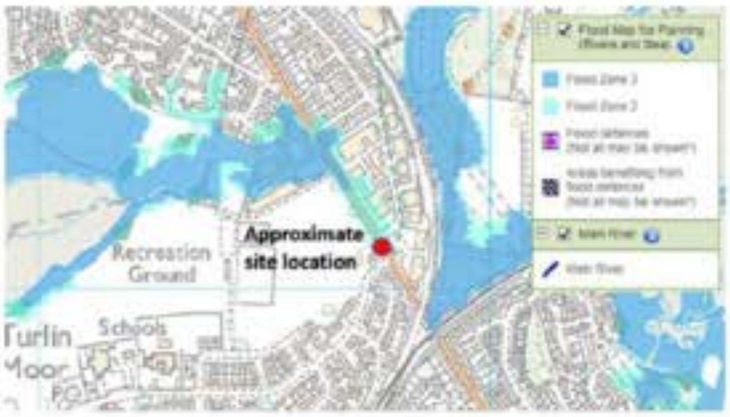
This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	POOLE	Post Code	
15273				
Site Type	NGR			
Sewage Pumping Station	Division	South	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark Bailey		
SP_PL	Contact Number	07884234605 (329)		

Site Plan

Location Plan

Environment Agency Flood Map

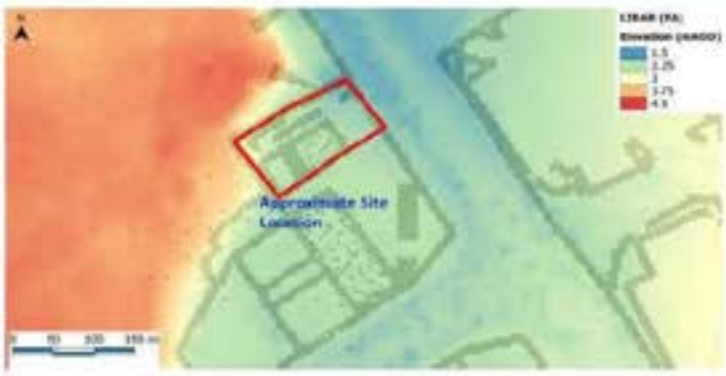


Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Tidal	Existing Flood Defence	No
Main Flooding Source	Holes Bay and Unnamed Ditch	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 2	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 2	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal Level (mAOD)	Fluvial / Coastal Depth (m)	Surface Water Level (mAOD)	Surface Water Depth (m)	Ground Water Flooding Susceptibility	Reservoir Level (mAOD)	Reservoir Depth (m)
2.10-2.18 (LIDAR)	2.14 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	2.21	0.00	N/A	0.00			
			1 in 200 year (0.5%)	2.27	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	2.49	0.19	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	2.41	0.11	N/A	N/A			
			1 in 200 year (0.5%)	2.47	0.17					
2.30			1 in 1000 year (0.1%)	2.69	0.39	N/A	N/A			
			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

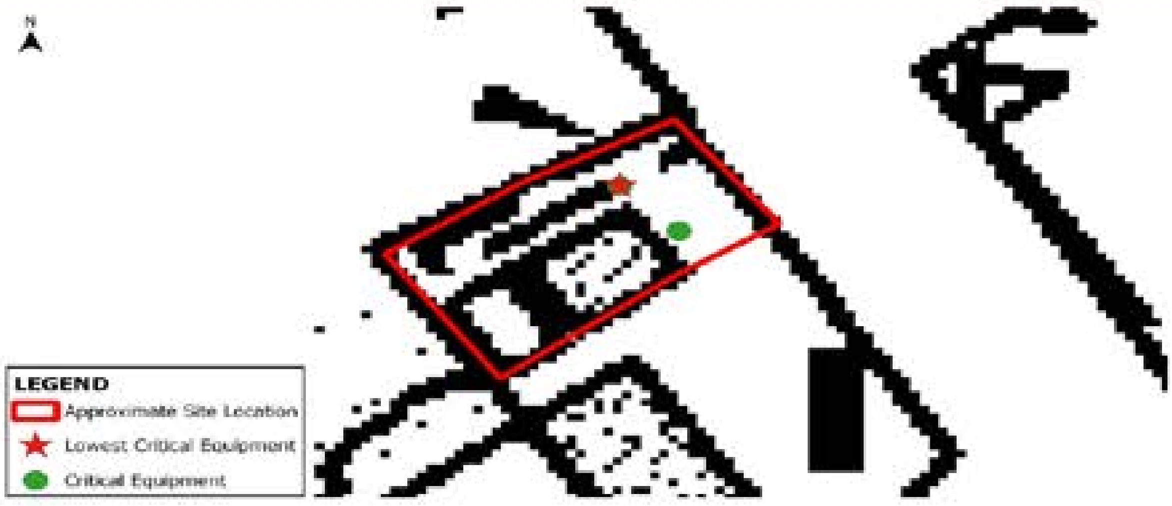
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Enrique Flores Diaz	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	Carrie Eller(MM) and Dave Whitelock(WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Control panel inc, mains incomer, pumps, generator	2.39	2.69	2.69	2.69	0.30
Generator	2.30	2.69	2.69	2.69	0.39

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. Wet well/dry well underground, MCC kiosk above ground, access to site affected. History of flooding on site (Critical Equipment drawing, Barry Park (WW)).	NONE

Phase 2 Mitigation Assessment

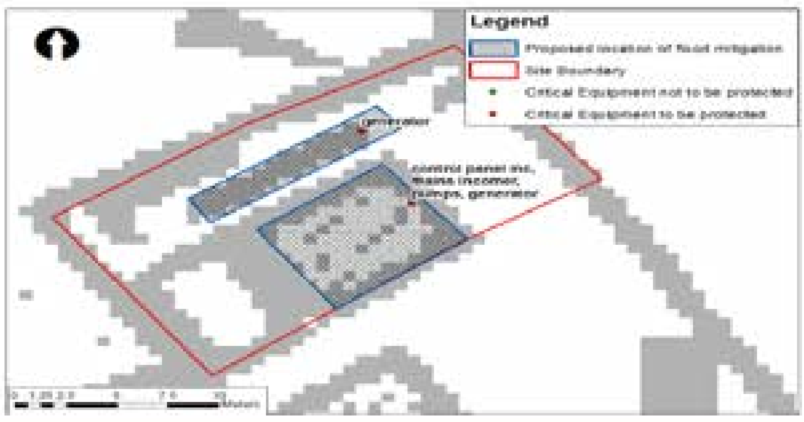
Flood Defence Description

1. Building waterproofing and flood doors are proposed as flood mitigation measures for the building which includes control panel, mains incomer, pumps and generator.
2. Generator cabinet to be raised 0.39m.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

2.69mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	1
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) Localised cabinet protection for the generator gabinet, this option would cause access problems and these works are far more expensive and not justifiable.
b) An earth bund to the north of the site as the site operator suggested, this option was discarded as the high volumes of water from tidal risk would find a way around through Blanford road.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent the site.

Source Data

LiDAR Data	Existing FRA and accompanying model files
LIDAR data for use in this Flood Risk Assessment has been obtained from the UK Government's national coverage lidar. LIDAR data was downloaded in December 2016.	Not Available

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
Not available	1. Preliminary Flood Risk Assessment produced by Borough of Poole Unitary Authority, June 2011 2. Strategic Flood Risk Assessment Level 1 by Borough of Poole Unitary Authority, January 2009 3. Strategic Flood Risk Assessment Level 2 by Borough of Poole Unitary Authority, April 2011
Watercourse Survey	
Not available	

Details of Existing Study

Fluvial Hydrology	Study Extent
Not available	
Tidal Hydrology	
Not available	

Hydraulic Model Construction	Return Periods Assessed in Model
Not available	Not available

Comments
n/a

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

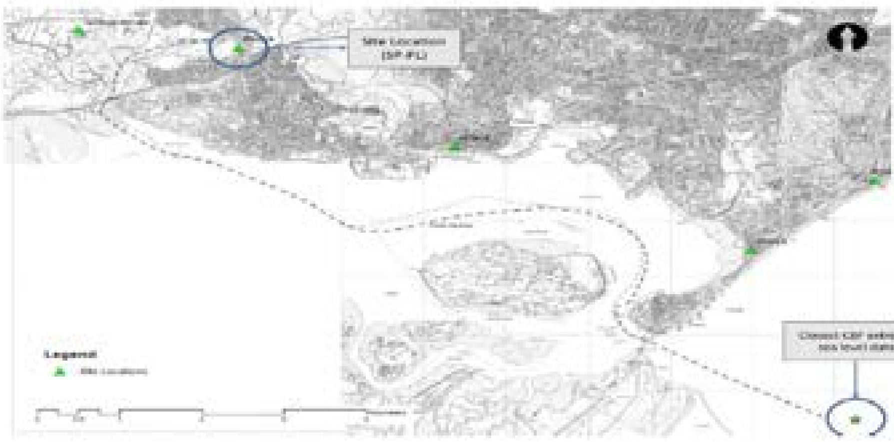
Fluvial Hydrology

Not applicable

Tidal Hydrology

Extreme Sea Levels from Coastal Flood Boundary (CFB) data, including upper bound confidence interval

Supporting Figure



Summary of Approach

The site and critical equipment levels (TOPO) were compared against the Extreme Sea Levels from the Coastal Flood Boundary (CFB).

Hydraulic Modelling

Not carried out

Results

The results show flooding on site and to critical equipment for the 100yr, 200yr, and 1000yr under Climate Change to 2050 (Upper End) return period events.

Comparison to previous studies / data

1. Hyder study and the analysis carried out concluded the flooding comes from the sea (tidal flooding).
2. Results are 20-30cm more conservative compared to the EA flood maps projected to the ground elevations from LIDAR.

Assumptions and Limitations

The approach does not take into account the possible flowpaths to the site, it represents the most conservative approach using CFB data.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	POOLE	Post Code	
15235				
Site Type	NGR			
Sewage Pumping Station	Division	South	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark Bailey		
SP_PS	Contact Number	07884234605 (329)		

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Tidal	Existing Flood Defence	No
Main Flooding Source	Poole Bay	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 1, 2 and 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
1.84 to 4.64 (TOPO)	2.10 (TOPO)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	2.60	0.56	N/A	0.00			
			1 in 200 year (0.5%)	2.66	0.62					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	2.88	0.84	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	2.80	0.76	N/A	N/A			
			1 in 200 year (0.5%)	2.86	0.82					
2.04			1 in 1000 year (0.1%)	3.08	1.04	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

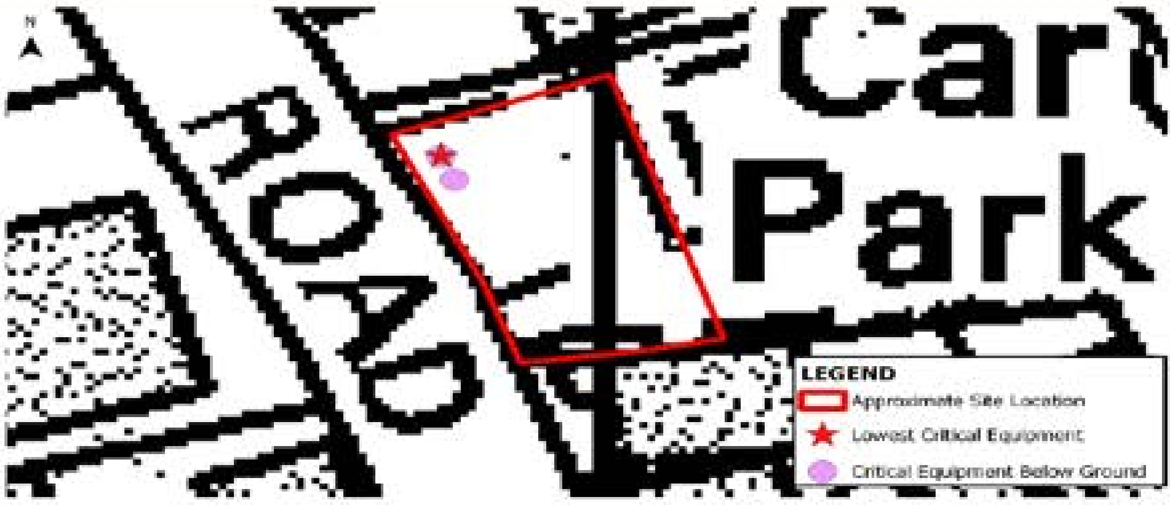
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Enrique Flores Diaz	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	Carrie Eller(MM) and Dave Whitelock(WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Control panel pumps and mains incomer	2.04	3.08	3.08	3.08	1.04
Storm pumping kiosk	2.04	3.08	3.08	3.08	1.04
Pumps and joining boxes	2.04	3.08	3.08	3.08	1.04

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
Wetwell/drywell and MCC are underground. History of flooding is only due to asset failure. (Barry Park, 17/11/2016)	1. Control panel pumps, mains incomer, storm pumping kiosk equipment, pumps and joining boxes are below ground. 2. Assuming the underwater room to be water tight, the equipment will start to inundate once flood water reaches the ground level. The level at the equipment is 1.10mAOD and the ground level at this location is at 3.45mAOD. (source: LiDAR). However the staircase to access the critical equipment has a ground elevation from 2.04mAOD to 2.21mAOD.

Phase 2 Mitigation Assessment

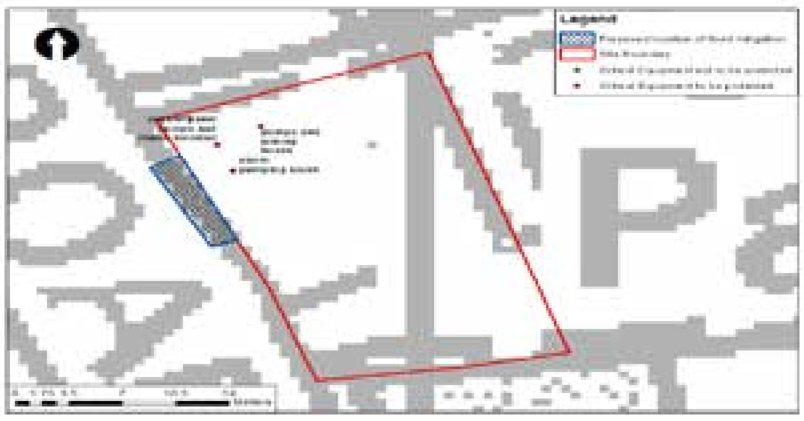
Flood Defence Description

1. Replace existing masonry wall at stairs with a 1.04m high flood wall around the access to the underground room containing the critical equipment. 2 flood doors to be installed at the two stairway entrances at pavement level.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

3.08mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	13
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. It was assumed that the flood risk occurs when the water level on the surface reaches a level sufficient to reach the entrance (staircase) to the underground room leading to the critical equipment. In order to prevent the flooding a walling of approximately 1m height around the access to the staircase is proposed. Lowest ground level at the staircase = 2.04 mAOD (Topo). Wall height = 1.04m. Wall length ~13m.

2. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred due to cost and constructability given that the critical equipment is located in the basement.
b) waterproofing of the building with flood doors at the existing door locations were considered. Given space allowances, the flood doors would potentially require significant changes to the existing door locations, potentially incurring higher costs.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	
	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent the site.

Source Data

LiDAR Data

LIDAR data for use in this Flood Risk Assessment has been obtained from the UK Government's national coverage lidar. LIDAR data was downloaded in December 2016.

Existing FRA and accompanying model files

No FRA was avaiable for this site.

Site Topographical Survey

Site topographical survey is available for the site on CAD format (.dwg).
SP_PS_15235 Shore Road Poole plan_20161122.dwg
SP_PS_15235 Shore Road Poole topo_20161122.dwg

Environment Agency / Local Authority Existing Studies

1. Preliminary Flood Risk Assessment produced by Borough of Poole Unitary Authority, June 2011
2. Strategic Flood Risk Assessment Level 1 by Borough of Poole Unitary Authority, January 2009
3. Strategic Flood Risk Assessment Level 2 by Borough of Poole Unitary Authority, April 2011

Watercourse Survey

Not applicable

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent

Tidal Hydrology

Not available

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

n/a

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

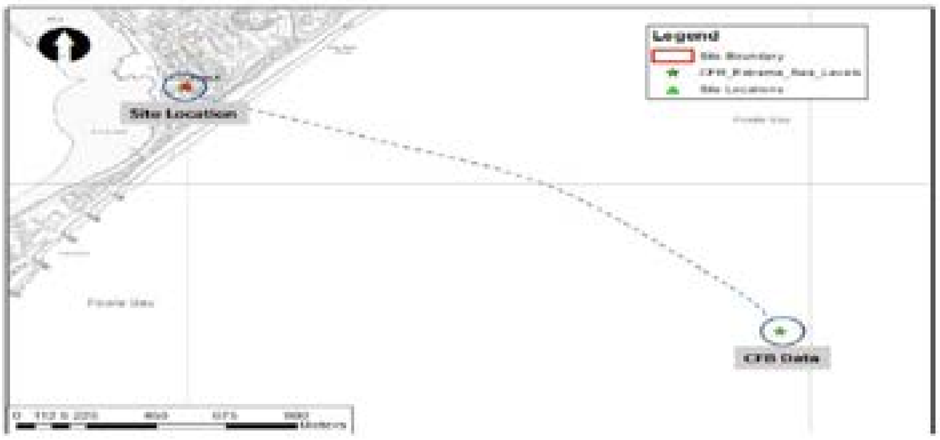
Fluvial Hydrology

Not applicable

Tidal Hydrology

Extreme Sea Levels from Coastal Flood Boundary (CFB) data, including upper bound confidence interval

Supporting Figure



Summary of Approach

The site and critical equipment levels (TOPO) were compared against the Extreme Sea Levels from the Coastal Flood Boundary (CFB). An allowance of 0.5m was added on top of sea levels to account for wave action and any possible sea level increments.

Hydraulic Modelling

Not carried out

Results

The results show flooding on site and to critical equipment for all the assessed events with exception of the 1%AEP and 2%AEP (including climate change to 2025 in both cases).

Comparison to previous studies / data

Results are around 20cm more conservative compared to the EA flood maps projected to the ground elevations from LIDAR.

Assumptions and Limitations

1. Report or hydraulic models were not available for the area.
2. The approach does not take into account the possible flowpaths to the site, it represents the most conservative approach using CFB data.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	POOLE	Post Code	
15270				
Site Type	NGR			
Sewage Pumping Station	Division	South	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark Bailey		
SP_PT	Contact Number	07884234605 (329)		

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Tidal	Existing Flood Defence	No
Main Flooding Source	Holes Bay and Unnamed Ditch	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
1.70-2.80 (LIDAR)	2.40 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	2.61	0.00	N/A	0.00			
			1 in 200 year (0.5%)	2.67	0.03					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	2.89	0.25	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	2.81	0.17	N/A	N/A			
			1 in 200 year (0.5%)	2.87	0.23					
			1 in 1000 year (0.1%)	3.09	0.45	N/A	N/A			
2.64			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 2, 3 and 4 of this summary sheet.

Revision Record

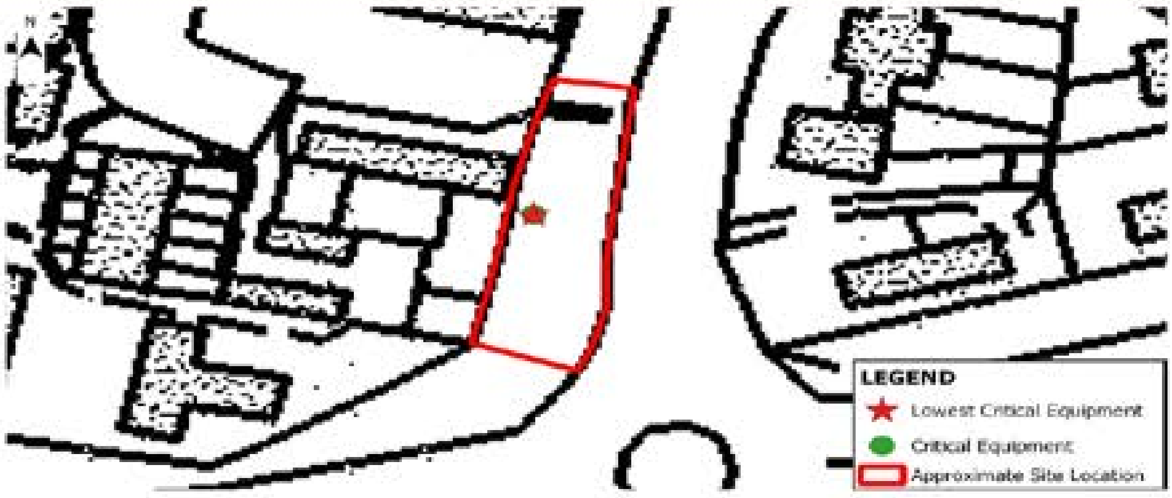
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Enrique Flores Diaz	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	Carrie Eller(MM) and Dave Whitelock(WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Control panels for pumps, mains incomer, compresor	2.64	3.09	3.09	3.09	0.45

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. During flood events, site access is possible next to roundabout over grass verge. (Dave Whitelock, Site visit 01/12/2016) 2. No record of previous flooding history on site. (Dave Whitelock, Site visit 01/12/2016)	NONE

Phase 2 Mitigation Assessment

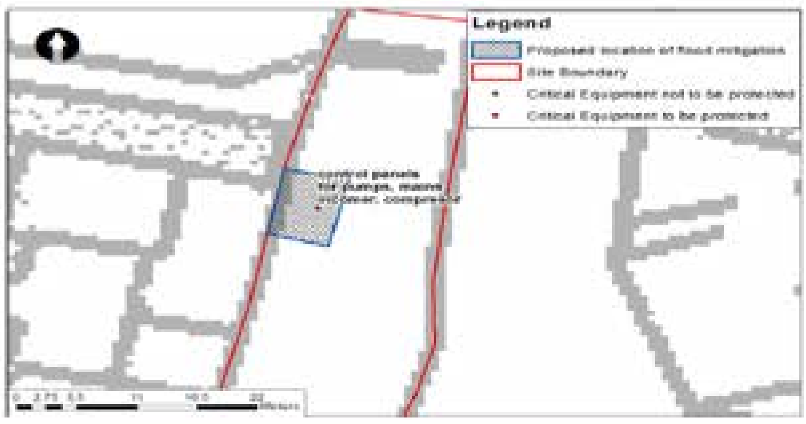
Flood Defence Description

Control panels for pumps, mains incomer and compressor to be raised 0.45m. Based on the site visit photographs it is assumed there is enough head room inside the building and therefore no structural changes are required.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

3.09mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	1. The preferred defence option is raising the equipment inside the building on a platform 0.45m high. If headroom does not allow the equipment to be lifted, the building should be waterproofed and the doors (x2) have to be replaced for flood doors. 2. The following mitigation measures were considered but not preferred for the following reasons: a) If headroom in the building does not allow for the equipment to be raised, alternatively the building could be waterproofed with flood doors installed. General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	0	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	0	
Raise other equipment	number	1	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent the site.

Source Data

LiDAR Data

LIDAR data for use in this Flood Risk Assessment has been obtained from the UK Government's national coverage lidar. LIDAR data was downloaded in December 2016.

Existing FRA and accompanying model files

No FRA was avaiable for this site.

Site Topographical Survey

Not available

Watercourse Survey

Not applicable

Environment Agency / Local Authority Existing Studies

1. Preliminary Flood Risk Assessment produced by Borough of Poole Unitary Authority, June 2011
2. Strategic Flood Risk Assessment Level 1 by Borough of Poole Unitary Authority, January 2009
3. Strategic Flood Risk Assessment Level 2 by Borough of Poole Unitary Authority, April 2011

Details of Existing Study

Fluvial Hydrology

Not available

Tidal Hydrology

Not available

Study Extent

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

n/a

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

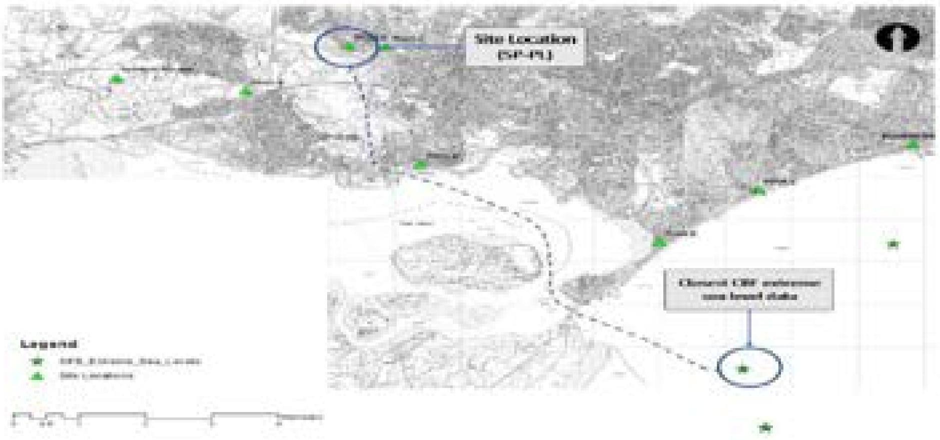
Fluvial Hydrology

Not applicable

Tidal Hydrology

Extreme Sea Levels from Coastal Flood Boundary (CFB) data, including upper bound confidence interval

Supporting Figure



Summary of Approach

The site and critical equipment levels (TOPO) were compared against the Extreme Sea Levels from the Coastal Flood Boundary (CFB). An allowance of 0.5m was added on top of sea levels to account for wave action and any possible sea level increment inside the Poole.

Hydraulic Modelling

Not carried out

Results

The results show flooding in the site and critical equipment for all the assessed events.

Comparison to previous studies / data

Results are around 20cm more conservative compared to the EA flood maps projected to the ground elevations from LIDAR.

Assumptions and Limitations

1. Report or hydraulic models were not available for the area.
2. The approach does not take into account the possible flowpaths to the site, it represents the most conservative approach using CFB data.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	POOLE	Post Code	
15383				
Site Type	NGR			
Sewage Pumping Station	Division	South	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark Bailey		
SP_PW	Contact Number	07884234605 (329)		

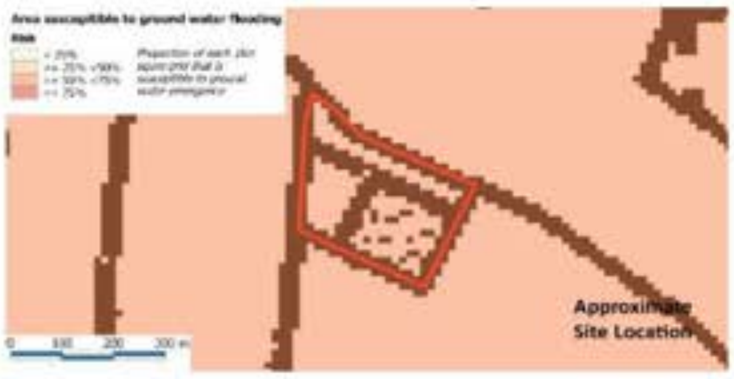
Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Tidal	Existing Flood Defence	Yes
Main Flooding Source	Poole Bay	EA Flood Warning Area	Lower Hamworthy and areas of Poole from Old Town, The Quay to Hunger Hill
Current Site Flood Zone	Flood Zone 3, Areas benefiting from flood defences	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3, Areas benefiting from flood defences	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
1.54-1.85 (LIDAR)	1.70 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	2.61	0.76	N/A	0.00			
			1 in 200 year (0.5%)	2.67	0.82					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	2.89	1.04	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	2.81	0.96	N/A	N/A			
			1 in 200 year (0.5%)	2.87	1.02					
			1 in 1000 year (0.1%)	3.09	1.24	N/A	N/A			
1.85			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

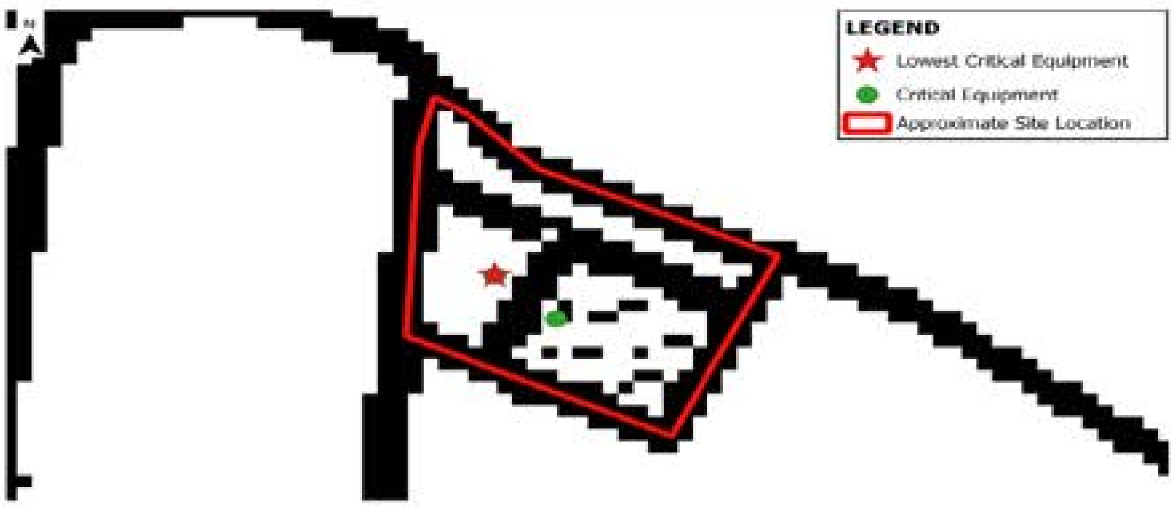
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Enrique Flores Diaz	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	Carrie Eller(MM) and Dave Whitelock(WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Generator	1.85	3.09	3.09	3.09	1.24
Control panel for pumps, mains incomer	1.94	3.09	3.09	3.09	1.15

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. History of flooding is only due to asset failure. (Barry Park, Site visit 17/11/2016) 2. Dry and wet well are underground while MCC is above ground. (Barry Park, Site visit 17/11/2016)	NONE

Phase 2 Mitigation Assessment

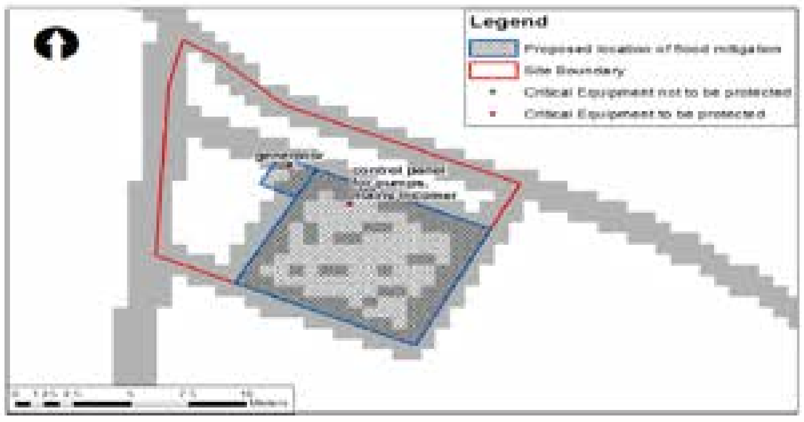
Flood Defence Description

1. A combination of building 1m wall, waterproofing and flood doors are proposed as flood mitigation measures for the building which contains control panel and mains incomer.
2. Generator cabinet to be raised 1.24m.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

3.09mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	31
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	1
Other	linear m	0

Comments:

1. The following mitigation measures were considered but not preferred for the following reasons:
a) Localised cabinet protection for the generator cabinet, this option would cause access problems and these works are far more expensive and not justifiable.
b) A 2m wall around the whole site was tested but was discarded as the works are far more expensive and not justifiable.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent the site.

Source Data

LiDAR Data	Existing FRA and accompanying model files
LIDAR data for use in this Flood Risk Assessment has been obtained from the UK Government's national coverage lidar. LIDAR data was downloaded in December 2016.	Not Available

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
Not available	1. Preliminary Flood Risk Assessment produced by Borough of Poole Unitary Authority, June 2011 2. Strategic Flood Risk Assessment Level 1 by Borough of Poole Unitary Authority, January 2009 3. Strategic Flood Risk Assessment Level 2 by Borough of Poole Unitary Authority, April 2011
Watercourse Survey	
Not available	

Details of Existing Study

Fluvial Hydrology	Study Extent
Not available	
Tidal Hydrology	
Not available	

Hydraulic Model Construction	Return Periods Assessed in Model
Not available	Not available

Comments

n/a

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

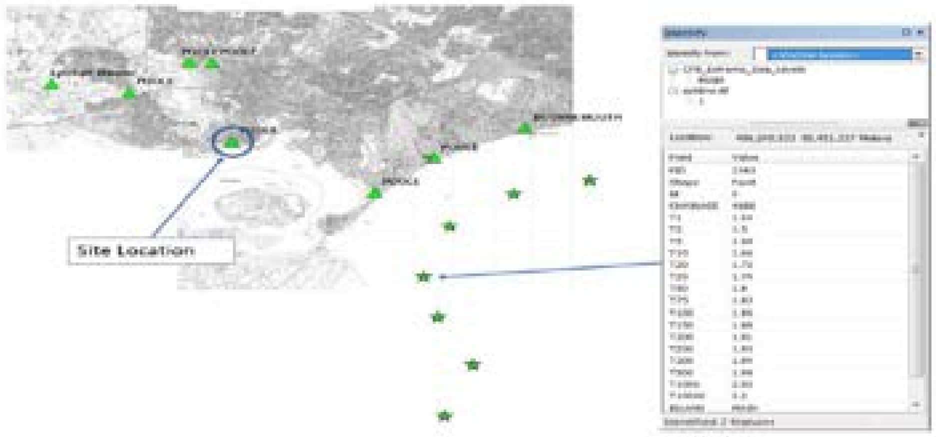
Fluvial Hydrology

Not applicable

Tidal Hydrology

Extreme Sea Levels from Coastal Flood Boundary (CFB) data, including upper bound confidence interval

Supporting Figure



Summary of Approach

The site and critical equipment levels (LIDAR) were compared against the Extreme Sea Levels from the Coastal Flood Boundary (CFB) data.
The latest Climate Change Guidance updates (2017) were follow to applied allowance for climate change to the year 2025 and 2050 respectively.

Hydraulic Modelling

Not carried out

Results

The results show flooding in the site and critical equipment for all the assessed events.

Comparison to previous studies / data

1. Results are 20-30cm more conservative compared to the EA flood maps projected to the ground elevations from LIDAR.
2. The assessment does not consider the impact of wind and/or waves in the area.

Assumptions and Limitations

1. Report or hydraulic models were not available for the area.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	TROWBRIDGE	Post Code	
14510				
Site Type	NGR			
Sewage Pumping Station	Division	North	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark James Cooper		
SP_TB	Contact Number	07776226970		

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Biss	EA Flood Warning Area	County Way Road to River Way Road, including the Library, and the area around Town Bridge
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
32.73-32.90 (LIDAR)	32.77 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	33.46	0.72	N/A	<0.30			
			1 in 200 year (0.5%)	33.56	0.82					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	33.79	1.05	N/A	> 0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	33.54	0.80	N/A	N/A			
			1 in 200 year (0.5%)	33.62	0.88					
			1 in 1000 year (0.1%)	33.88	1.14	N/A	N/A			
32.74			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

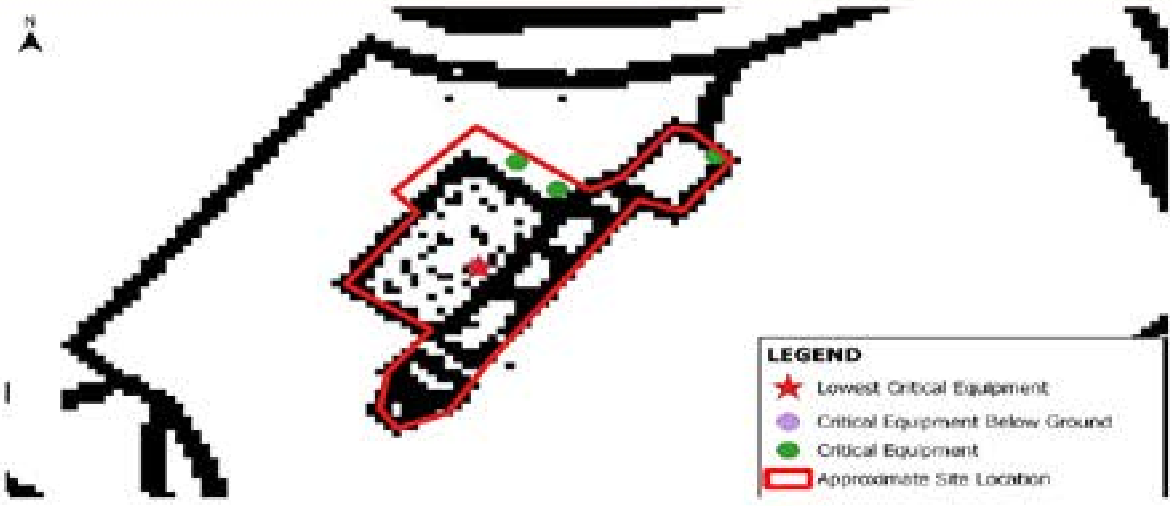
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Bill O'Leary	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	07/12/2016	Attendees	Carrie Eller (MM) and Duncan MacKie (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Pumps	32.90	33.88	34.06	34.06	1.16
SSE transformer	32.74	33.88	34.06	34.06	1.32
Control panels for site	33.18	33.88	34.06	34.06	0.88
Electricity equipment SSE owned	33.19	33.88	34.06	34.06	0.87

Summary of Key Client Comments

1. Flooding has occured every year in the past, and the flood levels have been around the road level, and the flood depth to be around couple of inches. (Duncan MacKie, Site Visit 07/12/2016)
2. As per STW and WTW Flood Resilience Database, the site has experienced surface water flooding of various processes as well as of the site access few times in last 5 years.
3. As per STW and WTW Flood Resilience Database, excessive water has entered in to the drainage pumping station, which has caused high level in humus return pumping station. This has caused overflow to operate, excess pumping and reduced humus tank desludging due to backing up.

Comments on Below Ground Equipment (if any)

1. Pumps are in basement with the critical level at 26.96mAOD. Water may enter the basement once water reaches the ground level at 32.90mAOD.
2. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.
3. For below ground equipment, flood depths listed in the above table represent the depth above ground level or finished flood level. Once the flood level becomes higher than the indicative threshold level listed in the above table for below ground equipment, flood depth at the equipment should be estimated with respect to critical equipment level, and not the indicative threshold level.

Phase 2 Mitigation Assessment

Flood Defence Description

1. The building housing the control panel and the electricity equipment SEE owned should be waterproofed and flood doors fitted to prevent flooding up to 0.88m in depth over the existing floor level.
2. The pumping station in the basement contains dry well pumps that should be replaced with IP68 rated equipment (medium size/medium complexity cost banding).
3. The SEE owned tranfomer should be raised 1.35m and an access platform constructed adjacent.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

34.06 mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Medium
Raise control panel or kiosk	number	0
Raise other equipment	number	1
Other	linear m	1

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred given the impact on flooding and the restriction of access in and around the site. Note the SEE owned transfomer would be accessed independently of Wessex operations.
b) Localised protection (cabinets or flood walls) were considered at various individual pieces of equipment however this may cause access issues and therefore raising the transfomer equipment is preferred.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minor. The proposed footprint of the raised plinth at the transfomer is relatively small in relation to the floodplain, however given potential high velocities there may be an impact. The impact due to the proposed defence at the existing building is small.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Not available

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site.
The Environment Agency confirmed that no hydraulic modelling studies are available covering the site.
Two models are available which cover Trowbridge upstream of the site. 1) Lambrok Stream (2013) Standard of Protection Study which has its downstream boundary roughly 500m upstream of the site, and 2) Trowbridge (2013) Standard of Protection Study which has its downstream boundary roughly 750m upstream of the site.

Details of Existing Study

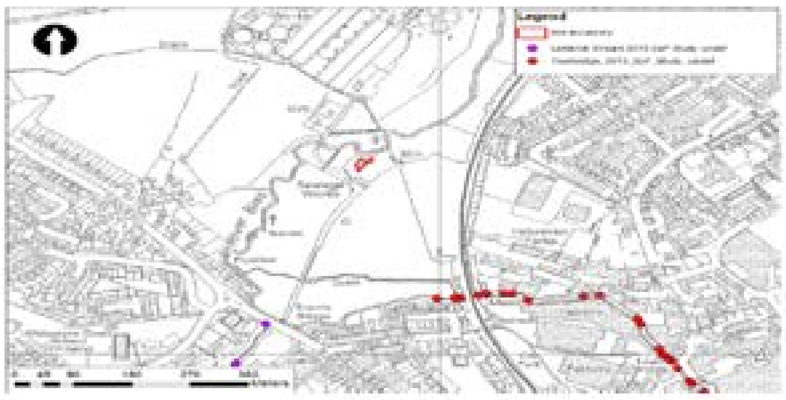
Fluvial Hydrology

Fluvial hydrology in the Trowbridge (2013) model is derived from the rainfall-runoff method using adjusted hydrological parameters (Tp x 2.37 and SPR x 1.35).

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent



Hydraulic Model Construction

1. A 1D-2D (ESTRY_TUFLOW) hydraulic model of the River Biss, with the downstream boundary at the railway bridge upstream of the site.
2. A 1D (HEC-RAS Steady State) hydraulic model of Lambrok Stream with the downstream boundary at Bradford Road at the confluence with the River Biss upstream of the site.

Return Periods Assessed in Model

2, 5, 10, 20, 20CC(20%), 50, 75, 100, 100CC(20%), 200 and 1000

Comments

The two modelling studies used in this assessment do not cover the site. Flows at the downstream end of these models have been combined in order to obtain an estimated flow at the site.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

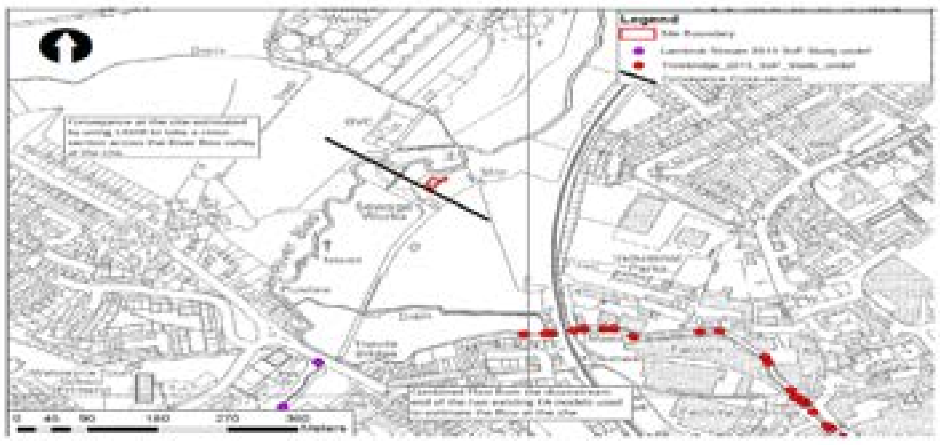
Fluvial Hydrology

Peak flows from the two existing studies provided by the EA were combined to estimate design flows at the site.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1) Hydrology from the two upstream existing models were combined to estimate the design flows at the site.
2) Conveyance in the channel adjacent to the site was estimated using LIDAR.
3) Based on the conveyance calculations, the peak water levels have been estimated at the site including an allowance for climate change.

Hydraulic Modelling

Not undertaken

Results

The results indicate that all critical equipment are at risk of flooding for the 1 in 1000yr(2050) flood event.
Resulting water levels are provided on pages 1 and 2.

Comparison to previous studies / data

The edges of the flood envelopes from the EA Flood Zone Maps have been compared to the ground level at the same location (from LIDAR). This gives a 1 in 100yr flood level of 33.36mAOD (compared with 33.40mAOD from the conveyance test) and a 1 in 1000yr flood level of 33.10mAOD (compared with 33.10mAOD from the conveyance test).

Assumptions and Limitations

1. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
2. The combined flow from the two existing Environment Agency models are assumed to represent the flow rate in the river channel adjacent the site.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	WARMWELL	Post Code	
13326				
Site Type	NGR			
Sewage Pumping Station	Division	South	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark Bailey		
SP_WA	Contact Number	07884234605 (329)		

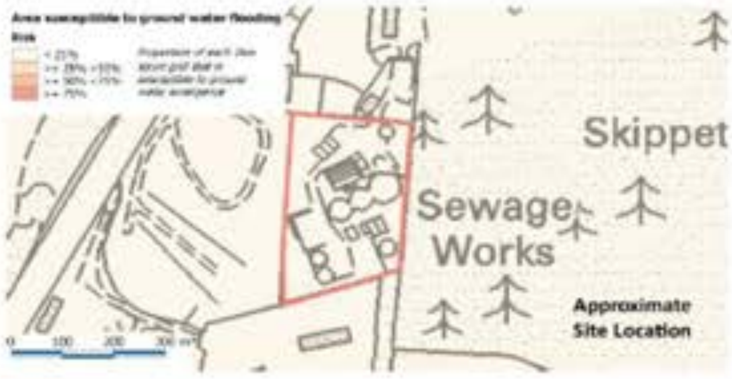
Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Groundwater	Existing Flood Defence	No
Main Flooding Source	Nearest watercourse is a tributary of the River Frome	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal Level (mAOD)	Fluvial / Coastal Depth (m)	Surface Water Level (mAOD)	Surface Water Depth (m)	Ground Water Flooding Susceptibility	Reservoir Level (mAOD)	Reservoir Depth (m)
48.19-48.38 (LIDAR)	48.23 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	35.39	0.00	N/A	0.00			
			1 in 200 year (0.5%)	35.44	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	35.44	0.00	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	35.59	0.00	N/A	N/A			
			1 in 200 year (0.5%)	35.64	0.00					
			1 in 1000 year (0.1%)	35.64	0.00	N/A	N/A			
48.37			Groundwater flooding					Negligible *		
			Reservoir							0.00

Comments

1. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).
2. Fluvial levels are estimated from nearest EA Flood Zone Map of River Frome. These do not represent the source of greatest risk to the site (groundwater). Please see pages 2, 3 and 4 for information on groundwater flood risk.

* Note: the EA groundwater risk map indicates that the risk of groundwater flooding is negligible. This is based on broad scale mapping. Based on our detailed assessment, we have identified some equipment at risk of groundwater flooding. This is summarised on pages 2, 3 and 4.

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	06/12/2016	Attendees	Carrie Eller (MM) and Tim (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Control panel for mains incomer, gen standby, pump	48.37	48.67	48.67	48.67	0.30
Nitrate dosing equipment	49.23	48.67	48.67	48.67	-0.56
Generator	49.26	48.67	48.67	48.67	-0.59

Summary of Key Client Comments

1. Areas located south and east of the site are swampy with some groundwater. (Tim, Site visit 06/12/2016)
2. No previous flooding has been observed at this site. (Tim, Site visit 06/12/2016)

Comments on Below Ground Equipment (if any)

NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. The building housing the control panel for the mains incomer, generator standby and pump should be provided with a stop lock door panel. This removable panel mounted to the frame of the door opening is to provide a 0.3m increase in the building threshold level.
2. Nitrate dosing equipment and Generator do not require protection. These items are raised off the ground, above the potential flood levels.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

48.67 mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	1. The following mitigation measures were considered but not preferred for the following reasons: a) Localised protection (cabinets or flood walls) were considered at various individual pieces of equipment however this may cause access issues and therefore providing flood door to the equipment is preferred General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	1	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	0	
Raise other equipment	number	0	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligible. The installation of the door protection will have no impact on flooding to other parts of the site or third parties due to no changes in flooded area or flood storage.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Not available

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

Not available

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

There is no existing model and/or report available from EA and Wessex Water in the vicinity of the site.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Groundwater

Supporting Figure

Fluvial Hydrology

The site is not affected from fluvial flood risk.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Summary of Approach

1. The level difference between the site and adjacent Flood Zone 2 extent is approximately 13m, therefore the site is not affected by fluvial flooding for 100yr and 1000yr return periods considering the climate change allowances. A further assessment of local drains and other potential sources of flooding indicates no other sources of fluvial flood risk.
2. Based on the Environment Agency data for "Area susceptible to ground water flooding", the designated risk of groundwater emergence in the vicinity of the site is <25% (Flood Type: Superficial Deposits Flooding) which is considered as negligible risk. Moreover, there is no previous groundwater flooding observed at this site, therefore, our assessment of exisitng data and comments from WxW site operator indicate that there is no significant risk due to groundwater flooding. However, if the groundwater emergence is observed at the site in future, then mitigation measures, such as local drains, could be installed at the site.
3. Study of the surrounding area revealed that there is a risk of groundwater flooding, particularly during prolonged rainfall periods during the winter season. The high permeability of the soils in the area give rise to the potential for groundwater flooding and a combination of groundwater and surface water during larger rainfall events. If groundwater emergence is observed at the site in future, then mitigation measures such as local drains could be installed at the site.

Hydraulic Modelling

Not applicable.

Results

Not applicable

Comparison to previous studies / data

1. Tributary of River Frome is the nearest watercourse to the site. EA Flood Zone 2 (1000yr return period) and EA Flood Zone 3 (100yr return period) extent is approximately 250m to 300m away from the site location.
2. Ground elevation at the site is 48.23mAOD. Flood levels for EA Flood Zone 2 estimated from EA LiDAR is approximately 35.00 mAOD.
3. As the level difference between the site and adjacent flood zone is approximately 13m, therefore the site is not affected by fluvial flooding for 1 in 100 year and 1 in 1000 year return periods considering the climate change allowance for the sources considered in the EA Flood Zone mapping.

Assumptions and Limitations

The risk of groundwater flooding has resulted in an allowance being applied to the site for protection against groundwater flooding. The resultant depths of flooding from groundwater are assumed based on analysis of the ponding and active flowpaths which would form within the site.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	WESTON-SUPER-MARE	Post Code	
15681				
Site Type	NGR			
Sewage Pumping Station	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark James Cooper		
SP_WE	Contact Number	07776226970		

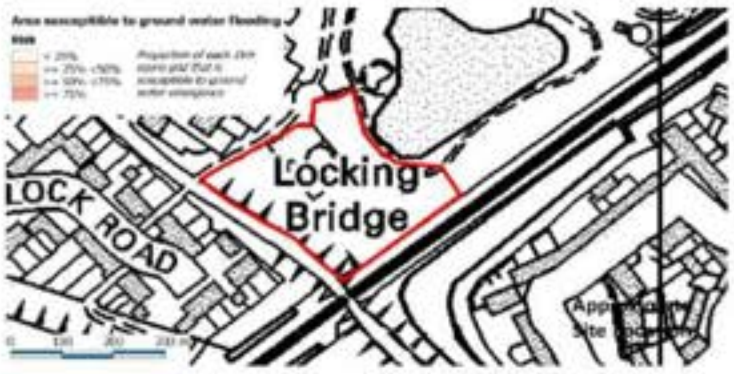
Site Plan

Location Plan

Environment Agency Flood Map

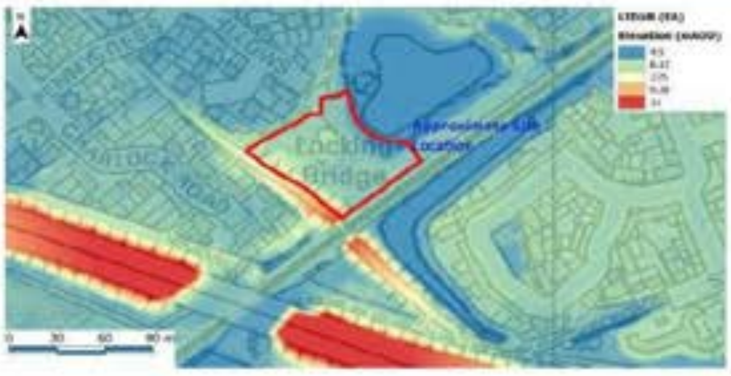
Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Coastal	Existing Flood Defence	Yes
Main Flooding Source	Bristol Channel	EA Flood Warning Area	The A3033 to the west to the M5 in the east, including Worle, Ebdon and St Georges to the north
Current Site Flood Zone	Flood Zone 3, Areas benefiting from flood defences	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3, Areas benefiting from flood defences	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	North Somerset Levels Internal Drainage Board

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal Level (mAOD)	Fluvial / Coastal Depth (m)	Surface Water Level (mAOD)	Surface Water Depth (m)	Ground Water Flooding Susceptibility	Reservoir Level (mAOD)	Reservoir Depth (m)
5.36 (LiDAR) to 6.06 (LiDAR)	5.71 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	8.85	2.93	N/A	0.00			
			1 in 200 year (0.5%)	8.98	3.06					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	9.50	3.58	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	9.11	3.19	N/A	N/A			
			1 in 200 year (0.5%)	9.24	3.32					
5.92			1 in 1000 year (0.1%)	9.76	3.84	N/A	N/A			
			Groundwater flooding					Data not available*		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

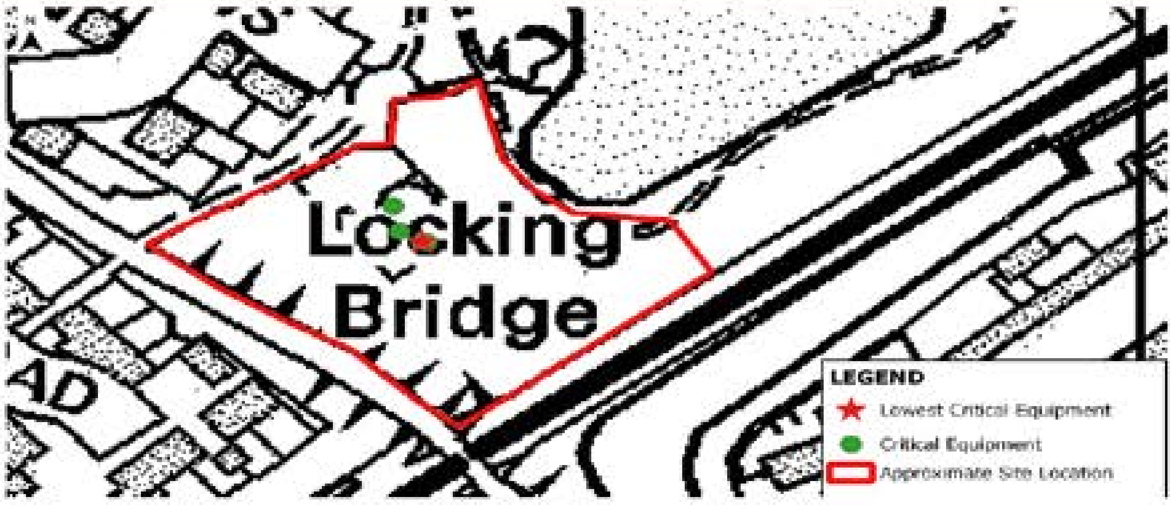
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Bill O'Leary	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	06/12/2016	Attendees	Domenico Santoro (MM) and Lee Weller (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Control panel	5.92	9.76	9.56	9.76	3.84
Generator	6.07	9.76	9.56	9.76	3.69
Main power incoming	6.33	9.76	9.56	9.76	3.43
Pump junction box	7.13	9.76	9.56	9.76	2.63

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
The site discharges the pumped flow into a small reservoir (probably and EA asset). It is advised to ask Gerald Turner (WW) for more information about the flood history of the site. (Lee Weller, Site visit 06/12/2016)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

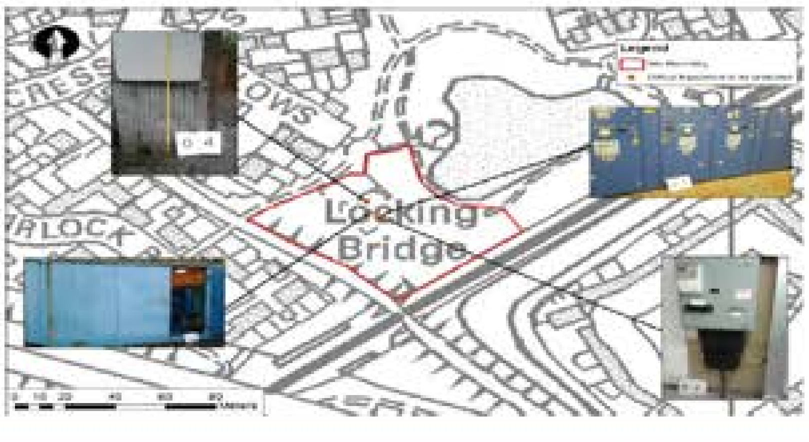
1. Given the extreme flood depths at this site, it is not possible to protect the site against the 1000yr+CC flood event. Please see comment box below.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

n/a

Note: given the extreme flood depths at this site, it is difficult to provide a standard of protection to the 1000yr+CC event.

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m		1. In view of the depth of flooding, it may not be feasible to protect the site against the design event (upper bound 1 in 1000 year including climate change to 2050). Potential reduced flood levels are as follows; 100MB (2025) - 8.55mAOD, 200MB (2025) - 8.68mAOD, 1000MB (2025) - 9.00mAOD, 100MB (2050) - 8.81mAOD, 200MB (2050) - 8.94mAOD, 1000MB (2050) - 9.26mAOD. [MB=median bound] 2. Providing flood mitigation measures to protect the site from flooding up to the 1000yr+CC flood event would be difficult given the required height of the defences required. It is noted that in the event of flooding at this site, the surrounding community is likely to experience extreme flood inundation as well. 3. The following flood mitigation measures were considered: a) whole site protection would be extremely costly given the required height of defences. b) local protection or further raising the equipment would be extremely costly given the required height of defences. c) an alternative solution would be to provide a reduced standard of protection (less than the 1000yr+CC flood event) to provide increased resilience for a more reasonable cost. For instance, raising the equipment to the 100yr (median bound) +CC (2025) would require raising of 2.63m (Control Panel), 2.48m (Generator), 2.22m (Main Power Incoming). The Pump Junction Box could be replaced with an IP68 rated (submersible) alternative. General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.
Walling up to 1m height	linear m		
Walling up to 2m height	linear m		
Walling up to 3m height	linear m		
Building waterproofing (treatment to existing buildings- height varies)	nr buildings		
Localised cabinet protection (max 1m height)	linear m		
Localised cabinet protection (max 2.1m height)	linear m		
Flood doors	number		
Flood gate up to 1m	number		
Flood gate up to 2m	number		
Movable/demountable defence	linear m		
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-		
Raise control panel or kiosk	number		
Raise other equipment	number		
Other	linear m		

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The site experiences tidal flooding and defending this area will remove a very small proportion of the floodplain storage.

Source Data

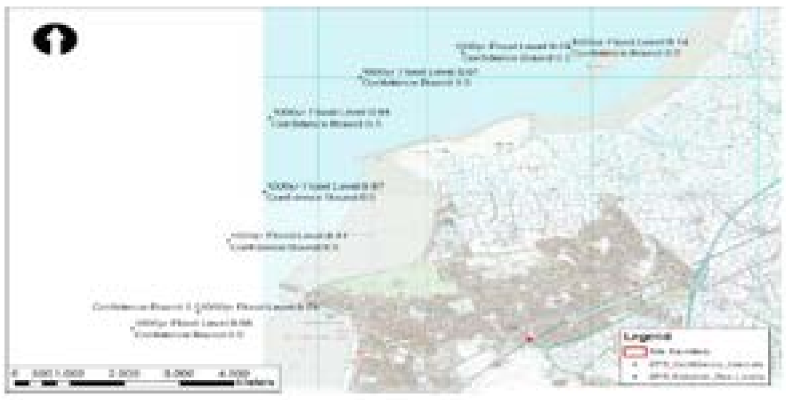
LiDAR Data	Existing FRA and accompanying model files
1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.	There is no existing FRA available for this site.

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
No site topographical survey is available for the site	A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Watercourse Survey

Not available

Details of Existing Study

Fluvial Hydrology	Study Extent
Not available	

Tidal Hydrology

CFB (2011)

Hydraulic Model Construction	Return Periods Assessed in Model
No Details	CFB (2011) includes results from the 1yr, 2yr, 5yr, 10yr, 20yr, 25yr, 50yr, 75yr, 100yr, 150yr, 200yr, 250yr, 300yr, 500yr, 1000yr and 1000yr events. These include both Median bound and Upper bound levels.

Comments

Model results have been provided by the Environment Agency for the defended and undefended 1 in 200yr and 1 in 1000yr events.
However, there have been no reports or modelling files provided with these results.
Therefore no details are known as to the base year of the modelling or the construction of the model and no assessment can be made as to the suitability of the model results for estimating flood levels at the site.
As such, the design flood levels for the site have been drawn from Coastal Flood Boundaries (2011) data.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Coastal

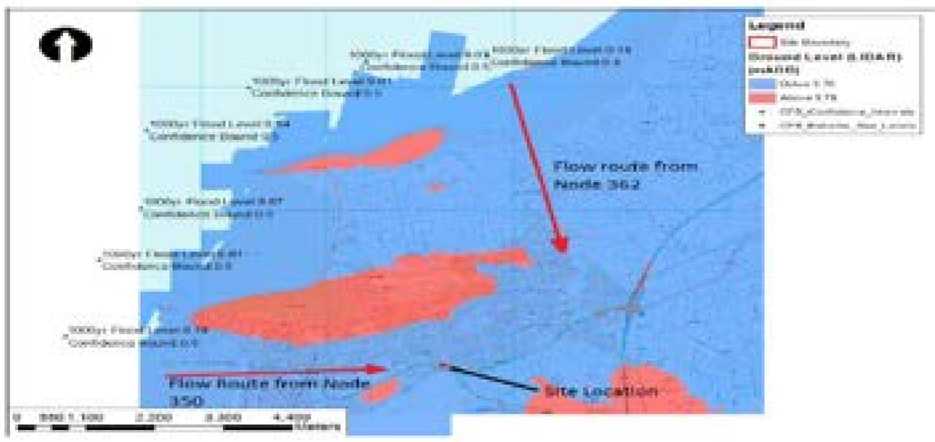
Fluvial Hydrology

The site is not affected from fluvial flood risk.

Tidal Hydrology

CFB (2011)

Supporting Figure



Summary of Approach

Have obtained the Coastal Flood Boundaries data along the coastline in the vicinity of the site and amended each of these to include the upper confidence bound and the impact of climate change to 2050.
Have used engineering judgement in order to make an assessment of which level is the most appropriate for use at the site.
The peak level at the site was estimated by calculating the mean level for Nodes 350 and 362 from the Coastal Flood Boundaries (2011) results.

Hydraulic Modelling

Not available

Results

The results show flooding in the site and critical equipment for all the assessed events.

Comparison to previous studies / data

1. Undefended results from model results show levels of 6.47mAOD (1000yr) and 6.34mAOD (200yr).
2. Defended results from model results show no flooding at the site.
3. These results are based on levels close to the tidal boundary of 8.82mAOD (1000yr) and 8.49mAOD (200yr) in the region of CFB (2011) Node 350.
4. This compares to the Upper Bound CFB (2011) levels used in this assessment of 9.56mAOD (1000yr) and 9.03mAOD (200yr) when including the impact of climate change to 2050.

Assumptions and Limitations

It is assumed that the level at the site is heavily influenced by the peak water levels at CFB (2011) Nodes 350 and 362.
It is assumed that no adaquate flood defences are provided in events of this extreme magnitude and as such water levels at the site are equal to levels from the CFB (2011) data.
Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

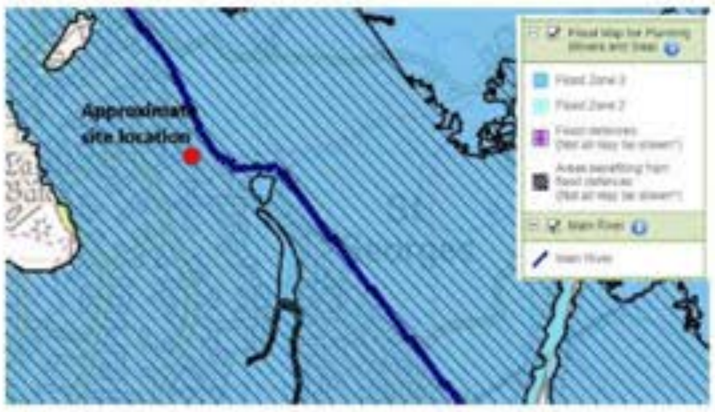
This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	WORLE	Post Code	
15588				
Site Type	NGR			
Sewage Pumping Station	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark James Cooper		
SP_WO	Contact Number	07776226970		

Site Plan

Location Plan

Environment Agency Flood Map



Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Tidal	**Existing Flood Defence**	Yes
Main Flooding Source	River Banwell, Bristol Channel	**EA Flood Warning Area**	The A3033 to the west to the M5 in the east, including Worle, Ebdon and St Georges to the north
Current Site Flood Zone	Flood Zone 3, Areas benefiting from flood defences	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3, Areas benefiting from flood defences	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	North Somerset Levels Internal Drainage Board

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
5.93 (LiDAR) to 6.04 (LiDAR)	5.97 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	9.05	3.12	N/A	0.00			
			1 in 200 year (0.5%)	9.18	3.25					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	9.70	3.77	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	9.31	3.38	N/A	N/A			
			1 in 200 year (0.5%)	9.44	3.51					
5.93			1 in 1000 year (0.1%)	9.96	4.03	N/A	N/A			
			Groundwater flooding					Data not available*		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

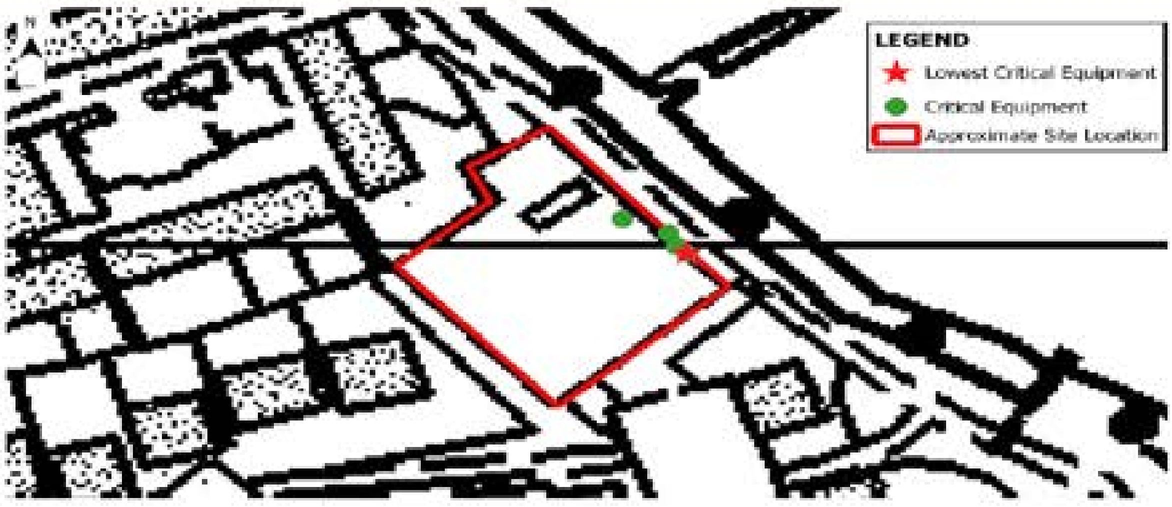
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Bill O'Leary	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	06/12/2016	Attendees	Domenico Santoro (MM) and Lee Weller (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Substation	5.93	9.96	9.76	9.96	4.03
Control panel 1	6.04	9.96	9.76	9.96	3.92
Pump junction panel	6.13	9.96	9.76	9.96	3.83
Control panel 2	6.44	9.96	9.76	9.96	3.52

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. As per site operator, no previous flooding has been observed at this site. (Lee Weller, Site visit 06/11/2016)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

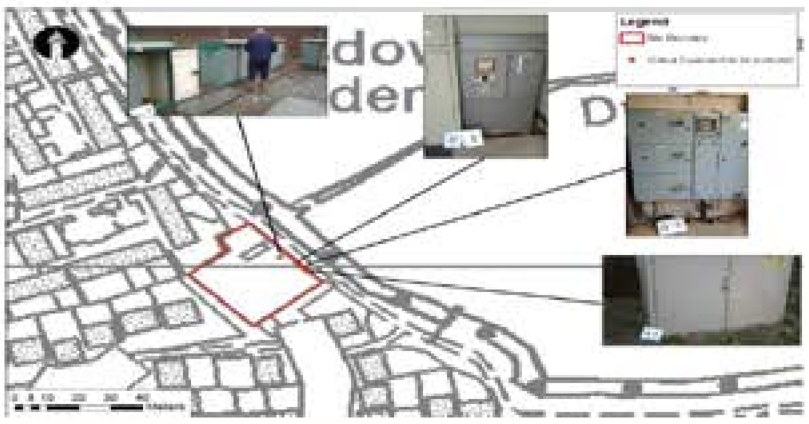
1. Given the extreme flood depths at this site, it is not possible to protect the site against the 1000yr+CC flood event. Please see comment box below.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

n/a

Note: given the extreme flood depths at this site, it is difficult to provide a standard of protection to the 1000yr+CC event.

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m		1. In view of the depth of flooding, it may not be feasible to protect the site against the design event (upper bound 1 in 1000 year including climate change to 2050). Potential reduced flood levels are as follows; 100MB (2025) - 8.75mAOD, 200MB (2025) - 8.88mAOD, 1000MB (2025) - 9.20mAOD, 100MB (2050) - 9.01mAOD, 200MB (2050) - 9.14mAOD, 1000MB (2050) - 9.46mAOD. [MB=median bound] 2. Providing flood mitigation measures to protect the site from flooding up to the 1000yr+CC flood event would be difficult given the required height of the defences. It is noted that in the event of flooding at this site, the surrounding community is likely to experience extreme flood inundation as well. 3. The following flood mitigation measures were considered: a) whole site protection would be extremely costly given the required height of defences. b) local protection or further raising the equipment would be extremely costly given the required height of defences. c) an alternative solution would be to provide a reduced standard of protection (less than the 1000yr+CC flood event) to provide increased resilience for a more reasonable cost. For instance, raising the equipment to the 100yr (median bound)+CC (2025) would require raising of 2.82m (Substation), 2.71m (Control Panel 1), 2.62m (Pump junction panel) and 2.31m (Control panel 2). General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.
Walling up to 1m height	linear m		
Walling up to 2m height	linear m		
Walling up to 3m height	linear m		
Building waterproofing (treatment to existing buildings- height varies)	nr buildings		
Localised cabinet protection (max 1m height)	linear m		
Localised cabinet protection (max 2.1m height)	linear m		
Flood doors	number		
Flood gate up to 1m	number		
Flood gate up to 2m	number		
Movable/demountable defence	linear m		
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-		
Raise control panel or kiosk	number		
Raise other equipment	number		
Other	linear m		

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The site experiences tidal flooding and defending this area will remove a very small proportion of the floodplain storage.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Watercourse Survey

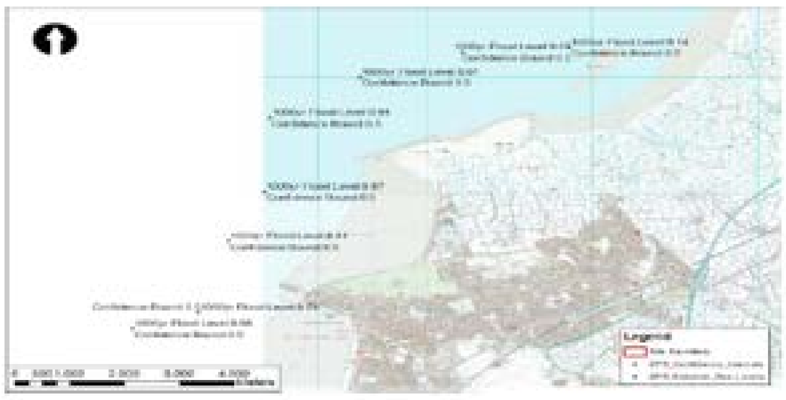
Not available

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent



Tidal Hydrology

CFB (2011)

Hydraulic Model Construction

No Details

Return Periods Assessed in Model

CFB (2011) includes results from the 1yr, 2yr, 5yr, 10yr, 20yr, 25yr, 50yr, 75yr, 100yr, 150yr, 200yr, 250yr, 300yr, 500yr, 1000yr and 1000yr events. These include both Median bound and Upper bound levels.

Comments

Model results have been provided by the Environment Agency for the defended and undefended 1 in 200yr and 1 in 1000yr events.
However, there have been no reports or modelling files provided with these results.
Therefore no details are known as to the base year of the modelling or the construction of the model and no assessment can be made as to the suitability of the model results for estimating flood levels at the site.
As such, the design flood levels for the site have been drawn from Coastal Flood Boundaries (2011) data.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

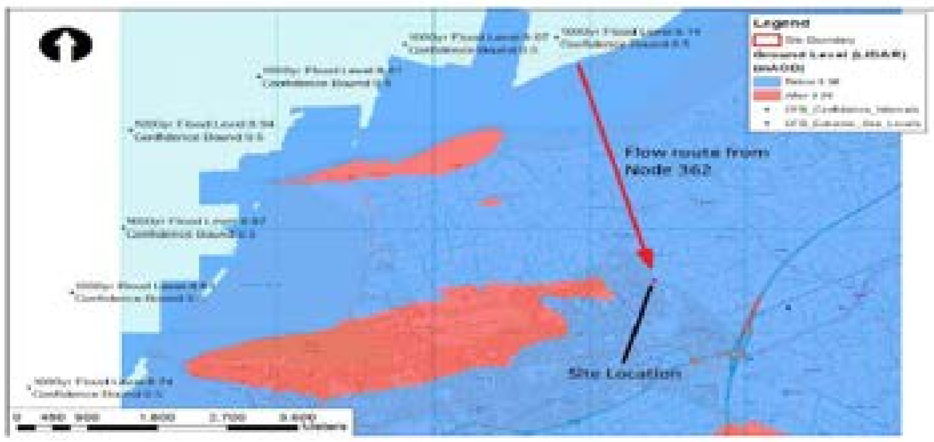
Fluvial Hydrology

The site is not affected from fluvial flood risk.

Tidal Hydrology

CFB (2011)

Supporting Figure



Summary of Approach

Have obtained the Coastal Flood Boundaries data along the coastline in the vicinity of the site and amended each of these to include the upper confidence bound and the impact of climate change to 2050.
Have used engineering judgement in order to make an assessment of which level is the most appropriate for use at the site.
The peak level at the site was estimated by using the level for Node 362 from the Coastal Flood Boundaries (2011) results.

Hydraulic Modelling

Not available

Results	Comparison to previous studies / data
The results show flooding in the site and critical equipment for all the assessed events.	1. Undefended results from model results show levels of 8.34mAOD (1000yr) and 7.99mAOD (200yr). 2. Defended results from model results show no flooding at the site. 3. These results are based on levels close to the tidal boundary of 9.15mAOD (1000yr) and 8.82mAOD (200yr) in the region of CFB (2011) Node 362. 4. This compares to the Upper Bound CFB (2011) levels used in this assessment of 9.56mAOD (1000yr) and 9.03mAOD (200yr) when including climate change to 2050.

Assumptions and Limitations

It is assumed that the level at the site is heavily influenced by the peak water levels at CFB (2011) Node 362.
It is assumed that no adaquate flood defences are provided in events of this extreme magnitude and as such water levels at the site are equal to levels from the CFB (2011) data.
Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Weston-Super-Mare (Black Rock)	Post Code	
13340				
Site Type	NGR			
Sewage Pumping Station	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Philip Leslie Strange		
SP_WS	Contact Number	07919111912		

Site Plan

Location Plan

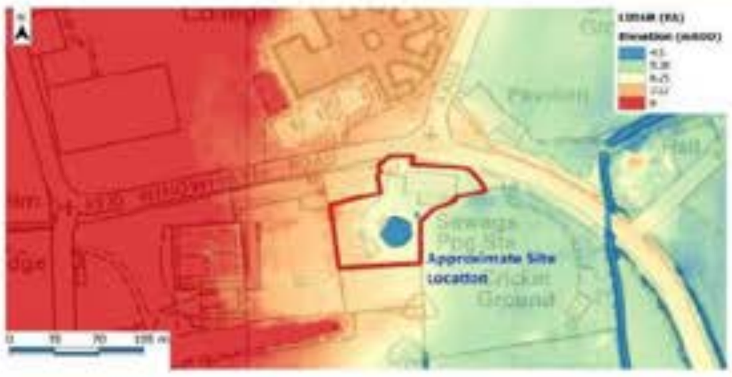
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Tidal	Existing Flood Defence	Yes
Main Flooding Source	Uphill Great Rhyne, Bristol Channel	EA Flood Warning Area	Coastline at Uphill from Links Road to Uphill Road and Grange Road to the south, the A370 to the east
Current Site Flood Zone	Flood Zone 3, Areas benefiting from flood defences	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3, Areas benefiting from flood defences	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	North Somerset Levels Internal Drainage Board

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal Level (mAOD)	Fluvial / Coastal Depth (m)	Surface Water Level (mAOD)	Surface Water Depth (m)	Ground Water Flooding Susceptibility	Reservoir Level (mAOD)	Reservoir Depth (m)
5.44 (Topo) to 7.30 (Topo)	6.37 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	8.65	0.31	N/A	0.00			
			1 in 200 year (0.5%)	8.77	0.43					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	9.30	0.96	N/A	> 0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	8.91	0.57	N/A	N/A			
			1 in 200 year (0.5%)	9.03	0.69					
8.34			1 in 1000 year (0.1%)	9.56	1.22	N/A	N/A			
			Groundwater flooding					Low		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

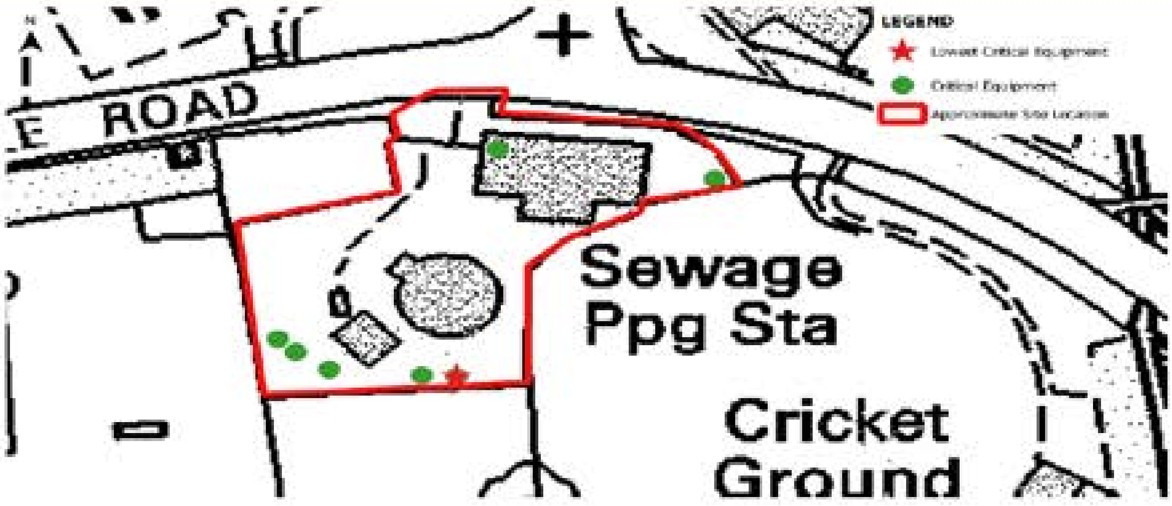
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Bill O'Leary	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	06/12/2016	Attendees	Domenico Santoro (MM) and Philip Strange (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Transformers	8.34	9.56	9.36	9.56	1.22
Screen kiosk	8.40	9.56	9.36	9.56	1.16
Load management kiosk	8.49	9.56	9.36	9.56	1.07
Storm pump MCC	8.53	9.56	9.36	9.56	1.03
Generators	8.58	9.56	9.36	9.56	0.98
Fuel tank	9.79	9.56	9.36	9.56	-0.23
Site SCADA	10.16	9.56	9.36	9.56	-0.60

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. In 2014, some of the critical equipment was raised above the 100 year water level for flood alleviation purposes (P. Strange, Site visit 06/12/2016) 2. During floods, some of the raised critical equipment might be reached by boat, but the fence is much higher than the level of the equipment. Consequently, the fence would prevent site entry. (P. Strange, Site visit 06/12/2016) 3. No operator knowledge of previous flooding history on site.	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

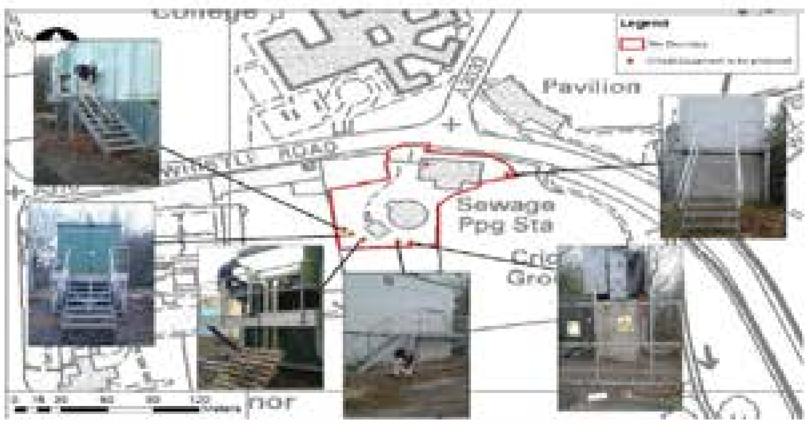
1. Given the extreme flood depths at this site, it is not possible to protect the site against the 1000yr+CC flood event. Please see comment box below.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

n/a

Note: given the extreme flood depths at this site, it is difficult to provide a standard of protection to the 1000yr+CC flood event.

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	
Walling up to 1m height	linear m	
Walling up to 2m height	linear m	
Walling up to 3m height	linear m	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	
Localised cabinet protection (max 1m height)	linear m	
Localised cabinet protection (max 2.1m height)	linear m	
Flood doors	number	
Flood gate up to 1m	number	
Flood gate up to 2m	number	
Movable/demountable defence	linear m	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	
Raise control panel or kiosk	number	
Raise other equipment	number	
Other	linear m	

Comments

1. All majority of the critical equipment on site are raised significantly above the ground level (between 1.7m and 4.2m). The critical equipment on the site is currently protected to within 10mm of the median bound 1 in 100yr (2025) level.
2. Although the equipment is raised, the resulting flood depths are significantly higher than the threshold levels of the critical equipment. Providing flood mitigation measures to protect the site from flooding up to the 1000yr+CC flood event would be difficult given the required height of the defences. It is noted that in the event of flooding at this site, the surrounding community is likely to experience extreme flood inundation as well.
3. The following mitigation measures were considered:
a) whole site protection would be extremely costly given the required height of defences.
b) local protection or further raising the equipment would be extremely costly given the required height of defences.
c) an alternative solution would be to provide a reduced standard of protection (less than the 1000yr+CC flood event) to provide increased resilience for a more reasonable cost. This could include further raising the equipment. In view of the depth of flooding, it may not be feasible to protect the site against the design event (upper bound 1 in 1000 year including climate change to 2050). Potential reduced flood levels are as follows; 100MB (2025) - 8.35mAOD, 200MB (2025) - 8.47mAOD, 1000MB (2025) - 8.80mAOD, 100MB (2050) - 8.61mAOD, 200MB (2050) - 8.73mAOD, 1000MB (2050) - 9.06mAOD. [MB=median bound]

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The site experiences tidal flooding and defending this area will remove a very small proportion of the floodplain storage.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Not available

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

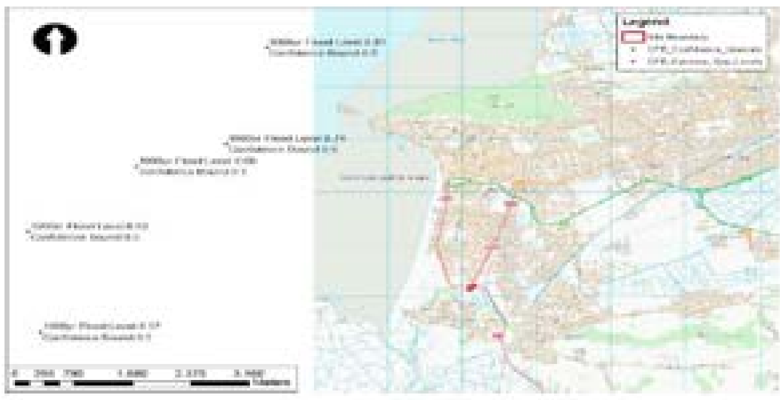
Fluvial Hydrology

Not available

Tidal Hydrology

CFB (2011)

Study Extent



Hydraulic Model Construction

No Details

Return Periods Assessed in Model

CFB (2011) includes results from the 1yr, 2yr, 5yr, 10yr, 20yr, 25yr, 50yr, 75yr, 100yr, 150yr, 200yr, 250yr, 300yr, 500yr, 1000yr and 1000yr events. These include both Median bound and Upper bound levels.

Comments

Model results have been provided by the Environment Agency for the defended and undefended 1 in 200yr and 1 in 1000yr events.
However, there have been no reports or modelling files provided with these results.
Therefore no details are known as to the base year of the modelling or the construction of the model and no assessment can be made as to the suitability of the model results for estimating flood levels at the site.
As such, the design flood levels for the site have been drawn from Coastal Flood Boundaries (2011) data.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

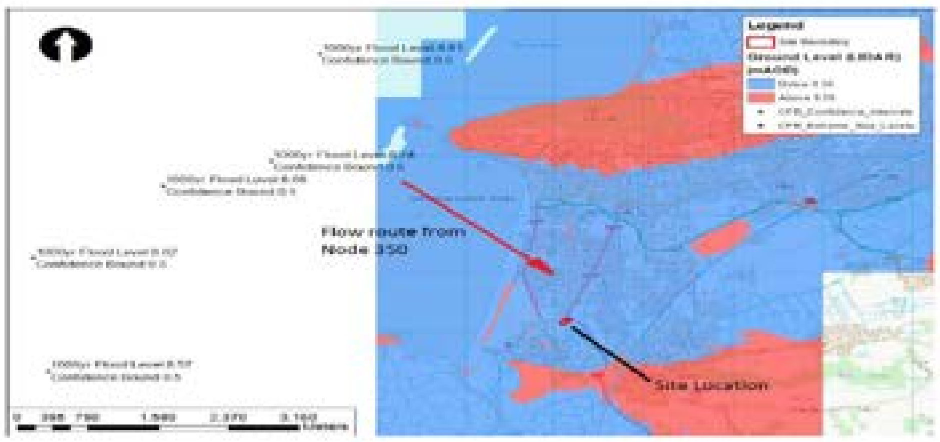
Fluvial Hydrology

The site is not affected from fluvial flood risk.

Tidal Hydrology

CFB (2011)

Supporting Figure



Summary of Approach

Have obtained the Coastal Flood Boundaries data along the coastline in the vicinity of the site and amended each of these to include the upper confidence bound and the impact of climate change to 2050.
Have used engineering judgement in order to make an assessment of which level is the most appropriate for use at the site.
The peak level at the site was estimated by using the level for Node 350 from the Coastal Flood Boundaries (2011) results.

Hydraulic Modelling

Not available

Results

The results show flooding in the site and critical equipment for all the assessed events.

Comparison to previous studies / data

1. Undefended results from the model show levels of 6.63mAOD (1000yr) and 6.50mAOD (200yr).
2. Defended results from the model show no flooding at the site.
3. These results are based on levels close to the tidal boundary of 8.82mAOD (1000yr) and 8.49mAOD (200yr) in the region of CFB (2011) Node 350.
4. This compares to the Upper Bound CFB (2011) levels used in this assessment of 9.56mAOD (1000yr) and 9.03mAOD (200yr) when including climate change to 2050.
5. FRA in 2011 states a 200yr peak water level of 8.41mAOD. This is approximately 2m above levels in this study.

Assumptions and Limitations

It is assumed that the level at the site is heavily influenced by the peak water levels at CFB (2011) Node 350.
It is assumed that no adaquate flood defences are provided in events of this extreme magnitude and as such water levels at the site are equal to levels from the CFB (2011) data.
Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

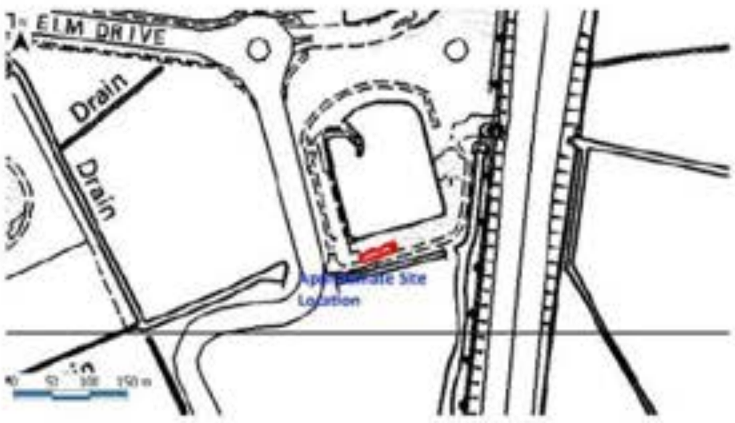
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

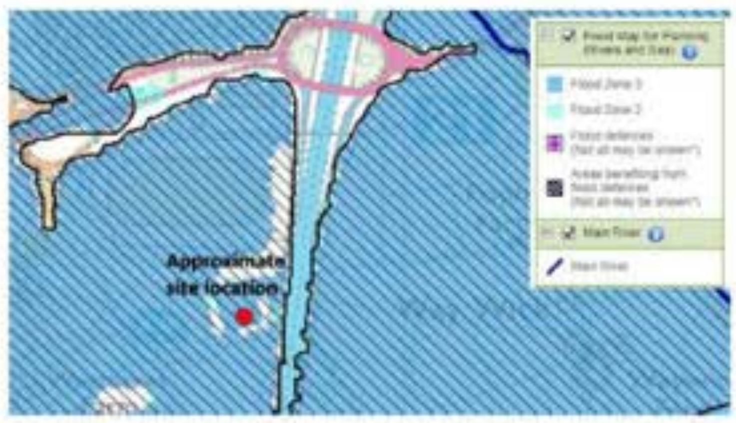
Wessex Water Site ID	Site Name	WEST WICK	Post Code	
19833				
Site Type	NGR			
Sewage Pumping Station	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Mark James Cooper		
SP_WW	Contact Number	07776220970		

Site Plan

Location Plan



Environment Agency Flood Map

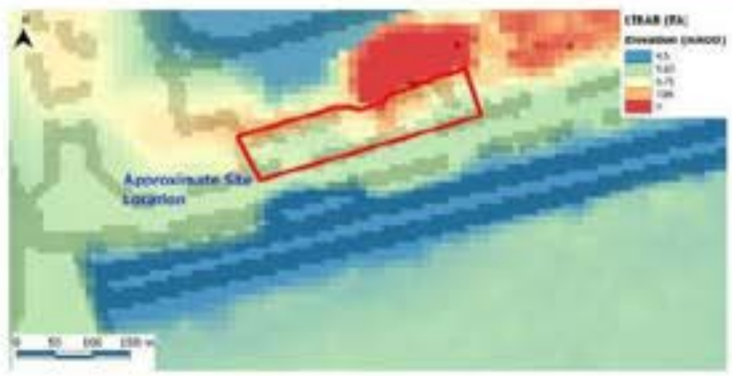


Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Tidal	Existing Flood Defence	Yes
Main Flooding Source	Blind Yeo Rhyne, Bristol Channel	EA Flood Warning Area	The A3033 to the west to the M5 in the east, including Worle, Ebdon and St Georges to the north
Current Site Flood Zone	Flood Zone 3, Areas benefiting from flood defences	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3, Areas benefiting from flood defences	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	North Somerset Levels Internal Drainage Board

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
5.91 (LiDAR) to 7.60 (LiDAR)	6.50 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	8.85	2.74	N/A	0.00			
			1 in 200 year (0.5%)	8.98	2.87					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	9.50	3.39	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	9.11	3.00	N/A	N/A			
			1 in 200 year (0.5%)	9.24	3.13					
6.11			1 in 1000 year (0.1%)	9.76	3.85	N/A	N/A			
			Groundwater flooding					Data not available*		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

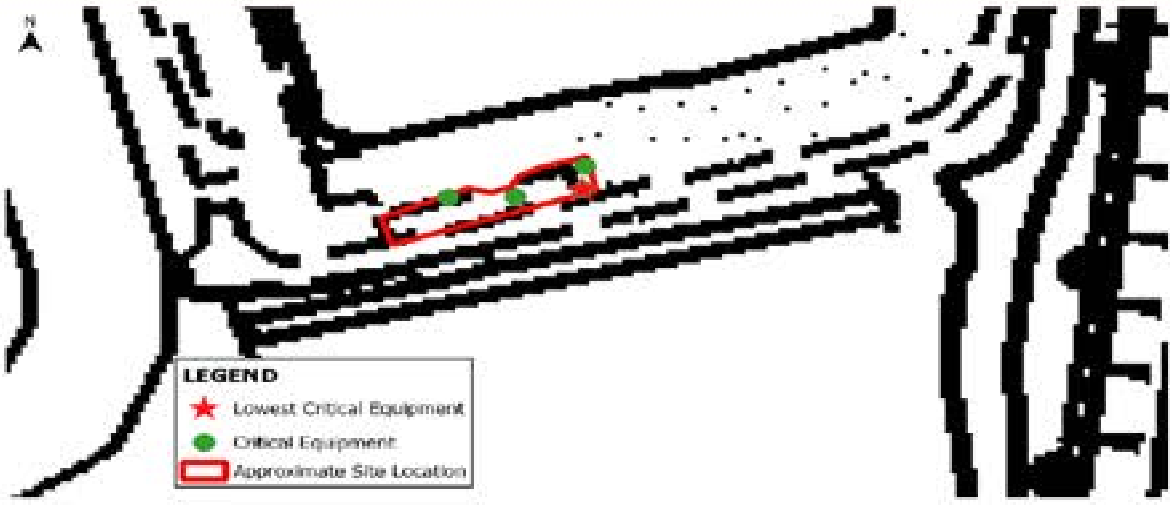
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Bill O'Leary	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	06/12/2016	Attendees	Domenico Santoro (MM), Lee Weller (WW) and Anthony Brinson (NSL IDB Rhyne Supervisor)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Electric cabinet	6.11	9.76	9.56	9.76	3.65
Control panel	7.72	9.76	9.56	9.76	2.04
Pump junction boxes	8.52	9.76	9.56	9.76	1.24
Pump control panel	8.62	9.76	9.56	9.76	1.14

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. This site does not have a past flood record. There is no provision of permanent flood defences and there are no temporary flood defences for rapid deployment on site. The site is protected against flood mainly by the flood gates or wall around the kiosks as well as walls around the sumps. Sandbags are used as temporary defences in case of an emergency. (Lee Weller, Site visit 06/12/2017) 2. It is observed that the pumping station recieves the land drainage water from the drainage system owned by the IDB. (Lee Weller (WW) and Anthony Brinson (NSL IDB Rhyne Supervisor), Site visit 06/12/2017) 3. Site on the left bank of a drain. The drain supervisor (Anthony Brinson, NSL IDB Rhyne Supervisor) was met on site during maintenance operation of the drain. He can be contacted in case of need for information.	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

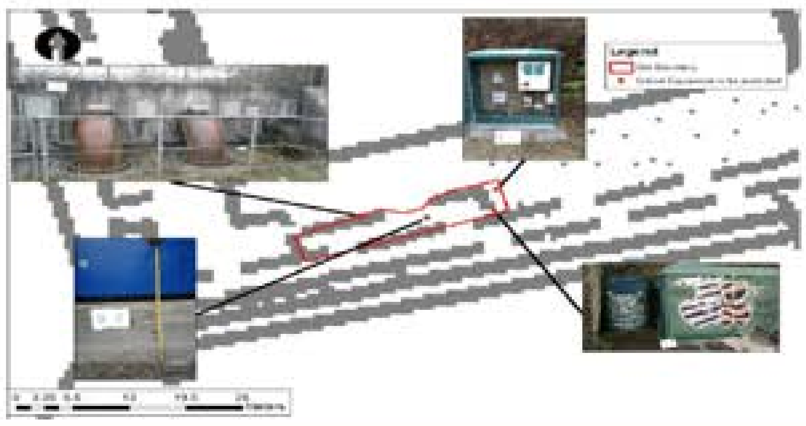
1. Given the extreme flood depths at this site, it is not possible to protect the site against the 1000yr+CC flood event.
2. As an alternative, it is proposed to raise the two lowest pieces of equipment (electric cabinet 2.41m, and control panel 0.70m) to the threshold level of the third lowest piece of equipment (junction boxes). This would provide protection within 30mm of the 100yr+CC (2025) median bound flood level.
3. No mitigation measures are proposed for the two highest pieces of equipment, the pump junction boxes and control panel.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

8.52mAOD

Note: this provides a standard of protection less than the 1000yr+CC event.

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	
Walling up to 1m height	linear m	
Walling up to 2m height	linear m	
Walling up to 3m height	linear m	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	
Localised cabinet protection (max 1m height)	linear m	
Localised cabinet protection (max 2.1m height)	linear m	
Flood doors	number	
Flood gate up to 1m	number	
Flood gate up to 2m	number	
Movable/demountable defence	linear m	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	
Raise control panel or kiosk	number	2
Raise other equipment	number	
Other	linear m	

Comments

1. In view of the extreme depth of flooding, it is not likely to be possible to protect the site against the design event (upper bound 1 in 1000 year including climate change to 2050). Potential reduced flood levels are as follows; 100MB (2025) - 8.55mAOD, 200MB (2025) - 8.68mAOD, 1000MB (2025) - 9.00mAOD, 100MB (2050) - 8.81mAOD, 200MB (2050) - 8.94mAOD, 1000MB (2050) - 9.26mAOD. [MB - median bound]
2. It is also noted that in the event of flooding at this site, a large portion of the surrounding community will also be inundated.
3. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection to the required level is not possible as this would require a flood wall that exceeds the 2m maximum allowance (for operational, visual and safety requirements). Whole site protection would be costly and may not prove necessary given that in the event of flooding, the surrounding community will also be inundated.
b) 'do nothing' is not preferred, as this would incur larger costs for replacement for inundated equipment and potentially require longer recovery duration to get the site back online following a flood event.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The proposed mitigation measures include raising equipment, which is unlikely to have an impact on floodplain storage.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Not available

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

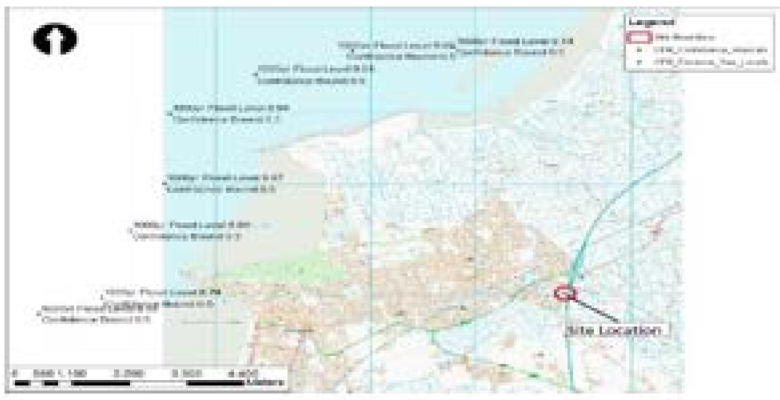
Fluvial Hydrology

Not available

Tidal Hydrology

CFB (2011)

Study Extent



Hydraulic Model Construction

No Details

Return Periods Assessed in Model

CFB (2011) includes results from the 1yr, 2yr, 5yr, 10yr, 20yr, 25yr, 50yr, 75yr, 100yr, 150yr, 200yr, 250yr, 300yr, 500yr, 1000yr and 1000yr events. These include both Median bound and Upper bound levels.

Comments

Model results have been provided by the Environment Agency for the defended and undefended 1 in 200yr and 1 in 1000yr events.
However, there have been no reports or modelling files provided with these results.
Therefore no details are known as to the base year of the modelling or the construction of the model and no assessment can be made as to the suitability of the model results for estimating flood levels at the site.
As such, the design flood levels for the site have been drawn from Coastal Flood Boundaries (2011) data.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

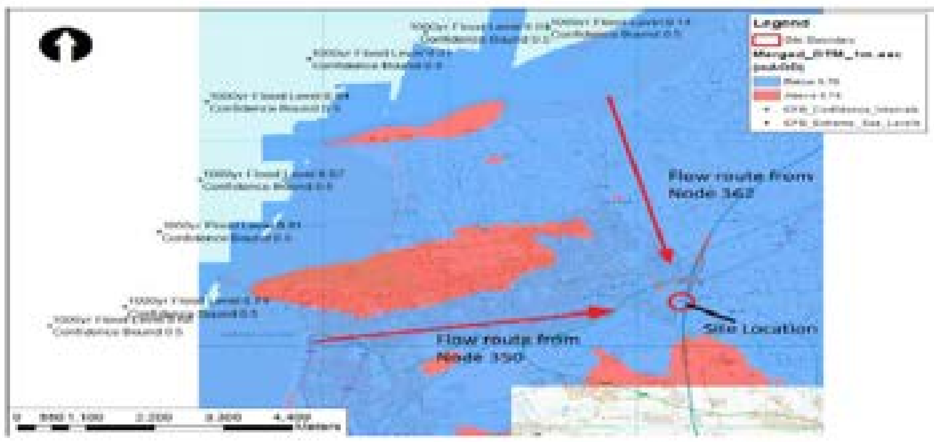
Fluvial Hydrology

The site is not affected from fluvial flood risk.

Tidal Hydrology

CFB (2011)

Supporting Figure



Summary of Approach

Have obtained the Coastal Flood Boundaries data along the coastline in the vicinity of the site and amended each of these to include the upper confidence bound and the impact of climate change to 2050.
Have used engineering judgement in order to make an assessment of which level is the most appropriate for use at the site.
The peak level at the site was estimated by calculating the mean level for Nodes 350 and 362 from the Coastal Flood Boundaries (2011) results.

Hydraulic Modelling

Not available

Results	Comparison to previous studies / data
The results show flooding in the site and critical equipment for all the assessed events.	1. Undefended results from the model show levels of 6.54mAOD (1000yr) and 6.27mAOD (200yr). 2. Defended results from the model show no flooding at the site. 3. These results are based on levels close to the tidal boundary of 8.82mAOD (1000yr) and 8.49mAOD (200yr) in the region of CFB (2011) Node 350. 4. This compares to the Upper Bound CFB (2011) levels used in this assessment of 9.76mAOD (1000yr) and 9.24mAOD (200yr) when including the impact of climate change to 2050.

Assumptions and Limitations

It is assumed that the level at the site is heavily influenced by the peak water levels at CFB (2011) Nodes 350 and 362.
It is assumed that no adaquate flood defences are provided in events of this extreme magnitude and as such water levels at the site are equal to levels from the CFB (2011) data.
Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

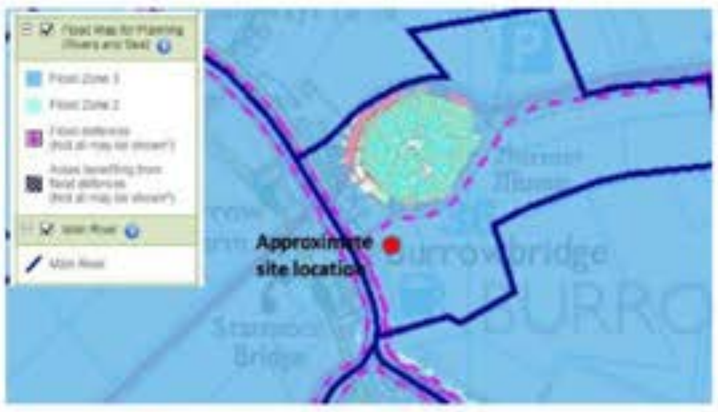
This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Burrowbridge	Post Code	
13040				
Site Type	NGR			
Sewage Treatment Works	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Simon Wilkins		
ST_BU	Contact Number	07771942984		

Site Plan

Location Plan

Environment Agency Flood Map



Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial and Coastal	Existing Flood Defence	No
Main Flooding Source	Tidal River Parrett, IDB Drains	EA Flood Warning Area	Salt Moor and North Moor including East Lyng, Burrowbridge, West Yeo, Moorland and Fordgate
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
5.37 (LiDAR) to 5.49 (LiDAR)	5.40 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	N/A*	N/A*	N/A	0.00			
			1 in 200 year (0.5%)	N/A*	N/A*					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	N/A*	N/A*	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	N/A*	N/A*	N/A	N/A			
			1 in 200 year (0.5%)	N/A*	N/A*					
			1 in 1000 year (0.1%)	6.10	0.49	N/A	N/A			
5.61			Groundwater flooding					High		
			Reservoir							0.00

Comments

1. * Based on engineering judgement, the flood level for the 1 in 1000 year return period with an allowance for climate change is estimated.
2. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

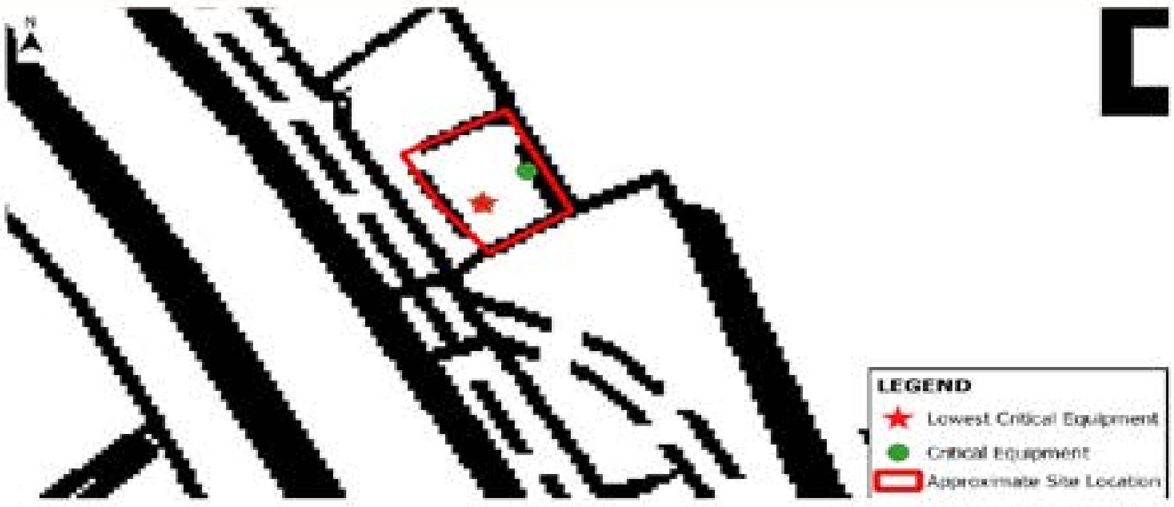
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	Domenico Santoro (MM),Tim Warren (WW) and Kris Paterson (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Junction box	5.61	6.11	6.41	6.41	0.80
Main power supplier	5.93	6.11	6.41	6.41	0.49

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. This site has experienced floods in the last 5 years. Prolonged heavy rainfall was the main cause of the floods. This is basically observed in the winters wherein the entire site was under water (site plant and electrics were affected). (Tim Warren (WW) and Kris Paterson (WW)) 2. As per STW and WTW Flood Resilience Database, "Operations" states that the fluvial flooding occurs each winter. All site plan and electrical equipment are below ground level, and no treatment is possible during flooding. In particular, damage to the MCC is likely and access is affected. 3. As per STW and WTW Flood Resilience Database, "Operations" states that regular dredging of the adjacent river will likely alleviate the flooding issue.	NONE

Phase 2 Mitigation Assessment

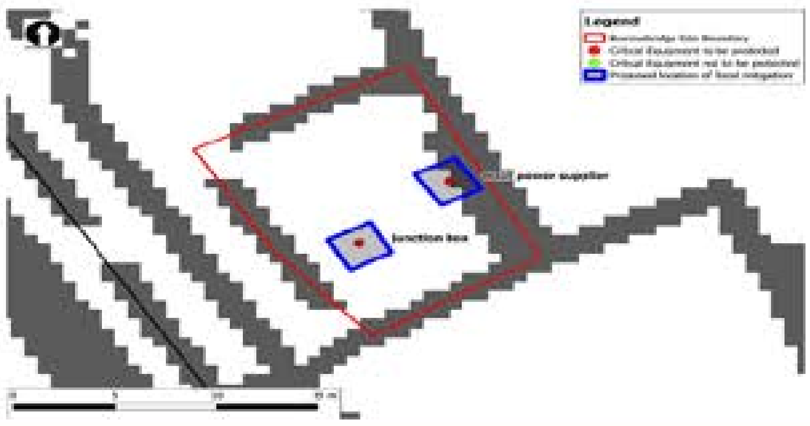
Flood Defence Description

1. Junction box and any other electrical equipment to be replaced with IP68 rated equipment. Given the limited number of equipment on site, this has been costed using the 'small site/low complexity' cost band.
2. Main power supply cabinet to be raised 49cm.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

6.41mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low
Raise control panel or kiosk	number	1
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) Localised cabinet protection at each piece of equipment, or combined protection of both pieces of equipment by a single localised cabinet was not preferred due to implications to site access.
b) Whole site protection was considered but found to be relatively expensive along with other shortcomings including ease of access.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligible. The proposed mitigation measures include raising and replacing equipment, which will have negligible impact on floodplain storage.

MOTT MACDONALD

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Topographic survey is not available. Wessex Water supplied a site schematic drawing for the purpose of this assessment.
Filename: ST_BU_Burrowbridge_13040102_20161122

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

The Environment Agency supplied the Somerset Levels and Moors Appraisal - Parrett River System, Lowlands (CH2M, 2016) report along with the hydraulic model developed in Flood Modeller Pro.

Details of Existing Study

Fluvial Hydrology

Hydrology within the existing study (CH2M, 2016) is obtained from The Black and Veatch 2014 study, wherein the catchments are schematised to differentiate between the primary river inflows and upland/lowland catchments as listed below:

1. Primary river inflows (Cary, Tone, Isle, Parrett and Yeo): Main watercourse catchments providing inflows to the top of the model (these are all gauged but not necessarily at the model inflow location).
2. Upland catchments: catchments draining into other watercourses or the moors; where rainfall falls directly and losses are assumed to be in the range 50 to 60% plus a baseflow (QTBDY) taken directly from the original baseline model (FEH unit).
3. Lowland catchments: receiving direct rainfall in the model; these are areas, usually the moors, where rainfall falls directly and losses are assumed to be 50% for dry areas and zero for wetted areas.

Study Extent

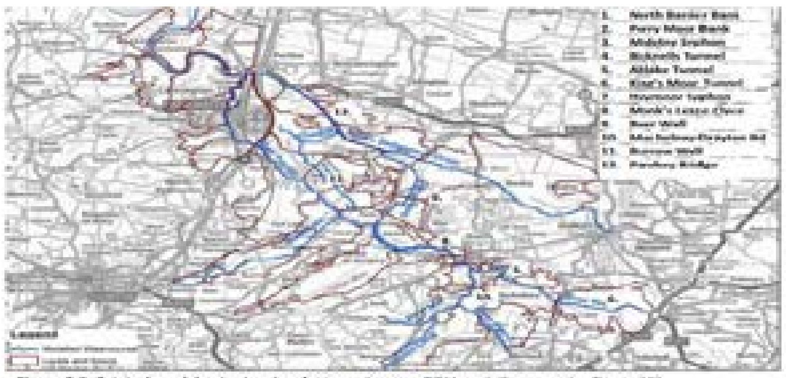


Figure 2.3 Original model extents – key features (source: B&V modelling report – Figure 10)

Tidal Hydrology

1. The MHWS tide was based on the repeating MHWS tide cycle included in the Haskoning 2011 model (source: Wessex North Coast Tidal Flood Zones Modelling project) but corrected to remove an abrupt step-change in the time series due to an incorrect specification of the tide period.
2. Design extreme tide series were constructed by shifting the 2013/14 observed tide series (B&V, 2014) up or down by applying a constant level adjustment to obtain time series with peak levels. (CH2M (HALCROW GROUP LTD), 2016)

Hydraulic Model Construction

1. 1D baseline hydrodynamic unsteady model was developed for the parts of Somerset Levels that fall within the Parrett catchment.
2. Model updating included revisions to the schematisation and extents of the original model, and some changes were also made to the model inflow boundaries and hydraulic parameters.
3. The subject site falls within an area of the model schematised by reservoir storage units alongside the main river channel, with spill units determining the routing of flood water between units.

Return Periods Assessed in Model

The fluvial return periods assessed are listed below (combined with MHWS tidal scenario):
1. 1 in 2 year
1. 1 in 5 year
2. 1 in 10 year
3. 1 in 20 year
3. 1 in 50 year
3. 1 in 75 year
5. 1 in 100 year
6. 1 in 200 year
7. 1 in 1000 year

Comments

1. The site is located in Southlake moor. Southlake moor is represented as reservoir unit in the existing model (CH2M, 2016).
2. The site may flood due to two flood mechanisms, first being the spill over the right bank of adjacent River Parrett and second being ponding in southlake moor in which the site is located. The model nodes in the vicinity of the site which represent both flooding mechanisms do not give an accurate representation of the flood level at the site. Spill from River Parrett right bank would be flowing like sheet flow in the right overbank to flood the site which is not represented in the model. Similarly, the entire southlake moor is modelled as one storage node in the model which will also not be suitable to assess flood levels at the site as the ideal filling of the available storage volume from lowest elevation is assumed.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial and Coastal, wherein main flooding sources are the River Parrett and IDB Drains.

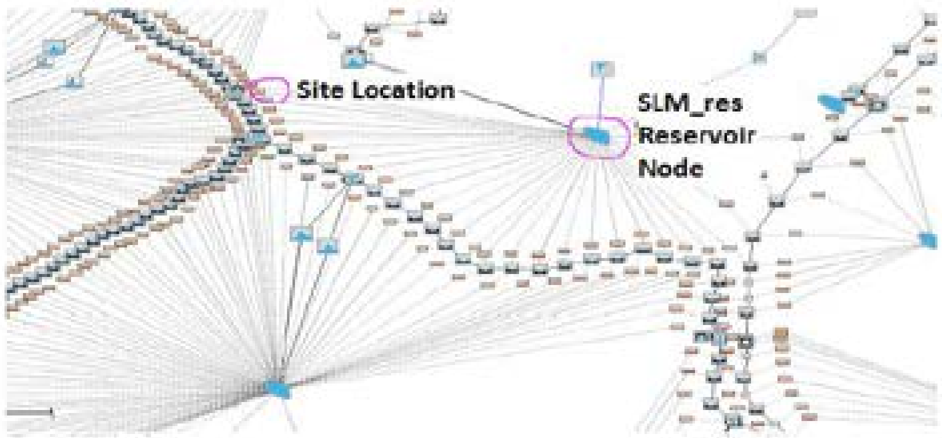
Fluvial Hydrology

Not applicable

Tidal Hydrology

Not applicable

Supporting Figure



Summary of Approach

1. The site may flood due to spill over the right bank of adjacent river channel and due to ponding in the East of the site (in Southlake moor).
2. Spill from River Parrett right bank would be flowing like sheet flow in the right overbank to flood the site, which is not represented in the model. The flood level at the site due to spill is estimated as the sum of typical ground level at the site and 0.3m depth of sheet flow.
3. The existing model (CH2M, 2016) is reviewed and observed that the Southlake moor is represented as reservoir unit in the vicinity of the site. It is noted that this node alone can not be used for flood level assessment at the site as it shows the cumulative storage in entire Southlake moor, and does not account for the actual flows to and from the moor. Hence, an engineering judgement is used for the flood level assessment at the site wherein level of the levee between Southlake moor and Eastlake moor is analysed to estimate peak flood levels at the site. A depth of 0.3m is added to this estimated flood level to account for routing through streets and ponding/storage in adjacent IDBs.
4. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. Ridge levels between two moors (Southlake moor and Earlake Moor) in the vicinity of the site is analyzed to assess the peak water level at the site.
2. The defence/ridge level for flow to overtop/spill from Southlake moor to Eastlake moor is 5.80 mAOD approximately as per the review of the 1m DTM. The flood level at the site corresponding to this is estimated as 6.10 mAOD (5.80mAOD + 0.30m). 30cm depth is added to account for routing through streets and ponding/storage in adjacent IDBs.
3. The flood level corresponding to spill over the Right bank of River Parrett is estimated as 5.7 mAOD (as explained in summary of approach).
4. On comparison of flood levels that result due to each flooding mechanism, the flood level is taken as the worst case level at the site which is 6.10 mAOD.

Results

1. The results of the assessment indicate that the site is prone to flooding inclusive of the site access.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The Wessex Water site operator commented that the site has experienced flooding in last five years. Whilst the model is not schematised to represent these flow paths individually, these field observations are supported through the application of the allowance for routing of spill flows from the river channel and ponding in and around IDB drains during heavy periods of rainfall.
2. Our assessment shows that the site floods with estimated depth of flooding at the site to be more than 0.8m during extreme return periods.

Assumptions and Limitations

1. Based on the Environment Agency data for "Area susceptible to ground water flooding", the designated risk of groundwater emergence in the vicinity of the site is >=75% (Flood Type: Superficial Deposits Flooding) which is considered as High risk. However, there is no previous groundwater flooding observed at this site based on comments from the Wessex Water site operator. If the groundwater emergence is observed at the site in future, then mitigation measures, such as local drains, could be installed at the site.
2. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

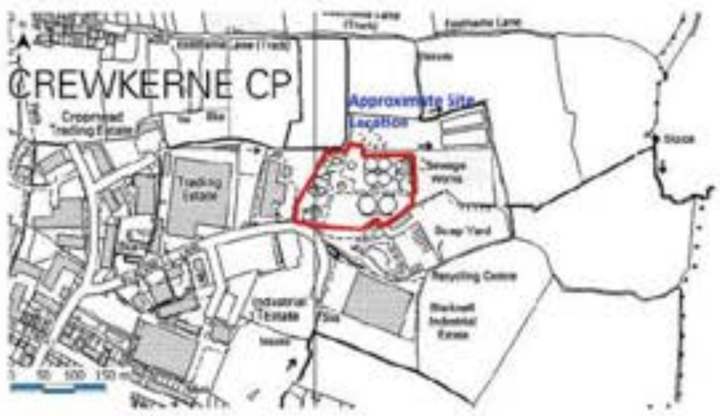
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Crewkerne	Post Code	
13084				
Site Type	NGR			
Sewage Treatment Works	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Simon Wilkins		
ST_CR	Contact Number	07771942984		

Site Plan

Location Plan



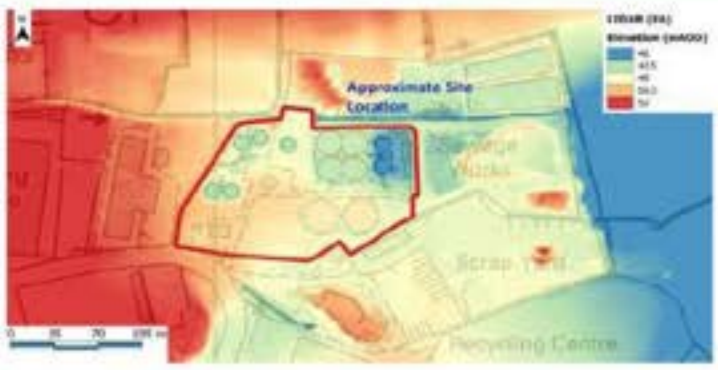
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial and Surface Water	Existing Flood Defence	No
Main Flooding Source	River Parrett, Unnamed Drains	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal Level (mAOD)	Fluvial / Coastal Depth (m)	Surface Water Level (mAOD)	Surface Water Depth (m)	Ground Water Flooding Susceptibility	Reservoir Level (mAOD)	Reservoir Depth (m)
45.41 (Topo) to 50.68 (Topo)	47.84 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	> 0.90			
			1 in 100 year (1%)	48.09	1.64	N/A	> 0.90			
			1 in 200 year (0.5%)	48.16	1.71					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	48.34	1.89	N/A	> 0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	48.13	1.68	N/A	N/A			
			1 in 200 year (0.5%)	48.18	1.73					
			1 in 1000 year (0.1%)	48.38	1.93	N/A	N/A			
46.45			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

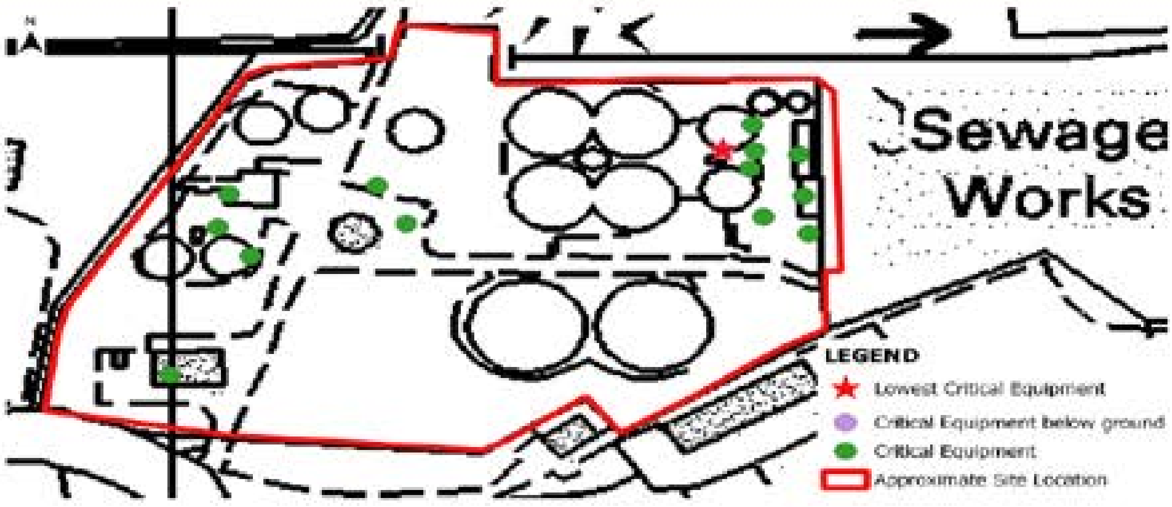
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Supriya Savalkar	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	30/11/2016	Attendees	Domenico Santoro (MM) and Tim Warren (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Humus desludge pump	46.45	48.38	48.62	48.62	2.17
Pumping station for the baff	46.54	48.38	48.62	48.62	2.08
Compressor kiosk	47.08	48.38	48.62	48.62	1.54
Baff cells	47.37	48.38	48.62	48.62	1.25
Generator	47.46	48.38	48.62	48.62	1.16
Humus tank drive motor	47.50	48.38	48.62	48.62	1.12
Blowers	47.52	48.38	48.62	48.62	1.10
MCC power supply and control panel	47.82	48.38	48.62	48.62	0.80
Primary tank bridge motor	47.95	48.38	48.62	48.62	0.67
Works drainage sump	49.05	48.38	48.62	48.62	-0.43

Summary of Key Client Comments

1. Site has flooded in the past from the river flowing east of the site, and from an internal source (inlet screen failure during heavy storms due to the large inflow). (Tim Warren, Site visit 30/11/2016)
2. Flooded area at the site was located near primary tanks. (Tim Warren, Site visit 30/11/2016)
3. Surface water: During heavy storm events, the storm drainage ditch to the north of the STW overtops its banks causing flooding of humus tanks and tertiary treatment plant. Operations reported flooding of the humus tanks to approximately the top of the handrailing i.e. approximately 1.5m above normal top water. (Source: STW and WTW Flood Resilience Database)
4. Sewage Flooding: The inlet works has inadequate capacity for high storm flows. During heavy storm events, flows arriving at the works back up from the 6 DWF storm weir to overtop the coping, leading to local flooding and pollution from crude sewage. (Source: STW and WTW Flood Resilience Database)
5. History of flooding has been due to surface water flooding. (Source: STW and WTW Flood Resilience Database)

Comments on Below Ground Equipment (if any)

1. Equipment below ground is the humus desludge pump. The finished floor of the equipment is located 0.70m below the ground level and it is at a height of 0.65m above the finished floor level, therefore the equipment level is 0.05m below ground level.
2. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.
3. For below ground equipment, flood depths listed in the above table represent the depth above ground level or finished flood level. Once the flood level becomes higher than the indicative threshold level listed in the above table for below ground equipment, flood depth at the equipment should be estimated with respect to critical equipment level, and not the indicative threshold level.

Phase 2 Mitigation Assessment

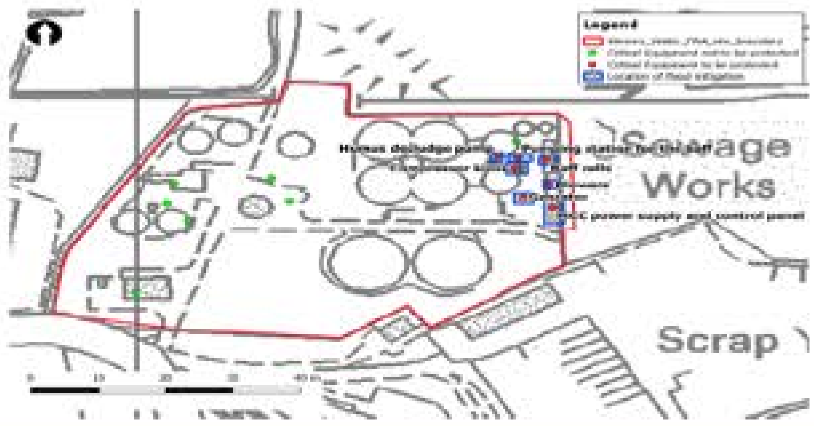
Flood Defence Description

1. The metal countainer/shed housing the MCC power supply and control panel should be reconstructed and raised to allow raising of equipment by 80cm.
2. 3 blowers to be raised 1.1m on concrete plinth with suitable access platform.
3. Generator to be raised 1.16m on concrete plinth with suitable access platform.
4. Electrics, junction box and control panel at the BAFF cell pumping station to be raised 2.08m with suitable access platform and stairs. This equipment is located in the lowest part of the site.
5. Compressor kiosk to be raised 1.54m with suitable access platform and stairs.
6. Where possible, electrical equipment to be replaced with IP68 rated equipment, such as the electrics at the humus desludge pump and the BAFF cells. Based on the size and complexity of the site, this has been costed under the 'high' costing band.
7. No protection is proposed at the humus tank drive motor and tank bridge motor. In the event of a flood, this equipment should be replaced. Costing for this is not considered in our assessment.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

48.62mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	High
Raise control panel or kiosk	number	1
Raise other equipment	number	4
Other	linear m	1

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection was considered but not preferred due to cost. The potential benefit of whole site protection is that this would allow protection of the open tanks from flooding. Without whole site protection, these tanks will flood and spill out, requiring clean-up after a flood event. Costs for clean-up operations have not been included in our assessment. Additionally, whole site protection would allow protection of the humus tank drive motor and tank bridge motor, which are otherwise difficult to protect given their location.
b) The humus tank drive motor and tank bridge motor cannot be protected with localised protection given the operational requirements and function of the equipment. Keeping spares on site for these motors is a suitable alternative to allow faster recovery time after a flood event. The cost of spares has not been included in our assessment.
c) In most cases, local protection was not preferred as this creates operational and access issues for this relatively dense site.
d) The MCC power supply and control panel are located within a metal container. Alternatives for protection include localised cabinet protection (raised 80cm) or waterproofing of the existing metal container. However, given the potential remaining risk, it is preferred to completely raise the equipment and reconstruct the structure to remove the equipment from risk.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The measures of flood mitigation include raising and replacement of equipment. This is unlikely to have impacts on floodplain storage or flood risk to others.

Source Data

LiDAR Data	Existing FRA and accompanying model files
1m resolution LiDAR data was downloaded in December 2016 from EA website.	Merriott, JBA Model :Report and model files are not available however results of peak level and peak flow for 100yr return period undefended scenario are available within a shapefile provided by the EA (Model date: 01/06/1999).
Site Topographical Survey	**Environment Agency / Local Authority Existing Studies**
Topo is available in .dwg format, which is received from Wessex Water in December, 2016. Name of the file: ST_WI_13347 Wickwar topo_20161122.dwg	A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.
Watercourse Survey	
Not available	

Details of Existing Study

Fluvial Hydrology	Study Extent
Not available	
Tidal Hydrology	
Not applicable since the site is not tidally influenced.	
Hydraulic Model Construction	**Return Periods Assessed in Model**
1. One dimensional HEC-RAS model was developed by JBA Consulting developed in 1999 for undefended scenario. 2. For 100yr return period, water level and flows were estimated at different nodes (At node 1392 (upstream of site), 1265 (adjacent to site), 1044 (downstream of site)) 3. Node 1392(considered as reference node) from the model is approximately 130m away from our site. 4. The difference between the peak water level at node 1392 for 100yr return period and typical level at the site is approx. 1.1m.	Not available

Comments

Report and model files are not available however results of peak level and peak flow for 100yr return period undefended scenario are available within a shapefile provided by the EA (Model date: 01/06/1999).

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial and Surface Water

Fluvial Hydrology

ReFH hydrologic assessment was conducted to prepare the hydrology for this study.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure

Summary of Approach

1. Two-dimensional (2D) unsteady hydrodynamic model was built using TUFLOW software.
2. Maximum water level output is extracted from the 2D model results to estimate flood levels at the site.
3. Further details of this approach is provided in following sections.

Hydraulic Modelling

1. Two-dimensional (2D) unsteady hydrodynamic model was developed in the TUFLOW software.
2. LIDAR data was reviewed to assess the catchment extent and define the 2D domain.
3. Two upstream inflow boundary conditions are applied as flow hydrograph obtained using ReFH methodology. One drain flows from south of the site and second drain flows from the west of the site.
4. The bed slope of 1:137 is assigned as the downstream boundary condition in the model.
5. Buildings are raised by 0.15m to account the plinth level.
6. Aerial view and recommended literature were used to define roughness. Manning's roughness of 0.06 is used for the river channel and floodplain for natural/vegetated areas. Manning's roughness of 0.045 is assigned for ponds, 0.035 is assigned for roads and 0.5 is assigned for raised structures and buildings. The Manning's roughness were assigned to represent field conditions.
7. Maximum water level output is extracted from the 2D model results to estimate flood levels at the site.
8.The model was tested for its senstivity against Manning's value (+/- 20%) and Downstream Boundary slopes (steep to flat). The results of this process indicated that the model was not sensitive to the changes in the Manning's value and downstream boundary slope.
9. Culverts and drains within the site are assumed to be blocked for this analysis.

Results

1. Flood levels are estimated from the water levels for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For 1 in 1000 year return period, MM(2017) flood level is 1.27m higher than that of EA flood level obtained from EA flood zone map. This new results are therefore comparable to previous study and slightly more conservative.
2. The site operator comments that the site has flooded during previous flood events which affects site access. As per this assessment, for extreme flood events, the site is flooded to depth over 2.00m at the lowest critical equipment, which is consistent with the anecdotal evidence from the site operator.
3. The site has observed flooding at the humus tank up to the top of handrailing (47.20mAOD) which is approximately 1.5m, similar level is obsereved at the hand railing for a flood level of 1000yr+CC with a 0.30m provision of freeboard.
4. As per the JBA's Model a depth of 1.1m was observed at the modelled node which is 130m away from the site for a return period 100yr. This result is similar to the flood depth observed in this study at the lowest critical equipment for 100yr which is approximately 1.50m.

Assumptions and Limitations

1. River channel and floodplain are represented using the latest EA LiDAR (1m resolution).
2.Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	East Lyng	Post Code		
18714					
Site Type	NGR				
Sewage Treatment Works	Division	West	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Simon Wilkins			
ST_EL	Contact Number	07771942984			

Site Plan

Location Plan

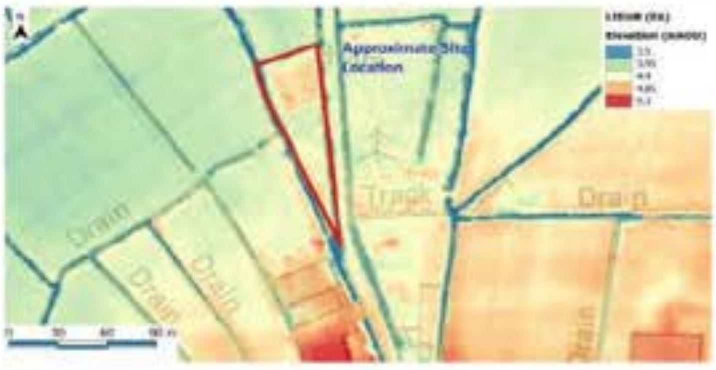
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial and Coastal	Existing Flood Defence	Yes
Main Flooding Source	River Tone, IDB Drains, River Parrett Moors	EA Flood Warning Area	Salt Moor and North Moor including East Lyng, Burrowbridge, West Yeo, Moorland and Fordgate
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	Parrett Internal Drainage Board

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
3.69 (LiDAR) to 4.53 (LiDAR)	4.11 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	4.45	0.3*	N/A	0.00			
			1 in 200 year (0.5%)	4.94	0.3*					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	5.70	0.94*	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	4.52	0.3*	N/A	N/A			
			1 in 200 year (0.5%)	4.94	0.3*					
4.76			1 in 1000 year (0.1%)	5.92	1.16*	N/A	N/A			
			Groundwater flooding					High		
			Reservoir							Over 2m

Comments

*Note: an allowance has been added to the flood depths to account for the risk from overland flowpaths and local ponding from the surcharging of IDB drains during extreme rainfall events.

1. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

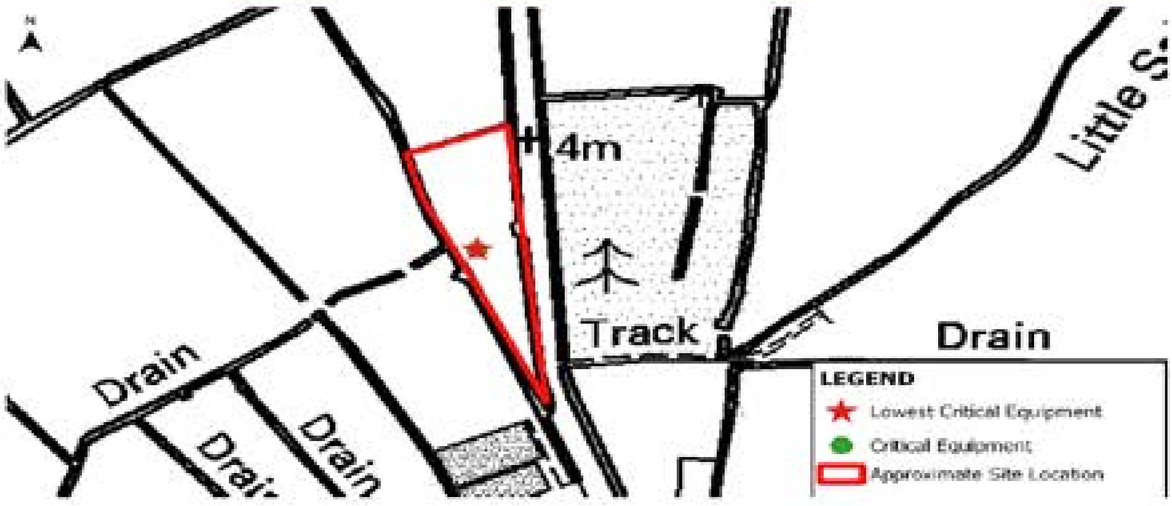
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipendiwar	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	Domenico Santoro (MM),Tim Warren (WW) and Kris Paterson (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Power main to the pump control panel	4.76	5.92	5.93	5.93	1.17

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. The river is tidal in this area, and it floods the site every year. During flooding, the site is not accessible. (Tim Warren, Site visit 02/12/2016) 2. This site has experienced floods in the last 5 years. Prolonged heavy rainfall was the main cause of the floods. This is basically observed in the winters wherein the entire site was under water (site plant and electrics were affected). (Source: STW and WTW Flood Resilience Database) 3. Operational Observations: Site completely inundated each winter including all plant and electrical equipment, and power feeds which required replacement. Damage took several months to repair. (Source: STW and WTW Flood Resilience Database)	NONE

Phase 2 Mitigation Assessment

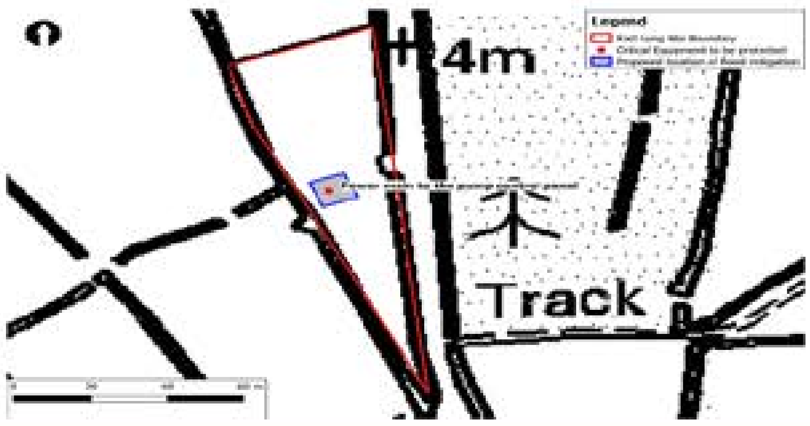
Flood Defence Description

1. Control panel to be raised 1.18m. An allowance for a suitable access platform and stairs has been included.
2. Any other electrical equipment to be replaced with IP68 rated equipment, or raised, such as the power main.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

5.93 mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	20
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low
Raise control panel or kiosk	number	1
Raise other equipment	number	0
Other	linear m	1

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred given the cost and limited number of equipment on site.
b) localised protection with a flood proof cabinet was considered but not preferred due to accessibility and operational requirements. Raised equipment and access platform allow the equipment to be raised above the flood level but also still provides suitable access.

2. Whilst protection is provided for the critical equipment, site access routes will be inundated therefore access to the site will not be possible in an extreme event.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The equipment is to be raised and will have little impact on floodplain storage and flood risk.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Topographical survey is not available.
Site Schematic is available:
ST_EL_East_Lyng_18714101_20161122.dwg

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

Somerset Levels and Moors Appraisal Parrett River System, Lowlands (CH2M, 2016) report is available from EA along with the hydraulic model developed in ISIS software package.

Details of Existing Study

Fluvial Hydrology

Hydrology within the existing study (CH2M, 2016) is obtained from the Black and Veatch Study (2014), wherein the catchments are schematised to differentiate between the primary river inflows and upland/lowland catchments as listed below:

1. Primary river inflows (Cary, Tone, Isle, Parrett and Yeo): Main watercourse catchments providing inflows to the top of the model (these are all gauged but not necessarily at the model inflow location).
2. Upland catchments: catchments draining into other watercourses or the moors; where rainfall falls directly and losses are assumed to be in the range 50 to 60% plus a baseflow (QTBDY) taken directly from the original baseline model (FEH unit).
3. Lowland catchments: receiving direct rainfall in the model; these are areas, usually the moors, where rainfall falls directly and losses are assumed to be 50% for dry areas and zero for wetted areas.

A review of the hydrology indicates it is suitable for use in the site specific assessment.

Tidal Hydrology

1. The Mean High Water Spring (MHWS) tide was based on the repeating MHWS tide cycle included in the Haskoning 2011 model (source: Wessex North Coast Tidal Flood Zones Modelling project).
2. Design extreme tide series were constructed by shifting the 2013/14 observed tide series (B&V, 2014) up or down by applying a constant level adjustment to obtain time series with peak levels. (CH2M, 2016)

Study Extent

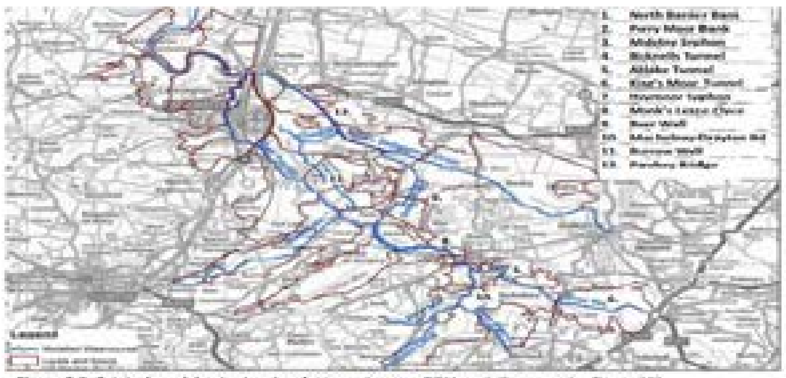


Figure 2.3 Original model extents – key features (source: B&V modelling report – Figure 10)

Hydraulic Model Construction

1. 1D baseline hydrodynamic unsteady model was developed for the parts of Somerset Levels that fall within the Parrett catchment.
2. Model updating included revisions to the schematisation and extents of the original model, and some changes were also made to the model inflow boundaries and hydraulic parameters.
3. The subject site falls within an area of the model schematised by reservoir storage units alongside the main river channel, with spill units determining the routing of flood water between units.

Return Periods Assessed in Model

The fluvial return periods assessed are listed below (combined with MHWS tidal scenario):
1. 1 in 2 year
1. 1 in 5 year
2. 1 in 10 year
3. 1 in 20 year
3. 1 in 50 year
3. 1 in 75 year
5. 1 in 100 year
6. 1 in 200 year
7. 1 in 1000 year

Comments

1. The nodes of the existing model (CH2M, 2016) are in the vicinity of the site location, therefore results of this existing model can be used to estimate the flood level at the site location.
2. The site is located in the North Moor reservoir unit of the ISIS model.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial and Coastal

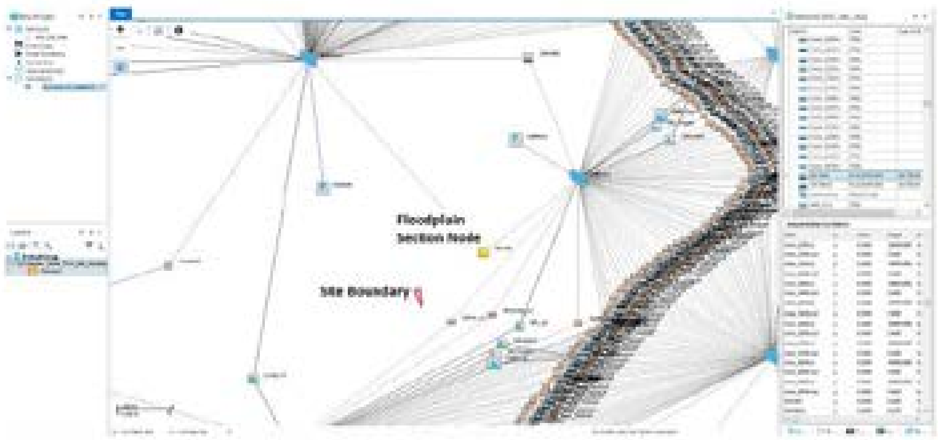
Fluvial Hydrology

Hydrology from the CH2M 2016 study was brought forward for this site specific assessment. An allowance for climate change has been made by increasing flows by 40% (to year 2050, Upper End).

Tidal Hydrology

The same tidal hydrology from the CH2M 2016 study was used for this site specific assessment.

Supporting Figure



Summary of Approach

1. The existing hydraulic model is used during our flood level assessment. The relationship between flow and stage is established for the model nodes nearest to the site.
2. Climate change is considered through analysis of the river and reservoir flows, and factoring for future scenarios.
3. An allowance of 0.3m is added to the estimated flood levels to account for surcharged IDB and ponding on the roadways, and the forming of flow paths within road reserves in the vicinity of the site. This level of detail regarding the local flow conditions is not represented in the existing model but can be inferred through analysis of modelled spill units.
4. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. The existing model nodes are identified in the vicinity of the site boundary that will represent stage levels at the site location.
2. Node SM_NM of the existing model is finalised for further estimation of stage levels for extreme return periods. Model node SM_NM represents the floodplain section near the site boundary.
3. The stage and flow data for the above node and associated spill conditions are extracted from the existing result files.
4. The Stage-Discharge relationship is established for the model node and extrapolated to assess flood levels for extreme flood events including climate change.
5. Allowances for local flooding effects including flow paths and ponding are applied, resulting in the proposed flood defence crest level.

Results

1. The flood levels indicate that the site and access roads become inundated during major flood events.
2. The resulting flood depths indicate that protection measures for individual critical equipment at the site are feasible.
3. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The Wessex Water site operator commented that the site has experienced flooding in last five years during which the site was not accessible. Our assessment of the spilling from the main river channel flooding and the local forming of ponded areas and flow paths supports this anecdotal evidence from the site operator. For the duration of the raised river levels, the site will not be accessible due to floodwaters within the road reserves and across the site itself.
2. In major flood events, the site floods up to depths in excess of 1.2m during extreme return periods, based on typical ground elevations prevailing at the site. In this case the wider area is fully inundated and not accessible. which is consistent with the anecdotal evidence from the site operator.

Assumptions and Limitations

1. It is assumed that the stage of SM_NM node represents stage at the site location.
2. Based on the Environment Agency data for "Area susceptible to ground water flooding", the designated risk of groundwater emergence in the vicinity of the site is >=75% (Flood Type: Superficial Deposits Flooding) which is considered as High risk. However, there is no previous groundwater flooding observed at this site based on comments from the Wessex Water site operator. If the groundwater emergence is observed at the site in future, then mitigation measures, such as local drains, could be installed at the site.
3. Climate change allowances are based on Environment Agency (2017) Climate Change Guidance.
4. The hydraulic model used is 1D only and therefore does not represent the complex 2D movement of flood flows. It is assumed that the 1D reservoir units and spillways accurately represent flood flow paths.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Taunton (Ham)	Post Code	
13305				
Site Type	NGR			
Sewage Treatment Works	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Simon Wilkins		
ST_HA	Contact Number	07771942984		

Site Plan

Location Plan

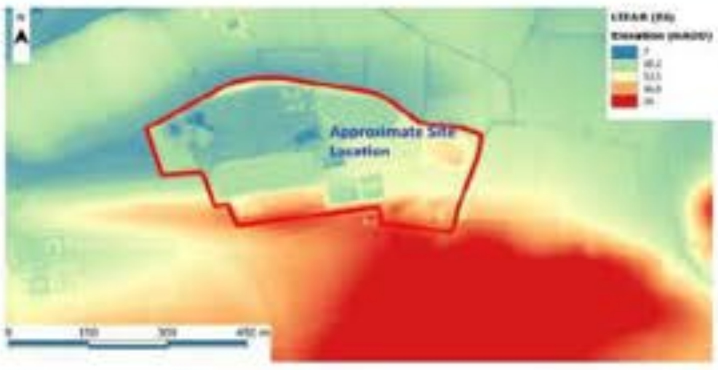
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Tone	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
7.00 to 13.00 (LiDAR)	8.70 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	< 0.30			
			1 in 100 year (1%)	9.47	0.70	N/A	< 0.30			
			1 in 200 year (0.5%)	9.55	0.78					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	9.83	1.06	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	9.53	0.76	N/A	N/A			
8.77			1 in 200 year (0.5%)	9.64	0.87					
			1 in 1000 year (0.1%)	9.95	1.18	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							Over 2m

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Jeffrey Mail	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	Domenico Santoro (MM), Jonathan Enticott (1st visit, WW), Andrew Sherring (2nd visit, WW), Tony Peasey (2nd visit, Nomenca)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Digestor feed pumps	8.77	9.95	10.09	10.09	1.32
Gas bag	8.80	9.95	10.09	10.09	1.29
Ups panel	8.80	9.95	10.09	10.09	1.29
Condensate sump	8.80	9.95	10.09	10.09	1.29
Chp gas boosters	9.05	9.95	10.09	10.09	1.04
Fst distribution board	9.06	9.95	10.09	10.09	1.03
Switchgear building	9.11	9.95	10.09	10.09	0.98
Wash water pumps control panel	9.19	9.95	10.09	10.09	0.90
Digester 3 pump	9.25	9.95	10.09	10.09	0.84
Digester 3 hot water recirculation pump	9.25	9.95	10.09	10.09	0.84

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. This is a large plant serving the entire Taunton city. The access road floods at every storm, preventing vehicles to pass. The site floods in the lower part of the plant (inlet). The New MCC (in construction) is lifted to provide flood protection. (Jonathan Enticott and Andrew Sherring, Site visit 02/12/2016) 2. The site has experienced flooding in last 5 years wherein the site was unable to discharge into the river. (Source: STW and WTW Flood Resilience Database) 3. The site has past record of flooding and the reason for this is high river level due to prolonged rainfall. It also hampered the STW processes. (Source: STW and WTW Flood Resilience Database)	NONE

Phase 2 Mitigation Assessment

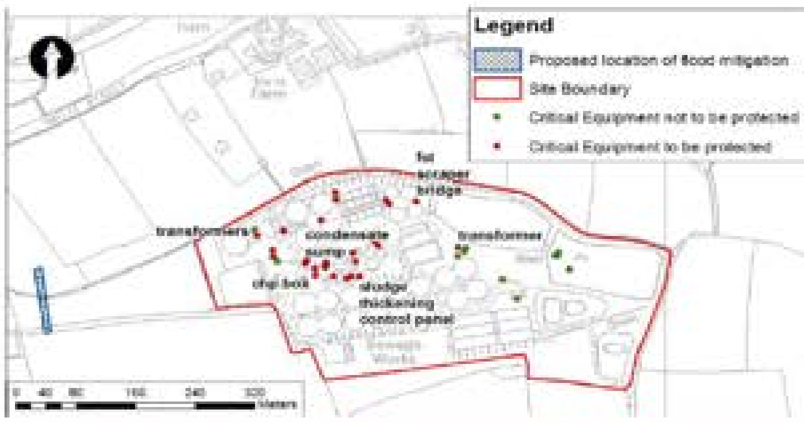
Flood Defence Description

1. A 90m earth bund to maximum 2m height to be provided across the access road to the west of the site.
2. Ramping of the access road including traffic management/road closure during construction is required.
3. IP68 rated pump equipment is required for drainage of the ditch on the upstream side of the bund.
4. Associated costs would include planning costs and the purchase of third party land.
5. Equipment protected includes everything with a critical level below the Flood Defence Crest level.
6. Equipment above the Flood Defence Crest level do not require protection to be resilient to the 1000yr climate change flood event.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

10.09 mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	90
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	1

Comments

1. An alternate for whole site protection comprising a wall of 2m height can protect the majority of equipment, with a total length of approx 700m. Two access gates would be required at the main entrance and across the access road to the equipment beyond the central site office building.
2. Another option includes individual equipment protection involving a mix of raising equipment, local cabinet protection and IP68 rated replacement equipment, but is not the preferred option due to;
a) the large number of at risk equipment
b) the complexity of pipework and requirements for penetrations
c) access issues

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Significant. With area protection measures the footprint of defended area is large. The associated impact on flood levels is will result in impacts to third parties.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Site topographical survey was provided by Wessex Water for this assessment. A PDF fomat was supplied, titled 13305 Taunton topo.pdf

Environment Agency / Local Authority Existing Studies

The Somerset Levels and Moors and Norton Fitzwarren studies were supplied for the assessment of flood risk at the site. The Norton Fitzwarren model provides the most relevant information, developed for the Norton Fitzwarren Flood Risk Study of 2014 by JBA Consulting.

Watercourse Survey

Not available

Details of Existing Study

Fluvial Hydrology

The existing study calculated the hydrology by determining the ReFH hydrographs, adjusting the time to peaks for local data and matching statistical peak flows.

Study Extent

Tidal Hydrology

The model has a downstream boundary at the confluence with the Somerset Levels. Sensitivity testing of this boundary condition revealed Ham as the extent of influence.

Hydraulic Model Construction

The Norton Fitwarren model is a 1d/2d mode with downstream level from the confluence with the Somerset Levels and Moors - River Parret system

Return Periods Assessed in Model

2, 5, 10, 20, 30, 50, 75, 100, 200, 1000 year return periods and the 100 year return period including a climate change allowance of 30% increase in flows.

Comments

Sensitivity analyses were completed on the Norton Fitzwarren model to examine the influence of model parameters on the flood levels. The existing analysis of the hydrology was judged to be the best available representation of the catchment, and suitable for use in this risk assessment.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial, from tributaries of the River Tone.

Fluvial Hydrology

The hydrological calculations summarised in the Norton Fitzwarren study to the Environment Agency were reviewed and found to be an appropriate representation of the catchment for the purpose of this flood risk assessment.

Tidal Hydrology

N/A

Supporting Figure

Summary of Approach

1. The Norton Fitwarren Model was reviewed for information on flooding in the vicinity of the site.
2. Hydraulic structures and urban features (roads/buildings) and their schematisation in the model was reviewed.
3. The modelled results were extracted from the dataset supplied by the EA.
4. Climate change allowances for increases in peak flow rate were examined to determine likely flood levels through future flooding events.

Hydraulic Modelling

The relationship between fluvial flood flow and the water level was reviewed by hydraulic modellers. Engineering judgement was used in the extrapolation of these results to yield future climate change results, based on the known response of the area to increases in fluvial flows, informed by the EA supplied modelling. Further hydraulic modelling was not undertaken for this site.

Results

Results indicate that the site and critical equipment are at risk of flooding. Resulting flood levels are shown on pages 1 and 2.

Comparison to previous studies / data

The flood levels calculated during this assessment are higher than the EA flood map results by approximately 0.5m. The EA flood maps are based on wide scale modelling, and the site specific assessment in this analysis is based on more refined modelling for the local catchment, undertaken by JBA in 2014.

Assumptions and Limitations

1. The section of model including the Back Stream was not surveyed and updated in the most recent update of the modelling. The result is that the model has varying accuracy in different locations within the model.
2. Features of recent developments have been incorporated into the model rather than through the use of recent lidar as areas of the model have been developed since the latest date of lidar collection.
3. In certain locations the lidar data has been updated with information from channel surveys. This indicates there is a level of uncertainty around the lidar data in some locations.
4. There are local flow paths indicating minor tributary flows reaching the main channel upstream of the subject site. The routing of these flow paths in the JBA study was maintained in this analysis. With climate change increases in rainfall it is possible that new flowpaths occur in these smaller subcatchments along the main channel.
5. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

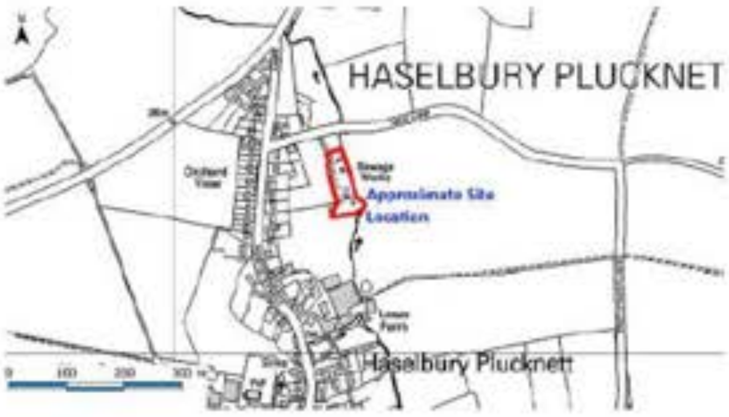
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Haselbury Plucknett	Post Code	
13144				
Site Type	NGR			
Sewage Treatment Works	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Simon Wilkins		
ST_HP	Contact Number	07771942984		

Site Plan

Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial and Surface Water	Existing Flood Defence	No
Main Flooding Source	Unnamed tributary of the River Parrett	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
37 (Panorama)	37 (Panorama)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	<0.30			
			1 in 100 year (1%)	N/A*	N/A*	N/A	<0.30			
			1 in 200 year (0.5%)	N/A*	N/A*					
			1 in 1000 year (0.1%)	N/A*	N/A*	N/A	0.30-0.90			
Indicative Threshold Level at the lowest critical equipment (mAOD)		2050 (Upper End Allowance)	1 in 100 year (1%)	N/A*	N/A*	N/A	N/A			
			1 in 200 year (0.5%)	N/A*	N/A*					
0.00			1 in 1000 year (0.1%)	N/A*	N/A*	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

*Due to lack of adequate resolution ground level data at the site it is not possible to report flood levels with a reasonable degree of accuracy. Therefore, flood levels are not summarised for the site in the above table.
Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Supriya Savalkar	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	05/12/2016	Attendees	Domenico Santoro (MM) and Kris Paterson (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Inlet screen	N/A	N/A	N/A	N/A	N/A
Rotation sensor box	N/A	N/A	N/A	N/A	N/A
Primary tank 1-2 control panel	N/A	N/A	N/A	N/A	N/A
Generator	N/A	N/A	N/A	N/A	N/A
MCC main control center	N/A	N/A	N/A	N/A	N/A
Rotation sensor box	N/A	N/A	N/A	N/A	N/A
Inlet actuator control panel	N/A	N/A	N/A	N/A	N/A
Auto desludge pump control panel (I)	N/A	N/A	N/A	N/A	N/A
Auto desludge pump control panel (II)	N/A	N/A	N/A	N/A	N/A
Rotating biological contact pump. Station control	N/A	N/A	N/A	N/A	N/A

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. As per site operator, tanks are hydraulically insufficient to treat the water coming during storms. (Kris Paterson, Site visit 05/12/2016) 2. The site fails when sewer inflow is high during storms. (Source: STW and WTW Flood Resilience Database) 3. This site has experienced floods in the last 5 years. Prolonged heavy rainfall was the main cause of the floods. This is basically observed in the winters. The ADE kiosks were damaged as the river backed up into the tidal pumping station thereon into the storm return sump through the wall flooding the primary tanks. (Source: STW and WTW Flood Resilience Database) 4. Operational Observations: River surcharging results in primary tank flooding which damages Auto-desludging (ADE) kiosk (takes time to replace electrical damage) thus affecting effluent quality due to less-frequent manual desludging. (Source: STW and WTW Flood Resilience Database)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

Due to the lack of adequate resolution ground level data at the site, it is not possible to estimate accurate flood levels. Therefore, proposed flood mitigation measures are not provided for this site.

However, per Wessex Water request, and given the history of flooding at the ADE kiosk (2 nr.) and request from the site operator that the primary tank control panel (1nr) is raised, we have costed for a nominal raising of these three kiosks. Note that the amount these are required to be raised has not been determined due to lack of detailed flood level data.

Flood Defence Layout

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

Due to the lack of adequate ground level information at this site, it is not possible to estimate a required flood defence height.

Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	The critical equipment is likely to flood at the site; however, given the lack of ground level information, mitigation measures are not assessed. As per Wessex Water request, and given the history of flooding at the ADE kiosk (2 nr.) and request from the site operator that the primary tank control panel (1nr) is raised, we have costed for a nominal raising of these three kiosks. Note that the amount these are required to be raised has not been determined due to lack of detailed flood level data, and therefore there is high uncertainty in the cost.
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	0	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	3	
Raise other equipment	number	0	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	N/A

MOTT MACDONALD

Source Data

LiDAR Data

LiDAR is not available for this site. OS Terrain 50 is a topographic dataset (with 50m grid resolution) available for this site which is consistent (with a deviation of up to 2m) with the OS Map spot elevation and thus it is used to build the model. Spot Elevation Comparison between OS Map, Google Earth and Panorama was also conducted to arrive at the appropriateness of the dataset to represent the site features.

Existing FRA and accompanying model files

Not available

Site Topographical Survey

Topographic survey is available in .dwg format, which is received from Wessex Water in December, 2016.
Name of the file:
ST_HP_13144 Hazelbury Plunckett topo_20161122.

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

Not available

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

A topographical drawing is available from Wessex Water but it does not include ground levels at critical equipment. It only has invert elevations at the storm drain pipes and outfall therefore it could not be used to delineate cross sections.
However, the invert level at the outfall is used to estimate the approximate level of left bank while using the measurements from field visit. This is subsequently used to update the left bank and bed elevation in the hydraulic model.
There is no existing hydraulic study available in the vicinity of this site

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial and Surface Water

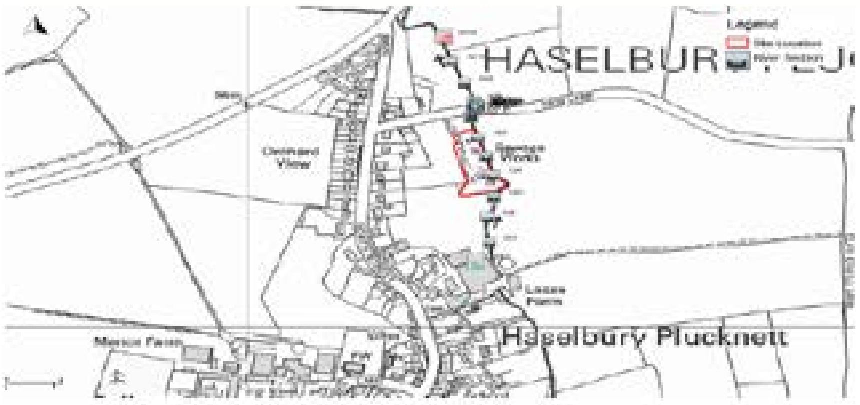
Fluvial Hydrology

ReFH hydrologic assessment was conducted to prepare the hydrology for this study.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1.One-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro. Since the LiDAR data is not available, therefore channel information from the field visit is used to estimate the cross sections. OS Terrain 50 data (50mX50m grid size) is used to estimate the slope of the channel as well as the floodplain slope to represent the channel and floodplain.
2. Structure dimensions were measured during the field visit for the culvert.
3. The hydraulic model developed using this approach is used to assess the flow paths and approximate flood levels at the site, however, due to the 50mX50m course resolution of terrain data, the quantitative estimation of flood levels is not possible using this hydraulic model. A summary of the flood mechanisms is provided in the Results section below.
4. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. One-dimensional (1D) unsteady hydrodynamic model was developed in Flood Modeller Pro.
2. Channel segment of the cross section was estimated using the information obtained from the field visit, wherein the floodplain segment of the cross sections is estimated from the coarse 50mX50m grid OS Terrain 50 data.
3. Upstream inflow boundary condition was applied to cover the range of peak flows for the critical return periods
4. The bed slope of 1:185 was assigned as the normal depth downstream boundary condition in the model by estimating the channel bed slope using the OS Terrain 50 data.
5. Manning's roughness used in model is 0.050 for channel, 0.065 for left bank and 0.10 for right bank for cross sections XS1 to XS10. For XS7 the Manning's roughness of 0.050 for channel and 0.065 for floodplains is used. The Manning's roughness were assigned to represent field conditions.
6. The model is simulated for critical return periods to understand flood mechanisms at the site.
7. The model was tested for its sensitivity for change in downstream boundary slope from 1 in 185 to 1 in 500. The results of this process indicated that the model was not sensitive to the change in the downstream boundary slope. Therefore, the sensitivity analysis showed that the ponding at A3066 roadway would not cause flooding at the upstream of the New Lane Road where the site is located

Results

1. Based on the analysis using the coarse 50mx50m grid Terrain50 data, and based on the field visit to observe the flow paths, the site is likely to flood from the floodplain flow while flood water would overtop on the left overbank upstream of the site and it would flow through the site in the left overbank. While flowing through the site on the left overbank, the flow will pass through some of the critical equipment such as inlet screen and primary tanks.

Comparison to previous studies / data

The broad level analysis shows that the flow path and flooding locations show that many critical equipment (including inlet screen and primary tanks) would be flooded during critical storm events, which is consistent with the historical flooding information as provided by the site operator. As per the site operator, the site has experienced floods in the last 5 years, and the river backed up into the storm return sump through the wall, flooding the primary tanks.

Assumptions and Limitations

1. Floodplain is represented within the 1D domain of the model.
2. Cross sections (channel and floodplain) are extracted from OS Terrain 50 (50m resolution).
3. Bend losses for meanders are not considered.
4. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
5. Information on the culvert and the roadbridge (New Lane) were collected and estimated by site visit staff. This does not constitute a formal watercourse survey and is an estimate only.
6. Detailed topographic survey should be commissioned for this site to prepare the hydraulic model to estimate flood levels at the site since OS Terrain 50 data does not have acceptable resolution to perform quantitative estimation of flood levels

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Lytchett Minster	**Post Code**		
13190					
Site Type	**NGR**				
Sewage Treatment Works	**Division**	South	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	William James Hollyoak			
ST_LM	**Contact Number**	07747892057			

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Tidal	**Existing Flood Defence**	No
Main Flooding Source	Rock Lea River, Lytchett Bay, Unnamed Drains	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
1.31 to 3.00 (TOPO)	2.41 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	2.51	0.36	N/A	0.00			
			1 in 200 year (0.5%)	2.57	0.42					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	2.89	0.74	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	2.81	0.66	N/A	N/A			
			1 in 200 year (0.5%)	2.87	0.72					
2.15			1 in 1000 year (0.1%)	3.09	0.94	N/A	N/A			
			Groundwater flooding					High		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 2, 3 and 4 of this summary sheet.

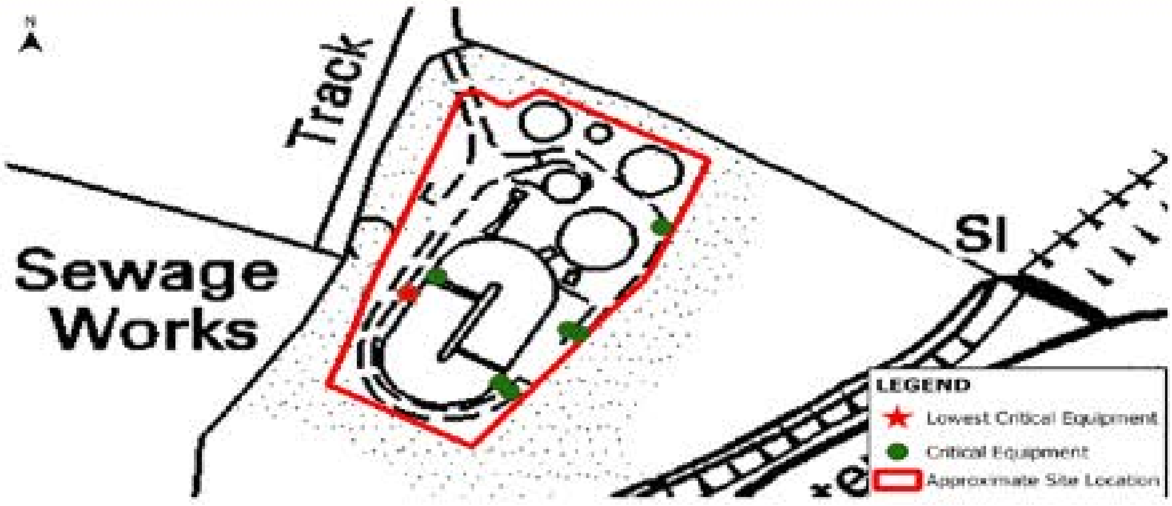
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Enrique Flores Diaz	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	28/11/2016	Attendees	Carrie Eller (MM) and Barry Park (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
General site MCC	2.15	3.09	3.09	3.09	0.94
UV treatment	2.20	3.09	3.09	3.09	0.89
Pumping station	2.24	3.09	3.09	3.09	0.85
UV treatment	2.24	3.09	3.09	3.09	0.85
Feed panel	2.28	3.09	3.09	3.09	0.81
UV MCC	2.35	3.09	3.09	3.09	0.74
Aerator	2.41	3.09	3.09	3.09	0.68
Motor for aerator	2.53	3.09	3.09	3.09	0.56
Storm tank MCC	2.86	3.09	3.09	3.09	0.23
Aerator feed panel 2 and 3	2.92	3.09	3.09	3.09	0.17

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. There is no secondary access to the site during flood (Barry Park, Site visit 28/11/2016). 2. Flooding to Lane occurs every year during heavy rainfall events. UV equipment was flooded in 2008 (Barry Park, Site visit 28/11/2016).	NONE

Phase 2 Mitigation Assessment

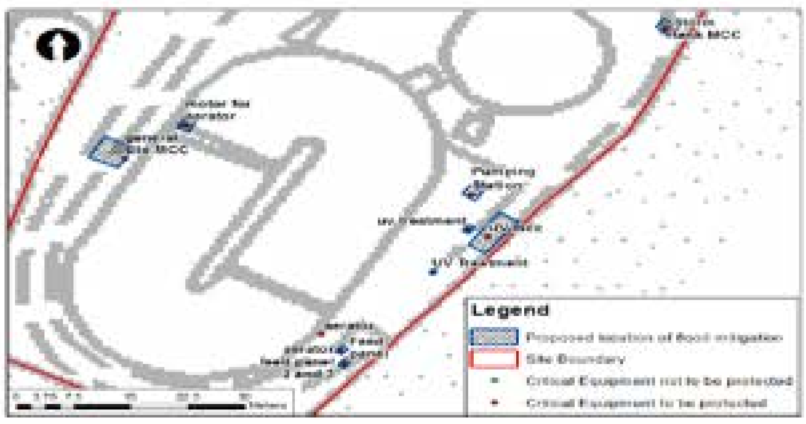
Flood Defence Description

1. Building waterproofing and a flood door are proposed as flood mitigation measures for the building which includes the general site MCC.
2. The connections for the UV treatment equipment and the pumping station are to be replaced with IP68 rated equipment. Given the size and complexity of these equipments, these have been costed using the 'low' banding cost.
3. Feed panel to be raised 0.81m.
4. Due to operational requirements, the aerator is difficult to protect, therefore it is recommended that the equipment is allowed to flood and then replaced if damaged by flood water. If prefered, spares could be kept on site.
5. Aerator motor to be raised 0.56m.
6. Storm tank MCC to be raised 0.23m.
7. Aerator feed panels to be raised 0.17m.
8. UV MCC and associated equipment to be raised 0.74m.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

3.09mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	1
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low
Raise control panel or kiosk	number	1
Raise other equipment	number	4
Other	linear m	0

Comments:

1. The following options were considered but not preferred for the following reasons:
a) Raising the General site MCC by 0.94m, site visit photos suggest there is not enough head room inside the building.
b) Localised cabinet protection for the aerator motor and the Storm tank MCC, these works are far more expensive and not justifiable.
2. There were no photos available for the feed panel, from aerial views it was assumed the equipment can be raised.
3. Due to operational requirements the aerator is difficult to protect, therefore it is recommended the equipment is allowed to flood and replaced if damaged by flood water. If aerator floods the tanks would also flood causing the need for a clean up operation. The cost associated with the clean up is not considered in the cost estimates.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent the site.

Source Data

LiDAR Data

LIDAR data for use in this Flood Risk Assessment has been obtained from the UK Government's national coverage lidar.

Existing FRA and accompanying model files

Not Available

Site Topographical Survey

Topo is available in .dwg format, which is received from Wessex Water in December, 2016.
Name of the files:
13190 Lytchett minster topo.dwg
13190 lytchet minster.dwg

Environment Agency / Local Authority Existing Studies

No other studies available

Watercourse Survey

Not applicable

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent

Tidal Hydrology

Not available

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

n/a

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Tidal

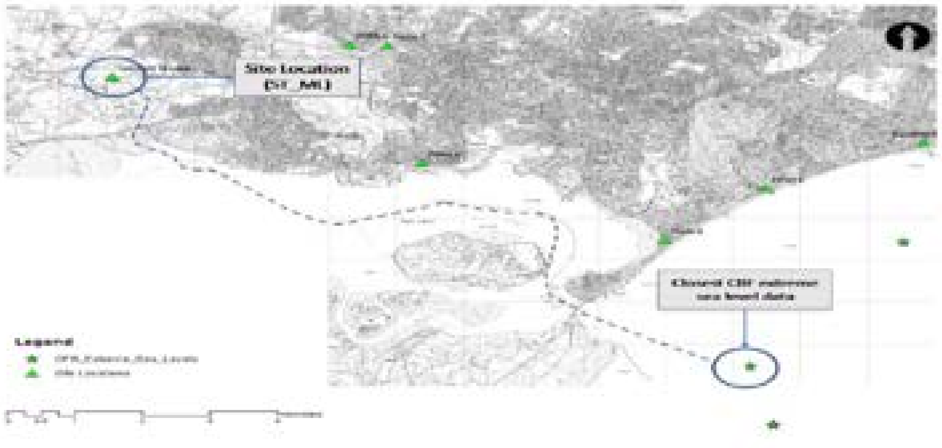
Fluvial Hydrology

Not applicable

Tidal Hydrology

Extreme Sea Levels from Coastal Flow Boundary (CFB) data

Supporting Figure



Summary of Approach

The site and critical equipment levels (TOPO) were compared against the Extreme Sea Levels from the Coastal Flow Boundary (CFB).

Hydraulic Modelling

Not carried out

Results

The results show flooding in the site and critical equipment for all the assessed events.

Comparison to previous studies / data

1. Hyder study and the analysis carried out concluded the flooding comes from the sea (tidal flooding).
2. Results are 20-30cm more conservative compared to the EA flood maps projected to the ground elevations from LIDAR.

Assumptions and Limitations

1. Report or hydraulic models were not available for the area.
2. The approach does not take into account the possible flowpaths to the site, it represents the most conservative approach using CFB data.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Merriott	**Post Code**		
13208					
Site Type	**NGR**				
Sewage Treatment Works	**Division**	West	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	Simon Wilkins			
ST_ME	**Contact Number**	07771942984			

Site Plan

Location Plan

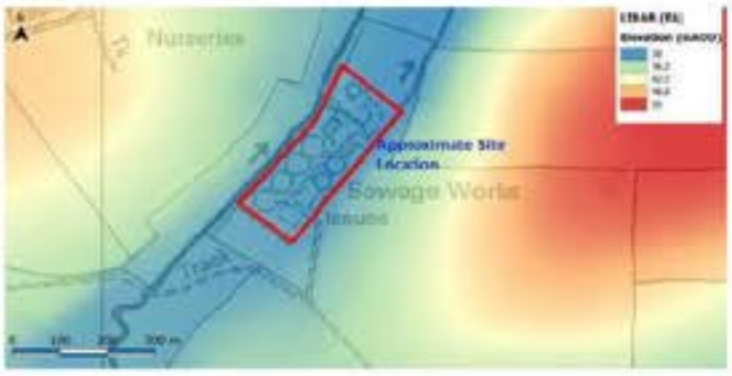
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	Unnamed tributary of River Parrett and other drains	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
29.65 (LiDAR) to 30.90 (LiDAR)	30.78 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	<0.3			
			1 in 100 year (1%)	31.55	1.33	N/A	<0.3			
			1 in 200 year (0.5%)	31.65	1.43					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	31.82	1.60	N/A	0.3-0.9			
		2050 (Upper End Allowance)	1 in 100 year (1%)	31.59	1.37	N/A	N/A			
			1 in 200 year (0.5%)	31.69	1.47					
			1 in 1000 year (0.1%)	31.87	1.65	N/A	N/A			
30.22			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

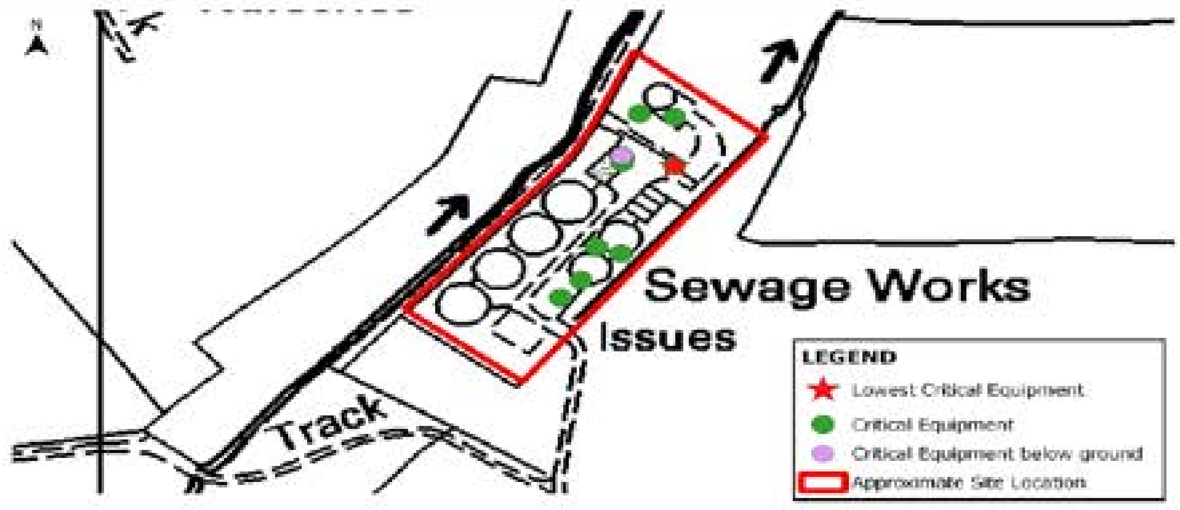
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	05/12/2016	Attendees	Domenico Santoro (MM) and Kris Paterson (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Inlet screen	30.22	31.42	31.64	31.64	1.42
Pumping station	30.49	31.87	32.11	32.11	1.62
Humus tank bridge	30.89	31.87	32.11	32.11	1.22
Storm return pumps	30.89	31.42	31.64	31.64	0.75
Storm return valve	31.04	31.42	31.64	31.64	0.60
Control panel	31.13	31.87	32.11	32.11	0.98
Primary sediment tank, bridge motor and gearbox	31.23	31.87	32.11	32.11	0.88
Primary auto desludging equipment	31.27	31.87	32.11	32.11	0.84
Compressors and blowers	31.70	31.87	32.11	32.11	0.41

Summary of Key Client Comments

1. The site is located between two watercourses. The plant discharges into the smallest one, which flows inside the operational area. In case of high water levels in the watercourse, the outlet flap valve closes, so outflow backs up into the plant and floods the humus tank. Thereafter, water from the humus tank floods the site. The small watercourse floods the access of the site as well. (Kris Paterson, Site visit 05/12/2016)
2. Flooding occurs almost every year at the site wherein the whole site gets under water and tide-locked. Last flooding was observed in 2016 when the flood depths were around 1.50m in the lowest part of the site. (Kris Paterson, Site visit 05/12/2016)
3. The boundary wall of filter distribution chamber has been raised recently to provide flood protection. (Kris Paterson, Site visit 05/12/2016)
4. Pumping station is inundated from ground water. It contains 5 dry well pumps that cannot work underwater. (Kris Paterson, Site visit 05/12/2016)

Comments on Below Ground Equipment (if any)

There is a pumping station room which contains 5 dry well pumps that cannot work underwater. The pumps are below ground however, as per our assessment, the pumping room will flood once the water level reaches the ground level of 30.49mAOD. The pumping station was also inundated from ground water during the field visit dated 05/12/2016. This pumping station room is a confined space, and it was not permitted to get in without proper training and equipment therefore levels inside the pumping room were not taken during the field visit dated 05/12/2016. The ground level at the inlet screen is lower than the ground level at the pumping station therefore the inlet screen is considered as the lowest critical equipment.

Phase 2 Mitigation Assessment

Flood Defence Description

1. The building housing the control panel and the pumping station should be reconstructed/raised to allow raising of the control panel by 1m.
2. The pumping station in the basement of the same building contains 5 dry well pumps that should be replaced with IP68 rated equipment (medium size/medium complexity cost banding).
3. The control panel at the primary auto desludging equipment should be raised by 84cm.
4. The compressors/blowers (4nr.) should be raised on a plinth 41cm.
5. Equipment to be replaced with IP68 rated equipment where possible (pump at inlet screen, junction boxes, emergency stops, instrumentation).
6. Sediment tank, humus tank and associated bridge motors are not to be protected. If these flood, there may be a requirement for clean-up costs after a flood event. The bridge motors cannot be protected or made IP68 rated therefore the preferred solution is replacement after a flood event, or storage of spares on site.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

32.11mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Medium
Raise control panel or kiosk	number	1
Raise other equipment	number	4
Other	linear m	1

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred given the cost and depth of flooding at site. Although this option could protect the sediment and humus tanks and associated bridge motors and equipment, given the cost it is preferable to allow these to flood. Note that an allowance has not been made for replacement of equipment or clean-up costs.
b) Localised protection (cabinets or flood walls) were considered at various individual pieces of equipment however this may cause access issues and therefore raising the equipment is preferred.
c) waterproofing of the building housing the control panel and pumping station was not preferred as the required waterproofing level exceeds the allowable 900mm allowance, so would require significant building hardening. Given the likely expected costs, it is preferable to reconstruct the building and raise the equipment to remove the equipment from risk.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

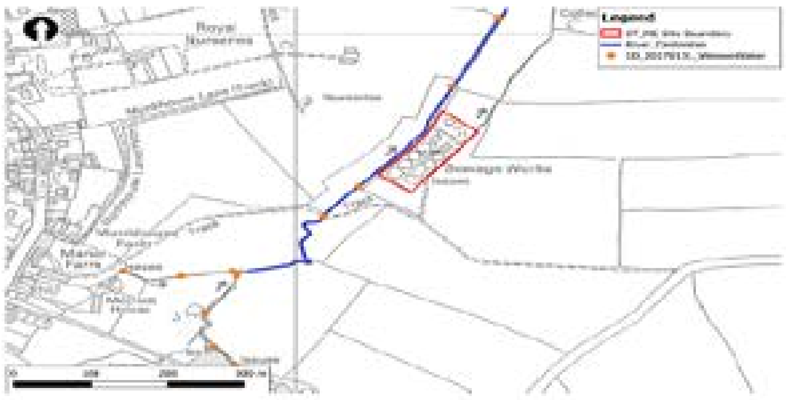
Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Likely impact to third parties is small given the small reduction in floodplain area by using localised protection.

Source Data

LiDAR Data	Existing FRA and accompanying model files
1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.	There is no existing FRA available for this site.

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
Topographic survey is available in .dwg format, which was received from Wessex Water in December, 2016. Name of the files: ST_ME_13208 Merriott topo_20161122.dwg ST_ME_13208 Merriott plan_20161122.dwg	Nodes of EA model (Meriott, JBA 1999) are available in the vicinity of the site from the shapefile (1D_20170131_WessexWater.shp) provided by the Environment Agency. The shapefile contains the flood level and flow for 1 in 100yr undefended scenario only. No model files are provided by the EA.
Watercourse Survey Not available	

Details of Existing Study

Fluvial Hydrology	Study Extent
Data provided by EA contains the peak flow corresponding to the 1 in 100 year return period which is 11.10 cumecs. No other hydrology data is available.	
Tidal Hydrology Not applicable since the site is not tidally influenced.	

Hydraulic Model Construction	Return Periods Assessed in Model
Not available	1in 100 year return period

Comments

1. There is no existing model available in the vicinity of this site.
2. However, the model node shapefile provided by EA contains the flood level corresponding to 1 in 100 year return period undefended scenario.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

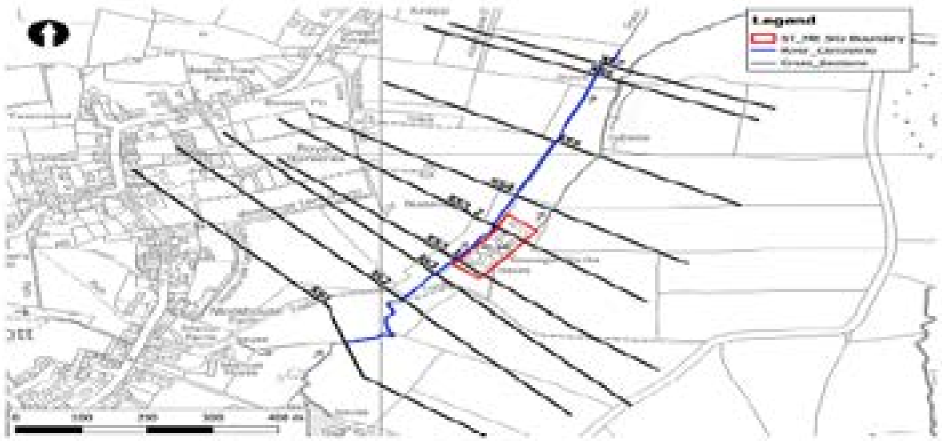
Fluvial Hydrology

ReFH hydrologic assessment was conducted to estimate the flows in the Unnamed tributary of River Parrett in the vicinity of the site.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. 1D unsteady hydrodynamic model was developed in Flood Modeller Pro.
2. This model is simulated for design return periods to calculate flood levels at the site.
3. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. Upstream inflow boundary (QT) condition is applied for each design return period. Growth factor 2.21 based on variation in peak flow for 1 in 100 year return period is applied to flow hydrograph of other return periods.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from EA website.
3. The bed slope of 1:125 at the downstream end of the model extent is assigned as the normal depth downstream boundary condition in the model.
4. Manning's roughness of 0.045 is used for the river channel. For floodplain, Manning's roughness ranges between 0.055 and 0.12. The Manning's roughness are assigned to represent field conditions.
5. The model is simulated for design return periods 1 in 100 year, 1 in 200 year and 1 in 1000 year with central and upper end allowances of climate change.
6. The model was tested for its senstivity against roughness value (+/- 20%) and Downstream Boundary slopes (steep to flat). The results of this process indicated that the flood levels at the site were not sensitive to the changes in the roughness value and downstream boundary slope.

Results

1. Nominal site flood levels are extracted for each design return period at cross section XS3_1.
2. Levels specific to pieces of critical equipment are extracted from the nearest cross section, based on their position on site.
3. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For 1 in 1000 year return period, MM(2017) flood level is 0.80m higher than that of EA flood level obtained from EA flood zone map. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator commented that the site floods every year. He has commented that during the heavy storm event in 2016, the flood depths were around 1.5m in the lowest part of the site. As per our assessment, the site is flooded to depth approximately 1.5m for extreme flood events, which is consistent with the anecdotal evidence from the site operator.
3. For 1 in 100 year return period, MM(2017) flood level is 0.1m higher than that obtained from EA model node data.

Assumptions and Limitations

1. Floodplain is represented within the 1D domain of the model.
2. Cross sections (channel and floodplain) are extracted from the latest EA LiDAR.
3. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Sherborne	Post Code	
13268				
Site Type	NGR			
Sewage Treatment Works	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Simon Wilkins		
ST_SH	Contact Number	07771942984		

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Yeo and small unnamed drains	EA Flood Warning Area	River Yeo (upper) from Sherborne to Yeovil
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
47.46 to 49.95 (TOPO)	48.47 (TOPO)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	49.19	0.79	N/A	0.00			
			1 in 200 year (0.5%)	49.27	0.87					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	49.51	1.11	N/A	0.30-0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	49.24	0.84	N/A	N/A			
			1 in 200 year (0.5%)	49.33	0.93					
48.40			1 in 1000 year (0.1%)	49.58	1.18	N/A	N/A			
			Groundwater flooding					Low		
			Reservoir							Over 2m

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

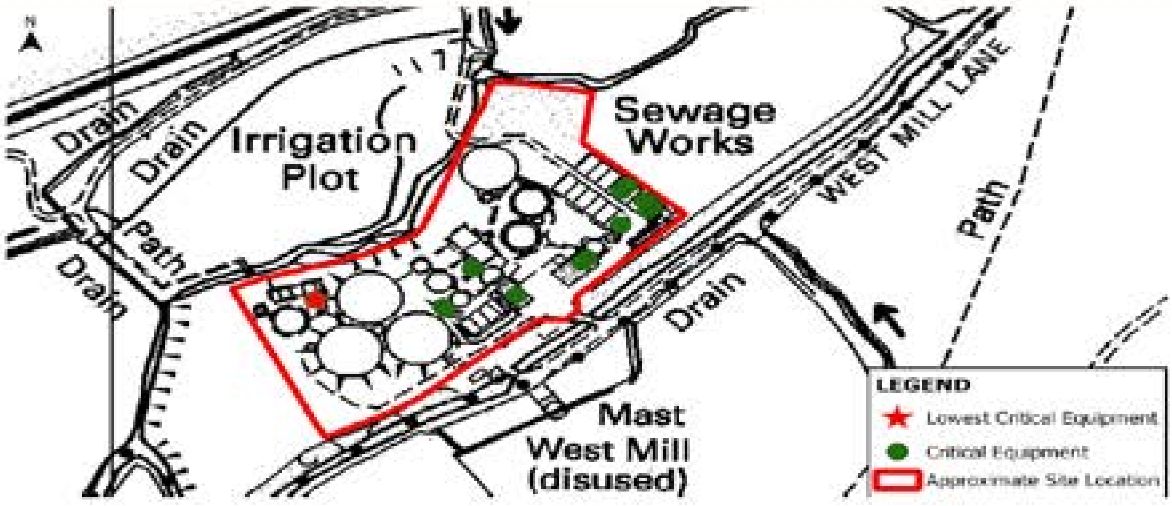
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Lisha Parambath	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	14/12/2016	Attendees	Carrie Eller (MM) and Kris P (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
high drop system pumps control panel	48.40	48.91	49.13	49.13	0.73
transformer	48.86	49.58	49.79	49.79	0.93
mcc	49.11	49.58	49.79	49.79	0.68
control panel for mains incomer and generator	49.17	49.32	49.53	49.53	0.36
wash water system for inlet screens	49.24	49.32	49.53	49.53	0.29
junction box for inlet screen	49.37	49.58	49.79	49.79	0.42
generator	49.77	49.58	49.79	49.79	0.02
control panel for dosing system	49.85	49.58	49.79	49.79	-0.06
macerator isolator	49.95	49.58	49.79	49.79	-0.16
diaphragm pumps for dosing	49.95	49.58	49.79	49.79	-0.16

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. Humus tanks sometimes overflow when river level raises and submerges the outlet. As per the site operator, the actual flooding itself is not a huge a problem, but it causes breach of consent. (Kris P, Site visit 14/12/2016) 2. Site floods few times a year during heavy rainfall events. (Kris P, Site visit 14/12/2016) 3. Operational Observations: The site is located directly on the river bank and during heavy rain, the river bursts it's banks causing the lower part of the site to flood. On this section of the site, SAF and WPL filter are located, both filters use power fed via an electrical kiosk, which is located at the ground level so it would be directly in the flood area and causing plant failure. (Source: STW and WTW Flood Resilience Database) 4. Equipment under flood levels and recent history of flooding - impacts large and key items of M&E which may take long time to repair/recover. (Source: STW and WTW Flood Resilience Database)	NONE

Phase 2 Mitigation Assessment

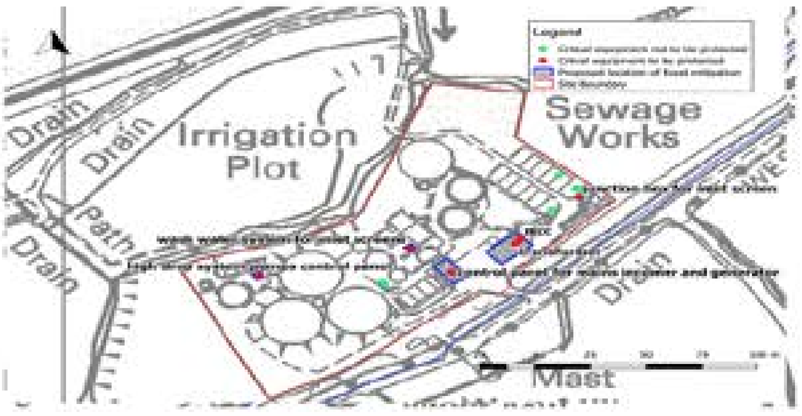
Flood Defence Description

1. Building waterproofing and 4 flood doors are proposed as flood mitigation measures for two buildings which house the transformer, MCC and control panel for mains incomer and generator at site.
2. Raise the control panel at the high drop system pump by 73cm.
3. Raise the washwater system electrics by 29cm. This includes a float.
4. Replacement with IP68 rated equipment where appropriate, such as the inlet screen junction box. Given the size and complexity of the site, a 'medium' cost banding has been applied.
5. The generator is raised above ground by 66cm, and is at risk of flooding to a depth of 2cm above the critical level. Given that the equipment is already raised, and the depth of potential flooding is small, we do not propose flood mitigation at this equipment.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

49.79mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	2
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	4
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Medium
Raise control panel or kiosk	number	2
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) the generator could be raised an additional 2cm (already raised 66cm above ground). Given the cost and the relatively small gain in flood resilience, this option was not preferred.
b) whole site protection was considered but not chosen due to cost. A potential benefit of whole site protection is that it would protect the open tanks on site. In the event of a flood, these tanks will inundate and spill out, resulting in potential site clean up requirements. The cost for clean up has not been included in our assessment.
c) Local protection at the high drop pump control panel and washwater system were considered but not prefered due to operational requirements.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The measures of flood mitigation include providing walling, replacement and raising of equipment. Minimal impacts anticipated to floodplain storage.

Source Data

LiDAR Data

2m resolution LiDAR data was downloaded in December 2016 from the EA website. 1m LiDAR data was not available from EA in the vicinity of the site.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Topographic survey is available in .dwg
Name of the file: 1. ST_SH_13268 SHERBORNE TOPO_20161122.dwg

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

There is no existing model and/or report available from EA and Wessex Water in the vicinity of the site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

Fluvial Hydrology

ReFH hydrologic assessment was conducted to estimate flows in River Yeo in the vicinity of the site.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure

Summary of Approach

1. One-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. 1D unsteady state hydraulic modelling approach has been used to calculate flood levels at the site for critical return period.
3. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from EA website.
2. Upstream inflow boundary condition is applied for peak flows for critical return periods.
3. The bed slope of 1:500 is assigned as the normal depth downstream boundary condition in the model.
4. Manning's roughness of 0.06 is used for the river channel. For floodplain, roughness in the range of 0.075-0.32 is assigned over the right bank and left bank. The Manning's roughness were assigned to represent field conditions.
5. There are two small road bridge structures crossing the drain adjacent to the site. Watercourse survey or details of these structures were not available. Dimensions of these structures estimated from LIDAR, aerial imagery and Google Street view and incorporated into the model using appropriate assumptions.
6. The model is simulated to generate the maximum stage corresponding to critical return periods.
7. The model was tested for its senstivity against Manning's value (± 20%) and Downstream Boundary slopes (±1:200, flat to steep). The results of this process indicated that the model was not sensitive to the changes in the Manning's value and downstream boundary slope. The variation of roughness resulted into +11.8cm and -13.4cm change in the stage of 1000C40 and variation of downstream boundary slope resulted in no change in the stage of 1000C40.

Results

1. Flood levels are estimated from the peak stage obtained at cross section XS3, XS3A, XS3B, XS3C and XS3D for critical return periods.
2. Flood levels relevant to each piece of critical equipment are taken from the nearest cross section.
3. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The 100yr return period flood level is estimated as 49.18mAOD during this assessment. The 100yr flood level calculated during this assessment is higher than the EA Flood Zone 3 (100yr return period) flood level which is 49.06mAOD. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator comments that the site floods a few times a year during heavy rainfall events. As per our assessment, the site is flooded to depth over 1.2m for extreme events, which is consistent with the anecdotal evidence from the site operator.

Assumptions and Limitations

1. Floodplain is represented within the 1D domain of the model.
2. Cross sections (channel and floodplain) are extracted from the latest EA LiDAR (2m resolution).
3. The hydrology calculated by ReFH method was used in this study.
4. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
5. The two road bridge crossings over the bridge adjacent to the site are represented in the model using dimensions estimated from LIDAR and photographs.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

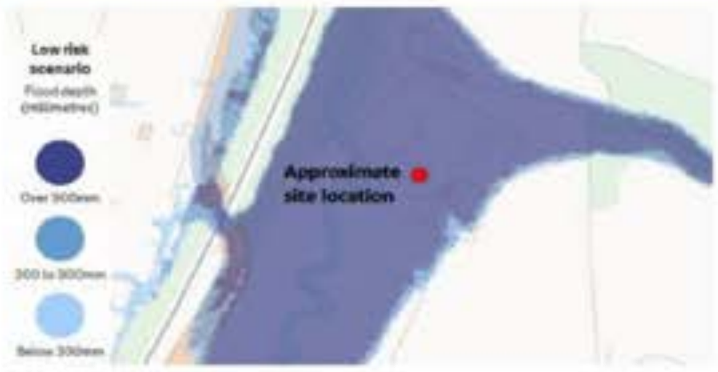
Wessex Water Site ID	Site Name	Wickwar	Post Code		
13347					
Site Type	NGR				
Sewage Treatment Works	Division	North	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Steven David Coombs			
ST_WI	Contact Number	07500128066			

Site Plan

Location Plan

Environment Agency Flood Map

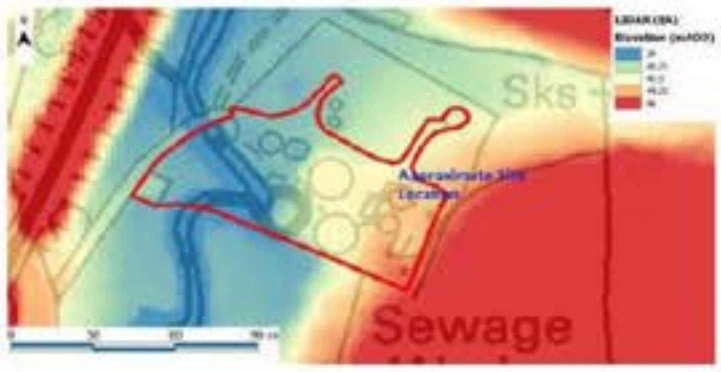
Surface Water Flood Map



Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Little River Avon	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 2 and 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 2	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
37.69 (LIDAR) TO 44.80 (LIDAR)	42.89(LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	> 0.90			
			1 in 100 year (1%)	41.31	1.55	N/A	> 0.90			
			1 in 200 year (0.5%)	41.61	1.85					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	43.20	3.44	N/A	> 0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	41.50	1.74	N/A	N/A			
			1 in 200 year (0.5%)	42.01	2.25					
39.76			1 in 1000 year (0.1%)	43.89	4.13	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

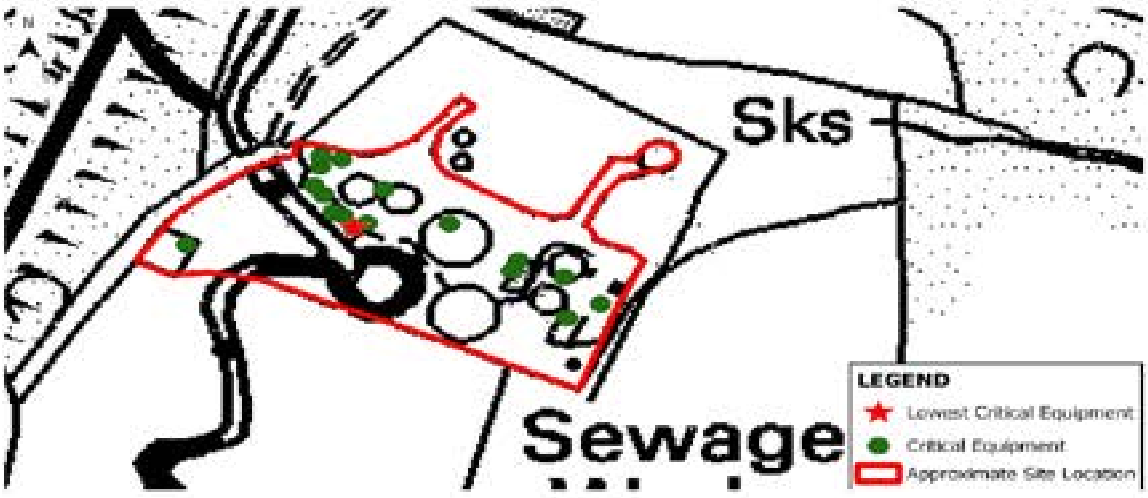
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Supriya Savalkar	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	02/12/2016	Attendees	David Tinning (MM) and Ian Barton (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Final Sample Effluent Point	39.76	43.89	43.27	43.89	4.13
Saf Pumps	39.90	43.89	43.27	43.89	3.99
Wpl Microscreen	40.21	43.89	43.27	43.89	3.68
Inlet Pump Station Control Kiosk	40.27	43.89	43.27	43.89	3.62
Desludge Kiosk	40.40	43.89	43.27	43.89	3.49
Saf Feed Pumps Panel	40.58	43.89	43.27	43.89	3.31
Washwater And Recirculation	40.73	43.89	43.27	43.89	3.16
Humus Return Pump	40.75	43.89	43.27	43.89	3.14
Liquor Return Pump	40.77	43.89	43.27	43.89	3.12
Humus Tanks	40.80	43.89	43.27	43.89	3.09

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. As per site operator, flooding occurs every year during heavy rainfall events and the final sample effluent point is often flooded.(Ian Barton, Site Visit 02/12/2016) 2. There was a major flooding about five years ago. (Ian Barton, Site Visit 02/12/2016)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. Due to excessive flood depths at the site it is not possible to protect the site against the 1000yr+CC flood event.
2. As an alternative approach, a maximum wall height of 2m is proposed in the lower part of the site (with flood gate) to protect the equipment in the lower part of the site, including humus tanks, SAF feed pump panels, de-sludge kiosk, WPL microscreen, SAF pumps, washwater and circulation system, liquor return and humus return pumps, and associated electrics. The final sample effluent point would also be located within the bounds of the flood wall. A maximum wall height has been specific by Wessex Water as allowable due to operational, visual and safety requirements.
3. Inlet pump station kiosk to be raised as high as possible.
4. Building waterproofing with 2 flood doors on the upper part of the site, to protect the main control room and the control panel and electrics at the mono pumps.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

Varies.

Proposed flood wall at lower part of site max 2m height (approx. 41.8mAOD). Note this provides a standard of protection less than the 1000yr+CC event.

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	100
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	1
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	1
Raise other equipment	number	0
Other	linear m	0

Comments

1. Due to excessive flood depths at this site, the proposed flood mitigation measures protect the site to a standard of protection less than the 1 in 1000 year event under climate change conditions.
2. Due to the proximity of the watercourse, flood defence consent from the Environment Agency may be required. The cost associated with this is not included in our cost estimate. The defences around the critical equipment are proposed in way as to not obstruct the flow in the creek.
3. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection to wall height over 4m (in the lower parts of the site) to protect the site from extreme flood events. The cost, constructability, safety and visual impacts of this option would be significant and therefore this is not the preferred option.
b) raising equipment (2m) and converting to IP68 rated equipment was considered but not preferable as it would make access and operation difficult. A cost estimate for this option has been provided (Option 2, Phase 2 report, Appendix B).
c) The SAF pumps, humus return pump and the liquor return pump and other electrical equipment in the lower part of the site could be replaced with IP68-rated (submersible) options. However, as some of the equipment requires protection/removal from flood risk in the lower area, it was determined preferable to provide a flood wall in the lower part of the site to protect all equipment in this area.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences

Significant. As any proposed defence would be located within the functional floodplain, it is likely to have a large impact on flood risk off site for extreme flood events.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from EA website.

Existing FRA and accompanying model files

Not available

Site Topographical Survey

Topographic survey is available in .dwg format, which is received from Wessex Water in December, 2016.
Name of the file:
ST_WI_13347 Wickwar topo_20161122.dwg

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Watercourse Survey

Not available

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

There is no existing hydraulic study available in the vicinity of this site.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

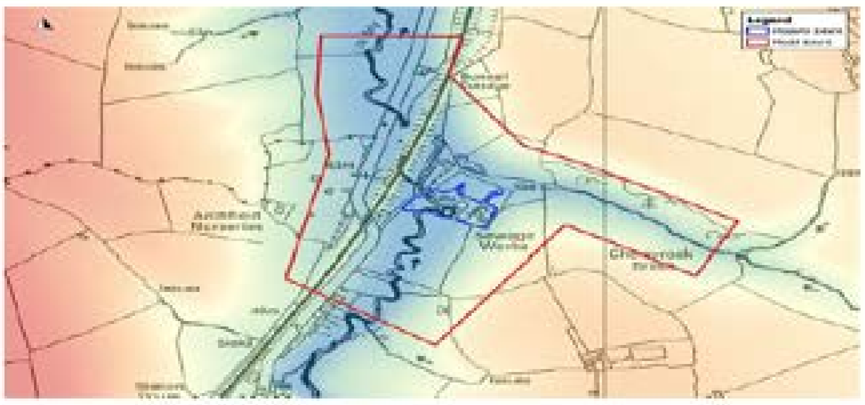
Fluvial Hydrology

ReFH hydrologic assessment was conducted to prepare the hydrology for this study.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. 1D-2D hydrodynamic model was developed in ESTRY-TUFLOW.
2. Maximum water level output is extracted from the 2D model results to estimate flood levels at the site.
3. Further details of this approach is provided in following sections.

Hydraulic Modelling

1. 1D-2D hydrodynamic model was developed in ESTRY-TUFLOW.
2. The upstream boundary was assigned as the flow hydrograph obtained through ReFH hydrologic methodology. Model inflows are applied at two locations: Little River Avon and Unnamed drain (East).
3. The downstream boundary was defined as normal depth based on the channel bed slope.
4. The Manning's roughness within the two dimensional model extent was assigned based on field conditions and land use, wherein the roughness values are assigned for the channel, woodlands, buildings, open areas, and roads.
5. Estimates of the key structure dimensions were collected during the site visits. These are estimates only and do not constitute formal watercourse survey. Based on the anecdotal evidence of the potential for these structures to be blocked by debris, a 40% blockage allowance has been considered at all structures.

Results

1. Flood levels are estimated from the plot output lines for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The EA Flood Zone 2 (1000yr return period) flood level is estimated as 45.56mAOD. The 1000yr flood level is estimated as 42.2mAOD during this assessment which is about 3.4m lower. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator comments that the site has flooded previously.The site is flooded for extreme events to a depth of 4m above typical ground level at the lower parts of the site, which is consistent with the anecdotal evidence from the site operator.

Assumptions and Limitations

1. River channel and floodplain are represented using the latest EA LiDAR (1m resolution).
2. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
3. Information on the culvert and the roadbridge (B4060) were collected and estimated by site visit staff. This does not constitute a formal watercourse survey and is an estimate only. The watercourse channel is modelled in 2D due to lack of detailed watercourse survey.

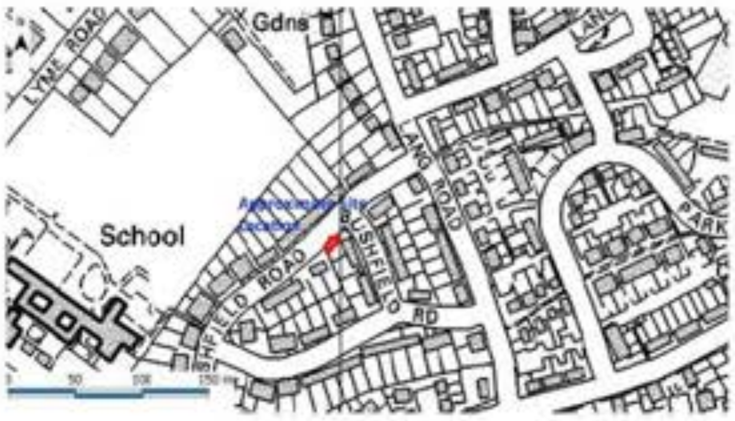
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Bushfield P.S.	**Post Code**	
11467				
Site Type	**NGR**			
Supply	**Division**	West	**Flood Resilience Design Life (years)**	25
Mott MacDonald Site Code	**Controller**	Martyn Brian Brooks		
SU_BC	**Contact Number**	07500033454		

Site Plan

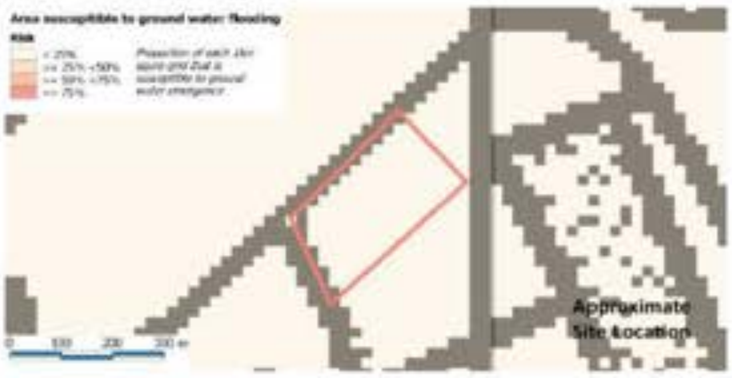
Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Surface Water Run-Off	**Existing Flood Defence**	No
Main Flooding Source	Surface Water	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 1	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
110.00 to 113.00 (LiDAR)	111.60 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	N/A	N/A	N/A	0.00			
			1 in 200 year (0.5%)	N/A	N/A					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	N/A	N/A	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	N/A	N/A	N/A	0.00			
			1 in 200 year (0.5%)	N/A	N/A					
111.60			1 in 1000 year (0.1%)	N/A	N/A	N/A	0.00			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

1. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).
2. 2D modelling of rainfall and overland flow has identified that the risk of surface water flooding is negligible.
3. The lowest critical equipment is below ground level.

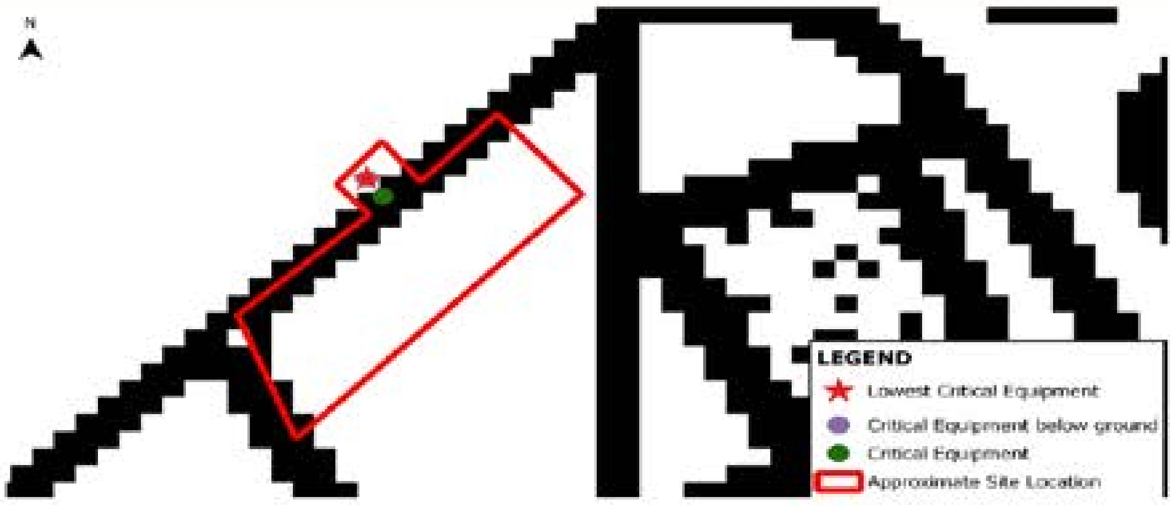
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Andy Beverton	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	Domenico Santoro (MM) and Marcus Healey (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Booster pumps	111.60	N/A	N/A	N/A	N/A
Pump control panel	111.79	N/A	N/A	N/A	N/A

Summary of Key Client Comments

1. Site is on the side of a steep road. (Marcus Healey, Site visit 01/12/2016)
2. The site includes only one cabinet for the pump control panel, and an underground chamber for the pumps. The chamber has been flooded by rain water coming from the road, but the operator (Marcus Healey) was not aware about date of flooding and water levels. The operator suggested to contact the person in charge for this site (Jason Edwards) to obtain more information. (Marcus Healey, Site visit 01/12/2016)
3. Site is manned once per month (unless special operations are necessary). (Marcus Healey, Site visit 01/12/2016)
4. Site has flooded in the past but the date and extent was not known. (Marcus Healey, Site visit 01/12/2016)

Comments on Below Ground Equipment (if any)

1. Pumps are in chamber. The entrance to the chamber is from the pedestrian walkway. The pumps are at approximately 109.75mAOD.
2. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.
3. For below ground equipment, flood depths listed in the above table represent the depth above ground level or finished flood level. Once the flood level becomes higher than the indicative threshold level listed in the above table for below ground equipment, flood depth at the equipment should be estimated with respect to critical equipment level, and not the indicative threshold level.

Phase 2 Mitigation Assessment

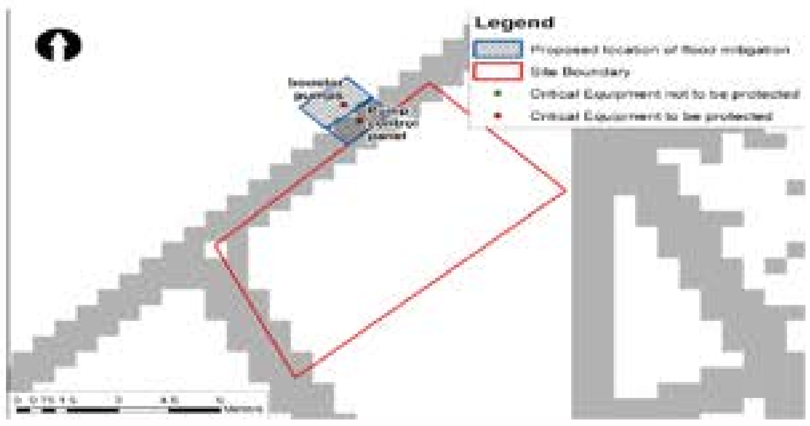
Flood Defence Description

1. Mitigation is considered to comprise replacement of the pumps with a submersible option.
2. Equipment to be replaced with IP68 rated equipment where possible (pumps, junction boxes, emergency stops, instrumentation).
3. Control panel does not require protection.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

N/A

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	1. The following mitigation measures were considered but not preferred for the following reasons: a) Localised protection (cabinets or flood walls) were considered at various individual pieces of equipment however this may cause access issues and therefore raising the equipment is preferred. 2. The position of the equipment on a public right of way prevents installation of typical defence options. 3. Whilst this assessment idetifies no significant flood risk from surface water the position of the Booster Pumps in a below ground chamber offers the potential for water to ingress the chamber through over land flow paths not represented within the 1m resolution LIDAR. General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	0	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low	
Raise control panel or kiosk	number	0	
Raise other equipment	number	0	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligible. There is no reduction in storage during flood events as a result of the mitigation measures.

Source Data

LiDAR Data	Existing FRA and accompanying model files
1m resolution LiDAR data was downloaded in December 2016 from EA website.	N/A

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
No Topographic survey available.	N/A

Watercourse Survey
N/A

Details of Existing Study

Fluvial Hydrology	Study Extent
N/A	

Tidal Hydrology
N/A

Hydraulic Model Construction	Return Periods Assessed in Model
N/A	N/A

Comments
There is no existing hydraulic study available in the vicinity of this site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Surface Water

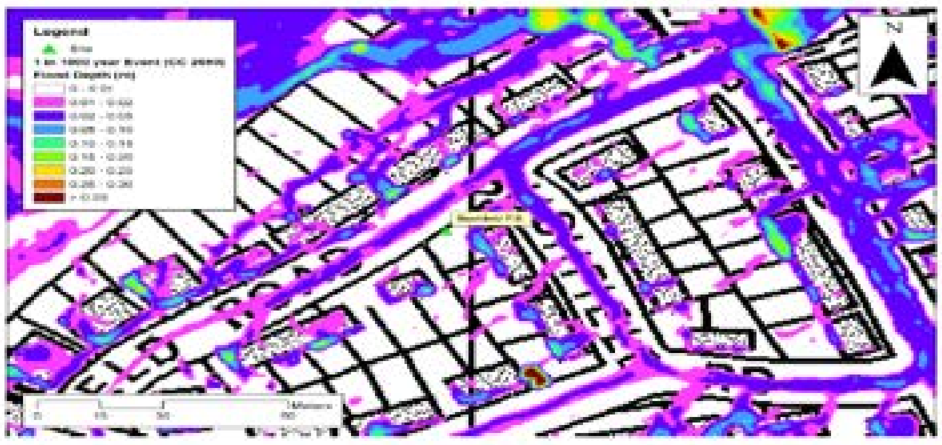
Fluvial Hydrology

N/A

Tidal Hydrology

N/A

Supporting Figure



Summary of Approach

1. A 2D modelling approach with application of direct rainfall was adopted to investigate the surface water risk to the site.
2. Recommended storm duration/Rainfall intensity was based on parameters obtained from FEH.
3. Allowances for Climate change follow the Environment Agency Guidleines (2017).
4. A standard 6mm absorbtion loss was applied for baseline runs.
5. A series of sensitivity tests were carried out comprising: 0.5*Storm Duration, 2*Storm Duration, +/- 20% Mannings, 12mm absorbtion loss. The results of the tests indicate that the model is slightly sensitive storm durations.
6. Peak Flood Levels were obtained from the model results at the location of the critical equipment.

Hydraulic Modelling

1. Direct rainfall 2D model was constructed for this assessment.
2. The model extent comprised 350,000m2
3. Rainfall was applied directly across the entire catchment.
4. Roughness co-efficents were dervied from land cover denoted in EA map data.
5. The model was run at a 1m grid cell size.

Results

1. Model results identify that the site is not at risk of from surface water up to, and including, the 1 in 1000 year (including an Upper Limit allowance for climate change).

Comparison to previous studies / data

The results of this assessment concur with the Environment Agency Surface Water flood map that denote no risk to the site.

Assumptions and Limitations

1. Due to the application of direct rainfall across the entire catchment modelled depths below 0.01m have not been taken into consideration when assessing flood risk.
2. This assessment is limited by the use of a 1m resolution DTM. Smaller overland flow paths not represented in the DTM have potential to produce flooding at the site may be obscured by the relatively coarse resolution.
3. Allowances for Climate Changes are taken from the Environment Agency Guidleines (2017).
4. The assessment assumes a 6mm loss to rainfall through absorbance snesitvity tests identified that an increased absorbance provided minimal impact to flood levels.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Balls Hill P.S.	Post Code	
11678				
Site Type	NGR			
Supply	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Christopher John Symes		
SU_BH	Contact Number	07831497140 S/D139		

Site Plan

Location Plan

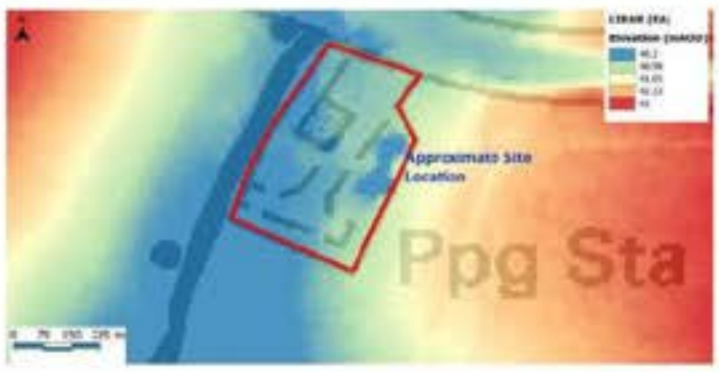
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Ball's Water	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 2	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 2	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal Level (mAOD)	Fluvial / Coastal Depth (m)	Surface Water Level (mAOD)	Surface Water Depth (m)	Ground Water Flooding Susceptibility	Reservoir Level (mAOD)	Reservoir Depth (m)
40.08 (Topo) to 40.78 (Topo)	40.63 (Topo)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.30-0.90			
			1 in 100 year (1%)	40.86	0.72	N/A	0.30-0.90			
			1 in 200 year (0.5%)	40.89	0.76					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	41.06	0.93	N/A	> 0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	40.88	0.75	N/A	N/A			
			1 in 200 year (0.5%)	40.93	0.80					
			1 in 1000 year (0.1%)	41.13	1.00	N/A	N/A			
40.13			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).
Note: Although the EA surface water map indicates that the site is at risk of surface water flooding, the fluvial risk is likely to exceed this, based on model results and anecdotal evidence from the site operator.

Revision Record

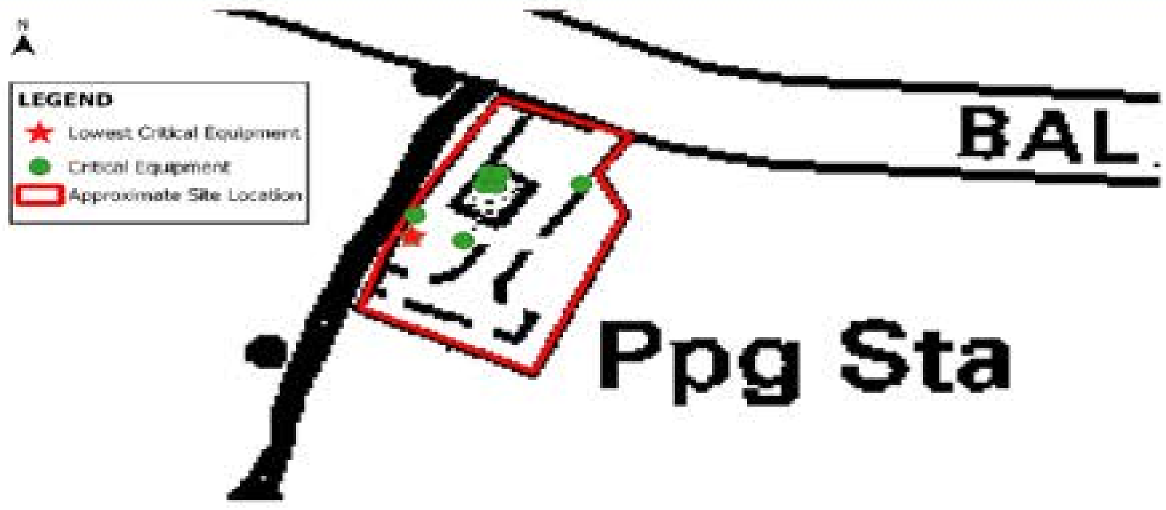
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Plech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	05/12/2016	Attendees	Domenico Santoro (MM), Marcus Healey (WW) and Nik Peterson (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Main transformer	40.13	41.13	41.33	41.33	1.20
Electric cabinet	40.42	41.13	41.33	41.33	0.91
Control panel	40.45	41.13	41.33	41.33	0.88
Generator	40.52	41.13	41.33	41.33	0.81
Pump	40.62	41.13	41.33	41.33	0.71
Import export meters	40.84	41.13	41.33	41.33	0.49
Spine main isolation valve	40.93	41.13	41.33	41.33	0.40
Transformer	41.11	41.13	41.33	41.33	0.22

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. Site is manned twice a month. It is on the bank of a small stream (Balls water). It floods often, and the site is not accessible during floods. (Marcus Healey and Nik Peterson, Site visit 05/12/2016) 2. During floods, operation stops due to the alarm system when water gets in to the pits having valves and pumps. (Marcus Healey and Nik Peterson, Site visit 05/12/2016) 3. Site flooded to a depth of approximately 0.2m in 2015. (Marcus Healy and Nik Peterson, Site Visit 05/12/2016) 4. Whole site could easily flood, chambers flood every year. Access road also floods. (Tom Wallace, 17/11/2016)	NONE

Phase 2 Mitigation Assessment

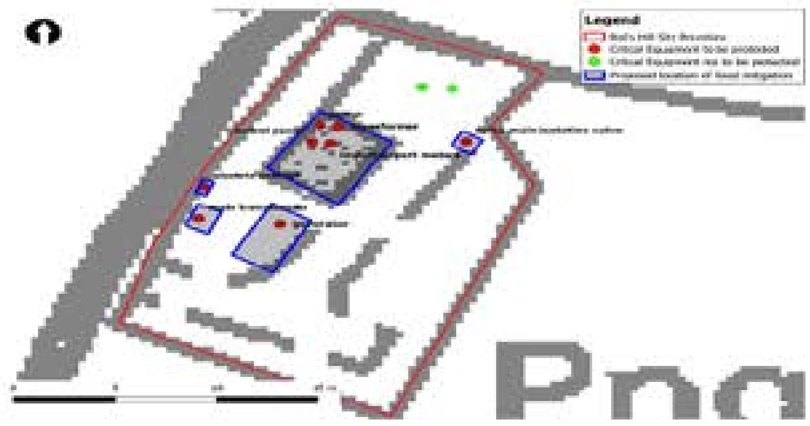
Flood Defence Description

1. Building waterproofing and 1 flood door are proposed as flood mitigation measures for the building which includes control panel, pump, import export meter and transformer.
2. Main transformer to be raised 1.2m.
3. Electric cabinet to be raised 0.88m.
4. Isolation valve and electric panel to be replaced with IP68 rated equipment. Given the size and complexity of the site, this has been costed using the 'low' banding cost.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

41.33mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	1
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low
Raise control panel or kiosk	number	1
Raise other equipment	number	1
Other	linear m	0

Comments

1. The following options were considered but not preferred for the following reasons:
a) Whole site protection by walling up to 2m in height, including flood gates. Protecting multiple equipment instead of localised protection was tested but these works are far more expensive and not justifiable.
2. The site access is prone to inundation. In the event of flooding access from the west will be cut by inundation of the roadway adjacent. The protected equipment may be safe during these flood events however likely not accessible.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. Due to the small footprint of mitigation measures, impacts on third parties from these flood protection measures will be of a small scale and isolated to areas immediately adjacent the site.

Source Data

LiDAR Data	Existing FRA and accompanying model files
1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.	Desk based flood risk assessment was conducted but no existing model is available in the vicinity of the site. (DM-_912494-v1-Balls_Hill_2007__Planning_Flood_Risk_Assessment.doc)

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
Topographic survey of the site was provided by Wessex Water for this study. Dwg format files were provided, titled: 1) SU_BH_Balls hill P.S._11678 Balls Hill topo_20161122.dwg 2) SU_BH_Balls hill P.S._11678 Balls Hill plan_20161122.dwg	A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.
Watercourse Survey	
Not available.	

Details of Existing Study

Fluvial Hydrology	Study Extent
Not available	
Tidal Hydrology	
Not applicable since the site is not tidally influenced.	

Hydraulic Model Construction	Return Periods Assessed in Model
Not available	Not available

Comments

There is no existing model available in the vicinity of the site.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

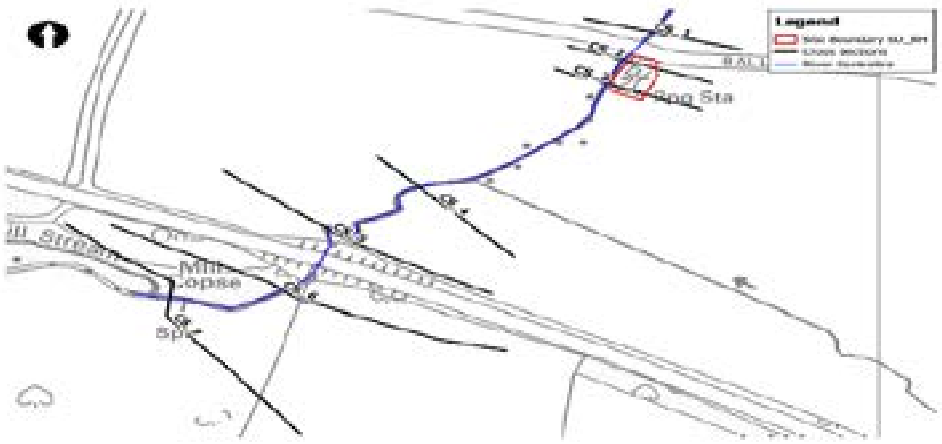
Fluvial Hydrology

ReFH hydrologic assessment was conducted to estimate the flows in the Ball's Water stream adjacent to the site. This analysis included the watercourse which joins Ball's Water at the confluence to the south of the site.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. 1D unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. This model is simulated for design return periods to calculate flood levels at the site.
3. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. Upstream inflow boundary (QT) condition was applied for each design return period.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from EA website.
3. The structure (culvert) at the downstream of the reach is modelled as a conduit of 3.0m diameter based on the measurements estimated during the site visit in April 2017. The road crossing structure just upstream of the site location is neglected (being conservative to assume no flood attenuation upstream of the culvert). The tributary to the south of the site is modelled by adding lateral inflow at the confluence location. The flow conveyed through the tributary is considered same as that conveyed through main channel based on a catchment assessment.
4. The mannings roughness coefficient is varied between 0.05 and 0.2 to model the channel and floodplain features, including site areas.
5. The normal depth criteria is used as the downstream boundary. The gradient for the normal depth boundary is assigned as 1 in 150.
6. The model is simulated for design return periods 1 in 100 year, 1 in 200 year and 1 in 1000 year with an upper end allowances of climate change.
7. The model was tested for its senstivity against downstream Boundary slopes (steep to flat). The results of this process indicated that the flood levels at the site were not sensitive to the changes in the downstream boundary slope.

Results

1. Flood levels are extracted for each design return periods at cross section CS_2.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For the 1 in 1000 year return period, the MM(2017) flood level is 0.28m higher than that of EA flood level obtained from EA flood zone 2. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. Site operators indicated that in 2015 the site was flooded to a depth of 0.2m. Based on this assessment, for extreme events (1000yr + CC upper end) flood depths of up to 1m depth are anticipated on site. This depth for extreme events appears consistent with anecdotal evidence of previous flood depths for smaller flood events.

Assumptions and Limitations

1. Floodplain is included within the 1D model extent.
2. Cross sections (channel and floodplain) are extracted from LiDAR.
3. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
4. Structures and channel cross sections are not based on water course survey.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Corscombe	Post Code	
11729				
Site Type	NGR			
Supply	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Luke Edward Beattie		
SU_CC	Contact Number	07786196950		

Site Plan

Location Plan

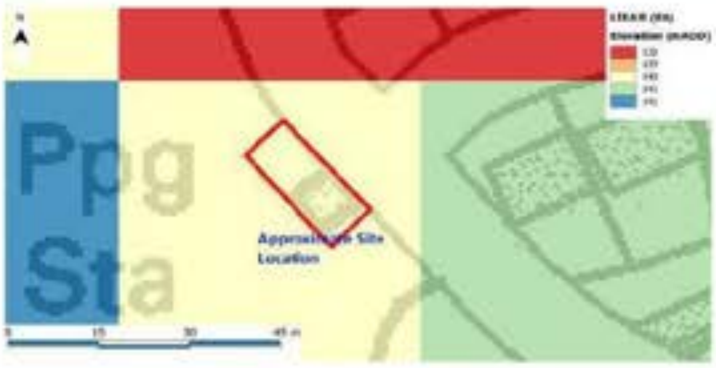
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial*	Existing Flood Defence	No
Main Flooding Source	Unnamed Drain	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
140 (Panorama)	140 (Panorama)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	N/A*	N/A*	N/A	0.00			
			1 in 200 year (0.5%)	N/A*	N/A*					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	N/A*	N/A*	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	N/A*	N/A*	N/A	N/A			
			1 in 200 year (0.5%)	N/A*	N/A*					
			1 in 1000 year (0.1%)	N/A*	N/A*	N/A	N/A			
N/A*			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

*Due to lack of adequate resolution ground level data at the site it is not possible to report flood levels or equipment threshold levels with a reasonable degree of accuracy. Therefore, flood levels are not summarised for the site in the above table.
Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

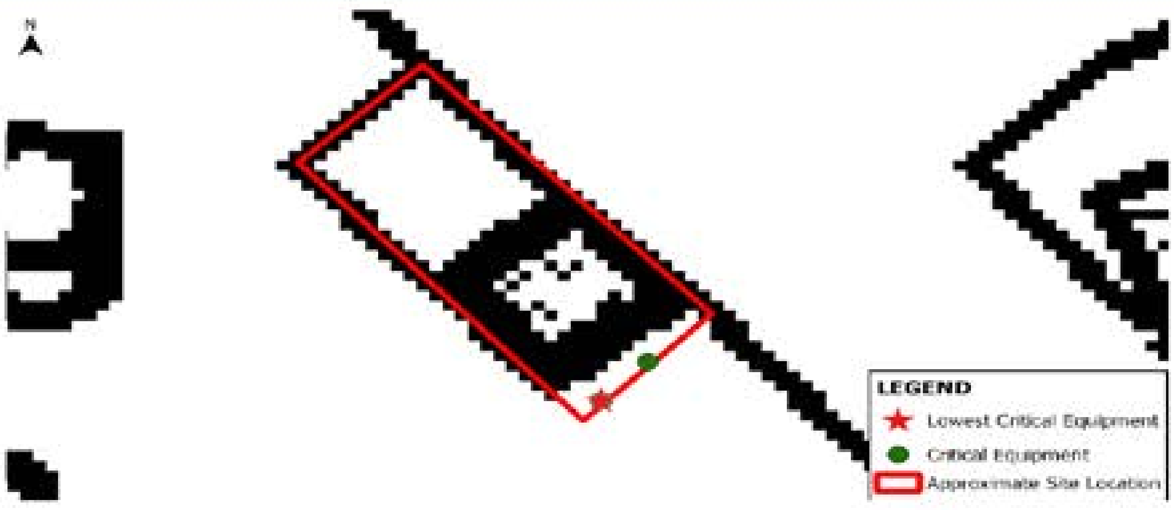
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Supriya Savalkar	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	12/12/2016	Attendees	Carrie Eller (MM), Jason (WW) and Marcus (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Generator	N/A	N/A	N/A	N/A	N/A
Motors on pumps	N/A	N/A	N/A	N/A	N/A

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. There is no previously reported flooding at the site. (Jason and Marcus, Site visit 12/12/2016)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

Due to the lack of adequate resolution ground level data at the site, it is not possible to estimate accurate flood levels. Therefore, proposed flood mitigation measures are not provided for this site.

Flood Defence Layout

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

Due to the lack of adequate ground level information at this site, it is not possible to estimate a required flood defence height.

Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	The critical equipment is likely to flood at the site; however, given the lack of ground level information, mitigation measures are not assessed.
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	0	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	0	
Raise other equipment	number	0	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	N/A

Source Data

LiDAR Data

LiDAR is not available for this site. OS Terrain 50 is a topographic dataset (with 50m grid resolution) available for this site which is consistent (with a deviation of up to 2m) with the OS Map spot elevation and thus it is used to build the model. Spot Elevation Comparison between OS Map, Google Earth and Panorama was also conducted to arrive at the appropriateness of the dataset to represent the site features.

Existing FRA and accompanying model files

Not available

Site Topographical Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Watercourse Survey

Not available

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

There is no existing hydraulic study available in the vicinity of this site.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

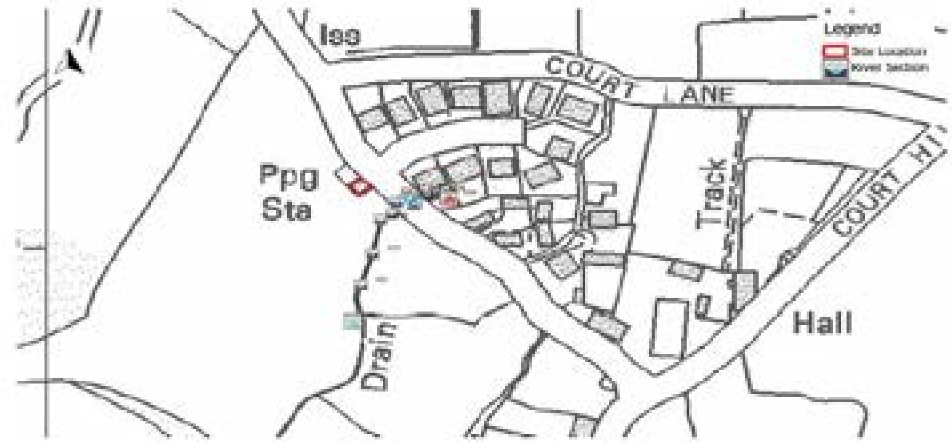
Fluvial Hydrology

ReFH hydrologic assessment was conducted to prepare the hydrology for this study.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1.One-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro. Since the LiDAR data is not available, therefore channel information from the field visit is used to prepare the cross sections. OS Terrain 50 data (50mX50m grid size) is used to estimate the slope of the channel as well as the floodplain slope to represent the channel and floodplain.
2. Structure dimensions were measured during the field visit for the culvert (Fudge Hill).
3. The hydraulic model developed using this approach is used to assess the flow paths and approximate flood levels at the site, however, due to the 50mX50m course resolution of terrain data, the quantitative estimation of flood levels is not possible using this hydraulic model. A summary of the flooding mechanisms is provided in the Results section below.
4. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. One-dimensional (1D) unsteady hydrodynamic model was developed in Flood Modeller Pro.
2. Channel segment of the cross section is estimated using the information obtained from the field visit, wherein the floodplain segment of the cross sections is estimated from the coarse 50mX50m grid OS Terrain 50 data.
3. Upstream inflow boundary condition was applied to cover the range of peak flows for the critical return periods
4. A constant head downstream boundary condition was used in the model to represent overtopping over the roadway (Fudge Hill).
5. Manning's roughness used in model is 0.045 for channel and 0.065 for floodplains. The Manning's roughness were assigned to represent field conditions.
6. The model is simulated for critical return periods to understand flood mechanisms at the site.

Results

1. Based on the analysis using the coarse 50mX50m grid Terrain50 data, and based on the field visit to observe the flow paths, the site is likely to flood from two mechanisms:
a) As the flood peak reaches the culvert under Fudge Hill Road, capacity of the culvert is overwhelmed causing water to overtop onto the roadway and then overland flow on the road towards the site.
b) Additionally, flood water will spill over in to left overbank wherein there are some low lying field storage, and once the low lying field storage fills up, water may flood the site which is also located on left overbank.

Comparison to previous studies / data

As per the site operator, the site has not experienced any flooding in the past. However, this broad level analysis shows that for critical return periods, the site is likely to flood during extreme events

Assumptions and Limitations

1. Floodplain is represented within the 1D domain of the model.
2. Cross sections (channel and floodplain) are extracted from OS Terrain 50 (50m resolution).
3. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
4. Information on the culvert and the roadbridge (Fudge Hill) were collected and estimated by site visit staff. This does not constitute a formal watercourse survey and is an estimate only.
5. Detailed topographic survey should be commissioned for this site to prepare the hydraulic model to estimate flood levels at the site since OS Terrain 50 data does not have acceptable resolution to perform quantitative estimation of flood levels.
6. Review of the OS Terrain 50 data, field pictures, and review of aerial imagery shows that the site may be at risk from surface water runoff from the development located north of the site, however this has not been investigated further during this study due to lack of topographic data. It is suggested to investigate this surface water flood mechanism during the design stage after obtaining suitable topographic data.

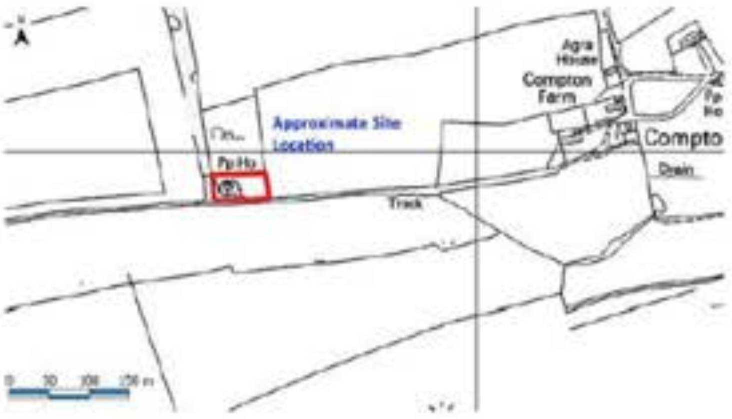
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Compton P.S.	Post Code	
12036				
Site Type	NGR			
Supply	Division	North	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Marc Hodgson		
SU_CO	Contact Number	07768035421		

Site Plan

Location Plan



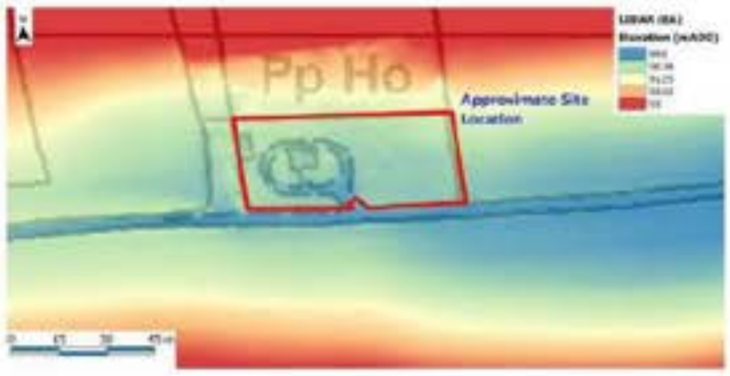
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Unnamed drain / overland flow	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
89.73 (TOPO) to 90.58 (TOPO)	90.16(LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	N/A			
			1 in 100 year (1%)	90.60	0.55	See Fluvial	See Fluvial			
			1 in 200 year (0.5%)	90.65	0.60					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	90.80	0.75	See Fluvial	See Fluvial			
		2050 (Upper End Allowance)	1 in 100 year (1%)	90.64	0.59	See Fluvial	See Fluvial			
			1 in 200 year (0.5%)	90.69	0.64					
90.05			1 in 1000 year (0.1%)	90.85	0.80	See Fluvial	See Fluvial			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Note: The position of the site on a dry valley floor at the mouth of the valley results in surface water run-off equating to a fluvial risk. As such results have been considered as fluvial rather than surface water.

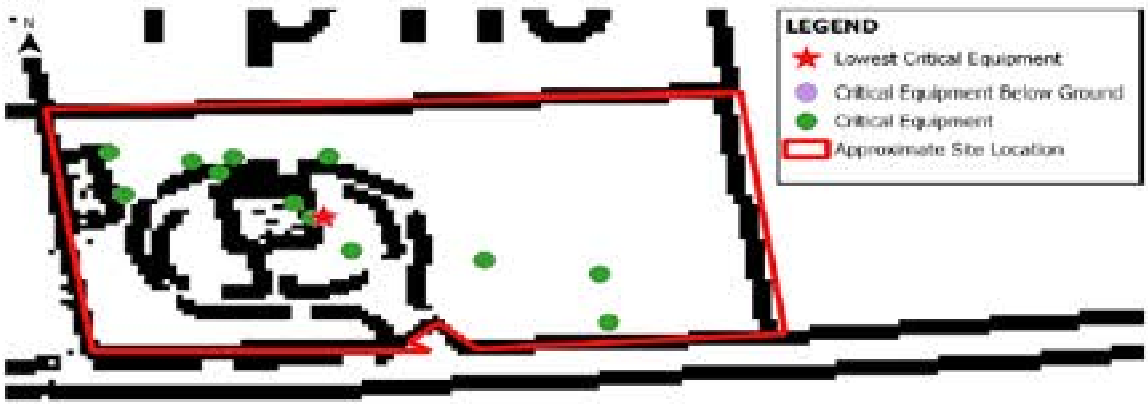
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Andy Beverton	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	29/11/2016	Attendees	David Tinning (MM) and Kieron Sloan (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Chlorination Dosing Mixing Chamber	90.61	90.94	91.19	91.19	0.58
Chamber for ESAS	90.05	90.85	91.10	91.10	1.05
Chlorine Store	90.24	91.01	91.25	91.25	1.01
Washout Chamber	90.51	90.92	91.17	91.17	0.66
Standby Generator	90.53	91.03	91.28	91.28	0.75
Borehole	90.55	91.01	91.26	91.26	0.71
Control Panels	90.55	90.96	91.21	91.21	0.66
Actuator	90.59	90.87	91.12	91.12	0.53
Surge Vessel Tank	90.68	90.94	91.19	91.19	0.51
Borehole (disused)	90.76	90.99	91.24	91.24	0.48

Summary of Key Client Comments

1. During previous flood events in 2013/2014, the maximum flood level has reached up to the steps of the building. (Kieron Sloan, Site visit 29/11/2016)
2. Access road can flood cutting off access to building, about once a year. Access road might be cut off for weeks affecting deliveries of gas etc. Ability to respond to alarms and compliance sampling is compromised as the site can not be accessed. (Kieron Sloan, Site visit 29/11/2016)
3. There does not seem to be an effect on water quality from high water levels. (Kieron Sloan, Site visit 29/11/2016)

Comments on Below Ground Equipment (if any)

1. Water could potentially enter below ground section through ducts thereby flooding the chlorine dosing mixing chamber. According to our assessment, the critical equipment level of chlorine dosing mixing chamber is 90.61 mAOD. (Kieron Sloan, Site visit 29/11/2016)
2. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.
3. For below ground equipment, flood depths listed in the above table represent the depth above ground level or finished flood level. Once the flood level becomes higher than the indicative threshold level listed in the above table for below ground equipment, flood depth at the equipment should be estimated with respect to critical equipment level, and not the indicative threshold level.

Phase 2 Mitigation Assessment

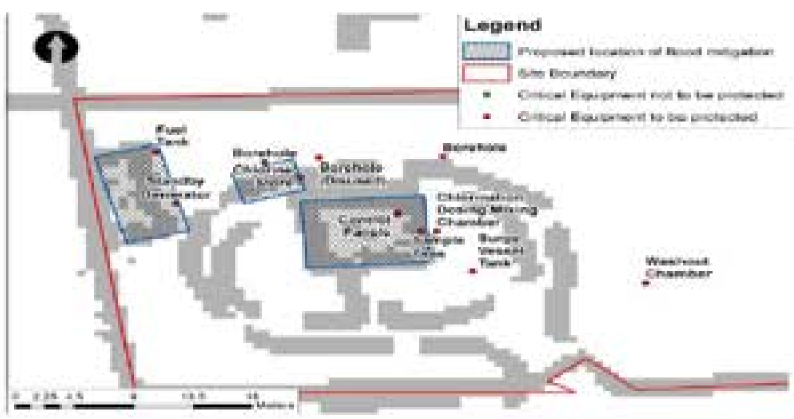
Flood Defence Description

1. Replacement of electrics to comply with IP68 regulations is required for Washout Chamber, Chamber for ESAS, Borehole 1, Borehole (disused), Borehole 2, Fuel Tank, surge tank vessel and actuator.
2. Building waterproofing for a structure perimeter of 28.2m is required to mitigate risk to the Standby generator, a perimeter of 17.5m for the Chlorine store, and a perimeter of 70m for the Chlorination dosing chamber, sample taps and control panels.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

91.28 mAOD (Maximum of multiple locations)

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	3
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	High
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) Localised protection (cabinets or flood walls) were considered at various individual pieces of equipment however this may cause access issues and therefore raising the equipment is preferred.
b) Raising critical equipment within existing cabinets to above 91.19mAOD was considered for the surge tank vessel, however IP68 rated replacement electrical equipment is preferred.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligible. There is no reduction in storage during flood events as a result of the mitigation measures.

Source Data

LiDAR Data	Existing FRA and accompanying model files
LiDAR data was not available for the site specific catchment.	N/A

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
No Topographic survey available.	N/A

Watercourse Survey
N/A

Details of Existing Study

Fluvial Hydrology	Study Extent
N/A	

Tidal Hydrology
N/A

Hydraulic Model Construction	Return Periods Assessed in Model
N/A	N/A

Comments
There is no existing hydraulic study available in the vicinity of this site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Surface Water

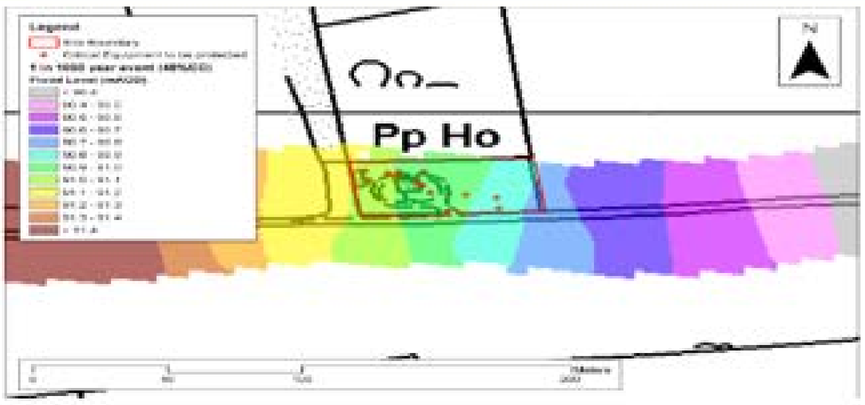
Fluvial Hydrology

N/A

Tidal Hydrology

N/A

Supporting Figure



Summary of Approach

1. A 2D modelling approach was adopted for this assessment.
2. Run-off was consdiered to be directly comparable to a fluvial risk and the derived inflow was applied as an upstream boundary condition.

Hydraulic Modelling

Due to the sites location on a valley floor at the outflow point of the catchment it was determined that surface water and fluvial risk are analagous. Consequently, the assessment used 2D modelling approach with the derived hydrology being applied upstream of the site.

Results

The results of the site specific modelling identify that the entire site is at risk of flooding during the 1 in 100 year event (including central limit climate change to 2025).

Comparison to previous studies / data

The results of the modelling are in line with anecdotal evidence received from site operators denoting that flood waters regularly reach the steps of the main building.

Assumptions and Limitations

1. The modelling approach has assume a static head for a downstream boundary.
2. The topography of the valley is assumed to prevent flood waters from the River Avon from reaching the site.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Charlton P.S.	**Post Code**		
12026					
Site Type	**NGR**				
Supply	**Division**	North	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	Marc Hodgson			
SU_CT	**Contact Number**	07768035421			

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial and Surface Water	**Existing Flood Defence**	No
Main Flooding Source	Tributary of River Avon	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
78.70 to 79.72 (TOPO)	79.20 (TOPO)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.30-0.90			
			1 in 100 year (1%)	79.23	0.30	N/A	0.30-0.90			
			1 in 200 year (0.5%)	NA	NA					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	79.53	0.60	N/A	0.30-0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	79.26	0.33	N/A	N/A			
			1 in 200 year (0.5%)	NA	NA					
78.93			1 in 1000 year (0.1%)	79.65	0.72	N/A	N/A			
			Groundwater flooding					Data not available*		
			Reservoir							0.30-2.00

Comments

1. 200year fluvial levels are not available.
2. Although the EA surface water mapping indicates that the site is at risk of surface water flooding, the risk of fluvial flooding is expected to be greater given the proximity to the watercourse and anecdotal flood evidence.
3. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

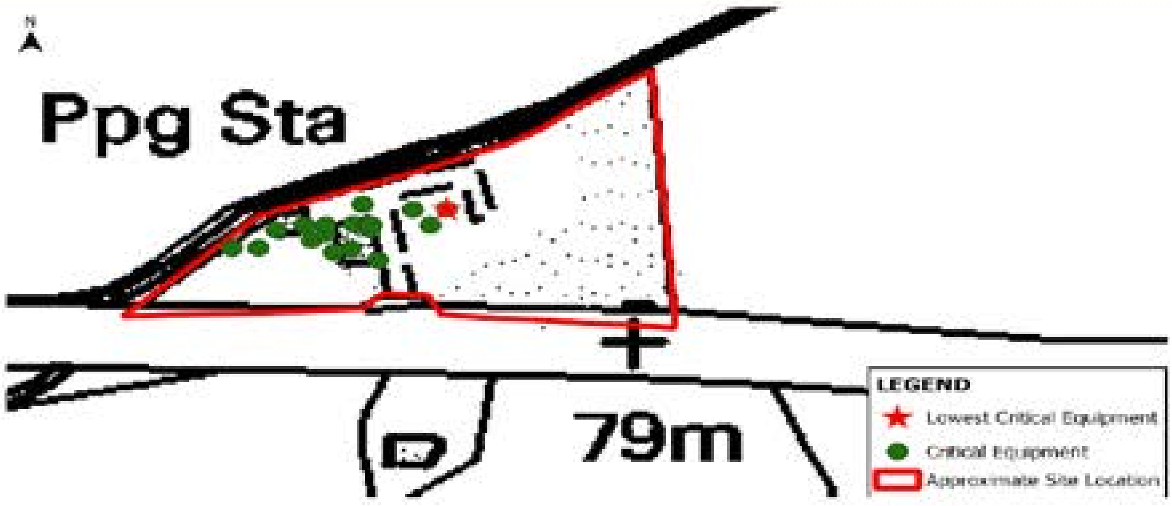
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Supriya Savalkar	Kelsey Plech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	David Tinning (MM) and Kieron Sloan (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Mixing Chambers	78.93	79.65	79.80	79.80	0.87
Mixing Chamber	78.93	79.65	79.80	79.80	0.87
Backup Boosters	79.23	79.65	79.80	79.80	0.57
Transformer	79.27	79.65	79.80	79.80	0.53
Generator	79.27	79.65	79.80	79.80	0.53
Actuator	79.47	79.65	79.80	79.80	0.33
Actuator X2	79.57	79.65	79.80	79.80	0.23
Control Panel Room	79.64	79.65	79.80	79.80	0.16
Chlorine Gas Storage	79.69	79.65	79.80	79.80	0.11
Borehole	79.69	79.65	79.80	79.80	0.11

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. There is almost regular flooding during storm events, which reaches up to the first step of the main entrance. (Kieron Sloan, Site visit 01/12/2016) 2. Back up boosters can flood, which will result in to loss of main and back up sources to Minety WT. (Kieron Sloan, Site visit 01/12/2016)	NONE

Phase 2 Mitigation Assessment

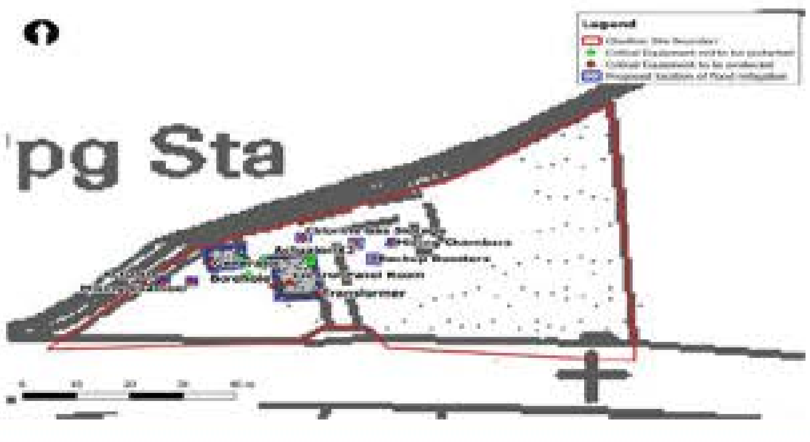
Flood Defence Description

1. Building waterproofing and flood doors are proposed as flood mitigation measures for the two buildings which house equipment on the site (Refer the Flood Defence Layout).
2. All equipment that could be replaced with IP68 rating to be removed and installed with appropriate IP68 rated replacement (actuators, mixing chamber instrumentation, emergency stops, juction boxes). Based on the complexity at the site, the site has been considered large/high complexity site for cost banding purposes.
3. Chloring gas storage to be raised 11cm above current FFL. Door thresholds and air vents to be reconstructed accordingly.
4. Transformer to be raised 53cm with associated access platform.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

79.80mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	2
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	7
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	High
Raise control panel or kiosk	number	0
Raise other equipment	number	1
Other	linear m	1

Comments

1. The following mitigation measures were considered but not chosen as the preferred option:
a) whole site protection not preferred given the depth of flooding on site, the potential to remove floodplain storage and cost.
b) all equipment to be replaced with IP68 rated equipment could be replaced after a flood event, or raised. Raising would have impacts on operational allowances and cost. Replacing the equipment after a flood event could be more cost effective; however, would require a longer time to get the site back online after a flood event.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The measures include waterproofing, and providing flood doors for existing buildings and local protection for the equipment at risk. No impacts anticipated to flooded area.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from EA website.

Existing FRA and accompanying model files

Not available

Site Topographical Survey

Topographic survey is available in .dwg format, which is received from Wessex Water in December, 2016.
Name of file: SU_CT_12026 Charlton topo_20161122
From Wessex Water, December 2016

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Watercourse Survey

Not available

Details of Existing Study

Fluvial Hydrology

Not available

Study Extent

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

There is no existing hydraulic study available in the vicinity of this site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial and Surface Water

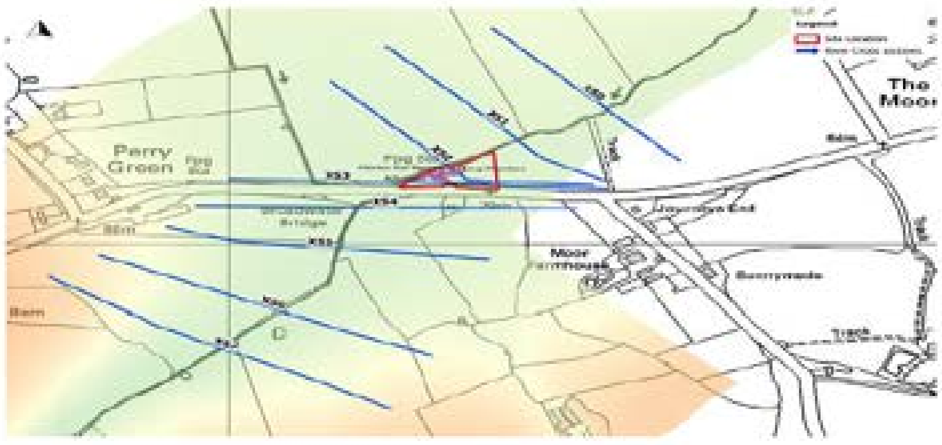
Fluvial Hydrology

ReFH hydrologic assessment was conducted to prepare the hydrology for this study. However, the results were not matching the anecdotal evidence from the site operator. Thus the flows were back calculated from the EA floodzones.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. One-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. Structure survey was obtained for the culvert at the B4040 and this data was incorporated into the model.
3. Section XS2 is representative of flood levels at the site, therefore Stage at this cross section is used to assess the flood levels for critical return periods.
4. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from EA website.
2. Upstream inflow boundary condition was applied to cover the range of peak flows for the critical return periods
3. The bed slope of 1:270 was assigned as the normal depth downstream boundary condition in the model.
4. Manning's roughness of 0.050 is used for the river channel. For floodplain, Manning's roughness is 0.065. The Manning's roughness for left bank of XS2 and XS3 is 0.200. The Manning's roughness were assigned to represent field conditions.
5. Estimates of the key structure dimensions were collected during the site visits. These are estimates only and do not constitute formal watercourse survey.
6. The model is simulated for critical return periods to obtain flood levels.
7. The model was tested for its senstivity against Manning's value (± 20%) and Downstream Boundary slopes (± 10%). The results of this process indicated that the model was not sensitive to the changes in the Manning's value and downstream boundary slope.

Results

1. The flood levels are extracted at cross section XS2 for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The EA Flood Zone 2 (1000yr return period) flood level is estimated as 79.40mAOD. The 1000yr flood level is estimated as 79.38mAOD during this assessment. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator comments that the site floods regularly during storm events and flood water reaches up to the first step of the building housing the equipments. Based on the site visit and topographic survey we estimate this level to be about 79.20mAOD. The results from this assessment indicate that for a 1000yr+CC event, water level will reach 79.65mAOD which is about 45cm higher.

Assumptions and Limitations

1. Floodplain is represented within the 1D domain of the model.
2. Cross sections (channel and floodplain) are extracted from the latest EA LiDAR (1m resolution).
3. Bend losses for meanders are not considered.
4. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
5. Information on the culvert and the roadbridge (B4040) were collected and estimated by site visit staff. This does not constitute a formal watercourse survey and is an estimate only.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

MOTT MACDONALD

Wessex Water Site ID	Site Name	Fivehead P.S.	Post Code	
17220				
Site Type	NGR			
Supply	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Michael Francis Derrick		
SU_FH	Contact Number	07768555142		

Site Plan

Location Plan

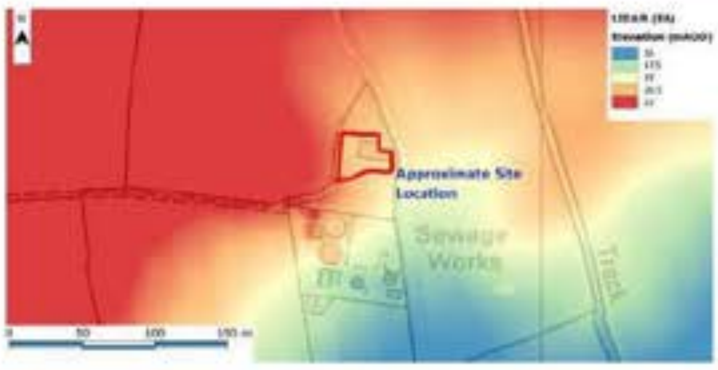
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Unnamed drain	EA Flood Warning Area	River Isle from Chard Reservoir to Hambridge
Current Site Flood Zone	Flood Zone 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
19.58 to 21.78 (LiDAR)	20.00 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	20.16	0.18	N/A	0.00			
			1 in 200 year (0.5%)	20.17	0.19					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	20.18	0.20	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	20.17	0.19	N/A	N/A			
			1 in 200 year (0.5%)	20.17	0.19					
19.98			1 in 1000 year (0.1%)	20.18	0.20	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

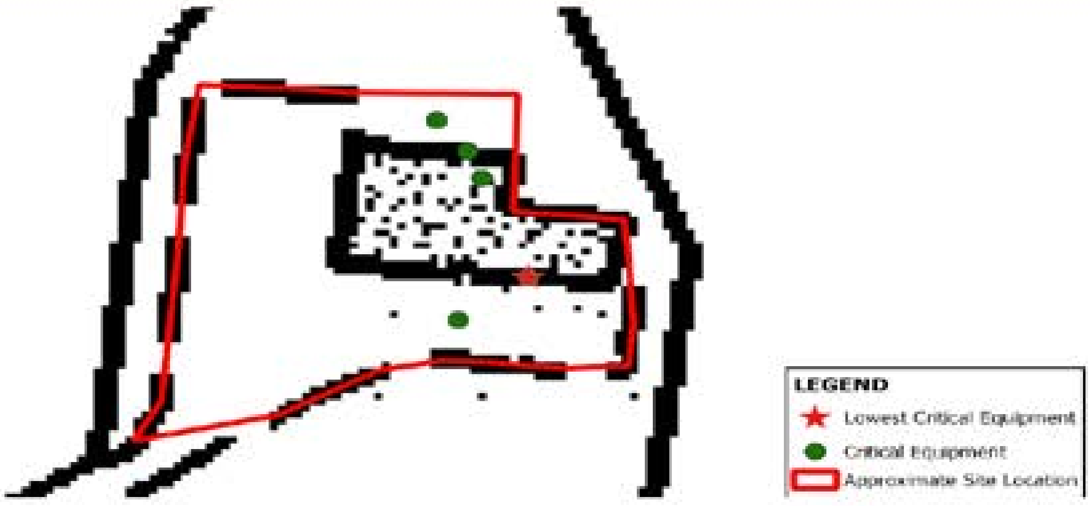
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Lisha Paramabath	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	09/12/2016	Attendees	Carrie Eller (MM), Jason (WW) and Marcus (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Chlorination room housing dosing equipment.	19.98	20.18	20.48	20.48	0.50
Back up panels	20.10	20.18	20.48	20.48	0.38
Control panels for mains incomer pumps etc	20.30	20.18	20.48	20.48	0.18
Rotork valve for bypass maim	20.46	20.18	20.48	20.48	0.02
Generator	20.61	20.18	20.48	20.48	-0.13

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
As per site operator, there is no previously observed flooding at this site. (Jason and Marcus, Site visit 09/12/2016)	NONE

Phase 2 Mitigation Assessment

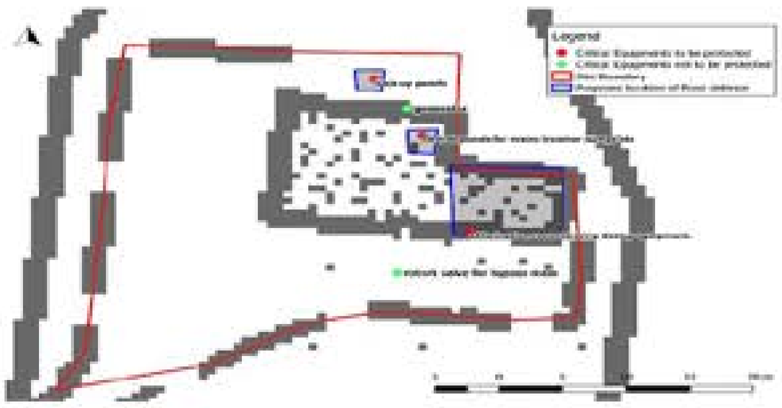
Flood Defence Description

1. Building waterproofing and two flood doors are proposed as flood mitigation measures for the building which houses the chlorination room housing the dosing equipment.
2. Back up panels and control panel for mains incomer pumps to be raised 38cm and 18cm, respectively.
3. The rotork valve is at risk of 2cm of flooding. It is currently raised 63cm above ground. Given that the equipment is already raised, and is at risk of a very small amount of flooding, it is not proposed to provide flood mitigation for this equipment.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

20.48mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	2
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) building waterproofing of the structure housing the backup panels and control panels was considered but not preferred due to cost and accessibility (flood doors).
b) no access was possible during the site visit to the chlorination room, and therefore the details of the equipment is unknown. During detailed design, it is recommended to consider where raising the critical equipment is a suitable alternative.
c) whole site protection was not preferred given the depth of flooding on site, and the associated cost.
d) given the limited amount of flooding expected at the rotork valve (2cm) and the fact that the equipment is already raised 63cm above ground, flood mitigation measures have not been proposed. Alternatively, the equipment could be replaced with IP68 rated equipment.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The measures of flood mitigation include building waterproofing and raising equipment. Minimal impacts to the floodplain storage are expected.

Source Data

LiDAR Data	Existing FRA and accompanying model files
1m resolution LiDAR data is downloaded in December 2016 from EA website.	There is no existing FRA available for this site.

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
Not available	Somerset Levels and Moors - Parrett Lowlands model: Report and model files are not available however results of peak levels and peak flows for 10yr, 30yr, 100yr and 1000yr return periods defended scenario are available within a shapefile provided by the EA (Model date: 30/09/2016). Note that this model does not assess the risk from the small drain adjacent to the site.
Watercourse Survey	
Not available	

Details of Existing Study

Fluvial Hydrology

Not available

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

Hydraulic Model Construction	Return Periods Assessed in Model
Somerset Levels and Moors - Parrett Lowlands model was developed in Flood Modeller Pro however model files are not available.	Not available

Comments

1. Node RI_026 from the Somerset Levels and Moors - Parrett Lowlands model is approximately 900m away from our site and the nearest EA flood zone 2 extent is approx. 330m.
2. The difference between the flood level at the EA flood zone 2 and typical level at the site is approx. 8m. Therefore, existing model extent does not represent the fluvial flood mechanism in the vicinity of the site, and a site specific model should be developed to assess the flood levels at the site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

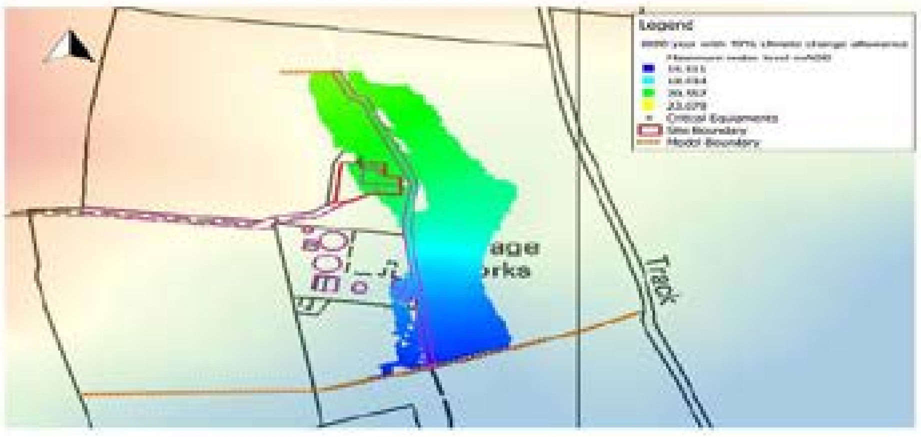
Fluvial Hydrology

ReFH hydrologic assessment was conducted to estimate flows in the small drainage ditch which runs north to south along the eastern edge of the site. The Catchment area is 0.9 square kilometres and the flow for 1000-year with 40% climate change is 2.6 cumecs.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. Two-dimensional (2D) unsteady hydrodynamic model is developed in the TUFLOW software.
2. Maximum water level output is extracted from the 2D model results to estimate flood levels at the site.
3. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. Upstream inflow boundary condition is applied as flow hydrograph obtained using ReFH methodology.
2. The bed slope of 1:50 is assigned as the downstream boundary condition in the model.
3. Manning's roughness of 0.035 is used for the river channel. For floodplain, Manning's roughness of 0.045 is assigned for the natural/vegetated areas, 0.015 is assigned for roads and 0.5 is assigned for raised structures and buildings. The Manning's roughness were assigned to represent field conditions using Google Earth Mapping as the reference.
4. The model was tested for its senstivity against Manning's value (+/- 20%) and Downstream Boundary slopes (+/-10). The results of this process indicated that the model at the site location was not sensitive to the changes in the Manning's value and downstream boundary slope.

Results

1. Flood levels are estimated from the maximum water level ASCII grid for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

The site operator comments that the site has not flooded previously. As per this assessment and the resulting flood levels from the northern boundary, the site floods a maximum depth of 0.6m and a typical depth of 0.2m for extreme flood events. Given the small catchment size and the small nature of the watercourse, the expected resulting flood levels on site are reasonable.

Assumptions and Limitations

1. River channel and floodplain are represented using the latest EA LiDAR (1m resolution).
2. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
3. Flood levels are taken from the northern site boundary to provide a conservative estimate.

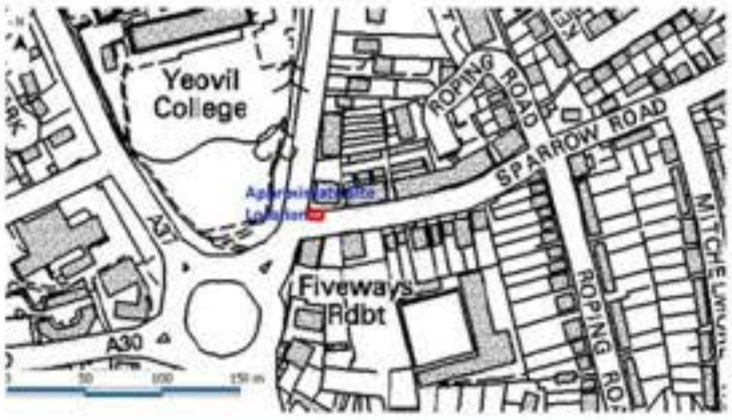
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Fiveways Valve Rotork chamber	**Post Code**	
11371				
Site Type	**NGR**			
Supply	**Division**	West	**Flood Resilience Design Life (years)**	25
Mott MacDonald Site Code	**Controller**	Martyn Brian Brooks		
SU_FW	**Contact Number**	07500033454		

Site Plan

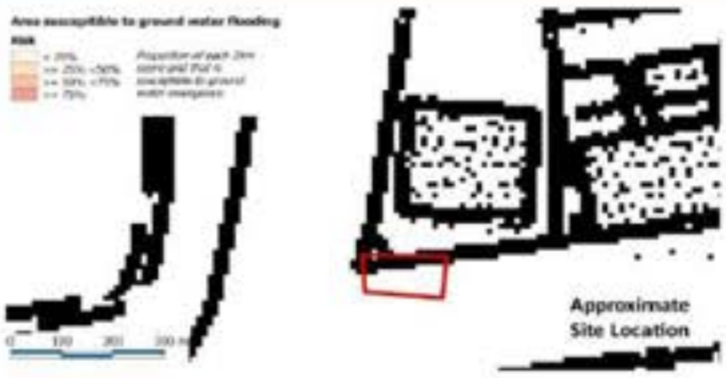
Location Plan



Environment Agency Flood Map

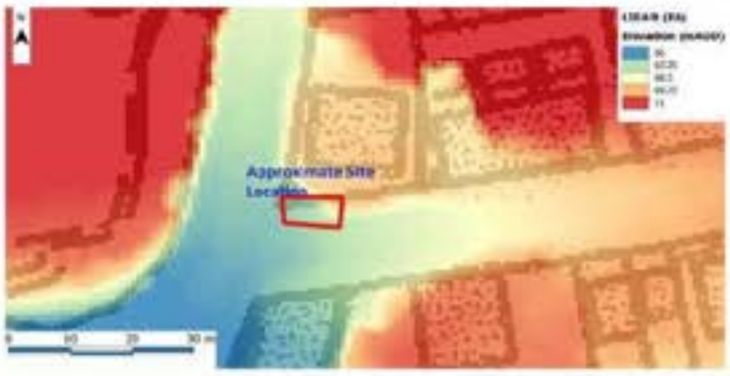
Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Surface Water	**Existing Flood Defence**	No
Main Flooding Source	Surface Water	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 1	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 1	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
67.00 to 69.00 (LiDAR)	67.20 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	N/A			
			1 in 100 year (1%)	NA	NA	67.29	0.05			
			1 in 200 year (0.5%)	NA	NA					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	NA	NA	67.32	0.08			
		2050 (Upper End Allowance)	1 in 100 year (1%)	NA	NA	67.29	0.05			
			1 in 200 year (0.5%)	NA	NA					
			1 in 1000 year (0.1%)	NA	NA	67.32	0.08			
67.24			Groundwater flooding					Data not available*		
			Reservoir							0.00

Comments

1. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).
2. 2D modelling of rainfall and overland flow has identified that the site is at risk of flooding from surface water run-off.
3. The lowest critical equipment is below ground level.

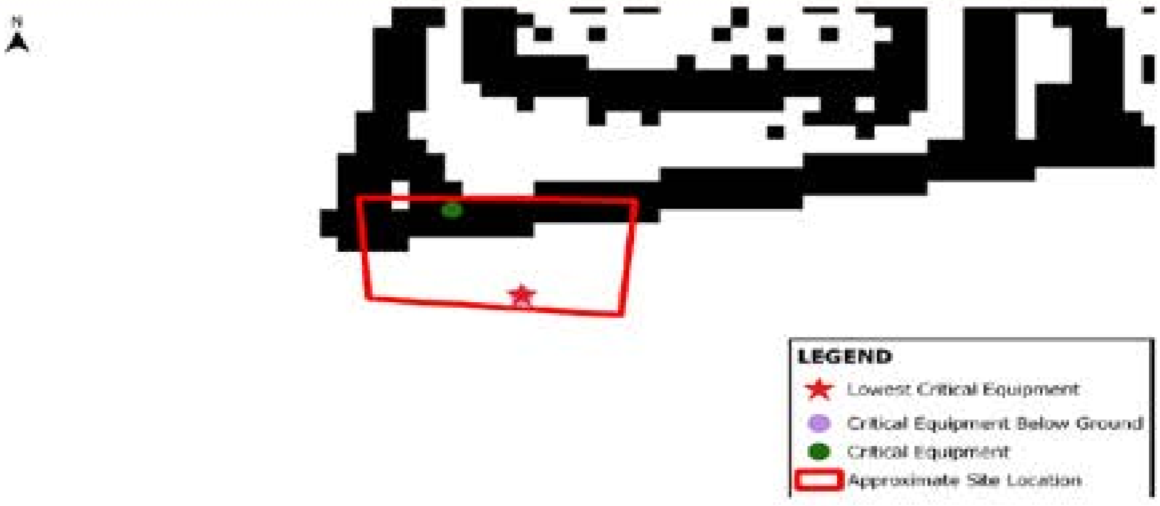
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Andy Beverton	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	12/12/2016	Attendees	Carrie Eller (MM), Jason (WW) and Marcus (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Rotork valve and control panel	67.24	67.32	67.62	67.62	0.38
Control panel for valves	67.28	67.20	67.50	67.50	0.22

Summary of Key Client Comments

Roundabout near the site has flooded in the past. There was also some surface water runoff down the road due to which chamber has flooded in the past. (Jason and Marcus, Site visit 12/12/2016)

Comments on Below Ground Equipment (if any)

1. This equipment is in a closed chamber and its critical level is 0.65m below the ground level. The water will only flood this chamber once it reaches the ground level (67.24 mAOD).
2. The indicative threshold level of rotork valve and control panel is 66.59mAOD.
3. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.
4. For below ground equipment, flood depths listed in the above table represent the depth above ground level or finished flood level. Once the flood level becomes higher than the indicative threshold level listed in the above table for below ground equipment, flood depth at the equipment should be estimated with respect to critical equipment level, and not the indicative threshold level.

Phase 2 Mitigation Assessment

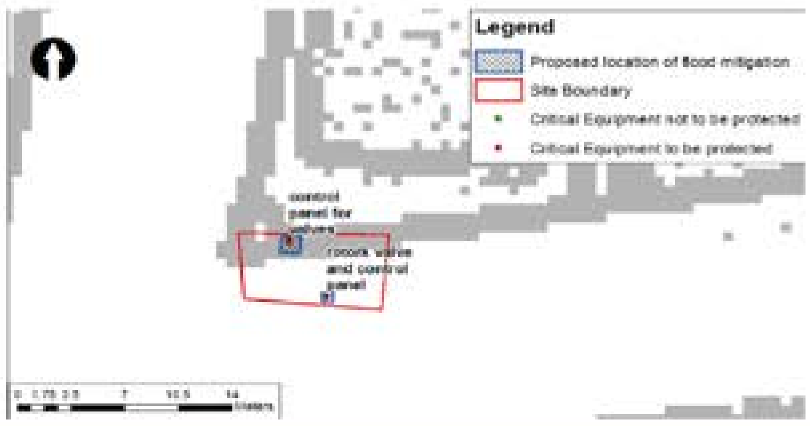
Flood Defence Description

1. Mitigation is considered to comprise replacement of the rotork valve with a submersible option.
2. Equipment to be replaced with IP68 rated equipment where possible (rotork valve, junction boxes, emergency stops, instrumentation).
3. Control panel to be raised 0.22m from current level.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

67.62 mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low
Raise control panel or kiosk	number	1
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) Localised protection (cabinets or flood walls) were considered at various individual pieces of equipment however this may cause access issues and therefore raising the equipment is preferred.

2. The position of the equipment on a public right of way prevents installation of typical defence options.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligible. There is no reduction in storage during flood events as a result of the mitigation measures.

Source Data

LiDAR Data	Existing FRA and accompanying model files
1m resolution LiDAR data was downloaded in December 2016 from EA website.	N/A

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
No Topographic survey available.	N/A

Watercourse Survey

N/A

Details of Existing Study

Fluvial Hydrology	Study Extent
N/A	

Tidal Hydrology

N/A

Hydraulic Model Construction	Return Periods Assessed in Model
N/A	N/A

Comments

There is no existing hydraulic study available in the vicinity of this site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Surface Water

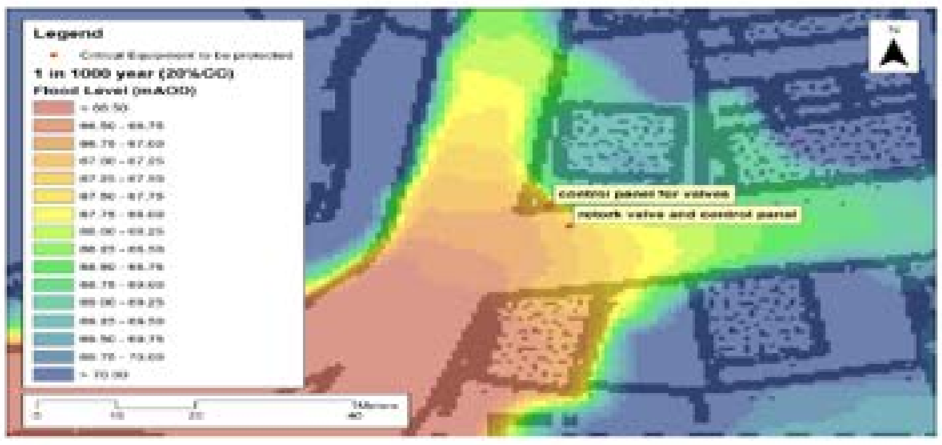
Fluvial Hydrology

N/A

Tidal Hydrology

N/A

Supporting Figure



Summary of Approach

1. A 2D modelling approach with application of direct rainfall was adopted to investigate the surface water risk to the site.
2. Recommended storm duration/Rainfall intensity was based on parameters obtained from FEH.
3. Allowances for Climate change follow the Environment Agency Guidelines (2017).
4. A standard 6mm absorption loss was applied for baseline runs.
5. A series of sensitivity tests were carried out comprising: 0.5*Storm Duration, 2*Storm Duration, +/- 20% Mannings, 12mm absorption loss. The results of the sensitivity tests identified that the model is slightly sensitive to storm duration and absorbance losses.
6. Peak Flood Levels were obtained from the model results at the location of the critical equipment.

Hydraulic Modelling

1. Direct rainfall 2D model was constructed for this assessment.
2. The model extent comprised 480,000 sq metres.
3. Rainfall was applied directly across the entire catchment.
4. Roughness coefficients were dervied from land cover denoted in EA map data.
5. The model was run at a 1m grid cell size.

Results

1. The results show that the site is at risk of flooding from surface water run-off during the 1 in 1000 year event including climate change to 2025 and 2050.
2. The sites position on a slope negates the risk of pooling water for the assessed events, flood risk is caused by overland flow.
3. Resulting Flood Levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

The results of this assessment are in accordance with the Environment Agency Surface Water flood maps when considering the increases resulting from the additon of climate change factors.

Assumptions and Limitations

1. Due to the application of direct rainfall across the entire catchment modelled depths below 0.01m have not been taken into consideration when assessing flood risk.
2. This assessment is limited by the use of a 1m resolution DTM. Flow paths that have potential to produce flooding at the site may be obscured by the relatively coarse resolution.
3. Allowances for Climate Changes are taken from the Environment Agency Guidleines (2017).
4. The assessment assumes a 6mm loss to rainfall through absorbance sensitivity tests identified that an increased absorbance provided minimal impact to flood levels.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

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MOTT MACDONALD

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Topographic survey is available in .dwg format, which is received from Wessex Water in December, 2016.
Name of the file:
SU_IF_12068 Ivyfields topo_20161122.dwg

Watercourse Survey

Topographic survey for the River Avon watercourse was carried out by Storm Geomatics in March 2015 as part of CH2M Study (2016).

Environment Agency / Local Authority Existing Studies

The Environment Agency (EA) commissioned CH2M and their sub-consultants Edenvale Young Associates (EVY) to undertake a modelling and mapping study of the Chippenham area. The study was completed in 2016. Environment Agency has provided a report "Chippenham and Calne Mapping and Modelling Study"and model files of this study.

Details of Existing Study

Fluvial Hydrology

FEH statistical method and Revitalized flood hydrograph method was implemented to estimate hydrology for critical return periods. As per CH2M Study (2016), after comparing FEH and ReFH hydrology, ReFH method estimates were used to derive design hydrographs. ReFH design hydrographs were subsequently applied in the model as lumped inflows at model upstream boundaries and as inflows in intervening catchments.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

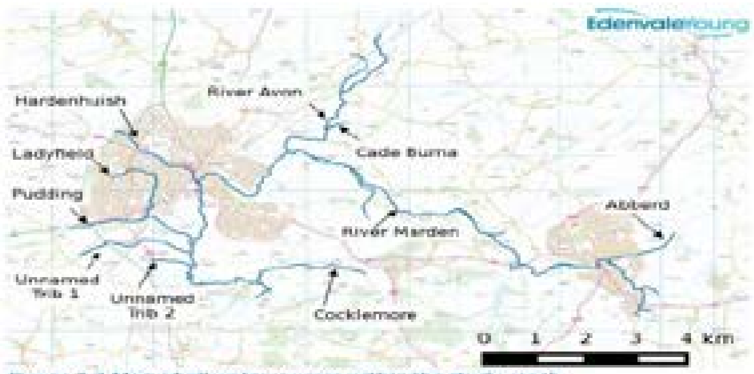

Figure 1.2 Map of all watercourses within the study reach

Hydraulic Model Construction

1. 1D-2D hydraulic model was developed using Flood Modeller Pro-TUFLOW to assess the fluvial flood risk of River Avon at Chippenham.
2. The 2D domain extends from the Great Western Railway north of Kellaways Weir at its upstream extent to Lackham College of Agriculture at its downstream extent.
3. Topographic survey was undertaken for the full 2D model extent.
4. Hydraulic structures across the river were represented in the 1D model. There are a number of floodplain structures that cross or interact with the floodplain of the River Avon in particular were represented in TUFLOW.

Return Periods Assessed in Model

The defended model was run for a number of return periods as below:
1. 1 in 2 year
2. 1 in 5 year
3. 1 in 10
4. 1 in 25
5. 1 in 30
6. 1 in 50
7. 1 in 75
8. 1 in 100
9. 1 in 100 year including climate change (+20% ,30%, 40%, 85% flow)
10. 1 in 200
11. 1 in 200 year including climate change (+20% flow)
12. 1 in 500 year
13. 1 in 1000 year.

Comments

Model results from the CH2M study (2016) were calibrated to the available gauge records. Results of this model are used for analysis and assessment of flood levels at the site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

Fluvial Hydrology

The hydrological data from the existing model is used in the analysis. The peak flow at 1000CC40 is calculated to be 399.564 m3/s

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure

Summary of Approach

1. The existing hydraulic model is used during our flood level assessment. The relationship between flow and stage is established for the model nodes nearest to the site to assess flood levels for climate change allowances.
2. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. Existing model nodes are identified in the vicinity of the site boundary that will represent stage levels at the site location.
2. Model node 1210_15580 represents the cross section of the river Avon near the site boundary which is considered as representative of the flood levels at the site.
3. The stage and flow data for the above node is extracted from the existing model files.
4. Based on this data, Stage-Discharge relationship is developed and extrapolated to obtain the flood levels for critical return periods.

Results

1. Flood levels are estimated from the Stage-Discharge relationship obtained at cross section 1210_15580 for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The EA Flood Zone 2 (1000yr return period) flood level is estimated as 45.48mAOD. The 1000yr flood level is estimated as 44.79mAOD during this assessment which is about 0.69m lower. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment. Additionally, the CH2M (2016) study, is assumed to supersede the EA flood zone mapping results.
2. The site operator commented that the whole site has not been known to flood, field (located rear of site near the borehole) has flooded and this assessment also shows flooding at the field, which is consistent with the anecdotal evidence from the site operator.
3. The site operator commented that the borehole to the south does not flood as it has been raised but the access to the borehole becomes difficult. The access has levels ranging from 44.24mAOD to 44.95mAOD and 1000-year flood with 40% climate change shows a stage of 45.17mAOD. Hence the borehole will become inaccessible in the case of extreme event which is consistent with the anecdotal evidence from the site operator.
4.The site operator has commented that there can be flood water ingress in borehole washout, thereby causing contamination. As per this assesment, it is certain that the borehole washout can be contaminated in the event of a flood, as the equipment is below the gound level which confirms the site operator's comment.

Assumptions and Limitations

2. This assessment is limited by the use of a 1m resolution DTM. Flow paths that have potential to produce flooding at the site may be obscured by the relatively coarse resolution.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

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Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from EA website.

Existing FRA and accompanying model files

N/A

Site Topographical Survey

No Topographic survey available.

Watercourse Survey

N/A

Environment Agency / Local Authority Existing Studies

N/A

Details of Existing Study

Fluvial Hydrology

N/A

Tidal Hydrology

N/A

Study Extent

Hydraulic Model Construction

N/A

Return Periods Assessed in Model

N/A

Comments

There is no existing hydraulic study available in the vicinity of this site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Surface Water

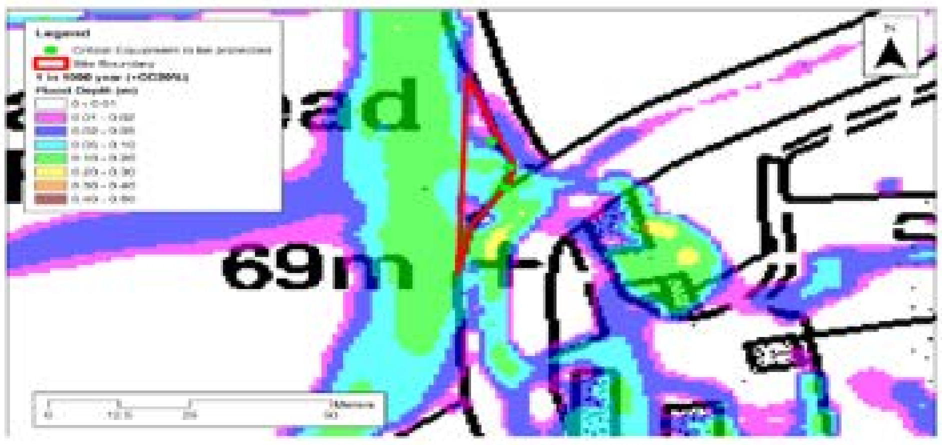
Fluvial Hydrology

N/A

Tidal Hydrology

N/A

Supporting Figure



Summary of Approach

1. A 2D modelling approach with application of direct rainfall was adopted to investigate the surface water risk to the site.
2. Recommended storm duration/Rainfall intensity was based on parameters obtained from FEH.
3. Allowances for Climate change follow the Environment Agency Guidleines (2017).
4. A standard 6mm absorbtion loss was applied for baseline runs.
5. A series of sensitivity tests were carried out comprising: 0.5*Storm Duration, 2*Storm Duration, +/- 20% Mannings, 12mm absorbtion loss. The results of the sensitivity tests identified that the model is slightly sensitive to storm duration and absorbance losses.
6. Peak Flood Levels were obtained from the model results at the location of the critical equipment.

Hydraulic Modelling

1. Direct rainfall 2D model was constructed for this assessment.
2. The model extent comprised 210,000 square metres.
3. Rainfall was applied directly across the entire catchment.
4. Roughness coefficients were dervied from land cover denoted in EA map data.
5. The model was run at a 1m grid cell size.

Results

Model results identify that the site is at risk from surface water for the 1000 year event (including an Upper Limit allowance for climate change).

Comparison to previous studies / data

1. The results of this assessment concur with the Environment Agency Surface Water flood maps denoting a flood risk across the majority of the site with the southern piece of critical equipment at risk.

Assumptions and Limitations

1. Due to the application of direct rainfall across the entire catchment modelled depths below 0.01m have not been taken into consideration when assessing flood risk.
2. This assessment is limited by the use of a 1m resolution DTM. Flow paths that have potential to produce flooding at the site may be obscured by the relatively coarse resolution.
3. Allowances for Climate Changes are taken from the Environment Agency Guidleines (2017).
4. The assessment assumes a 6mm loss to rainfall through absorbance sensitivity tests identified that an increased absorbance provided minimal impact to flood levels.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

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The picture can't be displayed.

Source Data

LiDAR Data	Existing FRA and accompanying model files
1m resolution LiDAR data was downloaded in December 2016 from EA website.	N/A

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
No Topographic survey available.	N/A

Watercourse Survey
N/A

Details of Existing Study

Fluvial Hydrology	Study Extent
N/A	

Tidal Hydrology
N/A

Hydraulic Model Construction	Return Periods Assessed in Model
N/A	N/A

Comments
There is no existing hydraulic study available in the vicinity of this site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment	Supporting Figure
Surface Water	
Fluvial Hydrology	
N/A	
Tidal Hydrology	
N/A	

Summary of Approach

1. A 2D modelling approach with application of direct rainfall was adopted to investigate the surface water risk to the site.
2. Recommended storm duration/Rainfall intensity was based on parameters obtained from FEH.
3. Allowances for Climate change follow the Environment Agency Guidleines (2017).
4. A standard 6mm absorbtion loss was applied for baseline runs.
5. A series of sensitivity tests were carried out comprising: 0.5*Storm Duration, 2*Storm Duration, +/- 20% Mannings, 12mm absorbtion loss. The results of the sensitivity tests identified that the model is sensitive to storm duration and absorbance losses.
6. Peak Flood Levels were obtained from the model results at the location of the critical equipment.

Hydraulic Modelling

1. Direct rainfall 2D model was constructed for this assessment.
2. The model extent comprised 84,000sq metres.
3. Rainfall was applied directly across the entire catchment.
4. Roughness co-efficents were dervied from land cover denoted in EA map data.
5. The model was run at a 1m grid cell size.

Results	Comparison to previous studies / data
1. The results of this assessment identify that the site lies within a large depression in the local topography. 2. During the 1000 year (+CC) rainfall event the depression allows pooling of surface water placing critical equipment at risk. 3. Resulting Flood Levels are reported on page 1 and 2 of this summary sheet.	The results of this assessment concur with the Environment Agency Surface Water flood map that reflect the same pooling effect and a similar flood extent.

Assumptions and Limitations

1. Due to the application of direct rainfall across the entire catchment modelled depths below 0.01m have not been taken into consideration when assessing flood risk.
2. This assessment is limited by the use of a 1m resolution DTM. Flow paths that have potential to produce flooding at the site may be obscured by the relatively coarse resolution.
3. Allowances for Climate Changes are taken from the Environment Agency Guidelines (2017).
4. The assessment assumes a 6mm loss to rainfall through absorbance sensitivity tests identified that an increased absorbance provided minimal impact to flood levels.

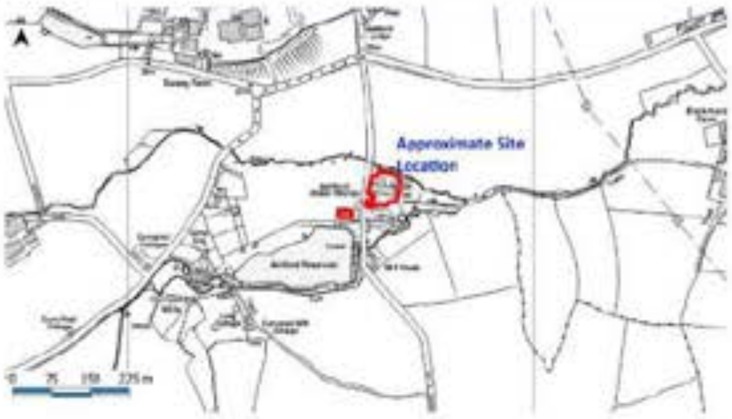
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Ashford	**Post Code**		
12004					
Site Type	**NGR**				
Water Treatment Works	**Division**	West	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	Tom Wallace			
WT_AS	**Contact Number**	07990788885 S/D 89			

Site Plan

Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	Tributaries of the River Parrett	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
30.04 (Topo) to 32.21 (Topo)	30.80 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	31.48	0.18	N/A	0.00			
			1 in 200 year (0.5%)	31.52	0.22					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	31.56	0.26	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	31.52	0.22	N/A	N/A			
			1 in 200 year (0.5%)	31.55	0.25					
			1 in 1000 year (0.1%)	31.60	0.30	N/A	N/A			
31.30			Groundwater flooding					Low		
			Reservoir							Over 2m

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

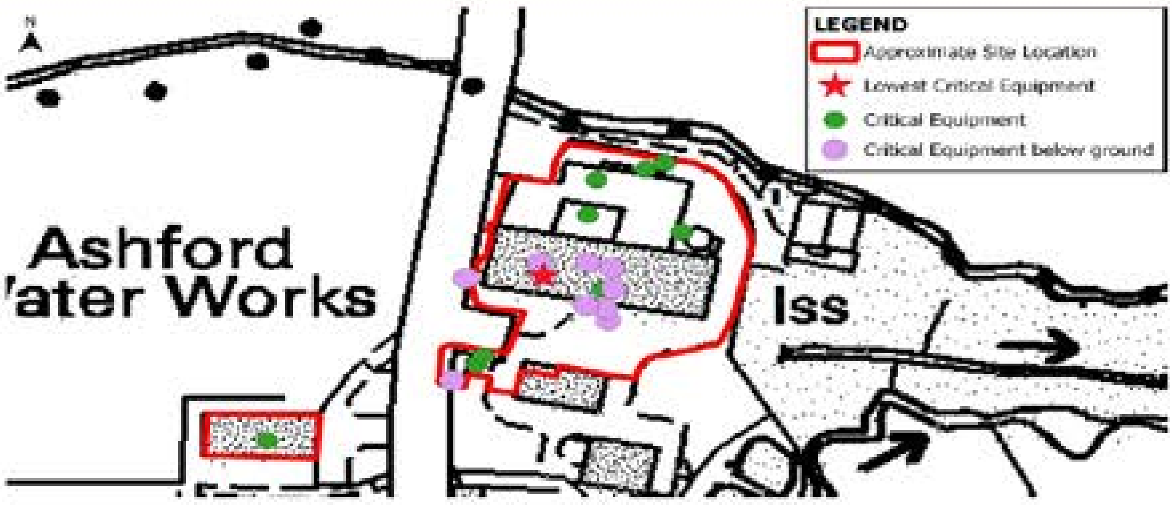
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Supriya Savalkar	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	03/12/2016	Attendees	Domenico Santoro (MM), Josh Coleman (WW) and Paul Lloyd (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Caustic dosing stroke control	31.30	31.60	31.85	31.85	0.55
Chemical process alarm	31.32	31.60	31.85	31.85	0.53
Sample pump mcc	31.32	31.60	31.85	31.85	0.53
Pumps	31.32	31.60	31.85	31.85	0.53
Phosphoric acid dosing plant MCC	31.32	31.60	31.85	31.85	0.53
Distribution panel db8	31.32	31.60	31.85	31.85	0.53
Inlet valve	31.32	31.60	31.85	31.85	0.53
Service water pumps	31.36	31.60	31.85	31.85	0.49
Chemical dosing inlet flowmeter	31.93	31.60	31.85	31.85	-0.08
Blowers for the filters	31.93	31.60	31.85	31.85	-0.08

Summary of Key Client Comments

1. Previous flooding not observed in the part of the site with equipment. However, the site was inaccessible during floods due to the road flooding close to the bridge. In 2016 there was 1.5m of flooding on site. (Josh Coleman and Paul Lloyd, Site visit 03/12/2016)
2. Sensors would cause the site to shutdown if flood water is detected at various points on the site. The site equipment has not flooded in the past, however the access to the site has been denied due to flooding. (Source: STW and WTW Flood Resilience Database)
3. The wooded area at the confluence of the two watercourses floods every year. In addition, surface water flows from the south down a steep hill, causing access issues. The stream at the north causes flooding on the northern part of the site. (Tom Wallace, 17/11/2016)

Comments on Below Ground Equipment (if any)

1. Chemical Process alarm (equipment at 2.59m below ground): As per our assessment, the equipment will start to inundate once the flood water reaches the ground level at 31.32mAOD. However, when water reaches 15mm (0.015m) above plant height the plant stops.
2. Other equipment below ground level: pumps, phosphoric acid dosing plant mcc, sample pump mcc, service water pumps, caustic dosing stroke control, distribution panel, inlet valve, chemical dosing inlet flowmeter

Phase 2 Mitigation Assessment

Flood Defence Description

1. Building waterproofing and flood doors are proposed as flood mitigation measures for the building which house maximum number of equipments on the site (Refer the Flood Defence Layout).
2. Equipment should be replaced with IP68 rated equipment where possible (actuators at inlet valve). Based on this assumption a cost using the medium size/complexity cost banding has been assumed.
3. The shed which houses the remaining electrical equipment at the inlet valve (other than the actuators) should be reconstructed to allow the remainder of the equipment in the shed to be raised 53cm above ground level.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

31.85mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	6
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Medium
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	1

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection would be expensive and have the potential to impact flood risk elsewhere.
b) waterproofing of the shed housing the inlet valve was considered but given the layout and construction below ground level, this would be logistically difficult, and therefore it's recommended to reconstruct the shed and raise the equipment.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences

Minimal. The proposed mitigation measures have a small footprint or consist of waterproofing existing building, and therefore the removal of floodplain storage is minimal.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from EA website.

Existing FRA and accompanying model files

FRA report titled "DV53311-DVR-03-Ashford FRA" prepared by Hyder Consulting (UK) Ltd. (June, 2008).
Existing ISIS model : ASHFORD_model V11.dat (From HYDER)

Site Topographical Survey

Topographic survey is available in .dwg format, which is received from Wessex Water in December, 2016.
Name of the file:
WT_AS_Ashford_12004 Ashford topo_20161122.dwg

Watercourse Survey

Watercourse survey is available in .dwg format from Hyder Study (2008).

Environment Agency / Local Authority Existing Studies

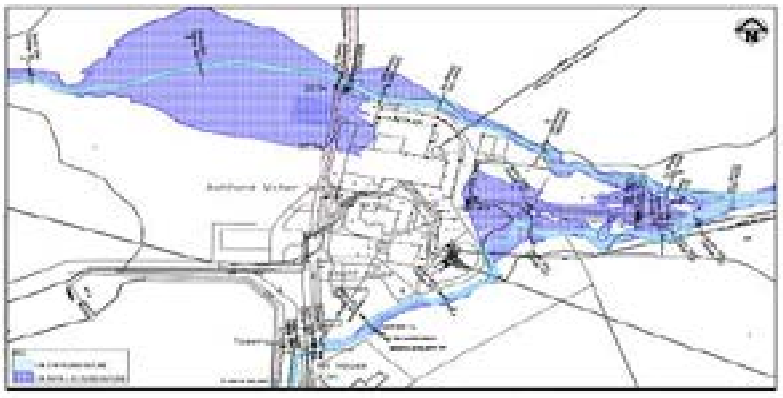
A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

Hyder Consulting (UK) Ltd carried out hydrological assessment by three methods namely ReFH, Pooled Catchment Descriptor and Gauged Donor Catchment Descriptor method.The ReFH Rainfall Run-off method provided an average flow value in both Currypool stream and Peart Water, thus this method was used in Hyder Study (2008) to ensure continuity in the calculations, especially as the two streams join to form Cannington Stream downstream of the site.
A review of the existing hydrology indicates it is suitable for use in the current (2017) assessment.

Study Extent



Tidal Hydrology

Not applicable since the site is not tidally influenced.

Hydraulic Model Construction

1. A detailed one dimensional unsteady hydraulic model was built using ISIS v3.0 for the catchment upstream and downstream of the site.
2. The model extent covered two main watercourses, Peart Water and Currypool Stream. The two streams converge to become Cannington Brook downstream of the site.
3. There were two inflow points to the model, for both Currypool Stream and Peart Water. These were included as unsteady flow/time boundary (QTBDY) 850m and 500m respectively upstream of Ashford WTW.
4. Manning's roughness is as below:
In Peart Water for channel was between 0.013-0.040 and flooplains was between 0.040-0.070.
In Currypool Stream for channel was between 0.013-0.035 and flooplains was between 0.013-0.050.
In Cannington Stream for channel was between 0.035 and flooplains was between 0.040.
5. The downstream boundary was included as the Normal/Critical Depth Boundary (NCDBDY) unit, which enables the user to specify a downstream boundary that automatically generates a flow-head relationship based on section data.

Return Periods Assessed in Model

The return periods assessed within the Hyder Study (2008) are below:
1. 1 in 5 year
2. 1 in 10 year
3. 1 in 25 year
3. 1 in 50 year
5. 1 in 100 year
6. 1 in 100 year including climate change (+20% flow)

Comments

The hydrology for 200 year and 1000 year return period was not calculated in the Hyder Study (2008).
The Ashford Reservoir Section 10 Report (February 2007) was provided by Wessex Water for this assessment.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

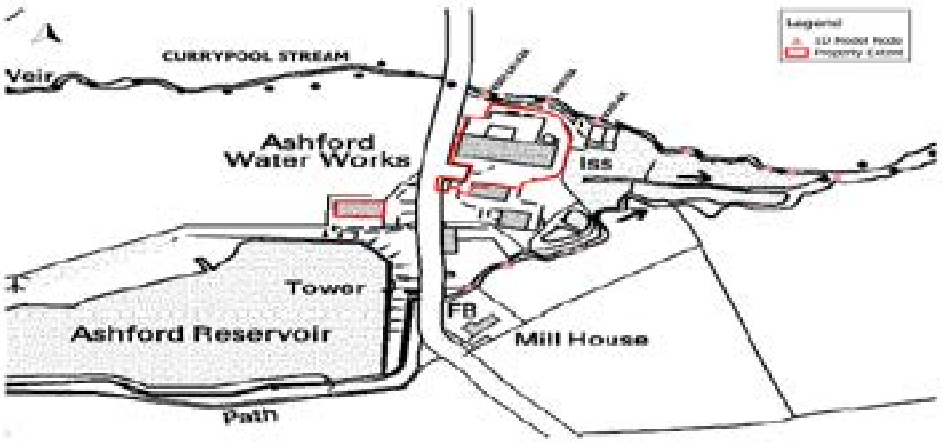
Fluvial Hydrology

The hydrology from the Hyder study (2008) is used for this study. The flows of critical return periods were obtained by extrapolation.
The flow at the Currypool Stream for 1000yr+CC (40%)= 14.33 cumecs.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. The existing Hyder ISIS model is used as the basis for the flood risk assessment.
2. Section XS11A1S2 in the existing model (Hyder Study, 2008) is representative of flood levels at the site, therefore Stage at this cross section is used to assess the flood levels for critical return periods.
3. A spill unit has been attached to the orifice unit at the section closer to the site in the existing model.
3. Flows from the Hyder study (2008) were extrapolated to include the 1000yr+CC flows and were used for the assessment of flood levels.
4. Further detail of the approach is provided in the following sections.

Note: A review of the Ashford Reservoir Section 10 Report indicates that the reservoir is offline, and confirms that for extreme events, the reservoir provides negligible attenuation and therefore no adjustment to the hydrology (Hyder, 2008) is required.

Hydraulic Modelling

1. Upstream inflow boundary condition is applied based on peak flows calculated in Hyder study (2008) for critical return periods.
2. The existing hydraulic model from the Hyder Study (2008) is used during this flood level assessment.
3. The hydrology for 200yr and 1000yr were extrapolated from the existing data. Further the flood level for 1000yr with a climate change allowance of 40% has been assessed.

Results

1. The flood levels are estimated at cross section XS11A1S2 for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The EA Flood Zone 2 (1000yr return period) flood level is estimated as 31.35mAOD. The 1000yr flood level is estimated as 31.50mAOD during this assessment which is about 0.15m higher. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator commented that the site was inaccessible during floods due to the road flooding close to the bridge. As per this assessment, roadway near the bridge is estimated to flood with flood depths of 0.5m for extreme flood events, which is consistent with the anecdotal evidence from the site operator.
3. As per site operator, there was 1.5m of flooding on site during a flood event in 2016 however no equipment was flooded. As per this assessment, flood depths at the lowest part of the site is approx 1.6m for extreme flood events, which is consistent with the anecdotal evidence from the site operator and previous flooding documentation in Hyder FRA study (2008).

Assumptions and Limitations

1. An allowance of 300mm has been added to the flood levels to take account of the uncertainity in the discharges from Ashford reservoir and the complex interaction between the two streams near the site.
2. It is assumed that stage XS11A1S2 represents stage at the site location.
3. The hydrology during the Hyder study (2008) is assumed to be suitable for use in this study.
4. Climate change allowance based on Environmental Agency (2017) Climate Change Guidance.

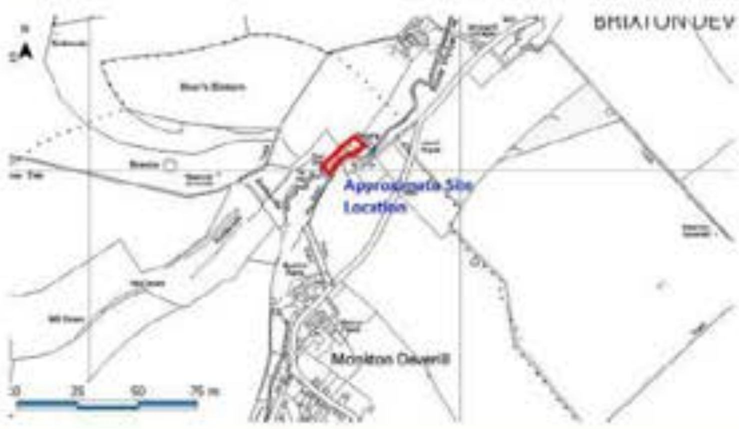
Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Brixton Deverill	Post Code	
12017				
Site Type	NGR			
Water Treatment Works	Division	North	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Marc Hodgson		
WT_BD	Contact Number	07768035421		

Site Plan

Location Plan



Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Wylye	EA Flood Warning Area	Longbridge Deverills, Henfords Marsh, Boreham, Water Lane and Norton Bavant
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
124.79 to 126.22 (TOPO)	125.42 (TOPO)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	125.41	0.62	N/A	0.00			
			1 in 200 year (0.5%)	N/A*	N/A*					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	125.83	1.04	N/A	< 0.3			
		2050 (Upper End Allowance)	1 in 100 year (1%)	125.44	0.65	N/A	N/A			
			1 in 200 year (0.5%)	N/A*	N/A*					
124.79			1 in 1000 year (0.1%)	125.88	1.09	N/A	N/A			
			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

1. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).
2. The flood level for 1 in 200 year return period was not calculated for this site with a fluvial primary source of flooding.
3. The fluvial levels are extracted from model node WTBD_CS3.

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	29/11/2016	Attendees	David Tinning (MM) and Kieron Sloan (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Septic Tank	124.79	125.88	126.11	126.11	1.32
Chlorine Room	125.53	125.88	126.11	126.11	0.58
Main Control Panels	125.53	125.88	126.11	126.11	0.58
Stream Support Kiosk	125.53	125.91	126.14	126.14	0.61
Borehole Control Kiosk	125.56	125.91	126.14	126.14	0.58
Surge Vessel Control Unit	125.62	125.88	126.11	126.11	0.49
Standby Generator	125.82	125.88	126.11	126.11	0.29
Motive Water Kiosk / Monitor	125.97	125.91	126.14	126.14	0.17
Divert Actuator	126.02	125.91	126.14	126.14	0.12
Motive Actuator	126.16	125.91	126.14	126.14	-0.02

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. Site has not been flooded previously. However, site access via the bridge, which crosses the river, is at risk due to flooding. (Kieron Sloan, Site visit 29/11/2016) 2. High water levels in river nearby may not flood site but are detrimental to water quality. This happens once every few years affecting output from the site. (Kieron Sloan, Site visit 29/11/2016)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. Building waterproofing and 5 flood doors are proposed as flood mitigation measures for the building which includes main control panel, chlorine room, surge vessel control unit and standby generator.
2. Equipment to be raised above flood level for motive water kiosk/monitor (17cm), borehole control kiosk (58cm) and stream support kiosk (61cm).
3. Equipment to be replaced with IP68 rated equipment where possible, including the divert actuator, associated electrical equipment. This has been costed using the 'medium size/complexity' cost banding given the nature of the equipment.
4. The septic tank is confirmed as non-critical equipment by Wessex Water, therefore no mitigation measures are proposed to protect this equipment.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

126.14mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	5
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Medium
Raise control panel or kiosk	number	3
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) localised protection was considered at the kiosks and control panels, however could have operational implications. Therefore, it is preferred to raise the equipment above the predicted flood level.
b) whole site protection was considered but not preferred given the cost and the depth of flood water on site.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligable. Given that the mitigation measures include raising equipment and building waterproofing, the reduction in floodplain storage is minimal and therefore not likely to impact flood risk elsewhere.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December, 2016 from EA website.

Existing FRA and accompanying model files

FRA report ("DV53311 Water Treatment Works - Brixton Deverill" report prepared by Hyder Consulting Limited in May 2008) is available.
HEC-RAS model from Hyder study (2008) is not available.

Site Topographical Survey

Topographic survey is available in .dwg format.
Name of the file: B0126_12017.dwg
The topo maps are obtained from "DV53311 Water Treatment Works - Brixton Deverill" report prepared by Hyder Consulting Limited in May 2008.

Watercourse Survey

Watercourse survey was commissioned by Hyder (2008) however it was not available for this study.

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

1. Flow estimates for River Wylye were derived in accordance with the FEH (1999).
2. Statistical, single site analysis and pooling group analysis methods were adopted to obtain the flow estimates.
3. The pooling group flows were adopted for Hyder study (2008).

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

Hydraulic Model Construction

1. 1D steady state hydraulic model was developed in HEC-RAS to assess the baseline fluvial flood risk within the River Wylye channel and floodplain.
2. A detailed topographical and river cross section survey was commissioned by Hyder and undertaken by ABS Surveys Limited in February/ March 2008. The survey included 11 cross sections taken at intervals along a 740m long section of the River Wylye and its associated floodplain in the vicinity of the WTW.The survey extended approximately 100m upstream of the WTW and 100m downstream of the Whitecliff farm access road.
3. Three hydraulic structures were modelled along the study reach.
4. Manning's roughness of 0.045 was used for the river channel. For the floodplain area upstream of WTW, the Manning's roughness of 0.045 was used while 0.03 was used for the floodplains downstream of WTW.
5. Normal depth was used as the downstream boundary. The gradient at the downstream boundary was estimated as 1 in 333.

Return Periods Assessed in Model

Based on the information extracted from the report, scenario 1 in 100 year return period flood with an allowance for climate change 20% was assessed in existing model.

Comments

1. Hyder (2008) model result files are not available.
2. The flood levels corresponding to 1-in-1000 year for climate change allowance are not mentioned in the FRA report (005-DV53311-NER-01_BrixtonV2_final.pdf).

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

Fluvial Hydrology

1. Available hydrological estimates based on pooling group analysis (Hyder study, 2008) are used for return periods 1 in 100 year, 1 in 100 year including climate chnage (20% flow).
2. Based on ReFH analysis for hydrology (Mott MacDonald, 2017), the flow corresponding to return period 1 in 1000 year is adopted as it shows a more conservative estimation of peak flow for this return period 1 in 1000 year .
3. 1 in 1000 year return period flow with an upper end allowance (40%) of climate change = 19.44 cumecs

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure

Summary of Approach

1. 1D unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. This model is simulated for design return periods to calculate flood levels at the site.
3. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. Upstream inflow boundary (QT) condition is applied for each design return period.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from EA website. The only part of the channel that was modified are cross sections CS5_WTBD and XS_6 as per the data of topo map obtained from the report "DV53311 Water Treatment Works - Brixton Deverill".
3. The hydraulic model is developed which includes the orifice (rectangular) and spill to account for the access road to the site.
4. The normal depth is used as the downstream boundary. The gradient for the normal depth boundary is assigned as 1 in 333.
5. Manning's roughness of 0.06 is used for channel and 0.06 to 0.1 for floodplain.
6. The model is simulated for design return periods 1 in 100 year, 1 in 200 year and 1 in 1000 year with central and upper end allowances of climate change.

Results

1. Flood levels are extracted for each design return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For 1 in 100 year return period with 20% allowance of climate change, MM (2017) flood levels are approximately 0.07m higher than the Hyder study (2008). This new results are therefore comparable to previous study and slightly more conservative.
2. For 1 in 1000 year return period, MM(2017) flood level is 0.10m higher than that of EA flood level obtained from EA flood zone map. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.

Assumptions and Limitations

1. Allowances for Climate Changes are taken from the Environment Agencys guidleines, current at the time fo this reports construction.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

MOTT MACDONALD

Wessex Water Site ID	Site Name	Black Lane	Post Code	
12008				
Site Type	NGR			
Water Treatment Works	Division	South	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Robert William Rawlings		
WT_BL	Contact Number	07825401068 S/D 602		

Site Plan

Location Plan

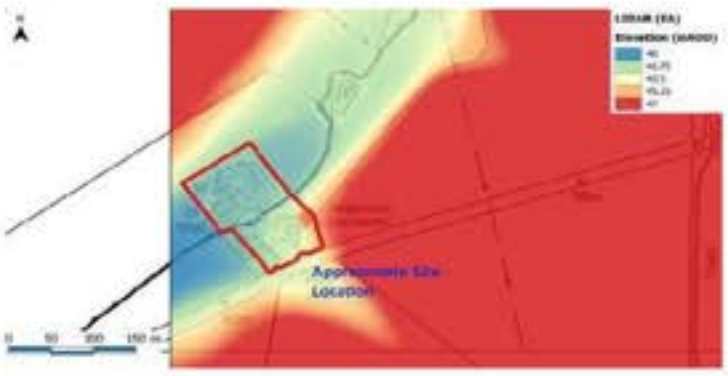
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Tributary of River Stour	EA Flood Warning Area	Groundwater information for the Pimperne Brook at Pimperne
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
40.81 (LIDAR) to 44.71 (Topo)	40.96 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	41.27	0.00	N/A	0.30-0.90			
			1 in 200 year (0.5%)	41.31	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	41.44	0.13	N/A	0.30-0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	41.28	0.00	N/A	N/A			
			1 in 200 year (0.5%)	41.32	0.01					
			1 in 1000 year (0.1%)	41.45	0.14	N/A	N/A			
41.31			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

1. Although the EA surface water map indicates that the site is at risk of flooding from this source, our assessment indicates that the primary flood risk to the site is from fluvial sources.
2. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

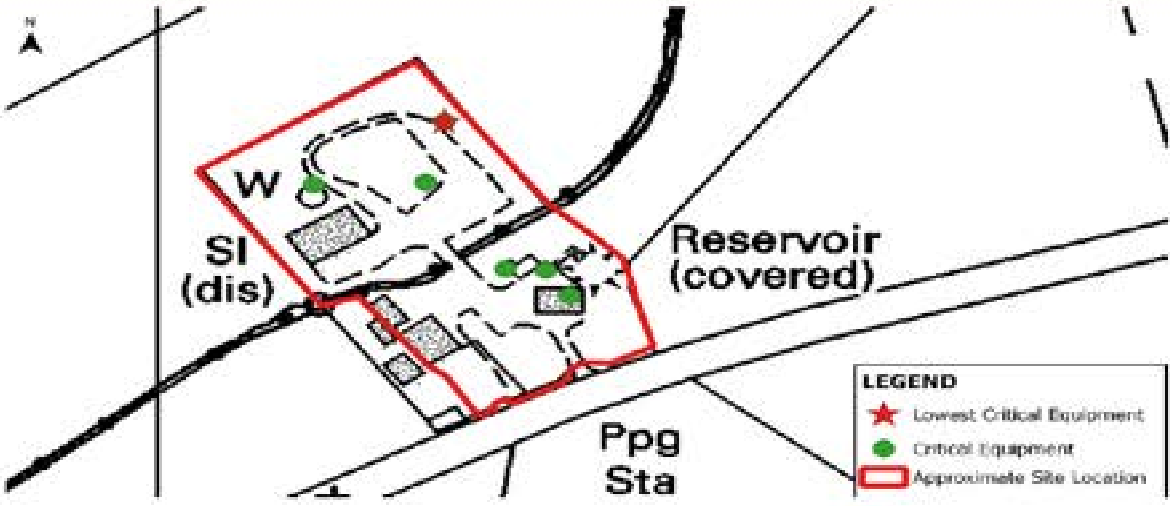
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Jeffrey Mail	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	30/11/2016	Attendees	Carrie Eller (MM) and James Theobald (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Borehole 3	41.31	41.45	41.74	41.74	0.43
Borehole number 4	41.34	41.45	41.74	41.74	0.40
Borehole 2	41.58	41.45	41.74	41.74	0.16
MCC	42.54	41.45	41.74	41.74	-0.80
Generator	42.60	41.45	41.74	41.74	-0.86
Network booster pump	42.71	41.45	41.74	41.74	-0.97

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. Site flooded in July 2014 or 2015 to a depth of about 1 foot. (James Theobold, Site Visit, 30/11/20016) 2. Earth bund is currently being constructed on the front and left sides of the site to provide the flood protection. (James Theobald, Site visit 30/11/2016) 3. During the previous flood events, Brook that runs through the site came out into fields just upstream of the site potentially due to blockage. EA screens were blocked at outfall under the carriage way, holding back the flood waters further. Once checked by catchment team and informed to the EA, flood waters had disappeared in 2 days. Construction activities on the site are in progress so there will be more critical equipment when the M&E gets installed. (James Theobald, Site visit 30/11/2016) 4. Ground and surface water from Pimperne Brook flooded the site following the prolonged heavy rains and the nitrate plant turn table which was in a sump, was at risk. Under the new scheme, the area which was previously flooded is now going to be in a waterproofed bunded salt plant area, the Nitrate building has now been moved to an area outside the known flood zone, and the building is now raised by another 150mm. (Robert Rawlings, 01/02/2017)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. Flood defence measures are currently being implemented for the three boreholes. Based on our analysis these defences should be provided with a crest level at a minimum 41.74mAOD to achieve the 1000yr resilience level including the affects of climate change to 2050. We assume the bund protection is being constructed to provide at least 75cm protection above ground level and is built as a water retaining structure. If the bund is not constructed to this level it will provide protection to the equipment but not to the 1000yr flood level inclusive of climate change effects.
2. The areas between the Brook and the public road do not require mitigation measures to achieve the required flood resilience, including the MCC, generator and network booster pump.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

41.74 mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	1

Comments:

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred given that bunding is already proposed/underway for the susceptible areas of the site.
b) raising of the critical equipment at the boreholes was considered but due to work already underway at the site this is not the preferred option.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minor. Impacts are likely to third parties in the immediate vicinity of the site. The affect of the mitigation on flood levels will diminish with distance.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

A previous study for the site was completed by Hyder, titled DV53311 Water Treatment Works - Black Lane (April, 2008) Report number DV53311-DVR-02-Black. This includes a 1D ISIS hydraulic model of the site and surrounding area.

Site Topographical Survey

Site topographical survey was provided by Wessex Water for this assessment in DWG format, titled:
12008 black lane topo.dwg

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A flood model and report assessment of Pimperne Brook by Capita Symonds (2010) titled Pimperne Brook ABD Study was supplied by the Environment Agency for use in this assessment. This includes a combined 1D-2D ISIS TUFLOW hydraulic model of the Brook.

Details of Existing Study

Fluvial Hydrology

1. Hyder (2008) Study
WINFAP hydrological analysis methodology has been used, adopting the pooled and adjusted method based on the highly permeable nature of the catchment.
2. Pimperne Brook (2010) Study
The ReFH method for generating peak flow estimates and design hydrographs has been used. Version 2.0 of the FEH CD-ROM and WINFAP-FEH have been used in this current study as it commenced before the release of the later versions in September 2009. Updates to the Statistical method and URBEXT2000 and associated new equations have been used where appropriate.

Study Extent

Tidal Hydrology

Potential flooding in the area is not susceptible to tidal influence.

Hydraulic Model Construction

1. Hyder (2008) Study
A detailed 1-D unsteady hydraulic model has been built using ISIS software. The inflow boundary conditions included an unsteady flow/time upstream boundary based on the WINFAP pooled adjusted method. The downstream boundary comprised a normal depth boundary with a fixed value for channel bed slope. Roughness values according to published resources including Chow were applied, with a value of 0.035 for in channel and overbank areas. Values up to 0.013 were used for paved areas.
2. Pimperne Brook (2010) Study
The combined 1D-2D model was configured using ISIS-TUFLOW. Mannings values, classified based on aerial phtotography included channels in urban areas of 0.025 and 0.035 for concrete and vegetation repectively and in rural areas 0.045 for vegetated areas. Sensitivity analyses were performed on design flows (+/-)20%), mannings roughness (+/-10%) for 1D and (+/-50%) in the 2D domain, structure parameters (+/-10%), and downstream boundary (+/-30cm).
The model extent can be observed in the image to the right.

Return Periods Assessed in Model

1. The Hyder study (2008) model was run for QMED, 5, 10, 25, 50, 100 year return periods and 100 year return period including climate change effects.
2. The Pimperne Brook (2010) model was run for defended and undefended scenarios for 2, 10, 20, 50, 75, 100, 200, 500 and 1000 year return periods, and 100 year return period including the effects of climate change.

Comments

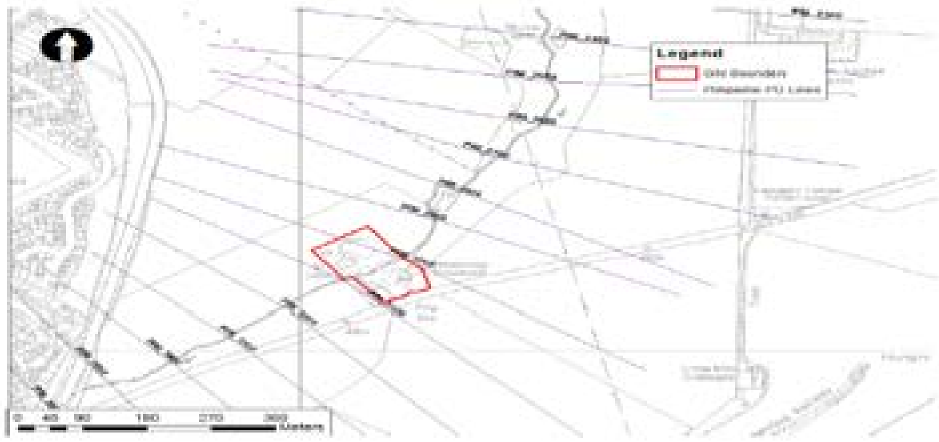
Hyder Assessment
1. The model is limited since there are no gauged records for comparison and calibration of the modelled flows.
2. The model includes assumptions of mannings roughness values and structure co-efficients.
Pimperne Brook Study
1. The Pimperne Brook Study is concerned with fluvial flooding and does not detail the flood risk from short duration intense storms resulting in flooding from surface water runoff.
2. Pump operation rules and initial operation within the model was assumed based on trigger levels in the model.
3. Higher mannings roughness values for the channel represent the significant level of vegetation growth through the channel.
4. Inflows were applied incrementally through Pimperne catchment to represent the build-up of channel flow.
5. Conservative flood results have been achieved by the omission of the Ham pumping station.
6. Limited calibration was performed on the modelling, with comparisons of flooded extent made with anecdotal evidence and video evidence of past flood events.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial, from Pimperne Brook

Supporting Figure



Fluvial Hydrology

The hydrological calculations summarised in the Pimperne Brook study from the Environment Agency were reviewed and found to be an appropriate representation of the catchment for the purpose of this flood risk assessment.

Tidal Hydrology

N/A

Summary of Approach

1. The Pimperne Brook model and the Hyder model were reviewed for information on flooding in the vicinity of the site.
2. Hydraulic structures and urban features (roads/buildings) and their schematisation in the two models were reviewed.
3. The Pimperne Brook model results were selected for use in this study due to the schematisation of both the channel and floodplain, and the more accurate representation of the flooding where spill from the channel begins to fill the lower floodplain section in the vicinity of the site.
4. The modelled results were extracted from the dataset supplied by the Environment Agency.
5. The results determined through this method were compared with the Hyder study results and the Environment Agency Flood Map information.
6. Climate change allowances for increases in peak flow rate were applied and extrapolated to determine likely flood levels under climate change conditions.

Hydraulic Modelling

The relationship between fluvial flood flow and the water level was reviewed by hydraulic modellers. Engineering judgement was used in the extrapolation of these results to yield future climate change results, based on the known response of the area to increases in fluvial flows, informed by the EA supplied modelling. Further hydraulic modelling was not undertaken for this site.

Results

The flood levels on page 1 reflect the worst case flooding on site, upstream of the 3 x 600mm dia culverts below the internal access road. Flood levels from a second location are also presented on page 2, where relevant to critical equipment in a lower portion of the site.

Comparison to previous studies / data

1. Environment Agency Flood Maps
The Environment Agency's flood zone mapping indicates flooding in the channel and overbank areas to a level of 41.5m AOD in the 1000yr return period and 41.3m AOD in the 100yr return period. The Environment Agency's information on surface water flooding suggests overland flow will be experienced within the site, with shallow flows leading to the main floodplain from the adjacent road access.
2. Hyder Study
The Hyder study modelled the 100yr return period event with the resulting level on site of 40.801m AOD. This study also considered a scenario where culverts below the site access driveway are blocked by debris, with a resultant 100year return period flood level of 41.087m AOD.
3. Previous flood events
The site operator reported that in 2014/2015 the site flooded to a depth of approximately 1 ft (30cm). The lowest point on site is 40.81m AOD based on lidar survey which translates a flood level of about 41.1m AOD from the 2014/2015 event. Based on updated assessment, flood levels are 41.45m AOD in the 1000 year return period, and 41.28m AOD in the 100 year return period, inclusive of climate change. This is in line with the anecdotal evidence.
4. The Pimperne Brook study (2010) lists the 100 year and 1000 year return period flood levels as 41.25m AOD and 41.41m AOD respectively.

Assumptions and Limitations

1. The defended results have been used in the assessment at this site, with functioning of the Blandford pumping station.
2. The Pimperne study represented the filling and subsequent overtopping of the culvert within the Wessex Water site. Only events over the capacity of the culverts, resulting in overtopping, were used in the extrapolation of results.
3. The peak level of flooding on site is susceptible to obstructions to flow such as vehicles and materials, which should be kept clear of the site. In the event of floodings any vehicle within the flooded extent will contribute to a higher resultant flood level.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Briantspuddle	Post Code		
12015					
Site Type	NGR				
Water Treatment Works	Division	South	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Robert William Rawlings			
WT_BP	Contact Number	07825401068 S/D 602			

Site Plan

Location Plan

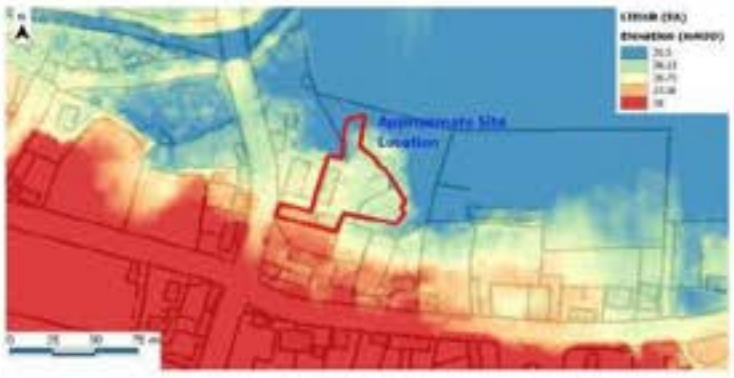
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Piddle	EA Flood Warning Area	Alton Pancras, Piddletrenthide, Piddlehinton, Druce, Puddletown, Athelhampton, Affpuddle, Briantspuddle, Throop and Wareham including Purbeck View Park
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
34.9 (Topo) to 37.76 (Topo)	35.1 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	35.87	0.00	N/A	0.00			
			1 in 200 year (0.5%)	35.89	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	35.92	0.00	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	35.89	0.00	N/A	N/A			
			1 in 200 year (0.5%)	35.91	0.00					
36.76			1 in 1000 year (0.1%)	35.94	0.00	N/A	N/A			
			Groundwater flooding					High		
			Reservoir							0.00

Comments

1. Although groundwater risk is noted as 'high' in the Environment Agency mapping, this is a generalised statement for a 1km square. Because the critical equipment is on higher ground, the likelihood of groundwater risk at the critical equipment is negligable.
2. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Lisha Parambath	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	29/11/2016	Attendees	Carrie Eller(MM) and Matt (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
main panel	36.76	35.94	36.22	36.22	-0.54
plc	36.76	35.94	36.22	36.22	-0.54
generator panel	36.76	35.94	36.22	36.22	-0.54
generator	37.23	35.94	36.22	36.22	-1.01
gas sensor	37.24	35.94	36.22	36.22	-1.02
borehole 2	37.40	35.94	36.22	36.22	-1.18
gas sensor 2	37.41	35.94	36.22	36.22	-1.19
borehole electric panel	37.61	35.94	36.22	36.22	-1.39
dosing pumps motors	37.80	35.94	36.22	36.22	-1.58
mains incomer	37.91	35.94	36.22	36.22	-1.69

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. The site floods annually in winter having flood depths from 0.30m to 0.60m. Flooding occurs at the low corner at the meadow. (Matt Taylor, Site visit 29/11/2016) 2. Majority of site remains outside of flood zone, however chlorine injection point may be affected during the 100yr flood event. (Source: STW and WTW Flood Resilience Database) 3. Under disinfection scheme which was completed recently, the new chlorine injection point has been moved outside of the MCC building which is roughly 3m higher than its original position (as noted in above point 2). Therefore it will not suffer from any flooding in its new position. (Robert Rawlings, 09/02/2017) 3. The site would shutdown on turbidity levels before it even gets flooded. The site has flooded in past but local site topography indicates that the key assets donot flood. (Source: STW and WTW Flood Resilience Database)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description	Flood Defence Layout
None Proposed	
Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard	
N/A	

Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	0	Our assessment indicates that the critical equipment is not at risk of flooding. Therefore, no mitigation measures are proposed.
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	0	
Raise other equipment	number	0	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	N/A

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

For the Wessex Water site, an FRA report titled "DV53311-DVR-02-Briantspuddle FRA" prepared by Hyder Consulting (UK) Ltd. (May 2008) is available along with the 1D Flood Modeller (ISIS) model files.

Site Topographical Survey

Topographic survey is available in .dwg format, received from Wessex Water in December, 2016 for the purpose of this study.
Name of the file:
WT_BP_Briantspuddle_12015 Briantspuddle plan_20161122.dwg

Watercourse Survey

Watercourse survey is available in .dwg format from FRA study carried by Hyder Consulting (UK) Ltd.

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

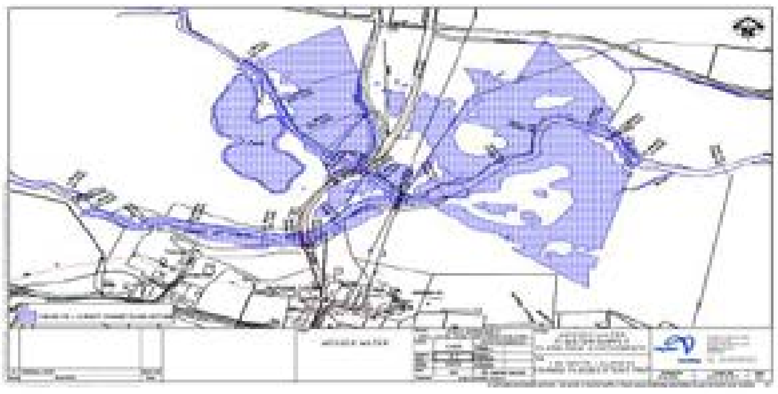
Fluvial Hydrology

Hyder Consulting (UK) Ltd carried out hydrological assessment by three methods namely ReFH Rainfall Runoff, Pooled Catchment Descriptor and Pooled (adjusted) Catchment Descriptor method. Pooled Catchment Descriptor method generated higher peak flows compared to other two methods therefore Pooled Catchment Descriptor method was used in the Hyder Study (2008).

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent



Hydraulic Model Construction

1. 1D unsteady hydraulic model was developed using ISIS v3.0 to assess the fluvial flood risk Briantspuddle.
2. The extent of the model was approximately 430m upstream of the site and 380m downstream of the site.
3. The inflow to the model was applied as an unsteady flow/time boundary (QTBDY) 430m upstream of Briantspuddle WTW. The data for the QTBDY hydrograph was taken from Pooled Catchment Descriptor estimates.
4. Manning's roughness of 0.035 and 0.045 were used at various portions of the the river channel. For the floodplain area, values varied from 0.04 to 0.05.
5. Normal Depth Boundary depth was used as the downstream boundary. The gradient at the downstream boundary was assigned as 1 in 582.01 (0.0017).

Return Periods Assessed in Model

The return periods assessed within the Hyder Study (2008) are below:
1. 1 in 5 year
2. 1 in 10 year
3. 1 in 25 year
3. 1 in 50 year
5. 1 in 100 year
6. 1 in 100 year including climate change (+20% flow)

Comments

The flood risk assesment for the site cannot be carried out using the Hyder model (2008) because the cross sections in the Hyder model do not adequately represent the floodplain. Due to misrepresentation of floodpain in the cross sections, the Hyder 100-yr flood extent is not appropriate, which is also evident when comparing the Hyder Study (2008) flood extent with EA Flood Zones. Hence, to estimate flood risk at the site during this study, a one dimensional unsteady model is created using Flood Modeller that adequately represents flood levels at site for critical storm events.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

Fluvial Hydrology

The hydrology from the Hyder study (2008) is used for this study.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure

Summary of Approach

1. One-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. The Hyder Study (2008) did not have 200-year and 1000-year return period flows. Flows from Hyder Study (2008) are extrapolated to estimate the 200 year and 1000 year return period flows. The lateral inflow hydrograph from the tributary was added to the main channel hydrograph to obtain the flow at critical return periods.
3. Further details of the approach is provided in the following sections.

Hydraulic Modelling

1. Upstream inflow boundary condition is applied based on peak flows for critical return periods for the sum of both the main river and the tributary.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from EA website.
3. Normal depth is used as the Downstream boundary condition by calculating the slope from the LiDAR data. Slope used here is 1 in 465.
4. The manning's roughness coefficient for river channel is assigned as 0.066 based on the condition of the channel. For the floodplain it is varied in the range of 0.066-0.18 to represent buildings, highly vegetated areas and field conditions respectively, as observed from Google Earth images near the site.
5. The model is simulated to generate the peak stage corresponding to critical return periods.
6. The model was tested for its senstivity against Manning's value (+/- 20%), Downstream, Boundary slopes (+/-10%) and very high flow. The results of this process indicated that the model was not sensitive to the changes in the Manning's value and downstream boundary slope.

Results

1. The modelling indicated that the site is susceptible to flooding. The flood levels are estimated at cross section XS4 for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The Hyder model flood level is estimated as 35.52mAOD for 100yr with 20% climate change allowance. The flood level is estimated as 35.86mAOD during this assessment which is about 0.34m higher.
2. The ground level at the lower end of the site is 35.0mAOD. The site operator commented that the flood depth is 0.6m annually. Thereby this can be taken as an event with 1-year return period having a stage of 35.6mAOD. As per our assesment the 2-year return period has a stage of 35.67mAOD and hence our assesment is consistent with the anecdotal evidence from the site operator.
3. Due to the slope of the site, the lowest critical equipment is 1.5m above the ground level at the lowest part of the site. It is also seen that the 1000-year return period with a 40% climate change allowance has a stage of 35.94mAOD. So although the site is at risk of flooding, the critical equipments are raised above the extreme flood events.

Assumptions and Limitations

1. Floodplain is represented within the 1D domain of the model.
2. It is assumed that the stage of XS4 node represents stage at the site location.
3. The hydrology calculated during the Hyder study (2008) is assumed to be suitable for use in this study.
4. As noted in the Hyder Study (2008), there is concern for water rising up and flooding the boreholes from within the site. This has not been taken into consideration during this assessment.
5. There was a spring which appeared on site (Hyder Study, 2008) and if this reappears, the site could be at risk from groundwater flooding which has not been taken into consideration during current assessment.
6. Based on the Environment Agency data for "Area susceptible to ground water flooding", the designated risk of groundwater emergence in the vicinity of the site is >=75% (Flood Type: Superficial Deposits Flooding) which is considered as High risk. Groundwater flood risk is not estimated as part of this study. If the groundwater emergence is observed at the site in future, then further investigations could be performed and mitigation measures, such as local drains, could be installed at the site.
7. Other residual flooding mechanisms include surface water flooding, which is a result of shorter intense rainfall events. This residual risk can be mitigated through the maintenance of surface water drainage networks and the maintenance of overland flow paths clear of materials, debris and vegetation.
8. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

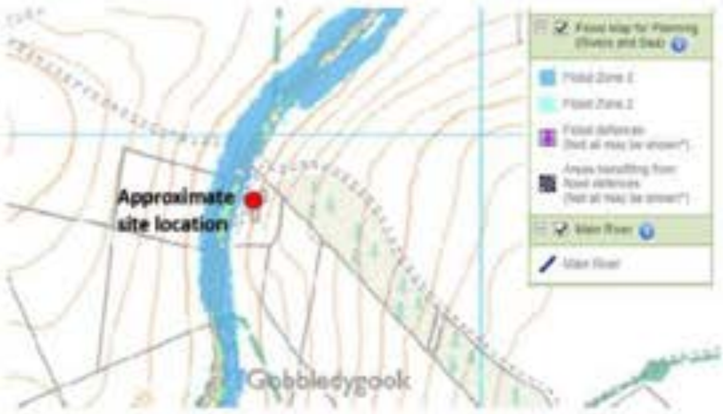
This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Chitterne	Post Code	
12030				
Site Type	NGR			
Water Treatment Works	Division	North	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Marc Hodgson		
WT_CH	Contact Number	07768035421		

Site Plan

Location Plan

Environment Agency Flood Map

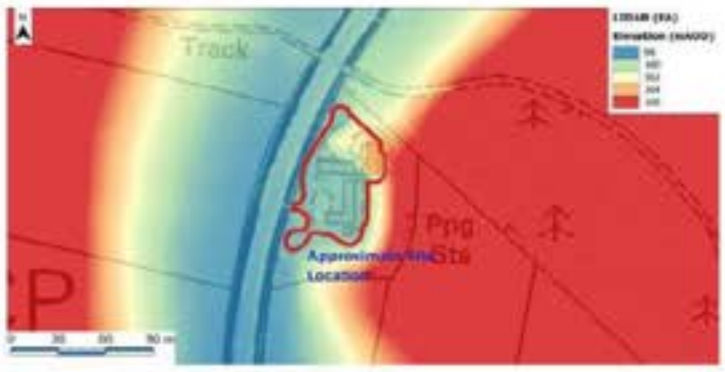


Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Chitterne Brook	EA Flood Warning Area	Groundwater information for Chitterne, Codford St Peter and Codford St Mary
Current Site Flood Zone	Flood Zones 3, 2 and 1	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
97.25 (Topo) to 109.99 (Topo)	99.00 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	98.87	0.00	N/A	< 0.30			
			1 in 200 year (0.5%)	98.97	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	99.34	0.36	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	98.90	0.00	N/A	N/A			
			1 in 200 year (0.5%)	99.02	0.03					
			1 in 1000 year (0.1%)	99.40	0.42	N/A	N/A			
98.98			Groundwater flooding					Low		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

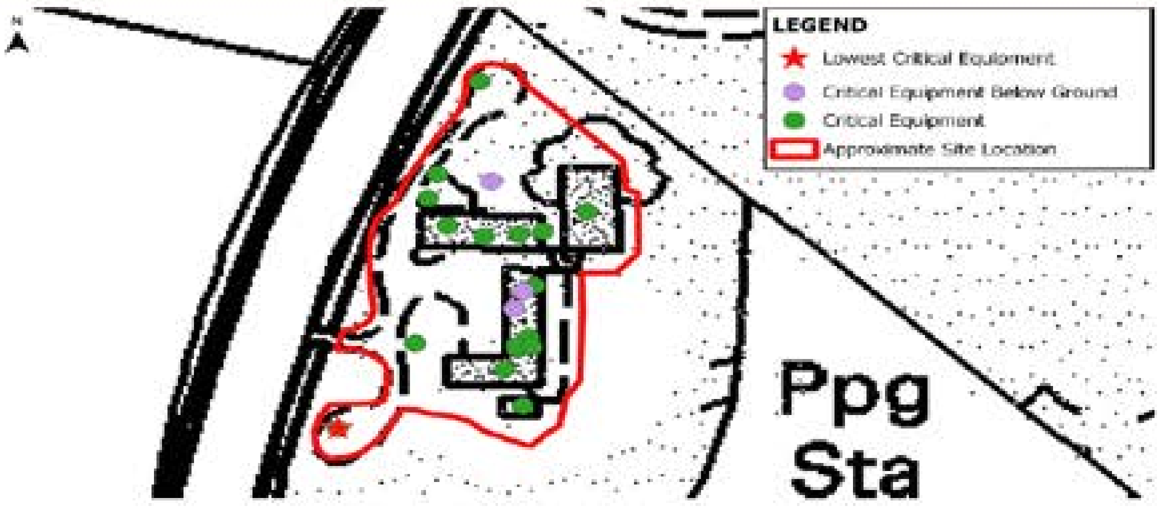
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Plech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	29/11/2016	Attendees	David Tinning (MM) and Kieron Sloan (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Actuator	98.98	99.40	99.62	99.62	0.64
Borehole	99.08	99.40	99.62	99.62	0.54
Septic Tank	99.07	99.40	99.62	99.62	0.55
Borehole	99.22	99.40	99.62	99.62	0.40
Pumps	99.05	99.40	99.62	99.62	0.57
Standby Generator	99.24	99.40	99.62	99.62	0.38
Surge Vessel Compressor	99.31	99.40	99.62	99.62	0.31
Sample Pump	99.36	99.40	99.62	99.62	0.26
Chlorine Gas Store	99.41	99.40	99.62	99.62	0.21
Communications	99.41	99.40	99.62	99.62	0.21

Summary of Key Client Comments

1. When the site was flooded in the past (2013/2014) then access was only possible from north on the road. During the flooding, below ground sections flooded including boreholes. (Keiron Sloan, Site visit 29/11/2016)
2. Standby generator at risk as it is not bunded. (Keiron Sloan, Site visit 29/11/2016)
3. Water can enter below ground area of main pump hall through ducts. (Keiron Sloan, Site visit 29/11/2016)

Comments on Below Ground Equipment (if any)

1. Actuator and Dosing chamber, injection chamber, and mixing chamber are below the ground and their critical equipment levels are 98.48mAOD and 99.58mAOD respectively.
2. In addition, there are 4 boreholes which have no access to measure the critical elevations, therefore ground elevation is assigned as indicative threshold elevation as 98.87mAOD, 99mAOD, 99mAOD and 99.07mAOD.
3. For the equipments below ground, the indicative threshold level is finished floor level or ground level in the above table.

Phase 2 Mitigation Assessment

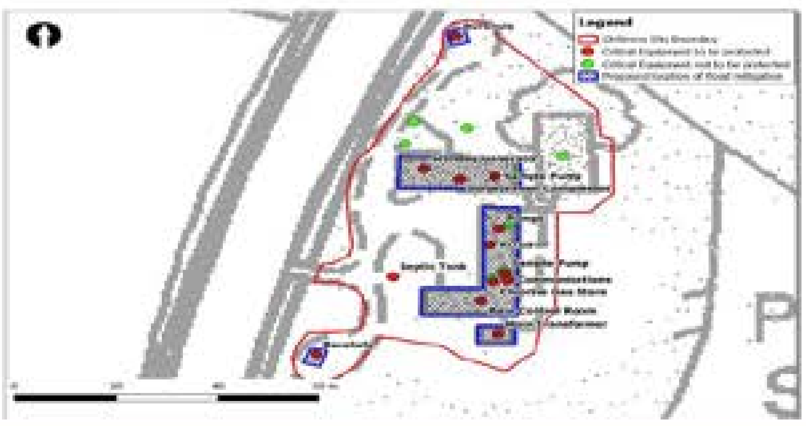
Flood Defence Description

1. Building waterproofing and flood doors are proposed as flood mitigation measures for the two buildings which include the Actuator, Pumps, Chlorine Gas Store, Communications, Sample Pump, Main Control Room, Standby Generator, Surge Vessel Compressor and Sample Pump.
2. Septic tank is confirmed by Wessex Water as a non-critical asset.
3. Main transformer to be raised 20cm.
4. Equipment that can be replaced with IP68 rated equipment (actuations and electrics, borehole instrumentation and electrics, junction boxes, emergency stops, etc.) to be replaced with appropriate IP68 rated equipment. Given the size and complexity of the site, the costing for this is based on 'large/high complexity' site cost banding.
5. There are 7 boreholes located on site or in the vicinity of the site. Given the number of boreholes, an additional allowance has been made for the protection of the boreholes to raise and/or replace electric equipment, control panels, kiosks with necessay IP68 rated equipment.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

99.62 mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	2
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	11
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	High
Raise control panel or kiosk	number	0
Raise other equipment	number	1
Other	linear m	1

Comments

1. The number of flood doors allowed for the protected buildings is estimated from site photographs, layout and survey drawings.

2. The following mitigation measures were considered but not preferred for the following reasons:
a) An alternate method for whole site protection, by means of a flood wall was investigated but considered not favourable due to the higher capital cost and larger impact on flood levels.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The area of mitigation measures which impacts on flooding is small and limited impact to flood levels is anticipated.

Source Data

LiDAR Data	Existing FRA and accompanying model files
1m resolution and 2m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.	There is no existing FRA available for this site.

Site Topographical Survey	Environment Agency / Local Authority Existing Studies
Topographic survey is available in .dwg Name of the file: WT_CH_12030 Chitterne topo_20161122.dwg Received from Wessex Water in December, 2016.	A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.
Watercourse Survey	
Not available	

Details of Existing Study

Fluvial Hydrology	Study Extent
Not available	
Tidal Hydrology	
Not applicable since the site is not tidally influenced.	

Hydraulic Model Construction	Return Periods Assessed in Model
Not available	Not available

Comments

There is no existing model available in the vicinity of this site.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

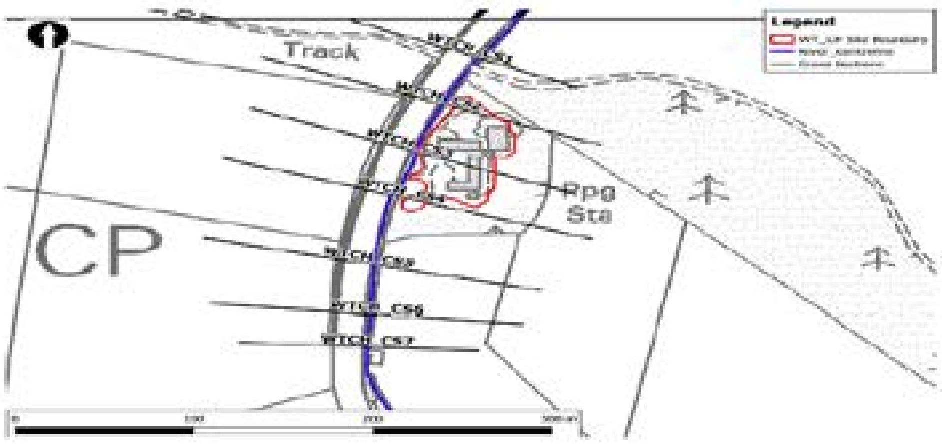
Fluvial Hydrology

ReFH hydrologic assessment was conducted to estimate the flows in Chitterne Brook in the vicinity of the site.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. 1D unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. This model is simulated for design return periods to calculate flood levels at the site.
3. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. Upstream inflow boundary (QT) condition is applied for each design return period.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from the EA website.
3. The culvert beneath the access road to the site and access to the equipment borehole at the upstream of the site is modelled as rectangular orifice. The dimensions of orifice is estimated based on the cross sectional data extracted from LiDAR and approximate length of access road.
4. The normal depth is used as the downstream boundary. The gradient for the normal depth boundary is assigned as 1 in 150 by estimating the bed slope at the downstream end.
5. For the river channel, Manning's roughness coefficient is taken as 0.05 while for floodplain, it varies between 0.055 to 0.2 to represent the channel/floodplain conditions.
6. The model is simulated for design return periods 1 in 100 year, 1 in 200 year and 1 in 1000 year with central and upper end allowances of climate change.
7. The model was tested for its senstivity against downstream boundary slopes (steep to flat). The results of this process indicated that the flood levels at the site were not sensitive to the changes in the downstream boundary slope.

Results

1. Nominal site flood levels are extracted for each design return period at cross section WTCH_CS2.
2. Flood levels specific to the location of critical equipment were also extracted for the design return period.
3. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For the 1 in 1000 year return period, MM (2017) flood level is 0.08m higher than that of the Environment Agency flood level, obtained from flood zone map. However, the Environment Agency flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator from Wessex Water commented that the site had experienced flooding in 2013-2014, and the access was only possible from North on the road. As per this assessment, the access road located south-west of the site is flooded with flood depth around 0.4m during extreme return periods, which is consistent with the anecdotal evidence from the site operator.

Assumptions and Limitations

1. Floodplain is represented within the 1D domain of the model.
2. Cross sections (channel and floodplain) are extracted from the latest EA LiDAR.
3. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Corfe Mullen	**Post Code**		
12038					
Site Type	**NGR**				
Water Treatment Works	**Division**	South	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	Robert William Rawlings			
WT_CM	**Contact Number**	07825401068 S/D 602			

Site Plan

Location Plan

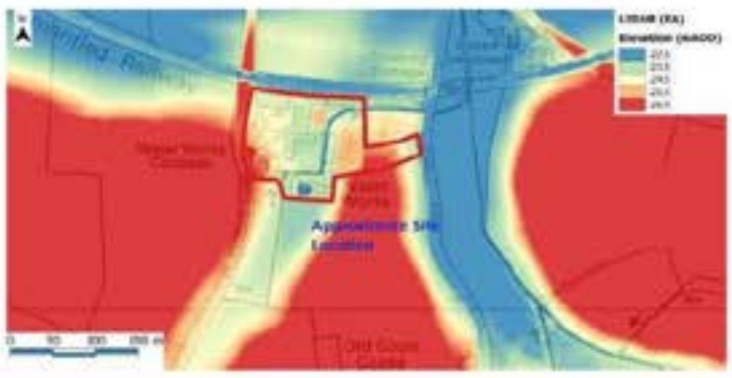
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	Tributary of River Stour	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
23.27 (Topo) to 26.58 (Topo)	23.70 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	24.04	0.06	N/A	0.00			
			1 in 200 year (0.5%)	24.09	0.11					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	24.22	0.24	N/A	<0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	24.04	0.06	N/A	N/A			
23.98			1 in 200 year (0.5%)	24.12	0.14					
			1 in 1000 year (0.1%)	24.25	0.27	N/A	N/A			
			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

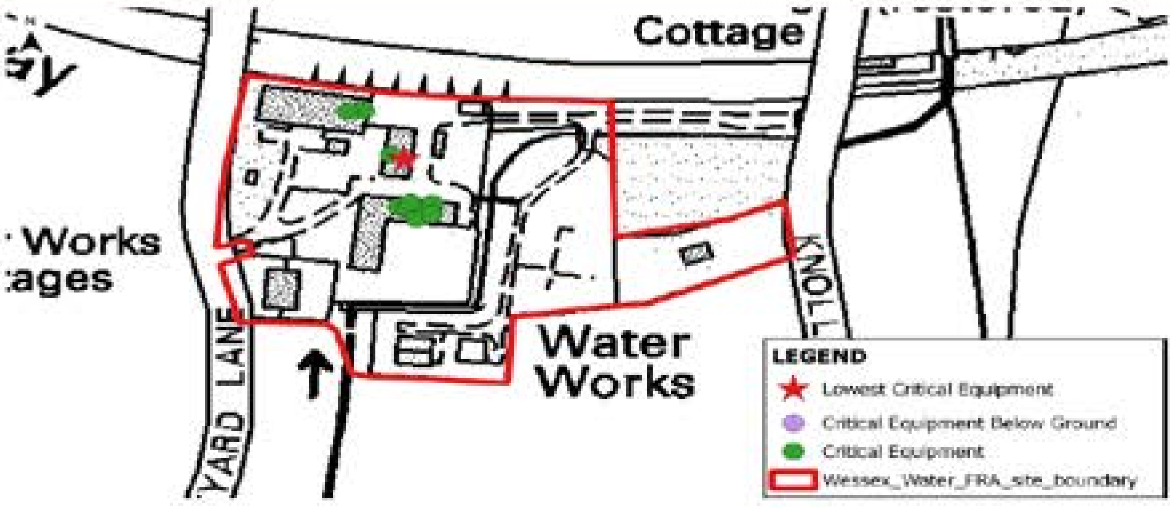
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Suprya Savalkar	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	28/11/2016	Attendees	Carrie Eller (MM) and Rob Rawlings (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Motor of pumps in sump below ground level*	23.98	24.22	24.50	24.50	0.52
Flow meter	24.12	24.25	24.50	24.50	0.38
Gas sensor	24.12	24.25	24.50	24.50	0.38
MCCs at top level of pump room/hall	24.12	24.22	24.50	24.50	0.38
Gas leakage sensors	24.17	24.25	24.50	24.50	0.33
Flooded level probes set 2	24.22	24.22	24.50	24.50	0.28
Control panel	24.30	24.25	24.50	24.50	0.20
Flooding probes from broken pipes	24.37	24.22	24.50	24.50	0.13
Control box electrical junction box	24.39	24.25	24.50	24.50	0.11
Clorinator	24.58	24.25	24.50	24.50	-0.08

Summary of Key Client Comments

1. There has been past flooding at this site. There was a flood event during the Christmas time (potentially year 2013). (Rob Rawlings, Site visit 28/11/2016)
2. As per site controller, new topographic data is required. (Rob Rawlings, Site visit 28/11/2016)
3. Sensors would cause the site to shutdown if flood water is detected at various points on the site but would not cause the site to shutdown in the pump hall, the low level sump float will start the sump pump. It is more robust than before but cannot stand an extreme event owing to its past flood records. During a previous flood event, runoff from the hill flooded the old treatment room through ducting into sump of pump hall. Ducts were sealed at the time by EMI (John Lewis), however it was believed that this would be added to the major scheme to ensure site had adequate flood protection, this never happened. The referred sensors are in the membrane building, this area of the site has not flooded in the past. (Rob Rawlings, Site visit 28/11/2016)
4. A bunded area was constructed near lamella plant, however it would not provide adequate protection, the bund should have continued to cover whole site and drainage ditch concrete lined through whole channel to provide adequate site drainage off site. This was not completed and the drainage ditch therefore requires constant maintenance due to vegetation growth. The ditch is several hundred metres in length. (Rob Rawlings, Site visit 28/11/2016)
5. The new integrated water supply grid due to be completed in 2017 should improve resilience. (Source: STW and WTW Flood Resilience Database).

Comments on Below Ground Equipment (if any)

Motor or pumps are present in sump below ground level. It is around 2.30m below pump room level (where MCCs are).

Phase 2 Mitigation Assessment

Flood Defence Description

1. Building waterproofing is proposed at three buildings to protect all of the critical equipment at this site. 12 flood doors will be required for access.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

24.50mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	3
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	12
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection such as earth bunding or flood walls up to 1m height with flood gates was considered but not preferred due to cost, construction time of the defences, acessibility issues and potential operational issues at the site post the construction.
b) localised protection or raising of the equipment in the buildings was considered but not preferred as this may require reconstruction of parts of the building to raise headroom, or cause access and operational issues due to multiple localised flood walls.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The only measures include waterproofing of existing buildings. No impacts anticipated to the floodplain storage.

Source Data

LiDAR Data

1m resolution LIDAR data was downloaded in December 2016 from EA website.

Existing FRA and accompanying model files

FRA report titled "DV53311-DVR-02-Corfe Mullen FRA" prepared by Hyder Consulting (UK) Ltd. (August, 2008).
FRA report ("DV53311 Water Treatment Works - Corfe Mullen" report prepared by Hyder Consulting Limited in August 2008) is available.
Hyder has developed a surface water model. ACAD and WINDES software was used to model the potential areas and extents and depth of surface water runoff was calculated using volume.

Site Topographical Survey

Topographic survey is available in .dwg format, which is received from Wessex Water in December, 2016.
Name of the file:
WT_CM_12038 Corfe Mullen topo_20161122.dwg

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Watercourse Survey

Not available

Details of Existing Study

Fluvial Hydrology

At the Corfe Mullen WTW the threat from overland flow entering the site was considered to present the greatest risk.
Fluvial flooding was not considered to be a problem.

Study Extent

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Hydraulic Model Construction

The main risk at the Corfe Mullen site is surface water flooding from the hillside to the south.
ACAD and WinDES software has been used to model the potential areas and extents and depth of surface water runoff using the calculated volume.

Return Periods Assessed in Model

The surface water model was assessed for the following return periods:
1. 1 in 2 year
2. 1 in 5 year
3. 1 in 10 year
4. 1 in 25 year
5. 1 in 30 year
6. 1 in 50 year
7. 1 in 100 year
8. 1 in 100 year Climate change.

Comments

1. A site topographical survey was undertaken and the volume of surface runoff was calculated to determine the level of flood risk at the site.
2. AutoCAD and WinDES software were used to model potential areas and extents and depth of surface water runoff using the calculated volume.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

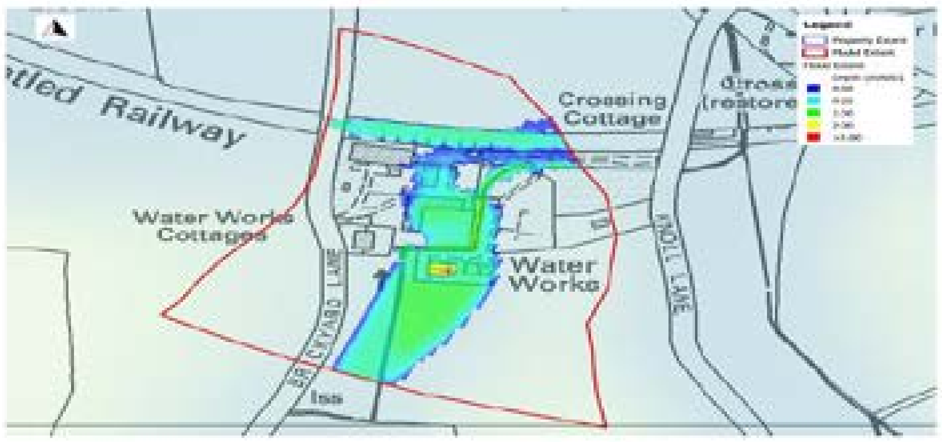
Fluvial Hydrology

ReFH hydrologic assessment was conducted to estimate flows in the tributary of River Stour, which passes through the site.
1000yr+CC(40%)=5.58 cumecs

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. Two-dimensional (2D) unsteady hydrodynamic model was developed in the TUFLOW software.
2. Maximum water level output is extracted from the 2D model results to estimate flood levels at the site.
3. Further details of this approach is provided in following sections.

Hydraulic Modelling

1. Model extent for the two dimensional hydrodynamic model extends from just downstream of the site at the dismantled railway, to roughly 100m upstream of the site.
2. Upstream inflow boundary condition was applied as flow hydrograph obtained using the ReFH methodology.
3. The downstream boundary was defined as normal depth based on the channel bed slope.
4. Manning's roughness 0.035 for roads, 0.013 for woodland, 0.055 for open grassed area and 0.50 for raised structures and buildings is assigned. The Manning's roughnesses were assigned to represent field conditions.
5. Sensitivity test for the downstream boundary for +/- 10% change in the normal depth was tested. This test was conducted as the site is close to the downstream boundary.
6. The culvert underneath the railway is assumed to be blocked in the hydraulic model to represent conservative estimate of flood risk since the culvert dimensions are not available.
7. Another Sensitivity Test was conducted wherein the downstream boundary was changed to a constant depth. The constant depth was set to 23.80mAOD which considered the allowance for climate change. In this test it was observed that there was no significant change in the flooding at site where the equipments are located. The flood depth at the dismantled railway increased by 0.8m.

Results

1. Flood levels were estimated from the water level at the lowet critical equipment for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For 1 in 1000 year return period, MM(2017) flood level is 0.17m less than that of EA flood level obtained from EA flood zone map. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator comments that there has been past flooding at this site. As per this assessment, for extreme flood events, the site is flooded to depth over 50cm, which is consistent with the anecdotal evidence from the site operator.

Assumptions and Limitations

1. River channel and floodplain are represented using the latest EA LIDAR (1m resolution).
2.Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Dewlish	**Post Code**		
12043					
Site Type	**NGR**				
Water Treatment Works	**Division**	South	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	Robert William Rawlings			
WT_DE	**Contact Number**	07825401068 S/D 602			

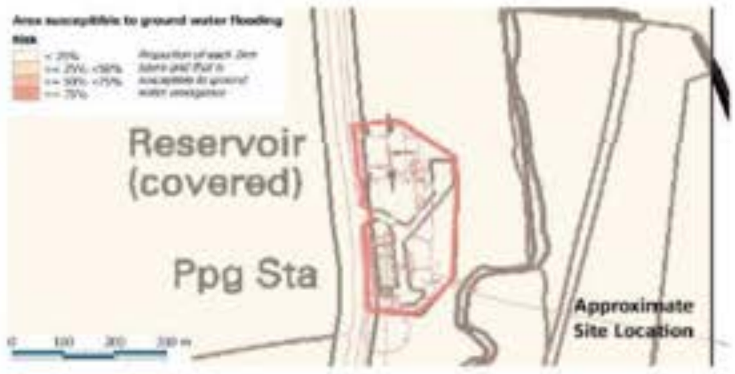
Site Plan

Location Plan

Environment Agency Flood Map

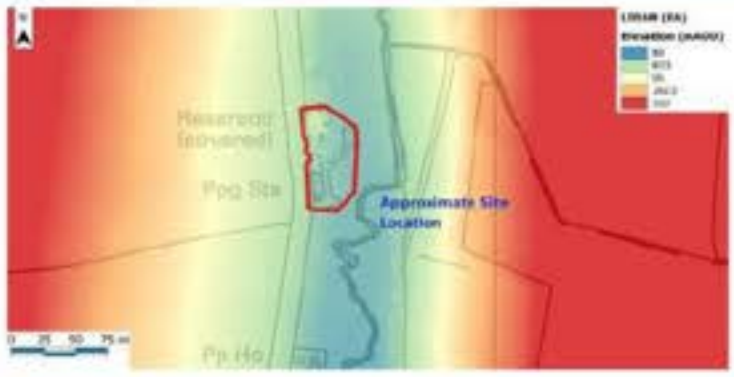
Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	Devil's Brook	**EA Flood Warning Area**	Groundwater information for the Devils Brook including Ansty, Cheselbourne and Dewlish
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
84.32 (Topo) to 87.63 (Topo)	85.00 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	85.08	0.00	N/A	0.00			
			1 in 200 year (0.5%)	85.13	0.01					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	85.22	0.10	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	85.11	0.00	N/A	N/A			
			1 in 200 year (0.5%)	85.15	0.03					
			1 in 1000 year (0.1%)	85.24	0.12	N/A	N/A			
85.12			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

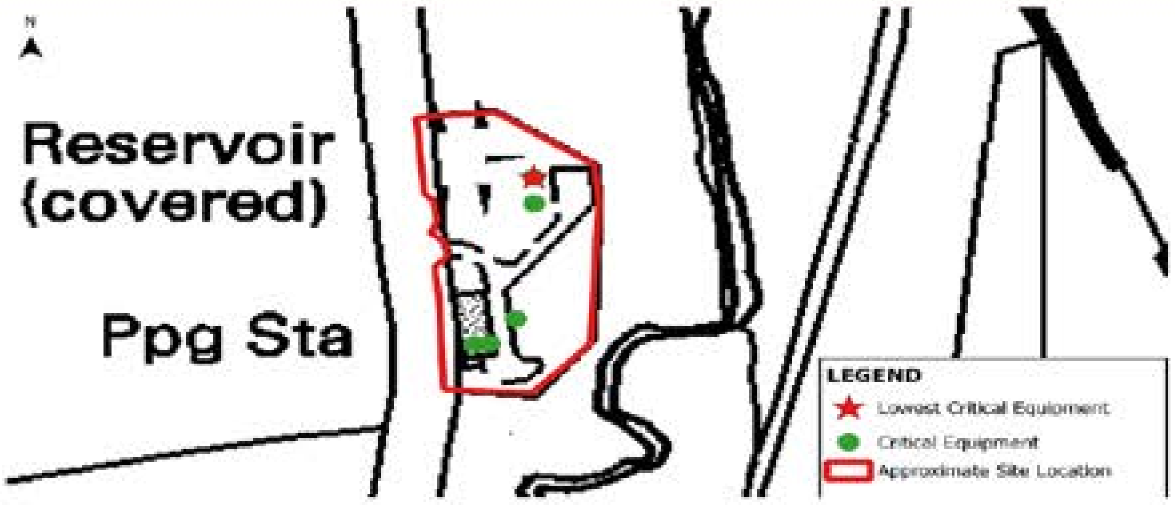
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindwar	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	29/11/2016	Attendees	Carrie Eller (MM) and Matt Taylor (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Turbidity meter	85.12	85.24	85.51	85.51	0.39
Control panel reliffs	85.55	85.24	85.51	85.51	-0.04
Control panel for pumps	85.55	85.24	85.51	85.51	-0.04
Generator	85.80	85.24	85.51	85.51	-0.29
UV control panel	85.83	85.24	85.51	85.51	-0.32

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. The site does not flood but the adjacent area next to stream floods having flood depth around 0.30m. (Matt Taylor, Site visit 29/11/2016) 2. There is risk to turbidity due to site flooding when stream backs up, however there is no risk to M&E plant. (Source: STW and WTW Flood Resilience Database) 3. Stream floods during winter and autumn but it is not regularly cleaned and maintained. (Source: STW and WTW Flood Resilience Database) 4. Regular maintenance of the stream will protect the site from flooding. (Robert Rawlings, 09/02/2017) 5. An extreme event will knock the site out on turbidity, but M&E equipment should not be compromised during such an event. (Robert Rawlings, 09/02/2017)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. Building waterproofing and flood doors are proposed as flood mitigation measures for the building which includes the lowest critical equipment turbidity meter. Other equipment including control panels, instrumentation and other electrics are located in this building.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

85.51mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	1
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) raising of the equipment within the building was not preferred given the number of pieces of equipment that must be raised. Given the small size of the building to be waterproofed, this option is preferable.
b) whole site protection is not preferred given the cost, and the small part of the site which is at risk of flooding.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Negligable. The mitigation measure proposed does not affect the available floodplain storage.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

FRA report titled "DV53311 Water Treatment Works - Dewlish" prepared by Hyder Consulting (UK) Ltd. (Oct 2008) is available along with the 1D Flood Modeller (ISIS) model files.

Site Topographical Survey

Topographic survey is available in .dwg format, which is received from Wessex Water in December, 2016.
Name of the file:
WT_DE_12043 Dewlish topo_20161122.dwg

Watercourse Survey

Watercourse survey is available from FRA study carried by Hyder Consulting (UK) Ltd.

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

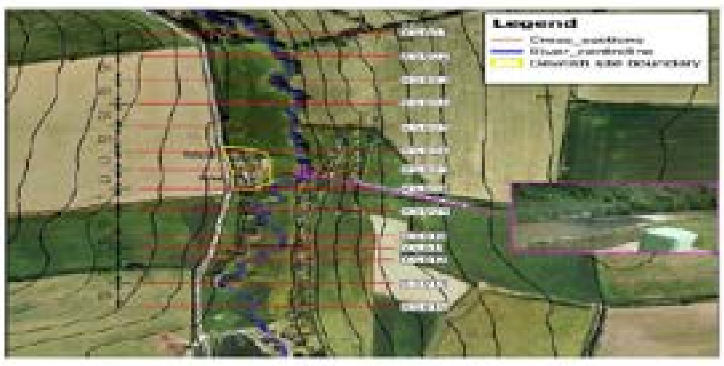
Fluvial Hydrology

Hyder Consulting (UK) Ltd carried out hydrological assessment by three methods namely ReFH, Pooled Catchment Descriptor and Gauged Donor Catchment Descriptor method. ReFH method generated higher peak flows compared to other two methods therefore, ReFH method was used in the Hyder Study (2008).

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent



Hydraulic Model Construction

1. 1D unsteady hydraulic model was developed using ISIS v3.0 to assess the fluvial flood risk within the Devils Brook.
2. The extent of the model was approximately 250m upstream of the site and 250m downstream of the site. The model included one main structure – a small crump weir situated adjacent to the site in the Devils Brook.
3. The inflow to the model was included as an unsteady flow/time boundary (QTBDY) 250m upstream of Dewlish WTW. The data for the QTBDY hydrograph was taken from the results of the ReFH Rainfall Runoff method.
4. Manning's roughness of 0.045 was used for the river channel. For the floodplain area, it varied from 0.04-0.06.
5. Normal depth was used as the downstream boundary. The gradient at the downstream boundary was assigned as 1 in 500 (0.002).

Return Periods Assessed in Model

The return periods assessed within the Hyder Study (2008) are below:
1. 1 in 5 year
2. 1 in 10 year
3. 1 in 25 year
3. 1 in 50 year
5. 1 in 100 year
6. 1 in 100 year including climate change (+20% flow)

Comments

The hydrology for 200 year and 1000 year return period was not calculated in the Hyder Study (2008).

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

Fluvial Hydrology

The hydrology from the Hyder study (2008) was reviewed and found suitable to be used in this study. 1 in 1000 year return period flow is estimated from the relationship derived for return period(log) and flow. 1 in 1000 year return period flow with an upper end allowance of climate change is estimated as 4.6 m3/s.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure

Historical flooding near the Turbidity meter (Borehole) (Hyder Study, 2008)

Summary of Approach

1. Node XS6_RHS in the existing model (Hyder Study, 2008) is representative of flood levels at the site, therefore flood levels at this section are estimated for design return periods.
2. The flows from the Hyder study (2008) were used for the assessment of flood levels.
3. The Hyder Study (2008) did not have 200 year and 1000 year return period flows. Flows from Hyder Study (2008) are extrapolated to estimate the 200 year and 1000 year return period flows.
4. Due to uncertainty of high ground between the main channel and floodplain at the site, 20cm is added to the flood levels obtained for design return periods.
5. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. The existing hydraulic model from the Hyder Study (2008) is used during this flood level assessment.
2. Design runs were conduted for the required return periods including central and upper end climate change.

Results

1. The flood levels are obtained from cross section XS6_RHS for the critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For 1 in 1000 year return period, estimated flood level is 0.2m higher than that of EA flood level obtained from EA flood zone map. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator commented that the site did not flood but the adjacent area next to stream flooded. As per this assessment, area near the equipment turbidity meter is flooded to depth over 0.40m for extreme flood events, which is consistent with the anecdotal evidence from the site operator and previous flooding documentation in Hyder FRA study (2008).
3. The photo shown above (Supporting Figure) depicts a flood event with recorded level estimated at 84.7mAOD. Based on this FRA, the 1000yr+ CC level (upper end) is 85.24 mAOD, about 50cm higher than the recorded level. Given the extreme nature of this event, the resulting levels are substantiated by the anecdotal evidence.

Assumptions and Limitations

1. It is assumed that the stage of XS6_RHS represents the stage at the site location.
2.The hydrology calculated during the Hyder study (2008) is assumed to be suitable for use in this study.
3.Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
4. The Hyder model assumes separate flow routes on the site (Right hand side floodplain) and the main channel of Devil's Brook, connected by spill units representing connection between the two. Due to the high level of uncertainity of the raised ground between the Devil's Brook and the site, an additional allowance of 20cm has been applied to the resulting flood levels.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Durleigh	Post Code	
12049				
Site Type	NGR			
Water Treatment Works	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Tom Wallace		
WT_DL	Contact Number	07990788885 S/D 89		

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Durleigh Brook	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
13.88 to 15.02 (LiDAR)	14.50 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	< 0.3			
			1 in 100 year (1%)	14.76	0.24	N/A	0.30-0.90			
			1 in 200 year (0.5%)	14.83	0.31					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	14.96	0.44	N/A	0.30-0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	14.82	0.30	N/A	N/A			
			1 in 200 year (0.5%)	14.89	0.37					
14.52			1 in 1000 year (0.1%)	15.02	0.50	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.30-2.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

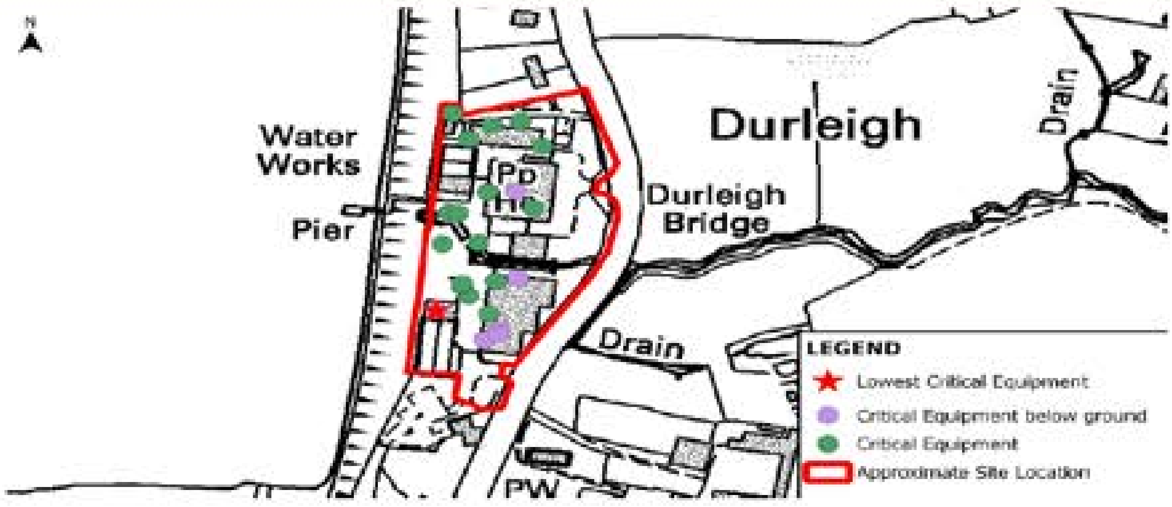
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	07/12/2016	Attendees	Domenico Santoro (MM) and Paul Lloyd (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Kaiser filter MCC panel	14.52	15.02	15.24	15.24	0.72
Softened water pump	14.63	15.02	15.24	15.24	0.61
Flowmeter	14.63	15.02	15.24	15.24	0.61
Chemical room	14.75	15.02	15.24	15.24	0.49
High lift pumps and new UV plant	14.63	15.02	15.24	15.24	0.61
Control room, sand filter backwash MCC	14.64	15.02	15.24	15.24	0.60
Low lift pump start panel	14.57	15.02	15.24	15.24	0.67
DAF monitoring	14.61	15.02	15.24	15.24	0.63
Compressors and control panel	14.67	15.02	15.24	15.24	0.57
Inlet valve control panel	14.73	15.02	15.24	15.24	0.51

Summary of Key Client Comments

1. Previous flooding which occured in 2010 resulted in flood depth on site around 0.15m. (Paul Lloyd, Site visit 07/12/2016)
2. The flooding in 2010 was provoked by the flow from the reservoir spillway. On the site, the outflow channel has a small radius bend, which is not ideal in case of high flows. In 2010, water was coming out from the channel in correspondence to the external wall of the bend. Contact person from WAX (Contractor) is Mike Sweeney, he can provide the construction drawings from AECOM (designer). (Paul Lloyd, Site visit 07/12/2016)
3. Operations comments: Sensors would cause the site to shutdown if flood water is detected at various points on the site. The site has flooded before. A capital scheme is currently addressing the risk of flooding to the site. (Paul Lloyd, Site visit 07/12/2016)
4. Durleigh is a major surface water treatment site supplying up to 28ML/day to Bridgwater and surrounding areas. (Source: STW and WTW Flood Resilience Database)
5. FRA currently being produced externally. Project team are modelling the brook. Concrete walls on the brook are being considered. (Tom Wallace, 17/11/2016)

Comments on Below Ground Equipment (if any)

1. Pumps are placed 4.2m below the ground level.
2. Equipment such as Kaiser filter MCC panel, Softened water pump, Flowmeter, Chemical room, High lift pumps and new UV plant and Control room sand filter backwash MCC are below ground and their critical equipment levels are 10.32mAOD, 10.78mAOD, 10.80mAOD, 11.35mAOD, 11.38mAOD and 11.80mAOD respectively.
3. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.

Phase 2 Mitigation Assessment

Flood Defence Description

1. A flood defence wall is proposed along the canal within the site boundary, with a height of 1m.
2. To account for the potential for the increased flows through the channel, the pedestrian bridge and road culvert are to be resized to allow clear passage of the 1000yr+CC flow. Wingwalls to be constructed and the road to be reprofiled to ensure no backwater effects of water backing up onto the site. May require traffic diversion and associated planning.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

15.24 mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	200
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	0
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	1

Comments

1. The following options were considered but not preferred for the following reasons:
a) whole site protection was considered but not preferred due to cost.
b) localised protection including building waterproofing, localised cabinet protection, local flood walls, etc. were considered but not preferred due to the significant operational impacts likely and impact on ease of access to equipment.

2. It is understood that a scheme is already in place to raise flood walls along the watercourse within the site. This option was discussed as a potential measure in the previous FRA (AECOM, 2016) carried out for the site. It is noted that the watercourse is a third party asset. Whilst more expensive than individual equipment specific measures, raising the channel parapet walls is an attractive option as it does not change the ease of access through the site and the current level of access to equipment is maintained. During detailed design, more detailed modelling should be undertaken to confirm the height of the required parapet wall and the potential additional allowance to be included to account for the energy losses along the channel or at culverts.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Moderate. The proposed parapet wall may increase velocity and scour during flood events due to the fact that all flow will be passed through the road culvert, rather than some flood waters passing as overland flow across the site.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

The FRA report titled "Durleigh WTW Reconstruction- Flood Risk Assessment " prepared by AECOM (Dec, 2016) was made available. The accompanying 1D-2D linked model (Flood Modeller Pro and TUFLOW) files and associated report titled "Durleigh Brook Hydraulic Modelling Report" were also available.

Site Topographical Survey

Wessex Water provided topographic survey in .dwg format for the purpose of this study. The name of the file provided is as follows:
WT_DL_12049 Durleigh topo_20161122.dwg

Watercourse Survey

Wessex Water provided watercourse survey in .dwg format for the purpose of this study. The name of the file provided is as follows:
8636-3.dwg

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

AECOM carried out hydrological assessment in two parts.
1. FEH methods (FEH statistical and ReFH2) were used to estimate peak flows from the catchment into the reservoir.
2. A spreadsheet model was used to assess outflows from the reservoir when the spillway overtopped. This outflow was used as inflow to the model.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

Figure 3-1: 1D/2D hydraulic model extents

Hydraulic Model Construction

1. 1D-2D hydraulic model was developed using Flood Modeller Pro (v4.1) -TUFLOW (2016-03-AA-iSP) to assess the fluvial flood risk to and from the WTW.
2. A 600m reach of Durleigh Brook was represented in the model, starting from the reservoir outflow at the east end of Durleigh Reservoir to the south east of Durleigh Brook Farm (downstream extents).
3. The inflow to the model was included as an unsteady flow/time boundary (QTBDY) at the upstream of Durleigh WTW.
4. Manning's roughness for the channel was adopted between 0.017-0.045. For 2D representation of the floodplain area, Manning's roughness was adopted between 0.02-0.06.
5. Normal depth was used as the downstream boundary. The gradient at the downstream boundary was assigned as 1 in 200.

Return Periods Assessed in Model

The return periods assessed within the AECOM study (2016) are as below:
1. 1 in 20 year
2. 1 in 75 year
3. 1 in 100 year
3. 1 in 1000 year
5. 1 in 100 year including climate change (+20% flow)
6. 1 in 100 year including climate change (+30% flow)

Comments

The scenarios for 200 year return period including climate change were not assessed in AECOM study (2016).

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

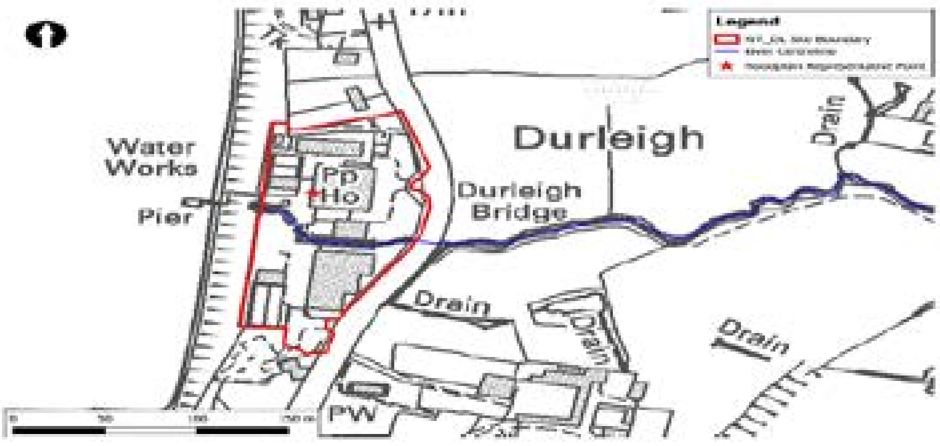
Fluvial Hydrology

The hydrology from the AECOM study (2016) is used for this study.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. The existing hydraulic model is used during our flood level assessment. The relationship between flow and stage is established for the representative node within the site to assess flood levels for climate change allowances.
2. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. A representative floodplain node is identified to estimate flood levels at the site. The node is located in the left overbank near the administrative building within the site.
2. Stage-Discharge relationship is established wherein the stage and flows are extracted from the existing model. The validity of this relation is checked against known flood levels for 100yr20%CC and 100yr30%CC return periods which was found consistent with the generated relationship. Hence, this Stage-Discharge relationship is further used to estimate flood levels corresponding to various return periods including climate change allowances.

Results

1. The flood levels are estimated from the Stage-Discharge relationship obtained.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For the 1 in 1000 year return period, the estimated flood level is 0.01m higher than that of the Environment Agency flood level obtained from the flood zone map. However, the flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator commented that previous flooding has resulted in flood depths around 0.15m. As per this assessment, the site is flooded to a depth over 0.45m for extreme flood events, which is consistent with the anecdotal evidence from the site operator and previous flooding documentation in AECOM study (2016).
3. The resulting flood level on site is dependent on flow in the channel and between buildings within the site. With obstructions such as stored materials or vehicles within the site, there is potential for higher flood levels than noted.

Assumptions and Limitations

1. Stages at the identified node near the administrative building within the site are assumed as representative of the flood levels at the site.
2. The hydrology calculated during the AECOM study (2016) is assumed to be suitable for this study.
3. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Durrington	Post Code		
12050					
Site Type	NGR				
Water Treatment Works	Division	South	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Robert William Rawlings			
WT_DU	Contact Number	07825401068 S/D 602			

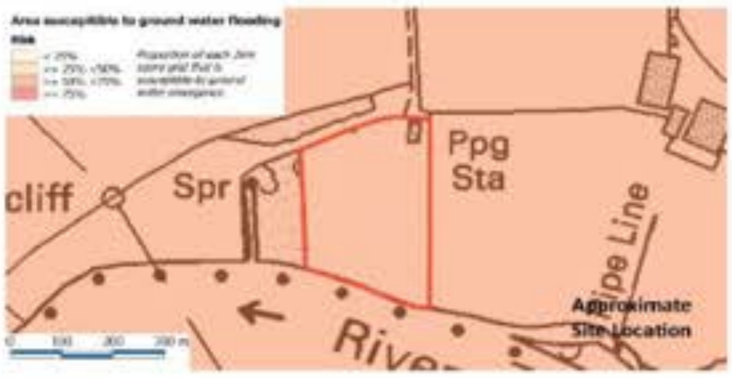
Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	River Avon	**EA Flood Warning Area**	areas in Upavon, Haxton, Haxton Bridge, Netheravon, Milston, Durrington and Bulford
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
70.00 to 75.00 (LiDAR)	71.34(LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	71.43	0.00	N/A	0.00			
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 200 year (0.5%)	N/A*	N/A*					
			1 in 1000 year (0.1%)	72.04	0.14	N/A	0.30-0.90			
71.90		2050 (Upper End Allowance)	1 in 100 year (1%)	71.48	0.00	N/A	N/A			
			1 in 200 year (0.5%)	N/A*	N/A*					
			1 in 1000 year (0.1%)	72.11	0.21	N/A	N/A			
			Groundwater flooding					Medium		
			Reservoir							0.00

Comments

1. The flood level for 1 in 200 year return period was not calculated for this site with a fluvial primary source of flooding.
2. Although the EA surface water mapping indicates that the site is at risk of surface water flooding, our assessment indicates that the primary risk is from fluvial flooding.
2. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

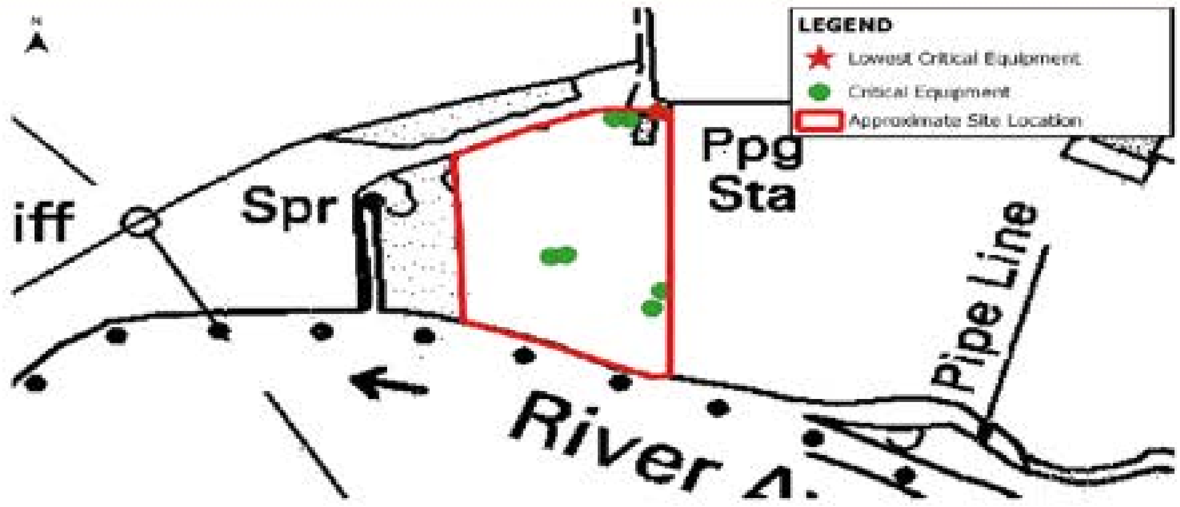
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	30/11/2016	Attendees	Carrie Eller(MM) and Keith (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Remote isolation panel at BH1 (potentially redundant)	71.90	72.11	72.34	72.34	0.44
Remote isolation panel BH2	72.14	72.11	72.34	72.34	0.20
Telemetry Panel	72.15	72.11	72.34	72.34	0.19
MCC	72.20	72.11	72.34	72.34	0.14
Borehole 1	72.32	72.11	72.34	72.34	0.02
Generator	72.61	72.11	72.34	72.34	-0.27
Borehole 2	72.88	72.11	72.34	72.34	-0.54

Summary of Key Client Comments	Comments on Below Ground Equipment (if any)
1. The site is generally at low level and the area near the river floods every year. The flooding reached up to the building in 2014, wherein the flood depth in the building was about 1 inch. (Keith C, Site visit 30/11/2016) 2. Operations feedback summary: Risk to turbidity is due to annual fluvial flooding of borehole, while there is no risk to M&E plant. (Source: STW and WTW Flood Resilience Database) 3. Flooding occurs every year and adjacent river overtops and floods the borehole area. (Source: STW and WTW Flood Resilience Database). 4. Previous flood events have not affected the MCC building. (Robert Rawlings, 09/02/2017)	NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. Building waterproofing and 1 flood door are proposed as flood mitigation measures for the building which includes the telemetry panel and MCC.

2. The remote isolation panels should be raised 44cm (borehole 1) and 20cm (borehole 2). It is noted by the site operator that the panel at borehole 1 is potentially redundant. For a conservative estimate we have costed for raising this item.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

72.34 mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	1
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	2
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) The isolation panels could be replaced with IP68 rated electrical equipment rather than raising the equipment. However, given the relatively low cost for raising these, the passive measure is preferred.
2. The Remote isolation panel at borehole (BH1) was identified by the site operator as potentially redundant. As a conservative assumption, flood mitigation measures are proposed at this equipment. This should be investigated further at the detailed design stage.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The small scale of mitigating measures to the isolated equipment will not result in flood impacts to third parties.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

A previous FRA report "DV53311 Water Treatment Works - Durrington" prepared by Hyder Consulting Limited in May 2008 was made available. However, the HEC-RAS model from this study is not available.

Site Topographical Survey

Topographic survey is available in .dwg format, supplied by the Environment Agency with "DV53311 Water Treatment Works - Durrington" FRA report prepared by Hyder Consulting Limited in May 2008.
Name of the file: 1. B0261_DURRINGTON_2.dwg 2. DURRINGTON 1.dwg

Watercourse Survey

Watercourse survey was commissioned for the 2008 Hyder Study, however it was not provided for use during this assessment.

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

1. Hydrology was calculated for the Hyder study (2008) using Flood Growth Curve. After reviewing the catchment size and other characteristics, such as the high permeability, these flood flow estimates and hydrologic approach is considered to be appropriate.
2. ReFH method was deemed unsuitable as the ReFH hydrological model is not calibrated to reliably estimate flows in permeable catchments such as the River Avon catchment.
3. It was therefore deemed suitable to use the statistical method to estimate flows.
4. Peak flows are available for 2, 5, 10, 25, 50, 100, 100+20% climate change and 1000 year return periods from Hyder study (2008).

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

Hydraulic Model Construction

1. The baseline hydraulic model in Hyder study (2008) was constructed from survey data for five cross sections of the River Avon.
2. The model comprises a single 251m long section of the River Avon.
3. The model is representative of all the main hydraulic elements associated with the section of the River Avon and its floodplain adjacent to the Durrington WTW.
4. An average Manning's value of 0.04 was chosen for the River Avon channel. This is characteristic of a clean, winding channel with some pools and shoals.
5. A Manning's value of 0.07 was chosen to represent the dense brush and trees on the floodplain upstream of Durrington WTW. Downstream of the WTW a value of 0.05 was used to represent the high grasses and brush characteristic of the floodplain downstream.
6. Normal depth was used as the downstream boundary. Using the surveyed cross sections the gradient of the modelled reach was estimated to be 0.00226m/m (1:442).

Return Periods Assessed in Model

The existing model (Hyder Study, 2008) was simulated for several return periods. However, the results for return period 1 in 100 year with 20% allowance for climate change was only recorded in the report.

Comments

1. A steady state hydraulic modelling approach was adopted. This approach is more simplistic than a hydrodynamic model, and does not allow time-varying impacts to be deduced.
2. The resultant flood water levels represent conservative estimates given that the steady-state approach does not account for the effect of flow attenuation at structures or on non-conveyant floodplains.
3. The peak flows have been estimated at the downstream extent of the modelled reach, but applied in the hydraulic model at the upstream extent of the modelled reach. This is a conservative assumption as the catchment area changes slightly over the length of the study reach, and will therefore result in a slightly lower peak flow at its upstream extent.
4. The cross sections input into the model are taken from the topographical survey commissioned for this project.

MOTT MACDONALD

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

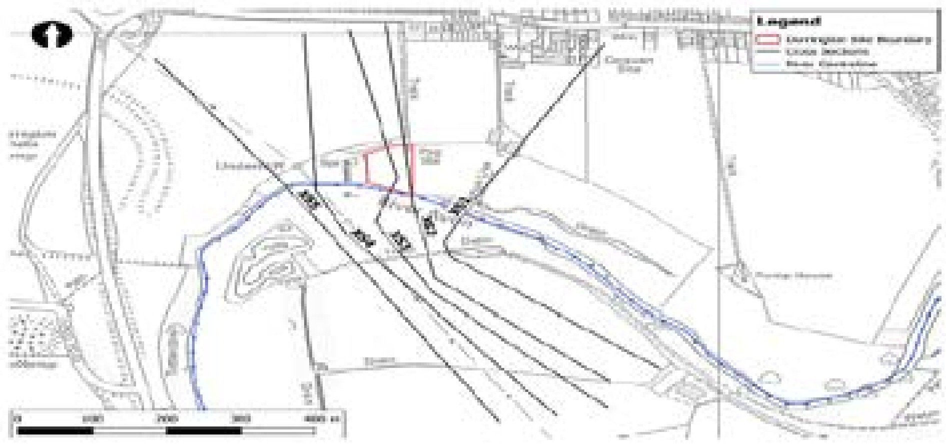
Fluvial Hydrology

Initial model tests were conducted using the Hyder (2008) hydrology; however, this produced results that were not in line with anecdotal evidence. Therefore, a conservative approach was taken to estimate flow from corresponding Flood Zone 2 and Flood Zone 3 flood levels by back-calculation to estimate peak flows of critical return periods. This results in flows approximately 9% higher than those calculated in the Hyder (2008) study.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. One-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. Hydrological inflows are applied at the upstream boundaries per the back-calculated flows.
3. The model is simulated for design return periods 1 in 100 year and 1 in 1000 year with an central and upper end allowances of climate change.
4. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. Upstream inflow boundary (QT) condition is applied for each design return period.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from EA website.
3. Downstream boundary condition configured as a normal depth with a slope of 1:442.
4. The roughness coefficient for river channel is assigned as 0.06 and for floodplain, it is assigned as 0.12. These values are based on the Hyder study (2008), and were adjusted to represent field conditions and anecdotal avidence from site operators.
5. The model is simulated for design return periods 1 in 100 year and 1 in 1000 year with an central and upper end allowances of climate change.

Results

1. The flood levels are extracted for each design return period at cross section XS2.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. A comparison was made with the Hyder Study (2008) and the flood levels in the Hyder study (2008) were 0.45m lower for the 1 in 100 yr return period with climate change (20%) flood event. The current study used higher manning's roughness values and inflows than those in the Hyder study.
2. The site operator comments that the site floods every year. This anecdotal evidence is supported by the assessment, with lower portions of the site inundated in low return periods. For extreme flood events, the site is flooded to depth over 0.9m and reaches the building at the higher portion of the site.
3. EA flood zone map flood levels match with peak flood levels from this analysis as EA flood zone 2 extent is used to assess the peak flood levels at the site using DTM, and corresponding flows are calculated using a hydraulic model which was prepared using the latest 1m Environment Agency DTM.

Assumptions and Limitations

1. The impact of hydraulic structures is not considered in this assessment, although no significant structures are located in the vicinity of the site.
2. The floodplain is represented within the the 1D domain of the model.
3. Cross sections (channel and floodplain) are extracted from latest EA LiDAR (1m resolution).
4. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Heytesbury	Post Code		
12063					
Site Type	NGR				
Water Treatment Works	Division	North	Flood Resilience Design Life (years)	25	
Mott MacDonald Site Code	Controller	Marc Hodgson			
WT_HE	Contact Number	07768035421			

Site Plan

Location Plan

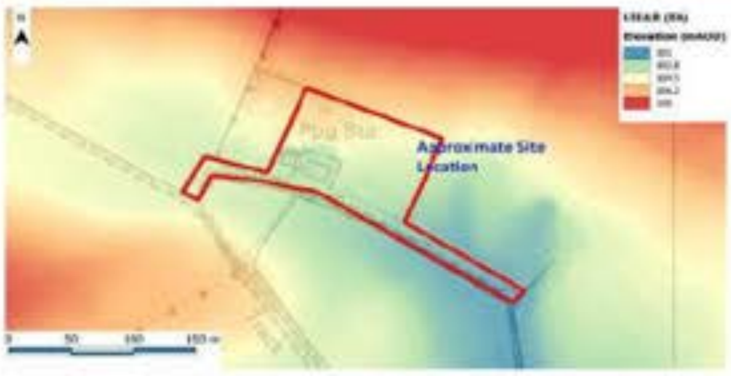
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Unnamed Drain (Tributary of River Wylye)	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
102.10 to 105.17 (LiDAR)	102.81(LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	103.82	0.92	N/A	0.00			
			1 in 200 year (0.5%)	103.85	0.95					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	103.92	1.02	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	103.83	0.93	N/A	N/A			
			1 in 200 year (0.5%)	103.86	0.96					
102.90			1 in 1000 year (0.1%)	103.95	1.05	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Lisha Parambath	Kelsey Plech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	29/11/2016	Attendees	David Tinning (MM) and Kieron Sloan (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Borehole 6 Disused	102.90	103.06	103.35	103.35	0.45
Chamber	103.10	103.60	103.88	103.88	0.78
Chemical Spill Tank	103.20	103.60	103.88	103.88	0.68
Cable Ducts	103.27	103.60	103.88	103.88	0.60
Control Panel	103.30	103.60	103.88	103.88	0.58
Transformer	103.31	103.60	103.88	103.88	0.57
Pumps	103.33	103.60	103.88	103.88	0.55
Flap Valves	103.34	103.92	104.21	104.21	0.87
Fuel Tank	103.36	103.60	103.88	103.88	0.52
Septic Tank	103.38	103.92	104.21	104.21	0.83

Summary of Key Client Comments

1. The previous flooding occured in 2013/2014 and it reached up to the concrete plinth in main pump room. The water also flooded the access to the site. (Keiron Sloan, Site visit 29/11/2016)
2. Generator area can flood through ducts even though the generator is bunded. (Keiron Sloan, Site visit 29/11/2016)
3. Water can run in from field and cause the stream located in front of the site to burst its banks. Water has been seen up to the septic tank during previous flood events. (Keiron Sloan, 17/11/2016)
4. Water can enter through ducts and submerge the below ground section of pump room. (Keiron Sloan, Site visit 29/11/2016)
5. There is risk of flood water going back up flap valves into boreholes. (Keiron Sloan, 17/11/2016)

Comments on Below Ground Equipment (if any)

1. Control panel is 0.47m below the ground level however it will only begin to flood once flood water reaches the ground level.
2. The critical equipment levels for control panel and pumps are 102.82mAOD and 102.98mAOD respectively.
3. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.
4. For below ground equipment, flood depths listed in the above table represent the depth above ground level or finished flood level. Once the flood level becomes higher than the indicative threshold level listed in the above table for below ground equipment, flood depth at the equipment should be estimated with respect to critical equipment level, and not the indicative threshold level.

Phase 2 Mitigation Assessment

Flood Defence Description

1. Building waterproofing at 1 building and 2 flood doors are proposed for the building at this site, housing; cable ducts, control panel, pumps, fuel tank, phosporic acid dosing, chlorine gas store.
2. Wessex Water has confirmed that septic tanks and chemical spill tanks are non-critical equipment, therefore costing for these measures is not included.
3. Borehole 6 is disused therefore mitigations measures are not proposed at this equipment.
4. Control panel at the standby generator to be raised.
5. Equipment to be replaced with IP68 rated alternatives at Borehole 10.
6. Transformer to be raised 57cm (not a Wessex Water asset).

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

104.21 mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Low
Raise control panel or kiosk	number	1
Raise other equipment	number	1
Other	linear m	0

Comments

1. There are three more pieces of equipment at the site (Chamber, cable ducts and flap valves without photographs). However, during the site visit the site operator did not mention these three elements as pieces of critical equipment and therefore no defence has been proposed for them.
2. Further boreholes are located outside the extent of the flood defence layout image above. This equipment does not have protection measures proposed.
3. Indicated scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within the proposed flood mitigation measures. Building waterproofing surface area is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigation impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The measures of flood mitigation include providing walling, flood doors and localised cabinet protection. No impacts anticipated to flooded area.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

Not Available

Site Topographical Survey

Site schematic and site plans were supplied by Wessex Water for this study. The filenames are as follows:
WT_HE_12063 Heytesbury plan_20161122
WT_HE_12063 Heytesbury topo_20161122

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Watercourse Survey

Not available

Details of Existing Study

Fluvial Hydrology

Not Applicable

Study Extent

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

There is no existing model available, so a new 1D model is built to assess the flooding at the site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

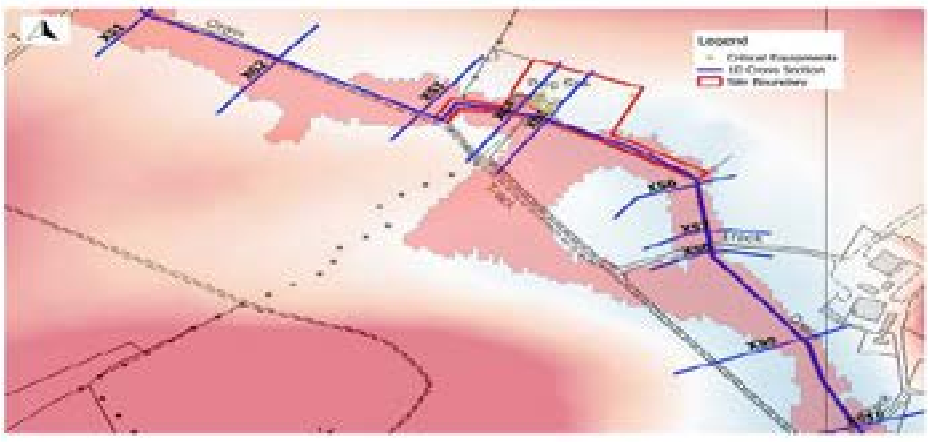
Fluvial Hydrology

ReFH hydrologic assessment is conducted to estimate flows in an unnamed drain (Tributary of River Wylye) in the vicinity of the site. ReFH used on permeable catchments gives conservative estimates.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. One-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. The model nodes XS3, XS4 and XS5 correspond with the relevant cross-sections used to estimate flooding for the equipment on site.
3. Information on the two culverts (unnamed tracks) were collected during a site visit and incorporated into the model.
4. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. An upstream inflow boundary condition is applied based on peak flows calculated in Hyder study (2008) for critical return periods.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from the Environment Agency website.
3. Normal depth is used as the downstream boundary condition by calculating the slope from the LiDAR data. The slope used is 1 in 200.
4. The roughness coefficient for the river channel is assigned as 0.045, for floodplain is assigned as 0.065 and the site is assigned as 0.1 and 0.15 depending on the terrain.
5. The model is simulated to generate the peak stage corresponding to critical return periods.
6. The model was tested for its senstivity against Manning's value (± 20%) and Downstream Boundary slopes (± 10%, flat to steep). The results of this process indicated that the model was not sensitive to the changes in the Manning's value and downstream boundary slope. With the adoption of conservative roughness values, the resulting stage at the site location was increased ±2.4cm in the 1000yr CC40 simulation.

Results

1. The nominal site flood levels are estimated at cross section XS3 for critical return periods.
2. Flood levels for specific pieces of critical equipment are determined from XS3, XS4 and XS5.
3. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. The EA Flood Zone 2 (1000yr return period) flood levels were estimated as 104.06mAOD. The 1000yr flood level is estimated as 103.88mAOD during this assessment which is 0.18m lower. However, the EA flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. A number of flood level results at particular equipment support anecdotal evidence from the site operator.
a) The Finished Floor Level of the Pump room is 102.85mAOD, with the plinth at 102.98mAOD (below ground level 103.328). The 1000CC40 stage at cross section XS4, which represents the flooding at the equipment, is 103.60mAOD. Hence the equipment would be flooded for critical return periods.
b) The access to the site is at 102.83mAOD. Hence it will get flooded for critical return periods.
c) Since the septic tank is at a critical level of 103.38mAOD, the 1000CC40 stage of 103.92mAOD will cause flooding.
d) Flap valves into the boreholes are at an elevation of 103.34mAOD, so the extreme return period flooding having a stage of 103.92mAOD will cause flooding at the site.

Assumptions and Limitations

1. Floodplain is represented within the 1D domain of the model.
2. It is assumed that the stage at XS3, XS4 and XS5 represent the stage at the equipments at site.
3. Cross sections (channel and floodplain) are extracted from latest EA LiDAR (1m resolution).
4. The hydrology calculated by ReFH method was used in this study.
5. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
6. Information on the two culverts and tracks were collected and estimated by site visit staff. This does not constitute a formal water course survet and is an estimate only.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Newton Toney	Post Code	
12089				
Site Type	NGR			
Water Treatment Works	Division	South	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	Robert William Rawlings		
WT_NT	Contact Number	07825401068 S/D 602		

Site Plan

Location Plan

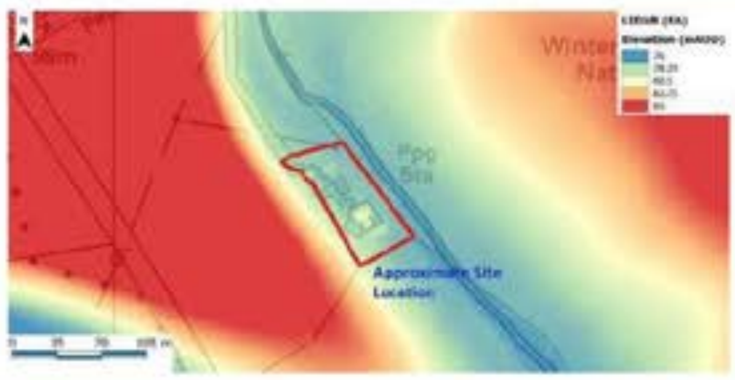
Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography



Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	River Bourne	EA Flood Warning Area	Groundwater information in the Bourne Valley for the Winterbournes and Salisbury areas
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
76.64 (Topo) to 78.90 (Topo)	77.47 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	77.49	0.20	N/A	0.00			
			1 in 200 year (0.5%)	N/A	N/A					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	77.60	0.31	N/A	< 0.30			
		2050 (Upper End Allowance)	1 in 100 year (1%)	77.52	0.23	N/A	N/A			
77.29			1 in 200 year (0.5%)	N/A	N/A					
			1 in 1000 year (0.1%)	77.64	0.35	N/A	N/A			
			Groundwater flooding					Low		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Supriya Savalkar	Kelsey Piech	Sun Yan Evans

MOTT MACDONALD

Client Review & Site Visit

Date of Site	30/11/2016	Attendees	Carrie Eller (MM) and Keith (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Generator	77.29	77.64	77.89	77.89	0.60
MCCs	77.37	77.64	77.89	77.89	0.52
Control panel	77.62	77.64	77.89	77.89	0.27
Pump station kiosk on plinth	77.69	77.50	77.76	77.76	0.07
Sampling lines in clorinator room	77.79	77.64	77.89	77.89	0.10
Transformer 2	78.56	77.64	77.89	77.89	-0.67
Transformer 1	78.87	77.50	77.76	77.76	-1.11
Electric controls for outlet valve	78.95	77.50	77.76	77.76	-1.19
Injector valves	79.30	77.50	77.76	77.76	-1.54

Summary of Key Client Comments

1. There have been several instances of past flooding including 2014 and 2015. In 2014, there was deep flooding in the relift rooms while about 1 inch of flood depths outside. (Keith C, Site visit 30/11/2016)
2. Currently flood water is being pumped out during flood events. Pumps are already fitted in the chamber. (Keith C, Site visit 30/11/2016)
3. The flood protection type observed at this site are Low bund (0.20m) around electricity compound and raised borehole.
4. Recent surface water flooding during exceptional rainfall causing infiltration of relift sump, and there is risk of damage to relift pumps. Drainage and ducting seals require review. (Source: STW and WTW Flood Resilience Database)
5. During 2014 flooding, runoff from nearby bourne flooded the surrounding area, and infiltrated through unsealed ducts and filled in the relift sump. During the flooding, 6" trash pump ran continuously to manage water level in the sump. Ducts are now sealed. (Source: STW and WTW Flood Resilience Database)
6. The duct sealing undertaken in-house may not secure the site in an extreme event, it would still need to be managed locally by hiring in large thrash pumps to maintain site operations and damage to EMI equipment. Therefore a full professional assessment would need to be carried out on site either through eliminating risk of flooding via ducting or bunding between site and the river. (Robert Rawlings, 09/02/2017)

Comments on Below Ground Equipment (if any)

NONE

Phase 2 Mitigation Assessment

Flood Defence Description

1. Building waterproofing and flood doors are proposed as flood mitigation measures for the buildings which includes the MCCs, generator, sampling lines in chlorinator room and control panel. The control panel in the relift room also requires maintenance of sealed ducts below ground level.
2. Pump station kiosk on plinth to be raised 6cm.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) including 300mm Freeboard

77.89mAOD

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	2	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	2	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	1	
Raise other equipment	number	0	
Other	linear m	0	

Comments:

1. It is noted that the relift room ducts, a source of previous infiltration requiring pump-out, have now been sealed. This sealing should be inspected and properly maintained to ensure performance during major rainfall events.

2. The following mitigation measures were considered but not preferred:
a) whole site protection is not warranted given the depth of flooding on site, and would have extensive cost.
b) raising the equipment in the buildings was considered but not preferred due to cost.
c) local protection at the pump station kiosk was not preferred due to operational implications and cost.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The proposed footprint of the localised building protection and raising equipment does not remove floodplain storage and therefore will have negligable impact.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the EA website.

Existing FRA and accompanying model files

The FRA report "DV53311 Water Treatment Works - Newton Tony" prepared by Hyder Consulting Limited (May 2008) is available. However the HEC-RAS model from the Hyder study (2008) is not available.

Site Topographical Survey

Topographical survey was supplied by Wessex Water in .dwg format, filename: NEWTON TONY_1.dwg, NEWTON TONY_2.dwg
The data was surveyed as part of the "DV53311 Water Treatment Works - Newton Tony" report prepared by Hyder Consulting Limited in May 2008.

Watercourse Survey

Watercourse survey data was collected for the Hyder (2008) study, which was not supplied for this assessment.

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

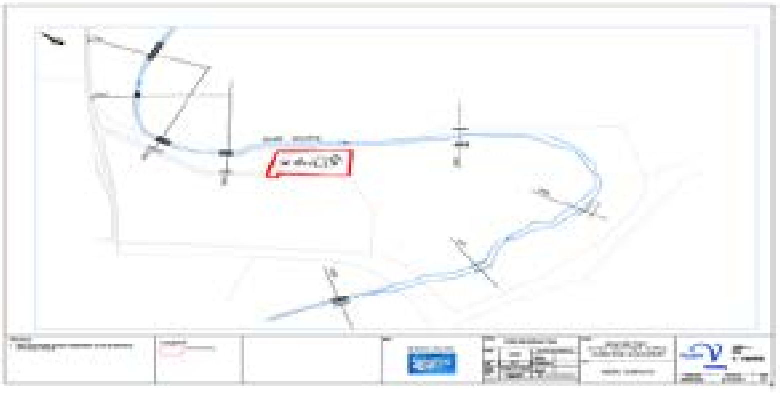
Fluvial Hydrology

1. Hydrology was calculated for the Hyder study (2008) using Flood Growth Curve. After reviewing the catchment size and other characteristics, such as the high permeability, these flood flow estimates and hydrologic approach is considered to be appropriate.
2. ReFH method was deemed unsuitable as the ReFH hydrological model is not calibrated to reliably estimate flows in permeable catchments such as the River Bourne catchment.
3. It was therefore deemed suitable to use the statistical method to estimate flows.
4. Peak flows are available for 2, 10, 20, 50, 100, 100+20% climate change and 1000 year return periods from Hyder study (2008).

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent



Hydraulic Model Construction

1. The baseline hydraulic model in Hyder study (2008) was constructed from survey data for the watercourse.
2. There are no main structures along the modelled reach of the River Bourne.
3. The model comprises of a single reach of the River Bourne approximately 1140m in length.
4. The modelled section of the River Bourne extends approximately 300m upstream and 723m downstream of the WTW
5. The model is representative of all the main hydraulic elements associated with the section of the River Bourne and its floodplain adjacent to the Newton Tony WTW.
6. Due to the perceived vulnerability of the WTW a conservative Manning's value of 0.05 was chosen for the channel and floodplain of the River Bourne. The central channel is characteristic of a natural channel, clean and winding, with some pools, shoals, weeds and stones.
7. For the floodplain a conservative Manning's value of 0.05 represents the grass and brush characteristic of the floodplain.
8. Inflows were applied at the upstream boundary of the model.
9. Normal depth was used as the downstream boundary. Using the surveyed cross sections the gradient of the modelled reach was estimated to be 1:196.

Return Periods Assessed in Model

1 in 100 year return period flood with an allowance for climate change i.e. 20%

Comments

1. A steady state hydraulic modelling approach was adopted. This approach is more simplistic than a hydrodynamic model, and does not allow time-varying impacts to be deduced.
2. The resultant flood water levels represent conservative estimates given that the steady-state approach does not account for the effect of flow attenuation at structures or on non-conveyant floodplains.
3. The peak flows have been estimated at the downstream extent of the modelled reach, but applied in the hydraulic model at the upstream extent of the modelled reach. This is a conservative assumption as the catchment area changes slightly over the length of the study reach, and will therefore result in a slightly lower peak flow at its upstream extent.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

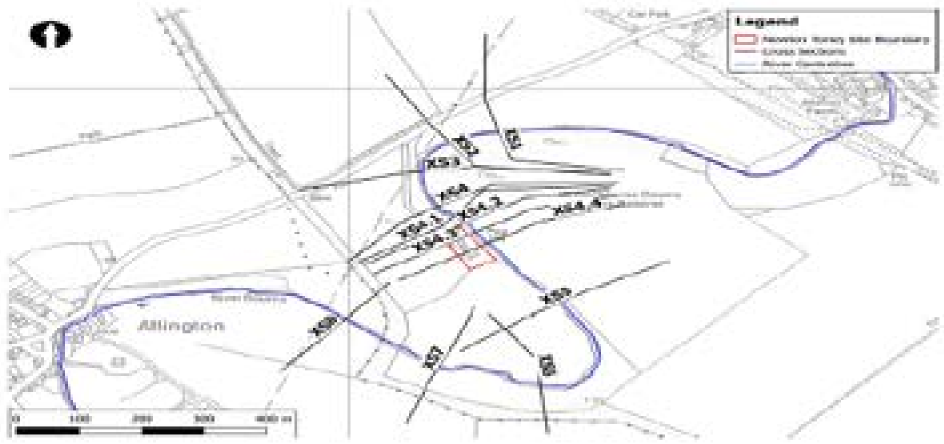
Fluvial Hydrology

ReFH hydrologic assessment was conducted to estimate the flows in the River Bourne in the vicinity of the site but due to high permeability within the catchment, hydrology from the Hyder study (2008) was adopted for flood level calculations which was based on flood growth curve.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. An one-dimensional (1D) unsteady hydrodynamic model was developed in Flood Modeller Pro.
2. The hydrological flows calculated in the Hyder study (2008) were applied for the assessment of flood levels for critical return periods.
3. Further detail of the approach is provided in the following sections.

Hydraulic Modelling

1. The upstream inflow boundary condition was applied based on peak flows calculated in the Hyder study (2008) for critical return periods.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from the Environment Agency website.
3. Same downstream boundary approach used as Hyder study (2008), however downstream slope is flattened to 1 in 500 to account for known bridge and culvert obstructions beyond the model extent.
4. Manning's roughness values for the channel and floodplain are assigned, ranging from 0.05 to 0.055.
5. Climate change factors to current day hydrological flow rates are applied and simulated in the model to assess future conditions.

Results

1. The flood levels are estimated at cross section XS2 for critical return periods.
2. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. Flood level of 77.41mAOD is estimated in the vicinity of the Newton Tony WTW for 1 in 100 yr with climate change (20%) as calculated by Hyder study (2008). Flood level calculated using Flood Modeller Pro as per our assessment is 77.47mAOD. Therefore, there is a difference of 0.06m which may be attributed due to the cross section data extracted from the latest EA LiDAR of 1m resolution during our assessment.
2. Flood level is interpreted as 77.55mAOD for Flood Zone 2 (1000 yr return period) from EA flood extents in the vicinity of our site while we have estimated the flood level to be 77.54mAOD for 1000yr return period.
3. Flood level is interpreted as 77.37mAOD for Flood Zone 3 (100 yr return period) from EA flood extents in the vicinity of our site while we have estimated the flood level to be 77.43mAOD for 100yr return period.
4. The site operator comments that the site floods every year. As per this assessment, for the 2 year return period event, the site would be flooded to a depth of approximately 0.5m in the lower portions of the site, which is consistent with the anecdotal evidence from the site operator. For extreme flood events the site is flooded to a depth over 0.17m above typical ground level and 1m in lower portions of the site.

Assumptions and Limitations

1. Floodplain is included within the 1D model extent.
2. Cross sections (channel and floodplain) are extracted from latest EA LiDAR (1m resolution).
3. Flow rates are calculated from published results of fluvial flooding from the Environment Agency flood maps.
4. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

MOTT MACDONALD

Wessex Water Site ID	**Site Name**	Rodbourne	**Post Code**		
12103					
Site Type	**NGR**				
Water Treatment Works	**Division**	North	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	Marc Hodgson			
WT_RB	**Contact Number**	07768035421			

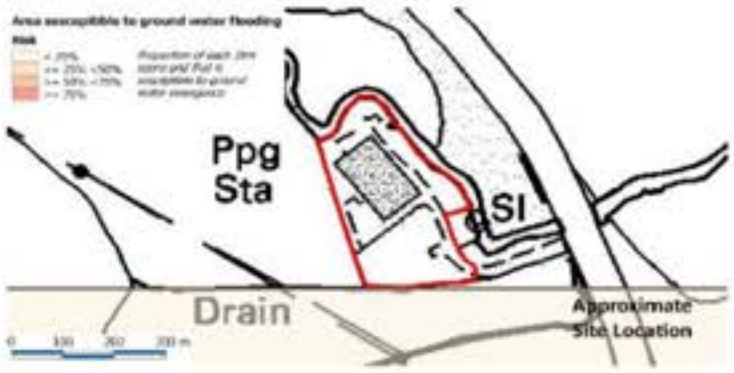
Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map



Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	Gauze Brook	**EA Flood Warning Area**	Bristol Avon and tributaries from downstream of Malmesbury to Chippenham including Cow Bridge etc.
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
67.14 to 67.60 (LiDAR)	67.39 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	67.63	0.51	N/A	0.00			
			1 in 200 year (0.5%)	67.74	0.62					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	67.90	0.78	N/A	0.00			
		2050 (Upper End Allowance)	1 in 100 year (1%)	67.64	0.52	N/A	N/A			
			1 in 200 year (0.5%)	67.84	0.72					
67.12			1 in 1000 year (0.1%)	67.92	0.80	N/A	N/A			
			Groundwater flooding					Data not available*		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

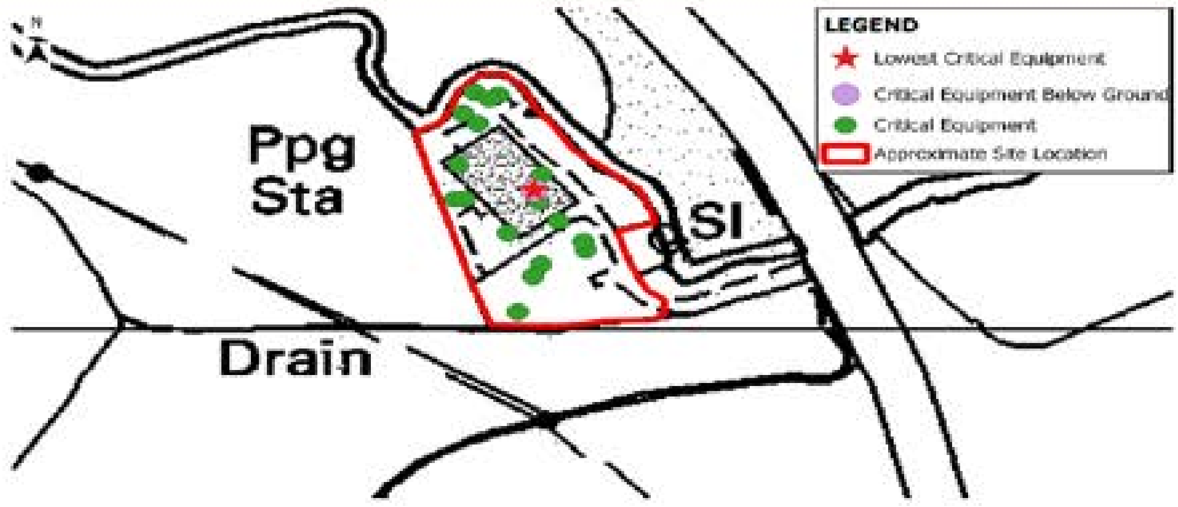
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Supriya Savalkar	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	01/12/2016	Attendees	David Tinning (MM) and Kieron Sloan (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Generator	67.12	67.92	68.19	68.19	1.07
Inlet Chamber	67.53	67.92	68.19	68.19	0.66
Borehole Kiosk	67.65	67.92	68.19	68.19	0.54
Borehole Kiosk	67.77	67.92	68.19	68.19	0.42
Septic Tank	67.83	67.92	68.19	68.19	0.36
Transformer	67.90	67.92	68.19	68.19	0.29
Borehole Control	67.93	67.93	68.20	68.20	0.27
Motive Water Sampling Pumps	67.95	67.92	68.23	68.23	0.28
Control Panel	68.08	67.92	68.23	68.23	0.15
Pumps	68.10	67.92	68.18	68.18	0.08

Summary of Key Client Comments

1. During flooding, it is difficult to get access. During previous flood events, entire site flooded up to the corner, beyond which further access to site for alarms or sampling was not possible. (Kieron Sloan, Site visit 01/12/2016)
2. Area around boreholes can flood, but it has never been seen above the headplates. (Source: STW and WTW Flood Resilience Database)
3. Raised mixer chamber can flood through ducts. (Source: STW and WTW Flood Resilience Database)
4. Generator has been flooded in the past, which poses diesel leak risk. (Source: STW and WTW Flood Resilience Database)
5. Two mixer chambers and dosing kiosk/bottle store have been raised for protection, but access in the event of any alarms is impossible in flood conditions. (Source: STW and WTW Flood Resilience Database)
6. The site has flooded before and access can be a problem but local site topography means the key assets do not flood. (Source: STW and WTW Flood Resilience Database)

Comments on Below Ground Equipment (if any)

1. Pumps are 0.90m below the ground level. They would start to flood once water reaches the finished floor level.
2. The main pump room is protected with sealed ducts. Water has never spilled into the building, but if the waters were a few inches higher or if the seals failed then the main pump room would flood. (Kieron Sloan, Site visit 01/12/2016)

Phase 2 Mitigation Assessment

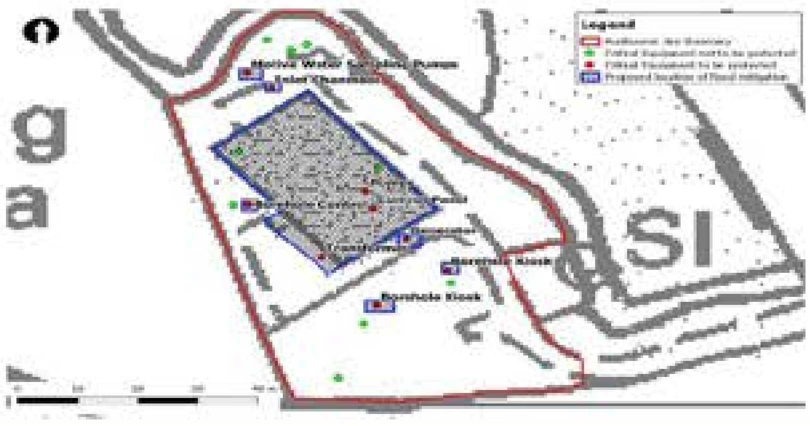
Flood Defence Description

1. Waterproofing of the existing building including building hardening to a height of 1m above FFL. Two flood doors assumed to be required. This will protect the equipment in the building, including the pumps, control panel and transformer.
2. Generator to be raised 1m on concrete plinth with access platform.
3. Borehole kiosk (2nr) and borehole control panel to be raised 54cm, 42cm and 27cm, respectively.
4. Electrical equipment at the inlet chamber and motive pumps to be replaced with IP68 submersible options. Given the medium size/complexity of the site, this has been costed using the 'medium' costing band.
5. The septic tank has been confirmed as non-critical equipment by Wessex Water and therefore mitigation measures are not proposed to protect this.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

68.23 mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Medium
Raise control panel or kiosk	number	3
Raise other equipment	number	1
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection was considered but not preferred due to cost.
b) localised protection in the form of flood proofed cabinets were considered at many of the individual pieces of equipment such as generator, kiosks and control panels outside of the building, however given the ability to raise the equipment, this is the preferred solution to remove the equipment from risk.

2. Site access may be restricted during flood events, with the site access road located adjacent the main channel of flow. This should be addressed in an emergency access plan prepared by Wessex Water.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The proposed mitigation measures include building waterproofing and raising of equipment, which has minimal impact on floodplain storage and therefore the impact on flood risk to others is likely to be small.

Source Data

LiDAR Data

1m resolution LIDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Not available

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

Not available

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

Hydraulic Model Construction

Not available

Return Periods Assessed in Model

Not available

Comments

There is no existing hydraulic study available in the vicinity of this site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

Fluvial Hydrology

A ReFH hydrologic assessment was conducted to estimate the flows in Gauze Brook in the vicinity of the site.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure

Summary of Approach

1. A one-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. Structure survey was obtained for the culvert and road bridge (Grange Lane) and this data was incorporated into the model.
2. The Stage at RB0_003 and RB0_004 has been used to asses the flood depth at the critical equipment.
3. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from the Environment Agency website.
2. Upstream inflow boundary conditions are calculated for various critical return periods.
3. The bed slope of 1:500 is assigned as the normal depth downstream boundary condition in the model.
4. Manning's roughness of 0.045 is used for the river channel and 0.065 for floodplain. At the RB0_006 over the right bank the manning's roughness is set to 0.15 to represent the field conditions.
5. Estimates of the key structure dimensions were collected during the site visits. These are estimates only and do not constitute formal watercourse survey.
6. The model is simulated for critical return periods to obtain flood levels.
7. The model was tested for its senstivity against Manning's value (+/- 20%) and Downstream Boundary slopes (steep to flat). The results of this process indicated that the model was not sensitive to the changes in the Manning's value and downstream boundary slope.

Results

1.The flood levels are extracted at cross sections for the peak flows of 100CC10, 100CC20, 100CC25, 100CC40, 200CC10, 200CC20, 200CC25, 200CC40, 1000CC10,1000CC20, 1000CC25,1000CC40 year return periods (and climate change scenarios).
2. Flood levels are obtained from cross seection RB0_004 for the critical return periods.
3. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. For the 1 in 1000 year return period, the flood level from this assessment is 0.45m higher than that of Environment Agency flood level obtained from flood zone maps. However, the flood zone mapping is based on a catchment wide study, and is not a site specific assessment.
2. The site operator comments that the site has flooded during previous flood events which affects site access. As per this assessment, for extreme flood events, the site is flooded to depths over 1.00m, which is consistent with the anecdotal evidence from the site operator.

Assumptions and Limitations

1. The floodplain is represented within the 1D domain of the model.
2. Cross sections (channel and floodplain) are extracted from the latest EA LiDAR (1m resolution).
3. Bend losses for meanders are not considered.
4. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
5. Information on the culvert and road bridge (Grange Lane) were collected and estimated by site visit staff. This does not constitute a formal watercourse survey and is an estimate only.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	Site Name	Sutton Bingham	Post Code	
12111				
Site Type	NGR			
Water Treatment Works	Division	West	Flood Resilience Design Life (years)	25
Mott MacDonald Site Code	Controller	James Robert Lovell		
WT_SB	Contact Number	07786196882 ed 606		

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	Existing Flood Defence	No
Main Flooding Source	Tributary of the River Yeo	EA Flood Warning Area	No results for the current location
Current Site Flood Zone	Flood Zone 3	Flood Warning Notice Period	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
43.00 to 46.00 (Topo)	44.2 (TOPO)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	0.00			
			1 in 100 year (1%)	43.60	0.00	N/A	< 0.3			
			1 in 200 year (0.5%)	43.94	0.00					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	44.34	0.00	N/A	< 0.3			
		2050 (Upper End Allowance)	1 in 100 year (1%)	43.89	0.00	N/A	N/A			
			1 in 200 year (0.5%)	44.30	0.00					
44.58			1 in 1000 year (0.1%)	44.44	0.00	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							Over 2m

Comments

1. The EA Surface Water map indicates some risk of surface water flooding on site, however based on our assessment likelihood of this risk is negligable.
2. Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

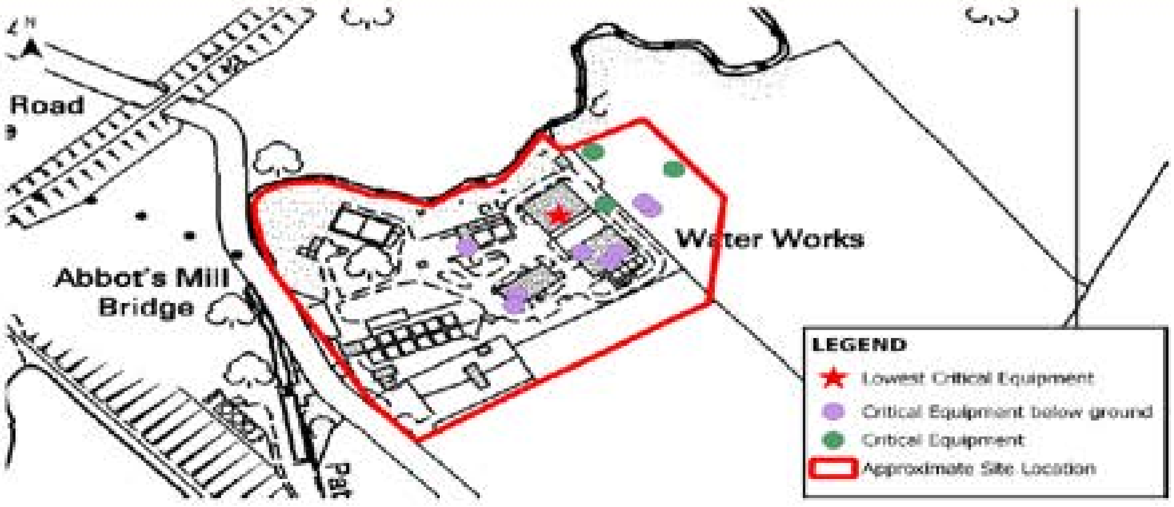
Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Samir Anipindiwar	Kelsey Piech	Sun Yan Evans

Client Review & Site Visit

Date of Site	30/11/2016	Attendees	Domenico Santoro (MM) and Spencer Martin (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Contact tank	44.58	43.97	44.16	44.16	-0.42
Main building-treated water tank sample pump	44.83	43.97	44.16	44.16	-0.67
Pump	44.86	43.97	44.16	44.16	-0.70
Clean washer tank flowmeter	45.33	43.97	44.16	44.16	-1.17
Manganese filters	45.55	43.97	44.16	44.16	-1.39
Treatment building 2 - GAC outlet sample pump	45.56	43.97	44.16	44.16	-1.40
Treatment building 1 - drain valve	45.65	43.97	44.16	44.16	-1.49
Valve	45.65	43.97	44.16	44.16	-1.49
Blower	45.65	43.97	44.16	44.16	-1.49
MCC - electric panel	45.77	43.97	44.16	44.16	-1.61

Summary of Key Client Comments

1. The previous flooding had occured about 4-5 years ago which was around 1m deep. (Spencer Martin, Site visit 30/11/2016)
2. Flood on the access road from dam release, but the plant iself was not flooded.(Spencer Martin, Site Visit 30/11/2016)
3. Operations comments: Sensors would cause the site to shutdown if flood water is detected at various points on the site. Access has been denied before but the site has not flooded. (Source: STW and WTW Flood Resilience Database)

Comments on Below Ground Equipment (if any)

1. In the past, the main building was submerged by water from a pipe. The sample pump and other pumps are in the basement and have motor at the ground floor, all pumps are critical equipment. There is also other equipment within the room that could be affected if the building was submerged. (Spencer Martin, Site visit 30/11/2016 and James Lovell, 01/02/2017)
2. Sample pump would only flood once the water level reaches the ground level at the main building.

Phase 2 Mitigation Assessment

Flood Defence Description

Although the lower portions of the site, near the watercourse, are flooded in extreme events, the critical equipment is not susceptible to flooding. No mitigation measures are proposed.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

N/A

Flood Defence Layout

Indicative Scope for Flood Mitigation

Description	Per	Quantity	Comments
Earth bunding up to 2m height	linear m	0	As described by the site operator, the site access is at a lower level than that of the critical equipment. During large discharges from the reservoir, access will be cut due to water flowing across the roadway and through the site at the site access location.
Walling up to 1m height	linear m	0	
Walling up to 2m height	linear m	0	
Walling up to 3m height	linear m	0	
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	0	
Localised cabinet protection (max 1m height)	linear m	0	
Localised cabinet protection (max 2.1m height)	linear m	0	
Flood doors	number	0	
Flood gate up to 1m	number	0	
Flood gate up to 2m	number	0	
Movable/demountable defence	linear m	0	
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0	
Raise control panel or kiosk	number	0	
Raise other equipment	number	0	
Other	linear m	0	

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	N/A

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

FRA report titled "Sutton Bingham Water Treatment Works, Proposed Extension" prepared by Grontmij (June 2011) is available however no model and result files are available. The Sutton Bingham Reservoir Section 10 Report (April 2007) was provided by Wessex Water for this assessment.

Site Topographical Survey

Topographical survey is available in .dwg
Name of the file: 1. WT_SB_12111 Sutton Bingham topo_20161122.dwg

Watercourse Survey

Not available

Environment Agency / Local Authority Existing Studies

A data request was submitted to the Environment Agency for this site requesting any relevant flood risk information in the vicinity of the site. The Environment Agency confirmed that no hydraulic modelling studies are available in the vicinity of the site.

Details of Existing Study

Fluvial Hydrology

No hydrological modelling was undertaken as part of Grontmij FRA (June 2011).

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Study Extent

Hydraulic Model Construction

No detailed survey or hydraulic modelling of the watercourse in the vicinity of the site was undertaken as part of Grontmij FRA (June 2011).

Return Periods Assessed in Model

Not available

Comments

1. There is no existing model available from EA and Wessex Water in the vicinity of the site. FRA report titled "Sutton Bingham Water Treatment Works, Proposed Extension" prepared by Grontmij (June 2011) is available from Wessex Water, however no model and result files are available.
2. There is a reservoir immediately upstream of the site which supplies it with raw water. If the reservoir is breached or overtopped, it would cause significant damage to the site. The reservoir comes under the Reservoirs Act (1975).
3. The dam at the reservoir is considered to be Category A as defined in the third edition of 'Floods and Reservoir Safety' published in 1996 by the Institution of Civil Engineers.
4. Based on calculations prepared by Messrs. Binnie and Partners in 1977, the probable maximum flood (PMF) routed outflow is 144cumecs. The probability of exceedance of the PMF is very small but greater than zero.
5. While estimating the PMF, Probable Maximum Precipitation (PMP) was assumed as 160mm for 2 hour duration and 310mm for 24 hour duration.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial

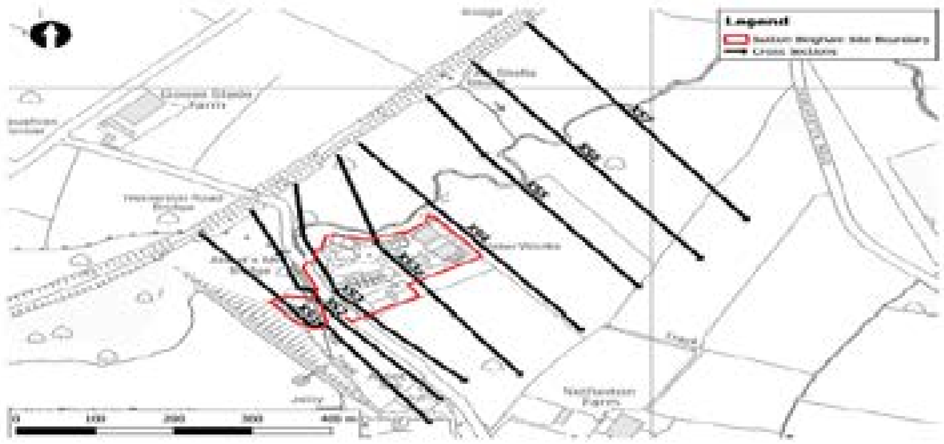
Fluvial Hydrology

Mott MacDonald conducted an ReFH hydrologic assessment to estimate the flows in the tributary of the River Yeo coming to the Sutton Bingham Reservoir. A 1D ISIS routing model was built using information from the Section 10 Report to obtain the attenuated hydrographs.

Tidal Hydrology

Not applicable since the site is not tidally influenced.

Supporting Figure



Summary of Approach

1. One-dimensional (1D) unsteady hydrodynamic model is developed in Flood Modeller Pro.
2. As a comparison, flood level is also estimated corresponding to the PMF as calculated by Messrs. Binnie and Partners in 1977. The comparison is performed as the fluvial hydrology calculated during this study does not take in to account flood risk associated with the reservoir breaching/overtopping.
3. Further detail of this approach is provided in following sections.

Hydraulic Modelling

1. The upstream inflow boundary (QT) condition is applied for each design return period.
2. Cross sections are extracted from the latest LiDAR downloaded in December 2016 from the Environment Agency website.
3. The bed slope of 1:220 is assigned as the normal depth downstream boundary condition in the model.
4. The culvert underneath Netherton Lane was not included in the hydraulic model to represent a more conservative estimate of flood risk downstream this road, culvert dimensions are not available.
5. Manning's roughness of 0.07 is used for the river channel. For floodplain a roughness value of 0.12 is assigned for the right overbank crossing through the site. The Manning's roughness values downstream were assigned to represent field conditions.
6. The model is simulated for design return periods 1 in 100 year, 1 in 200 year and 1 in 1000 year with central and upper end allowances of climate change.
7. The model was tested for its senstivity against roughness value (+/- 20%), downstream boundary slopes (steep to flat), and ponding resulting from a 90% blocked downstream bridge.
8. The flow was observed in the vicinity of the site for extreme return periods where flows outside the main channel continue over the right bank between section XS2 and section XS3. These results indicate that the site is flooded at the lower reaches near the channel but the equipment is not susceptible to flooding.
9. The model is tested for the PMF flow rate provided in the reservoir report.

Results

1. Flood levels for the site are estimated at cross section XS3 for design return periods.
2. Flood levels relevant to each piece of critical equipment are taken from the nearest cross section.
3. The resulting water levels are reported on page 1 and 2 of this summary sheet.

Comparison to previous studies / data

1. Flood levels estimated from Environment Agency flood zone mapping are not comparable to the flood levels by our assessment.
2. The site operator has commented that the site was previously flooded from dam release but that the plant wasn't flooded. As per our assessment, the site is flooded for critical storm events but none of the equipment is flooded which is consistent with the anecdotal evidence from the site operator.
3. The overflow structure in the 1D ISIS routing model was calibrated using the PMF flow and stage obtained from the Section 10 report.

Assumptions and Limitations

1. The impact of hydraulic structure (culvert underneath the road crossing) is not considered in this assessment.
2. Floodplain is represented within the 1D domain of the model.
3. Cross sections (channel and floodplain) are extracted from the latest Environment Agency LiDAR (1m resolution).

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Sutton Poyntz	**Post Code**		
12112					
Site Type	**NGR**				
Water Treatment Works	**Division**	South	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	Robert William Rawlings			
WT_SP	**Contact Number**	07825401068 S/D 602			

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	River Jordan and drainage ditch	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
21.49 to 29.59 (LiDAR)	24.63 (LIDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	< 0.30			
			1 in 100 year (1%)	24.01	0.58	N/A	< 0.30			
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 200 year (0.5%)	24.08	0.65					
			1 in 1000 year (0.1%)	24.22	0.79	N/A	0.30-0.90			
23.43		2050 (Upper End Allowance)	1 in 100 year (1%)	24.08	0.65	N/A	N/A			
			1 in 200 year (0.5%)	24.14	0.71					
			1 in 1000 year (0.1%)	24.31	0.88	N/A	N/A			
			Groundwater flooding					Low		
			Reservoir							0.00

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Jeffrey Mail	Kelsey Plech	Sun Yan Evans

Client Review & Site Visit

Date of Site	29/11/2016	Attendees	Carrie Eller (MM) and Matt Taylor (WW)

Location of Critical Equipment

Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
Mains incomer	23.43	24.31	24.50	24.50	1.07
Control panel for orthophosphoric dosing system	23.43	24.31	24.50	24.50	1.07
Control panel	24.23	24.31	24.50	24.50	0.27
Control panel for chlorination system	28.55	27.39	27.57	27.57	-0.98
Solenoid valve	28.70	27.39	27.57	27.57	-1.13
UV treatment system	29.15	27.39	27.57	27.57	-1.58

Summary of Key Client Comments

1. Adjacent culvert floods during heavy rainfall, having around 0.3m of flood depth. (Matt Taylor, Site visit 29/11/2016)
2. Meadow and river flood during heavy storm events. (Matt Taylor, Site visit 29/11/2016)
3. There is pedestrian access around back of the site when culvert floods during high rainfall. (Matt Taylor, Site visit 29/11/2016)
4. The flooding becomes worse when there is water quality issue as the site would be shut down resulting in more water in the culvert. (Matt Taylor, Site visit 29/11/2016)
5. Critical Infrastructure Impacted (using information available from FRAs conducted PR09): Only affected asset is the Cottage, and it is unclear if the houses or any other infrastructure would be affected by flooding. This site has not undergone an FRA and requires further assessment. (Source: STW and WTW Flood Resilience Database)
6. The assets at the site are not at risk from flooding, however the risk of flooding is downstream of the site, particularly the properties near or adjacent to the pond and Silver Street (lowest point). (Robert Rawlings, 09/02/2017)

Comments on Below Ground Equipment (if any)

1. Critical equipment below ground level are control panel for orthophosphoric dosing system and mains incomer. Mains incomer is in basement room. The critical equipment level of mains incomer is 2.45m below ground.
2. The critical equipment levels for control panel for orthophosphoric dosing system and mains incomer are 21.76mAOD and 21.77mAOD respectively.
3. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.
4. For below ground equipment, flood depths listed in the above table represent the depth above ground level or finished flood level. Once the flood level becomes higher than the indicative threshold level listed in the above table for below ground equipment, flood depth at the equipment should be estimated with respect to critical equipment level, and not the indicative threshold level.

Phase 2 Mitigation Assessment

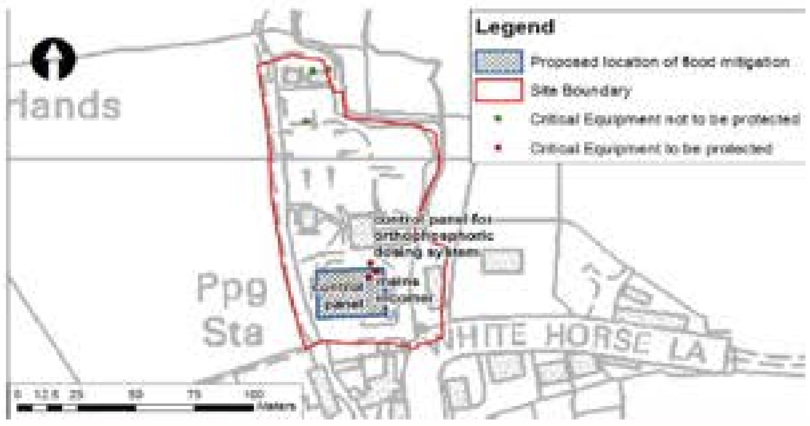
Flood Defence Description

1. Building waterproofing and the fitting of flood doors is proposed to the main building on site including the Mains incomer, Control panel for orthophosphoric dosing system and control panel.
2. The Control panel for chlorination system, solenoid valve and UV treatment systems are not to be protected.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

24.5 mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	1
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	2
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	0
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred given that flood levels are very sensitive to obstructions and this would cause excessive flooding to third parties.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The only measures include waterproofing of existing buildings. No impacts anticipated to flooded area.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

There is no existing FRA available for this site.

Site Topographical Survey

Site topographical survey was provided by Wessex Water for this assessment in DWG fomat, titled:
WT_SP_12112 Sutton Poyntz topo_20161122.dwg
This survey covers approximately half the site, including ground level information for the northern portion only.

Watercourse Survey

The existing model comprises watercourse data collected over a number of different occasions:
1. River cross-sections surveyed by CSL (April 2005)
2. Topographical survey data supplied by Weymouth & Portland BC (March 2005)
3. Environment Agency detailed survey of cross sections and structures (June, 2007)
No further watercourse survey was gathered for this assessment.

Environment Agency / Local Authority Existing Studies

The River Jordan Hydraulic Modelling Report (Royal Haskoning, 2009) was supplied by the Environment Agency for use in this study. A flood model was supplied but the extent was limited to the confluence near Puddledock Lane, downstream of the site.

Details of Existing Study

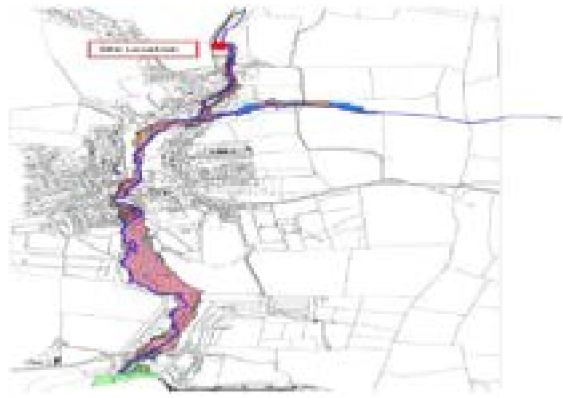
Fluvial Hydrology

Catchment descriptors were exported from the Flood Estimation Handbook (FEH) version 2 CDROM. These were input into the FEH Rainfall Runoff Method in ISIS to produce the inflows for each of the 5 sub-catchments.

Tidal Hydrology

The downstream boundary at Weymouth uses the tide level for the Highest Astronomic tide (HAT), and the curve shape taken from "Report on Regional Extreme Tide Levels, South West Region", Posford Haskoning, 2003. The site is located outside of the tidal influence due to its position and elevation in the catchment.

Study Extent



Hydraulic Model Construction

1. The model consists of a 1D-2D linked ISIS TUFLOW model with a 2m grid size.
2. The extent includes a 3.1km reach of the River Jordan and 665m of Osmington Brook. The River Jordan model has an upstream boundary approximately 300m upstream of the Sutton Poyntz WTW.
3. The downstream boundary of the model is located at the mouth of the River Jordan where it discharges at Weymouth.
4. Structures in the supplied model are represented as bridges within the ISIS with spill units representing flow over the top of the bridge structure. It is not documented how the culvert sections are represented for portions of the model upstream of the confluence.
5. Manning's roughness values have been applied per guidance from published texts including Chow, Open Channel Hydraulics, 1959. Values applied include:
 0.05 for grass, gardens, parks and pasture
 0.1 for rough ground
 0.02 for roads
 0.6 for trees and hedgerows

Return Periods Assessed in Model

5, 10, 25, 50, 100 and 200 year return periods.

Comments

1. No gauge records are available for calibration of the modelling. Calibration was carried out to photographic and wrack mark evidence from previous flood events.
2. Surface water flooding was not accounted for in the modelling. Preliminary modelling of combined flooding including surface water was considered to over estimate flood levels as no losses/infiltration was considered. The fluvial flood model was selected as the best representation of flooding in the area.
3. Defences modelled as part of the modelling study are located well downstream of the site and their influence on flood levels does not extend to the site.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial, from the River Jordan

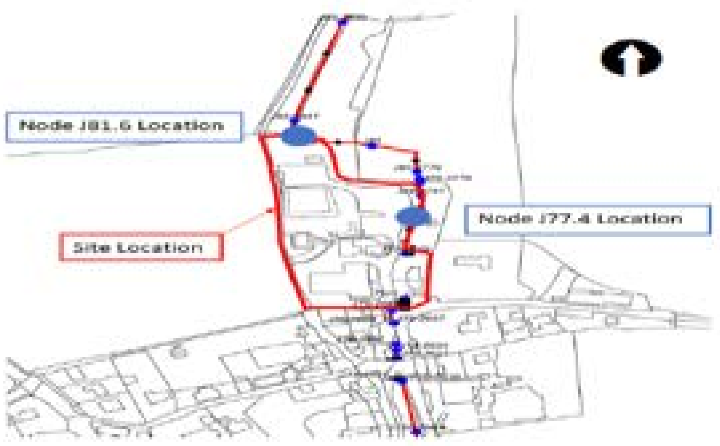
Fluvial Hydrology

The hydrological calculations summarised in the River Jordan Hydraulic Modelling Report from the Environment Agency were reviewed and found to be an appropriate representation of the catchment for the purpose of this flood risk assessment.

Tidal Hydrology

The tidal boundary for the existing model comprises tide data for the Weymouth downstream model boundary.

Supporting Figure



Summary of Approach

1. The Jordan River Model was reviewed for information on flooding in the vicinity of the site.
2. Hydraulic structures and urban features (roads/buildings) and their schematisation in the model was reviewed.
3. The level or structure overtop was reviewed for different return period to confirm the events providing results valid for the extrapolation approach.
4. The modelled results were extracted from the dataset supplied by the EA.
5. Flood levels for return periods not previously modelled, were extrapolated from the available results at nodes J81.6 and J77.4.
6. Climate change allowances for increases in peak flow rate were examined to determine likely flood levels through future flooding events.

Hydraulic Modelling

The relationship between fluvial flood flow and the water level was reviewed by hydraulic modellers. Engineering judgement was used in the extrapolation of these results to yield future climate change results, based on the known response of the area to increases in fluvial flows, informed by the EA supplied modelling. Further hydraulic modelling was not undertaken for this site.

Results

The access lane becomes a flow path for flood water which enters the site further upstream, before the section of culvert. The flood levels in this report are from two locations where spilling from the channel will occur during flooding. These two locations are relevant to the critical equipment in the upper and lower portions of the site as indicated in the Location of Critical Equipment Plan. Results indicate that the site and critical equipment are at risk of flooding. Resulting flood levels are shown on pages 1 and 2.

Comparison to previous studies / data

1. The Environment Agency's flood zone mapping doesn't extend to the site. The Environment Agency's information on surface water flooding suggests similar overland flow paths through the site as would be experienced with fluvial flooding spilling out of the channel. The steep nature of the site means that from both sources of flooding, the site is susceptible to flooding depending on the availability of clear flow paths for the water to travel south to White Horse Lane.
2. The site operator reports that the site floods during heavy rainfall including areas adjacent the culvert and the meadow. Flood depths of up to 0.3m have been observed in the vicinity of the culvert. The modelled levels are supported by these observations in that heavy rainfall results in overland flow through the site. It follows that the extreme flood events reported in this analysis include flow paths in these areas of the site to greater depths than observed.

Assumptions and Limitations

1. The site is relatively steep and flooding which breaks out of the channel into the site is susceptible to ponding and buildup around obstructions such as buildings and vehicles. The resultant flood level at the entrance to buildings will vary depending on whether flow paths over the pavements are clear.
2. No gauge records are available for calibration of the modelling. Calibration was carried out to photographic and wrack mark evidence from previous flood events.
3. Surface water flooding was not accounted for in the modelling. Preliminary modelling of combined flooding including surface water was considered to over estimate flood levels as no losses/infiltration was considered. The fluvial flood model was selected as the best representation of flooding in the area.
4. Default hydraulic co-efficients for structures were used in the modelling, optimised during the model build by the hydraulic modellers.
5. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.
6. There is a high level of uncertainty in the estimation of hydrology for the 1000 year return period. No gauge records are available to inform the hydrology assessment.
7. The culverts are modelled with the assumption that they are free of blockage.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

Wessex Water Site ID	**Site Name**	Washpool	**Post Code**		
12118					
Site Type	**NGR**				
Water Treatment Works	**Division**	North	**Flood Resilience Design Life (years)**	25	
Mott MacDonald Site Code	**Controller**	Marc Hodgson			
WT_WP	**Contact Number**	07768035421			

Site Plan

Location Plan

Environment Agency Flood Map

Surface Water Flood Map

Ground Water Flood Map

Reservoir Flood Map

Site Topography

Key Characteristics

Primary Flood Mechanism	Fluvial	**Existing Flood Defence**	No
Main Flooding Source	St Catherine's Brook	**EA Flood Warning Area**	No results for the current location
Current Site Flood Zone	Flood Zone 3	**Flood Warning Notice Period**	EA aim to give at least 2 hours lead time.
Current Access Road Flood Zone	Flood Zone 3	**Other Drainage Consultees (Internal Drainage Board, Local Authority, Highways Agency, British Waterways etc.)**	To Be Confirmed

Flood Analysis (depth calculated at lowest critical equipment)

Site Ground Level Range (Min to Max) (mAOD)	Typical Ground Level (mAOD)	Climate Condition Year	Return Period (AEP%)	Fluvial / Coastal		Surface Water		Ground Water	Reservoir	
				Level (mAOD)	Depth (m)	Level (mAOD)	Depth (m)	Flooding Susceptibility	Level (mAOD)	Depth (m)
41.33 to 42.76 (LiDAR)	41.40 (LiDAR)	2025 (Upper End Allowance)	1 in 30 year (3%)			N/A	< 0.30			
			1 in 100 year (1%)	42.06	1.60	N/A	< 0.30			
			1 in 200 year (0.5%)	42.10	1.64					
Indicative Threshold Level at the lowest critical equipment (mAOD)			1 in 1000 year (0.1%)	42.18	1.72	N/A	0.30-0.90			
		2050 (Upper End Allowance)	1 in 100 year (1%)	42.10	1.64	N/A	N/A			
			1 in 200 year (0.5%)	42.13	1.67					
40.46			1 in 1000 year (0.1%)	42.21	1.75	N/A	N/A			
			Groundwater flooding					Negligible		
			Reservoir							Over 2m

Comments

Please see comments on flood level calculations on pages 3 and 4 of this summary sheet (Appendix of Supporting Information).

Revision Record

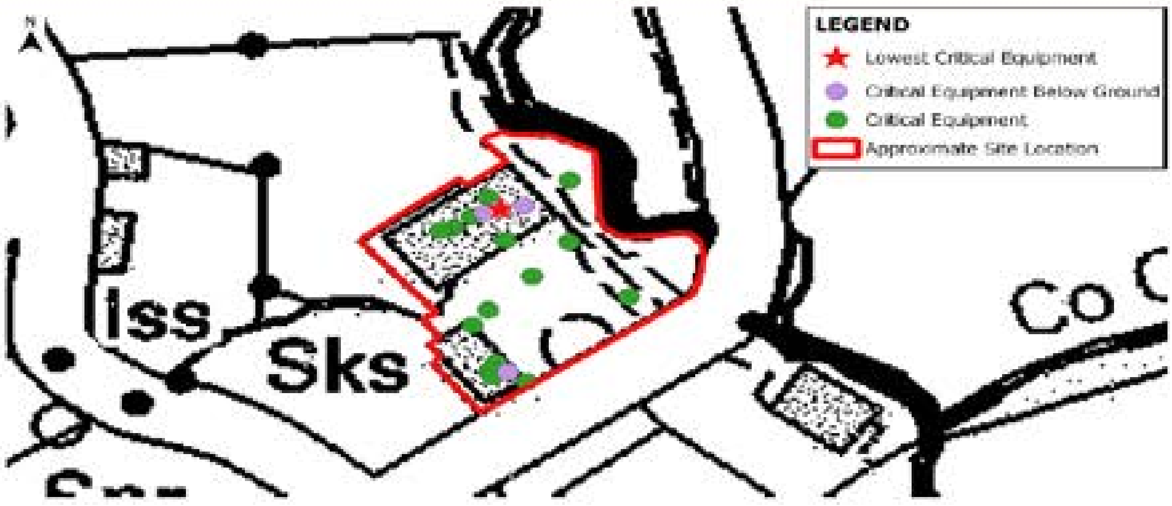
Revision	Issue Date	Originator	Checker	Approver
A	30/06/2017	Jeffrey Mall	Kelsey Piech	Sun Yan Evans

M M
MOTT MACDONALD

Client Review & Site Visit

Date of Site	30/11/2016	Attendees	David Tinning (MM) and Kieron Sloan (WW)

Location of Critical Equipment



Critical Equipment (10 Lowest Equipment)	Indicative Threshold Level (mAOD)	1000yr+CC (2050 Upper End) not including 300mm Freeboard (mAOD)	1000yr+CC (2050 Central) including 300mm Freeboard (mAOD)	Proposed Flood Defence Crest Level (mAOD)	Depth above threshold level (m)
High Level Float	41.20	42.21	42.46	42.46	1.26
Sump Pump	40.46	42.21	42.46	42.46	2.00
Actuator In Neutr. Chemical Waste Tank Room	40.99	42.21	42.46	42.46	1.47
Submersible Chamber / Pump Chamber	41.03	42.21	42.46	42.46	1.43
Valve Chamber	41.09	42.21	42.46	42.46	1.37
Chlorine Injection	41.96	42.21	42.46	42.46	0.50
Compressors	41.35	42.21	42.46	42.46	1.11
Control Panel	41.35	42.21	42.46	42.46	1.11
Valve Chamber	41.51	42.21	42.46	42.46	0.95
Process Motors	41.61	42.21	42.46	42.46	0.85

Summary of Key Client Comments

1. During the flood event in 2013/2014, the access lane was flooded. There was 0.6m depth in the neutralization room during the flood event. (Kieron Sloan, Site visit 30/11/2016)
2. Brook was dredged and cleared of debris after 2013/2014 floods. This seems to have helped alleviate the flooding. However, Chambers can flood from rising ground water. (Kieron Sloan, Site visit 30/11/2016)
3. Bridge seems to back up flood water. River can burst its banks, but access to the site is always possible. (Kieron Sloan, Site visit 30/11/2016)
4. Actuated valve chamber and Submersible chamber can flood. It has a sump pump, but pump can fail, or sometimes not keep up with the inflow. (Kieron Sloan, Site visit 30/11/2016)
5. Chemical neutralization bund can flood. This can shut the plant down. (Kieron Sloan, Site visit 30/11/2016)
6. Main pump room could potentially flood through ducts, but this has not yet been witnessed. There is also an injection point in the main pump room. (Kieron Sloan, Site visit 30/11/2016)
7. This site has not previously undergone a FRA and requires further assessment. (Source: STW and WTW Flood Resilience Database)

Comments on Below Ground Equipment (if any)

1. The critical equipment below ground level are high level float, sump pump, actuator in neutralization chemical waste tank room and chlorine injection . When flood water reaches the ground level at the critical rquipment then the equipment will start to inundate however the critical equipment level is 0.96m below the ground level.
2. For above ground equipment, indicative threshold level is equal to the critical equipment level in the above table while for below ground equipment, the indicative threshold level is finished floor level or ground level in the above table.
3. For below ground equipment, flood depths listed in the above table represent the depth above ground level or finished flood level. Once the flood level becomes higher than the indicative threshold level listed in the above table for below ground equipment, flood depth at the equipment should be estimated with respect to critical equipment level, and not the indicative threshold level.

Phase 2 Mitigation Assessment

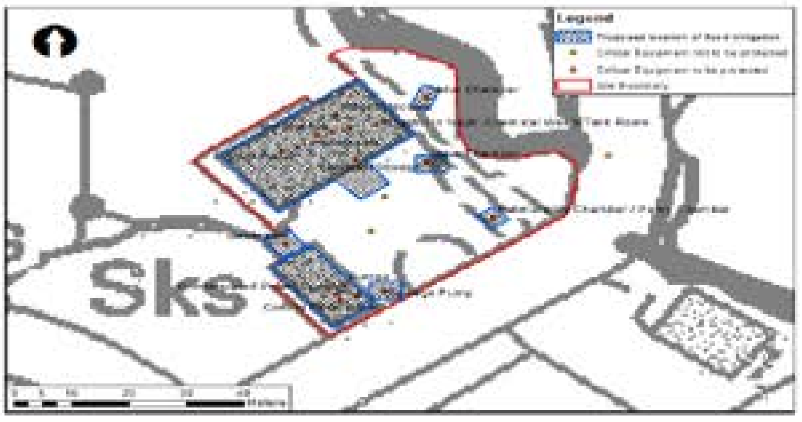
Flood Defence Description

1. The buildings housing the high level float, sump pump, control panel, chlorine storage, membranes, compressors, Actuator in Neutr. Chemical Waste Tank Room, Process Motors, Uninterrupted power supply, Pumps, Control Panel Room chlorine injection, chlorine bottle room and Generator should be hardened/waterproofed and flood doors installed to the openings.
2. Equipment to be replaced with IP68 rated equipment where possible (valve chambers, submersible chamber/pump chamber, sewage pump, junction boxes, emergency stops, instrumentation).
3. The chemical spill tank is not to be protected. If this floods, there may be a requirement for clean-up costs after a flood event.

Flood Defence Crest Level 1000 yr + CC (2050 Upper End) or 1000 yr + CC (2050 Central) Including 300mm Freeboard

42.46 mAOD

Flood Defence Layout



Indicative Scope for Flood Mitigation

Description	Per	Quantity
Earth bunding up to 2m height	linear m	0
Walling up to 1m height	linear m	0
Walling up to 2m height	linear m	0
Walling up to 3m height	linear m	0
Building waterproofing (treatment to existing buildings- height varies)	nr buildings	3
Localised cabinet protection (max 1m height)	linear m	0
Localised cabinet protection (max 2.1m height)	linear m	0
Flood doors	number	12
Flood gate up to 1m	number	0
Flood gate up to 2m	number	0
Movable/demountable defence	linear m	0
Replace equipment with IP68 rating (low, medium or high complexity site banding)	-	Medium
Raise control panel or kiosk	number	0
Raise other equipment	number	0
Other	linear m	0

Comments

1. The following mitigation measures were considered but not preferred for the following reasons:
a) whole site protection is not preferred given the cost and depth of flooding at site. Note that an allowance has not been made for replacement of equipment or clean-up costs.
b) Localised protection (cabinets or flood walls) were considered at various individual pieces of equipment however this may cause access issues and therefore raising the equipment is preferred.

General caveat: Indicative scope for Flood Mitigation includes an allowance for construction cost, design and project management, but does not include operational costs. Does not include the requirement for pumps that may be required to remove excess rainwater or groundwater seepage from within localised protection flood mitigation measures. Building waterproofing is calculated from Finished Floor Level. This may also require waterproofing of air vents, cable duct sealing or other potential entrance points. Proposed flood defences may require additional costs to mitigate impact on flood risk to third parties. During detailed design, an assessment of the appropriate freeboard allowance should be made. It is assumed that any cabling on site is already sealed and the costs for cable/duct sealing are not included. Our cost estimate does not include an allowance for clean-up costs that may be required after a flood event.

Anticipated Impact on Flood Risk to Third Parties due to Proposed Flood Defences	Minimal. The area protected by building hardening will reduce the storage for floodwater within the site.

Source Data

LiDAR Data

1m resolution LiDAR data was downloaded in December 2016 from the Environment Agency website.

Existing FRA and accompanying model files

No previous FRA was available for review in this assessment.

Site Topographical Survey

Topographic survey was provided by Wessex Water for this assessment in dwg format, filename: 12118 washpool topo.dwg

Watercourse Survey

St Catherine's Brook was surveyed by Civil Engineering Surveyors as part of a wider agreement for the Environment Agency in 1999. The HEC-RAS model (BBV, 2000) based on these surveyed cross sections was available for review.

Environment Agency / Local Authority Existing Studies

The St Catherine's Brook was modelled by Binnie Black & Veatch (BBV) for Bristol City and Bath and North East Somerset District Councils in 2000 as part of a joint project with Capita Symonds. The modelling report titled Bath, North East Somerset and Bristol Watercourses and model files were supplied by the Environment Agency for analysis in this study.

Details of Existing Study

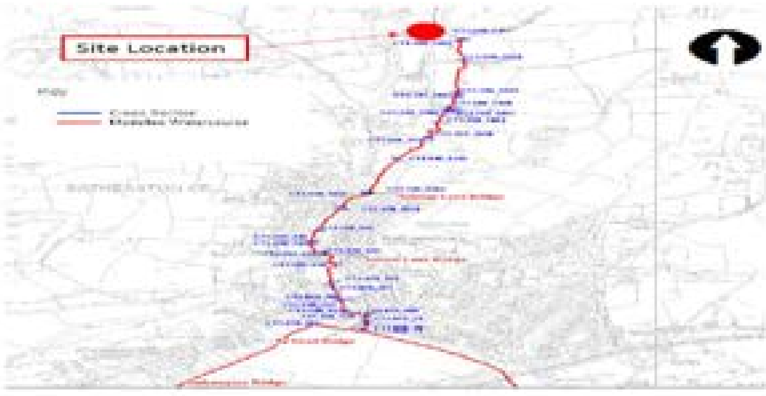
Fluvial Hydrology

St Catherine's Brook was assessed and hydrology calculated using statistical methods per the Flood Estimation Handbook using the index QMED flood and the flood growth curve.

Tidal Hydrology

The watercourses near this site are not tidally influenced.

Study Extent



Hydraulic Model Construction

The modelled reach of St Catherines Brook extends 2.4km upstream from its confluence with the River Avon to the head of the main river. This reach covers both the areas of Batheaston and Northend. The modelling was completed as a steady-state simulation using HEC-RAS software. Peak inflows from the hydrological model were applied upstream, with the downstream boundary condition consisting of the River Avon water surface level. Bridges and culverts have been added to the model with the exeption of farm crossings and footbridges judged to have no hydraulic significance. Manning's n values adopted were 0.045 for the main channel and 0.060 for overbank sections representing the more dense vegetation. Sensitivity tests were completed on the 100yr return period event, accounting for
1. channel roughness (+/-10%)
2. flow rates (+/-20%)
3. structure coefficients (+/-10%)
4. water level boundary conditions (+/-10%)

Return Periods Assessed in Model

The St Catherine's Brook Hydrological analysis was performed for the following return periods:
2 year
5 year
10 year
20 year
50 year
100 year

Comments

1. The hydrological assessment for the St Catherine's Brook modelling is valid for the site as calculations were made for the brook immediately downstream of the site.
2. The hydraulic assessment of St Catherine's Brook did not provide relevant information as the model extent finishes south of the site, and does notinclude the Oakford Lane culvert crossing downstream of the site.
3. No calibration of the St Catherine's Brook modelling was carried out, however sensitivity analyses were performed on roughness, flow rates, structure co-efficients and water level boundary conditions.

Site Specific Flood Level Assessment

Primary Source of Flooding considered in this Assessment

Fluvial, from St Catherine's Brook immediately east of the site. This Brook is a tributary of the River Avon.

Supporting Figure

Fluvial Hydrology

The hydrological calculations summarised in the Bath, North East Somerset and Bristol Watercourses Report to the Environment Agency were reviewed and found to be an appropriate representation of the catchment for the purpose of this flood risk assessment.

Tidal Hydrology

N/A

Summary of Approach

1. The St Catherine's Brook modelling was reviewed to find previously modelled flood levels in the vicinity of the site.
2. Cross sections of St Catherine's Brook adjacent the site and at key downstream structures are compared with LIDAR survey.
3. The model's bed levels and results are extrapolated further up the reach of the brook, past the subject site.
4. Structures are examined for the likely influence on water surface levels, and conservative assumptions on blockage made in extending the water surface profiles for the extended upstream reach.
5. Extrapolation of the hydrological results from the previous modelling is made to reveal likely flows for return periods not included in the previous assessment.
6. Flood levels are determined, based on the relationships between structures and the resultant water levels downstream.
7. The latest guidance from climate change projections is applied to model results to reveal likely flood levels in the future.
8. To verify results of the extrapolation, model cross sections are assigned mannings values by inpection of aerial photography, and assessed for conveyance using ISIS software.
9. Flood levels are determined, based on the relationships of flow and flood level determined through the assessment of conveyance.
10. The extended model results and results of the cross section analysis are compared with other sources of flooding information such as EA flood maps.

Hydraulic Modelling

1. The modelled bed levels and water surface profiles were extended to locations upstream of the site, informed by LIDAR survey and the observations of structure performance downstream.
2. Increases in water surface level relative to key structures were made based on the hydraulic assessment of Oakford Lane using weir equations and a conservative assumption of a blocked culvert structure.
3. For verification, key cross sections through the model extension were extracted from LIDAR survey. Hydraulic roughness was assigned according to published resources, based on the judgement of the hydraulic modeller and inspection of site photography in addition to aerial photography.
4. The slope of the channel was determined through inspection of the lidar and plotting longsections of the river channel.

Results

Results indicate that the site and critical equipment are at risk of flooding. Resulting flood levels are shown on pages 1 and 2.

Comparison to previous studies / data

1. The site operator notes previous flooding in 2013/2014, with depths of 0.6m recorded within the neautralisation room. Based on site survey, this would represent flooding to approximately 41.6mAOD and be the equivalent of a 20 year return period flood event, when compared with the extended model analysis. The operator also notes that dredging of the channel has occured since this flooding and that the flow carrying capacity in the vicinity of the site is now considered higher than in 2013/2014.
2. The results from the analysis indicate flood levels for the 1000yr return period which are generally higher than the EA flood map data by approximately 0.5m. The EA flood maps have been generated from a course assessment and are not based on a site specific assessment.

Assumptions and Limitations

1. This assessment does not account for obstructions to flow within the floodplain of St Catherine's Brook. The floodplain includes the pavements within the Wessex Water site boundaries, adjacent sites' access driveways, Oakford Lane and the yard opposite Oakford Lane to the south. Obstructions here including vehicles and stored machinery or materials could increase the risk from flooding by locally causing ramping up of flood levels.
2. In the assessment of the hydraulic flow at Oakford Lane, the culvert below the roadway was assumed 100% blocked. This analysis revealed the likely flood levels based on ponding from blockage of the culvert.
3. Surface water was not analysed, and surface water flooding inclusive of surcharging from drains in the immediate vicinity of the site is asource of residual flood risk.
4. Climate change allowances based on Environment Agency (2017) Climate Change Guidance.

Caveat

This Flood Level Analysis (FLA) accompanies the Flood Risk Assessment Summary Sheet prepared for this site. This FLA has been produced to support the PR19 cost estimate for flood mitigation measures at this site. This assessment is not suitable for detailed design. Further detailed analysis should be undertaken for detailed design of flood defences at the site.

B. Summary of Flood Mitigation Measure Indicative Cost Estimates

Site ID	Site Name	Site Code	Proposed Mitigation Measure	Total Cost Estimate (£)	Cost Estimate Breakdown	Comment on Standard of Protection
12001	Admiralty	SO_AD	1. The brick building containing boreholes MCC is at risk of flooding 7cm above finish floor level. Revisions to the building to raise the building threshold, raise any air vents or other pathways of flooding into the site to be provided to a level 7cm above FFL. 2. The generator is located on a plinth covered with metal siding and is at risk of flooding 16cm above ground level. The critical equipment threshold level has been assumed as ground level, however it is noted by the site operator that some flooding is likely to be possible without flooding the generator. Therefore, flood mitigation measures have not been proposed at the generator. Please see comments box below for alternative options.	15,000	1. Raising building threshold = £15,000	
12004	Ashford	WT_AS	1. Building waterproofing and flood doors are proposed as flood mitigation measures for the building which house maximum number of equipments on the site (Refer the Flood Defence Layout). 2. Equipment should be replaced with IP68 rated equipment where possible (actuators at inlet valve). Based on this assumption a cost using the medium size/complexity cost banding has been assumed. 3. The shed which houses the remaining electrical equipment at the inlet valve (other than the actuators) should be reconstructed to allow the remainder of the equipment in the shed to be raised 53cm above ground level.	520,000	1. Building waterproofing £400,000 with 6 flood doors £24,000. 2. Medium complexity IP68 banding = £40,000 3. Reconstruct and raise shed = £50,000	
11678	Balls Hill P.S.	SU_BH	1. Building waterproofing and 1 flood door are proposed as flood mitigation measures for the building which includes control panel, pump, import export meter and transformer. 2. Main transformer to be raised 1.2m. 3. Electric cabinet to be raised 0.88m. 4. Isolation valve and electric panel to be replaced with IP68 rated equipment. Given the size and complexity of the site, this has been costed using the 'low' banding cost.	110,000	1. Building waterproofing £30,000 and 1 flood door £4,000 2. Main transformer raised on platform=£50,000 3. Electric cabinet raised= £10,000 4. IP68 rating equipment replacement (small/low complexity) = £15,000	
14002	BATH	SP_BA	NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event. 1. The transformer, Western Power substation, liquid oxygen panels, actuator and building housing the main control room should be protected by a wall of 2m height including a flood gate for access. 2. Equipment to be replaced with IP68 rated equipment where possible (actuator and liquid oxygen panels, inclusive of junction boxes, emergency stops, instrumentation).	1,350,000	1. Construct 2m flood wall to site perimeter, including flood gate for access. £1,331,000	Note: the proposed mitigation measure provides a standard of protection less than the 1000yr+CC flood event.
17142	BATH	SP_BW	NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event. 1. Whole site protection with flood wall to 2m maximum height, including flood gate for access.	490,000	1. Construct 2m flood wall to site perimeter, including flood gate for access. £490,000	Note: the proposed mitigation measure provides a standard of protection less than the 1000yr+CC flood event.
12008	Black Lane	WT_BL	1. Flood defence measures are currently being implemented for the three boreholes. Based on our analysis these defences should be provided with a crest level at a minimum 41.74mAOD to achieve the 1000yr resilience level including the affects of climate change to 2050. We assume the bund protection is being constructed to provide at least 75cm protection above ground level and is built as a water retaining structure. If the bund is not constructed to this level it will provide protection to the equipment but not to the 1000yr flood level inclusive of climate change effects. 2. The areas between the Brook and the public road do not require mitigation measures to achieve the required flood resilience, including the MCC, generator and network booster pump.	0	1. Flood defence is already under construction therefore nothing proposed	
15019	BOURNEMOUTH	SP_BO	Building waterproofing and flood doors are proposed as flood mitigation measures for the building which contains control panels, mains incomer, pumps and screen and the pumps in the basement.	210,000	1. Building waterproofing £200,000 and 2 flood doors £8,000	
12015	Briantspuddle	WT_BP	None Proposed	0	n/a	
14016	Bristol (Ashton Ave)	SP_BR	1. The entire site should be protected by a wall of 2m height connecting two areas of higher ground. Blocking off the narrow section of localised low ground prevents water entry to the site from fluvial flooding.	40,000	1. Construct flood wall to 1m maximum height. £38,000	
12017	Brixton Deverill	WT_BD	1. Building waterproofing and 5 flood doors are proposed as flood mitigation measures for the building which includes main control panel, chlorine room, surge vessel control unit and standby generator. 2. Equipment to be raised above flood level for motive water kiosk/monitor (17cm), borehole control kiosk (58cm) and stream support kiosk (61cm). 3. Equipment to be replaced with IP68 rated equipment where possible, including the divert actuator, associated electrical equipment. This has been costed using the 'medium size/complexity' cost banding given the nature of the equipment. 4. The septic tank is confirmed as non-critical equipment by Wessex Water, therefore no mitigation measures are proposed to protect this equipment.	190,000	1. Building waterproofing £100,000 and 5 flood doors £20,000 2. Raise equipment = £30,000 3. IP68 rated equipment (medium band) = £40,000 4. n/a	
15341	BURNHAM ON SEA	SP_BS	NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event. 1. The building housing the Pump control panel and the Generator control panel should be hardened to 0.9m height (the maximum practical on advice from suppliers). 2. The Western Power substation should be raised by as much as is permitted by the asset owner, and at least 1.5m. This equipment will require stair access/working platform at the new height.	120,000	1. Building hardening of whole site building £50,000 2. Flood doors 3no £12,000 3. Raise transformer over 1m (high as possible) including new access stairs £50,000	Note: the proposed mitigation measure provides a standard of protection less than the 1000yr+CC flood event.
13040	Burrowbridge	ST_BU	1. Junction box and any other electrical equipment to be replaced with IP68 rated equipment. Given the limited number of equipment on site, this has been costed using the 'small site/low complexity' cost band. 2. Main power supply cabinet to be raised 49cm.	25,000	1. IP68 rated equipment 'low complexity' cost band = £15,000 2. Raise main power supply cabinet = £10,000	
11467	Bushfield P.S.	SU_BC	1. Mitigation is considered to comprise replacement of the pumps with a submersible option. 2. Equipment to be replaced with IP68 rated equipment where possible (pumps, junction boxes, emergency stops, instrumentation). 3. Control panel does not require protection.	15,000	1. IP68 rated equipment (low complexity) = £15,000	
12026	Charlton P.S.	SU_CT	1. Building waterproofing and flood doors are proposed as flood mitigation measures for the two buildings which house equipment on the site (Refer the Flood Defence Layout). 2. All equipment that could be replaced with IP68 rating to be removed and installed with appropriate IP68 rated replacement (actuators, mixing chamber instrumentation, emergency stops, juction boxes). Based on the complexity at the site, the site has been considered large/high complexity site for cost banding purposes. 3. Chloring gas storage to be raised 11cm above current FFL. Door thresholds and air vents to be reconstructed accordingly. 4. Transformer to be raised 53cm with associated access platform.	230,000	1. Building waterproofing £50,000 and flood doors (7) £28,000 2. IP68 rating large site= £70,000 3. Raise chlorine gas store = £30,000 4. Raise transformer = £50,000	
12030	Chitterne	WT_CH	1. Building waterproofing and flood doors are proposed as flood mitigation measures for the two buildings which include the Actuator, Pumps, Chlorine Gas Store, Communications, Sample Pump, Main Control Room, Standby Generator, Surge Vessel Compressor and Sample Pump. 2. Septic tank is confirmed by Wessex Water as a non-critical asset. 3. Main transformer to be raised 20cm. 4. Equipment that can be replaced with IP68 rated equipment (actuators and electrics, borehole instrumentation and electrics, junction boxes, emergency stops, etc.) to be replaced with appropriate IP68 rated equipment. Given the size and complexity of the site, the costing for this is based on 'large/high complexity' site cost banding. 5. There are 7 boreholes located on site or in the vicinity of the site. Given the number of boreholes, an additional allowance has been made for the protection of the boreholes to raise and/or replace electric equipment, control panels, kiosks with necessay IP68 rated equipment.	540,000	1. Building waterproofing 2 buildings £300,000, 11 flood doors £44,000 2. n/a 3. Raise transformer=£50,000 4. IP68 equipment replacement=£70,000 5. Additional allowance for borehole instrumentation, electrics IP68 replacement= £70,000	
12036	Compton P.S.	SU_CO	1. Replacement of electrics to comply with IP68 regulations is required for Washout Chamber, Chamber for ESAS, Borehole 1, Borehole (disused), Borehole 2, Fuel Tank, surge tank vessel and actuator. 2. Building waterproofing for a structure perimeter of 28.2m is required to mitigate risk to the Standby generator, a perimeter of 17.5m for the Chlorine store, and a perimeter of 70m for the Chlorination dosing chamber, sample taps and control panels.	570,000	1. Building waterproofing 3 buildings £500,000 2. IP68 equipment £70,000	
12038	Corfe Mullen	WT_CM	1. Building waterproofing is proposed at three buildings to protect all of the critical equipment at this site. 12 flood doors will be required for access.	450,000	1. Building waterproofing at 3 buildings = £400,000 2. 12 flood doors = £48,000	
11729	Corscombe	SU_CC	Due to the lack of adequate resolution ground level data at the site, it is not possible to estimate accurate flood levels. Therefore, proposed flood mitigation measures are not provided for this site.	0	n/a	
13084	Crewkerne	ST_CR	1. The metal countainer/shed housing the MCC power supply and control panel should be reconstructed and raised to allow raising of equipment by 80cm. 2. 3 blowers to be raised 1.1m on concrete plinth with suitable access platform. 3. Generator to be raised 1.16m on concrete plinth with suitable access platform. 4. Electrics, junction box and control panel at the BAFF cell pumping station to be raised 2.08m with suitable access platform and stairs. This equipment is located in the lowest part of the site. 5. Compressor kiosk to be raised 1.54m with suitable access platform and stairs. 6. Where possible, electrical equipment to be replaced with IP68 rated equipment, such as the electrics at the humus desludge pump and the BAFF cells. Based on the size and complexity of the site, this has been costed under the 'high' costing band. 7. No protection is proposed at the humus tank drive motor and tank bridge motor. In the event of a flood, this equipment should be replaced. Costing for this is not considered in our assessment.	310,000	1. Reconstruct and raise metal container= £100,000 2. Raise 3 blowers= £30,000 3. Raise generator= £50,000 4. Raise electrics at BAFF cell pumping station=£50,000 5. Raise compressor kiosk=£10,000 6. IP68 equipment replacement medium bank = £70,000 7. n/a	
12043	Dewlish	WT_DE	1. Building waterproofing and flood doors are proposed as flood mitigation measures for the building which includes the lowest critical equipment turbidity meter. Other equipment including control panels, instrumentation and other electrics are located in this building.	25,000	1. Building waterproofing = £20,000 2. Flood door = £4,000	
12049	Durleigh	WT_DL	1. A flood defence wall is proposed along the canal within the site boundary, with a height of 1m. 2. To account for the potential for the increased flows through the channel, the pedestrian bridge and road culvert are to be resized to allow clear passage of the 1000yr+CC flow. Wingwalls to be constructed and the road to be reprofiled to ensure no backwater effects of water backing up onto the site. May require traffic diversion and associated planning.	1,500,000	1. Flood defence wall=£500,000 2. Culvert resizing at roadway downstream of site, installation of wing walls at roadway culvert entrance, road reprofiling, traffic diversion = £1,000,000	
12050	Durrington	WT_DU	1. Building waterproofing and 1 flood door are proposed as flood mitigation measures for the building which includes the telemetry panel and MCC. 2. The remote isolation panels should be raised 44cm (borehole 1) and 20cm (borehole 2). It is noted by the site operator that the panel at borehole 1 is potentially redundant. For a conservative estimate we have costed for raising this item.	35,000	1. Building waterproofing £20,000 and flood door £4,000 2. Raising two remote isolation panels=£10,000	
18714	East Lyng	ST_EL	1. Control panel to be raised 1.18m. An allowance for a suitable access platform and stairs has been included. 2. Any other electrical equipment to be replaced with IP68 rated equipment, or raised, such as the power main.	35,000	1. Raise control panel with access platform and stairs=£20,000 2. IP68 equipment replacement 'low' banding = £15,000	

15078	FERNDOWN	SP_FD	1. The building housing the mains incomer control panel and other electrical equipment to be waterproofed, with two flood doors. 2. The generator is to be raised 68cm. 3. The SEE substation is to be raised 1.03m. This method of protection will require approval from the asset owner, and be subject to the operational requirements for the substation.	160,000	1. Building waterproofing £50,000 and two flood doors £8,000 2. Raise generator= £50,000 3. Raise substation= £50,000	
17220	Fivehead P.S.	SU_FH	1. Building waterproofing and two flood doors are proposed as flood mitigation measures for the building which houses the chlorination room housing the dosing equipment. 2. Back up panels and control panel for mains incomer pumps to be raised 38cm and 18cm, respectively. 3. The rotork valve is at risk of 2cm of flooding. It is currently raised 63cm above ground. Given that the equipment is already raised, and is at risk of a very small amount of flooding, it is not proposed to provide flood mitigation for this equipment.	70,000	1. Building waterproofing=£40,000, 2 flood doors=£8,000 2. Raise backup panels and control panel = £20,000	
11371	Fiveways Valve Rotork chamber	SU_FW	1. Mitigation is considered to comprise replacement of the rotork valve with a submersible option. 2. Equipment to be replaced with IP68 rated equipment where possible (rotork valve, junction boxes, emergency stops, instrumentation). 3. Control panel to be raised 0.22m from current level.	25,000	1. Raise control panel=£10,000 2. IP68 rating equipment replacement (small/low complexity site) £15,000	
13144	Haselbury Plucknett	ST_HP	Due to the lack of adequate resolution ground level data at the site, it is not possible to estimate accurate flood levels. Therefore, proposed flood mitigation measures are not provided for this site. However, per Wessex Water request, and given the history of flooding at the ADE kiosk (2 nr.) and request from the site operator that the primary tank control panel (1nr) is raised, we have costed for a nominal raising of these three kiosks. Note that the amount these are required to be raised has not been determined due to lack of detailed flood level data.	30,000	1. Raising three kiosks = £30,000	
12063	Heytesbury	WT_HE	1. Building waterproofing at 1 building and 2 flood doors are proposed for the building at this site, housing: cable ducts, control panel, pumps, fuel tank, phosporic acid dosing, chlorine gas store. 2. Wessex Water has confirmed that septic tanks and chemical spill tanks are non-critical equipment, therefore costing for these measures is not included. 3. Borehole 6 is disused therefore mitigations measures are not proposed at this equipment. 4. Control panel at the standby generator to be raised. 5. Equipment to be replaced with IP68 rated alternatives at Borehole 10. 6. Transformer to be raised 57cm (not a Wessex Water asset).	110,000	1. Building waterproofing £20,000 and two flood doors £8,000 2. n/a 3. n/a 4. Raise control panel=£10,000 5. IP68 rating equipment replacement (small/low complexity site) £15,000 6. Transformer raised=£50,000	
14374	HIGHBRIDGE	SP_HB	NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event. 1. Building waterproofing and hardening up to 2m height, with 1 flood door, to protect the mains and generator incomer, screw pumps MCC feeder. 2. Wester Power transformer to be raised 1.6m to meet defence level of building protection (8.67mAOD). 3. Generator to be raised 0.6m to meet defence level of building protection (8.67mAOD).	210,000	1. Building waterproofing, structural hardening with flood door: £104,000 2. Raised transformer: £50,000 3. Raised generator: £50,000	Note: the proposed mitigation measure provides a standard of protection less than the 1000yr+CC flood event.
12068	Ivyfields P.S.	SU_IF	None proposed	0	n/a	
13190	Lytchett Minster	ST_LM	1. Building waterproofing and a flood door are proposed as flood mitigation measures for the building which includes the general site MCC. 2. The connections for the UV treatment equipment and the pumping station are to be replaced with IP68 rated equipment. Given the size and complexity of these equipments, these have been costed using the 'low' banding cost. 3. Feed panel to be raised 0.81m. 4. Due to operational requirements, the aerator is difficult to protect, therefore it is recommended that the equipment is allowed to flood and then replaced if damaged by flood water. If prefered, spares could be kept on site. 5. Aerator motor to be raised 0.56m. 6. Storm tank MCC to be raised 0.23m. 7. Aerator feed panels to be raised 0.17m. 8. UV MCC and assosiated equipment to be raised 0.74m.	190,000	1. Building waterproofing £40,000 and 1 flood door £4,000 2. Connections replaced with IP68 rated equipment=£45,000 (£15k each) 3. Feed Panel raised=£10,000 4. Aerator not to be protected=£0 5. Aerator motor raised=£10,000 6. Storm tank MCC raised=£20,000 7. Aerator panel raised=£10,000 8. UV MCC raised=£50,000	
14205	MALMESBURY	SP_MA	1. The metal cabinet/building housing the control panel for mains incomer and pumps is to be raised 0.71m. Suitable access platform included in the cost estimate. 2. Pump joining boxes and wet well joining box to be replaced with suitable IP68 rated equipment. Costing based on 'low' complexity cost banding.	35,000	1. Raise metal cabinet/building= £20,000 2. IP68 rated equipment replace 'low' cost banding = £15,000	
13208	Merriott	ST_ME	1. The building housing the control panel and the pumping station should be reconstructed/raised to allow raising of the control panel by 1m. 2. The pumping station in the basement of the same building contains 5 dry well pumps that should be replaced with IP68 rated equipment (medium size/medium complexity cost banding). 3. The control panel at the primary auto desludging equipment should be raised by 84cm. 4. The compressors/blowers (4nr.) should be raised on a plinth 41cm. 5. Equipment to be replaced with IP68 rated equipment where possible (pump at inlet screen, junction boxes, emergency stops, instrumentation). 6. Sediment tank, humus tank and associated bridge motors are not to be protected. If these flood, there may be a requirement for clean-up costs after a flood event. The bridge motors cannot be protected or made IP68 rated therefore the preferred solution is replacement after a flood event, or storage of spares on site.	410,000	1. Reconstruct and raise building £200,000, raise control panel and construct platform £120,000 2. IP68 equipment replacement medium size/complexity cost banding=£40,000 3. Raise Desludging equipment control panel= £10,000 4. Raise 4nr compressors/blowers= £40,000	
12090	Newton Meadows	SO_NM	NOTE: the proposed mitigation measures provide a standard of protection less than the 1000yr+CC flood event. 1. Equipment to be replaced with IP68 rated equipment where possible (Mains Pipe (Bristol Water Inlet), Piping, Chlorine Dosing and actuator, inclusive of junction boxes, emergency stops, instrumentation). 2. Equipment already raised within the existing building including the Chlorine gas store, Control panel room and the Treatment room will not receive protective measures due to already being raised and the difficulty in providing protection to non ground floor structures. 3. Equipment not to be protected includes the septic tank. Wessex Water has confirmed the septic tank is not critical.	70,000	1. IP68 rated 'high complexity' for the ground level equipment £70,000	Note: the proposed mitigation measure provides a standard of protection less than the 1000yr+CC flood event.
12089	Newton Toney	WT_NT	1. Building waterproofing and flood doors are proposed as flood mitigation measures for the buildings which includes the MCCs, generator, sampling lines in chlorinator room and control panel. The control panel in the relift room also requires maintenance of sealed ducts below ground level. 2. Pump station kiosk on plinth to be raised 6cm.	70,000	1. Building waterproofing: £50,000 2. Flood doors: £8,000 3. Raising pump station kiosk: £10,000	
15263	POOLE	SP_PF	1. Building waterproofing and flood doors are proposed as flood mitigation measures for the building which contains the control panels for the pumps (2 panels, 1 for each pump) and the mains incomer control panel. 2. Generator cabinet to be raised 0.74m.	110,000	1. Building waterproofing £80,000 and 2 flood doors £8,000 2. Generator cabinet raised= £20,000	
15383	POOLE	SP_PW	1. A combination of building 1m wall, waterproofing and flood doors are proposed as flood mitigation measures for the building which contains control panel and mains incomer. 2. Generator cabinet to be raised 1.24m.	120,000	1. Walling up to 1m= £78,000. Building waterproofing £12,000 and 2 flood doors £8,000 2. Generator cabinet raised= £20,000	
15270	POOLE	SP_PT	Control panels for pumps, mains incomer and compressor to be raised 0.45m. Based on the site visit photographs it is assumed there is enough head room inside the building and therefore no structural changes are required.	20,000	1. Equipment to be raised= £20,000	
15240	POOLE	SP_PB	1. It is proposed to build a curb or similar feature around the wooden fence at the stairs, with a ramp up the entrance. This feature should have a crest level 10cm above ground leve to stop the water the water entering the stair/basement.	10,000	1. Construction of curb ramp= £10,000	
15273	POOLE	SP_PL	1. Building waterproofing and flood doors are proposed as flood mitigation measures for the building which includes control panel, mains incomer, pumps and generator. 2. Generator cabinet to be raised 0.39m.	150,000	1. Building waterproofing £120,000 and 2 flood doors £8,000 2. Generator cabinet raised= £20,000	
15235	POOLE	SP_PS	1. Replace existing masonry wall at stairs with a 1.04m high flood wall around the access to the underground room containing the critical equipment. 2 flood doors to be installed at the two stairway entrances at pavement level.	45,000	1. Walling up to 1m = £33,000 2. Flood doors = £8,000	
12103	Rodbourne	WT_RB	1. Waterproofing of the existing building including building hardening to a height of 1m above FFL. Two flood doors assumed to be required. This will protect the equipment in the building, including the pumps, control panel and transformer. 2. Generator to be raised 1m on concrete plinth with access platform. 3. Borehole kiosk (2nr) and borehole control panel to be raised 54cm, 42cm and 27cm, respectively. 4. Electrical equipment at the inlet chamber and motive pumps to be replaced with IP68 submersible options. Given the medium size/complexity of the site, this has been costed using the 'medium' costing band. 5. The septic tank has been confirmed as non-critical equipment by Wessex Water and therefore mitigation measures are not proposed to protect this.	430,000	1. Waterproofing of building £300,000 with two flood doors £8,000. 2. Raise generator=£50,000 3. Raise two borehole kiosks and one borehole control panel = £30,000 4. IP68 equipment replacement for medium size/complexity site = £40,000	
13268	Sherborne	ST_SH	1. Building waterproofing and 4 flood doors are proposed as flood mitigation measures for two buildings which house the transformer, MCC and control panel for mains incomer and generator at site. 2. Raise the control panel at the high drop system pump by 73cm. 3. Raise the washwater system electrics by 29cm. This includes a float. 4. Replacement with IP68 rated equipment where appropriate, such as the inlet screen junction box. Given the size and complexity of the site, a 'medium' cost banding has been applied. 5. The generator is raised above ground by 66cm, and is at risk of flooding to a depth of 2cm above the critical level. Given that the equipment is already raised, and the depth of potential flooding is small, we do not propose flood mitigation at this equipment.	170,000	1. Building waterproofing £90,000 and 4 flood doors £16,000 2. Raise control panel and high drop system= £10,000 3. Raise washwater system electrics= £10,000 4. IP68 equipment replacement medium cost banding= £40,000 5. n/a	
12111	Sutton Bingham	WT_SB	Although the lower portions of the site, near the watercourse, are flooded in extreme events, the critical equipment is not susceptible to flooding. No mitigation measures are proposed.	0	n/a	
12112	Sutton Poyntz	WT_SP	1. Building waterproofing and the fitting of flood doors is proposed to the main building on site including the Mains incomer, Control panel for orthophosphoric dosing system and control panel. 2. The Control panel for chlorination system, solenoid valve and UV treatment systems are not to be protected.	130,000	1. Building waterproofing £120,000 2. Flood doors 2no £8,000	
13305	Taunton (Ham)	ST_HA	1. A 90m earth bund to maximum 2m height to be provided across the access road to the west of the site. 2. Ramping of the access road including traffic management/road closure during construction is required. 3. IP68 rated pump equipment is required for drainage of the ditch on the upstream side of the bund. 4. Associated costs would include planning costs and the purchase of third party land. 5. Equipment protected includes everything with a critical level below the Flood Defence Crest level. 6. Equipment above the Flood Defence Crest level do not require protection to be resilient to the 1000yr climate change flood event.	560,000	1. 90m earth bund £189,000 2. IP68 Pump for catchment drainage 'Low' £15,000 3. Ramping for access road £350,000	

14510	TROWBRIDGE	SP_TB	1. The building housing the control panel and the electricity equipment SEE owned should be waterproofed and flood doors fitted to prevent flooding up to 0.88m in depth over the existing floor level. 2. The pumping station in the basement contains dry well pumps that should be replaced with IP68 rated equipment (medium size/medium complexity cost banding). 3. The SEE owned tranformer should be raised 1.35m and an access platform constructed adjacent.	310,000	1. Building waterproofing (control panels and see electrical equipment) £ 200,000 2. Flood doors 2no. £ 8,000 3. Raise SEE tansformer £ 50,000 and provide access platform $10,000 4. IP68 medium complexity for upgrade of basement pumps £ 40,000	
13326	WARMWELL	SP_WA	1. The building housing the control panel for the mains incomer, generator standby and pump should be provided with a stop lock door panel. This removable panel mounted to the frame of the door opening is to provide a 0.3m increase in the building threshold level. 2. Nitrate dosing equipment and Generator do not require protection. These items are raised off the ground, above the potential flood levels.	5,000	1. Flood door panel to control panel building= £4,000	
12118	Washpool	WT_WP	1. The buildings housing the high level float, sump pump, control panel, chlorine storage, membranes, compressors, Actuator in Neutr. Chemical Waste Tank Room, Process Motors, Uninterrupted power supply, Pumps, Control Panel Room chlorine injection, chlorine bottle room and Generator should be hardened/waterproofed and flood doors installed to the openings. 2. Equipment to be replaced with IP68 rated equipment where possible (valve chambers, submersible chamber/pump chamber, sewage pump, junction boxes, emergency stops, instrumentation). 3. The chemical spill tank is not to be protected. If this floods, there may be a requirement for clean-up costs after a flood event.	270,000	1. Provide 1m flood wall/structural reinforcement to existing buildings exterior walls and waterproofing £180,000 2. IP68 equipment replacement medium size/complexity cost banding=£40,000 3. Flood doors to existing building= £48,000	
11648	West Grimstead P.S.	SU_WG	1. The building housing the control panel for pumps and mains incomer and pumps should be waterproofed. 2. The Generator is not to be protected.	55,000	1. Waterproofing of building £48,000 with two flood doors £4,000.	
19833	WEST WICK	SP_WW	1. Given the extreme flood depths at this site, it is not possible to protect the site against the 1000yr+CC flood event. 2. As an alternative, it is proposed to raise the two lowest pieces of equipment (electric cabinet 2.41m, and control panel 0.70m) to the threshold level of the third lowest piece of equipment (junction boxes). This would provide protection within 30mm of the 100yr+CC (2025) median bound flood level. 3. No mitigation measures are proposed for the two highest pieces of equipment, the pump junction boxes and control panel.	20,000	1. n/a 2. Raise electric cabinet and control panel= £20,000	
15681	WESTON-SUPER-MARE	SP_WE	1. Given the extreme flood depths at this site, it is not possible to protect the site against the 1000yr+CC flood event. Please see comment box below.	0	n/a	Note: given the extreme flood depths at this site, it is not possible to protect against the 1000yr+CC flood event.
13340	Weston-Super-Mare (Black Rock)	SP_WS	1. Given the extreme flood depths at this site, it is not possible to protect the site against the 1000yr+CC flood event. Please see comment box below.	0	n/a	Note: given the extreme flood depths at this site, it is not possible to protect against the 1000yr+CC flood event.
11344	Whychurch Tower & GT	SU_WT	1. Mitigation is considered to comprise raising of the equipment within the existing cabinet by 0.11m. 2. Site control panels including pumps main incomer, and pump and motor do not require protection.	5,000	1. Raising of equipment within existing cabinet comprising 2 days labour £2000	
13347	Wickwar (option 1)	ST_WI	1. Due to excessive flood depths at the site it is not possible to protect the site against the 1000yr+CC flood event. 2. As an alternative approach, a maximum wall height of 2m is proposed in the lower part of the site (with flood gate) to protect the equipment in the lower part of the site, including humus tanks, SAF feed pump panels, de-sludge kiosk, WPL microscreen, SAF pumps, washwater and circulation system, liquor return and humus return pumps, and associated electrics. The final sample effluent point would also be located within the bounds of the flood wall. A maximum wall height has been specific by Wessex Water as allowable due to operational, visual and safety requirements. 3. Inlet pump station kiosk to be raised as high as possible. 4. Building waterproofing with 2 flood doors on the upper part of the site, to protect the main control room and the control panel and electrics at the mono pumps.	560,000	1. n/a 2. Flood wall= £470,000, flood gate £14,500 3. Inlet pump station kiosk raised = £10,000 4. Building waterproofing= £50,000, 2 flood doors=£8,000	Note: the proposed mitigation measure provides a standard of protection less than the 1000yr+CC flood event.
13347	Wickwar (option 2)	ST_WI	Second cost has been provided per Wessex Water request: 1. n/a 2. Instead of flood wall around lower part of site, cost is provided for raising or local protection of equipment in the lower site area. 2a. replace the following equipment with IP68 rated equipment: equipment at final effluent sampling point, SAF pumps and electrical equipment, humus return pump and equipment, liquor return pump and equipment. 2b. raise the following equipment as high as possible (noting that this equipment is already raised 48-110cm above ground): WPL microscreen and equipment, desludge kiosk, SAF feed pujmp panel, washwater and recirculation. 2c. SAF tank is already raised 2.59m above ground and is sealed. No mitigation measure proposed. 2d. No mitigation measure proposed at humus tanks. Allow to flood and follow with clean-up operation. 3. Inlet pump station kiosk to be raised as high as possible. 4. Building waterproofing with 2 flood doors on the upper part of the site, to protect the main control room and the control panel and electrics at the mono pumps.	200,000	1. n/a 2a. IP68 rating (high complexity band) = £70,000 2b. Raise equipment = £60,000 2c. £0 2d. £0 3. Inlet pump station kiosk raised = £10,000 4. Building waterproofing= £50,000, 2 flood doors=£8,000	Note: the proposed mitigation measure provides a standard of protection less than the 1000yr+CC flood event.
15588	WORLE	SP_WO	1. Given the extreme flood depths at this site, it is not possible to protect the site against the 1000yr+CC flood event. Please see comment box below.	0	n/a	Note: given the extreme flood depths at this site, it is not possible to protect against the 1000yr+CC flood event.

SUM £ 11,130,000 (with Wickwar Option 1)
SUM £ 10,770,000 (with Wickwar Option 2)

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